WATER QUALITY STATUS REPORT ● REPORT NO. 83

VINYARD CREEK
Jerome County, Idaho
1986

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

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Prepared by
R. Tim Litke

Twin Falls Field Office
963 Blue Lakes Blvd., Suite 1
Twin Falls, Idaho 83303

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ABSTRACT

Vinyard Creek is located in Jerome County, east of Twin Falls, Idaho. This small creek (length <2 km) arises from a spring-fed lake, and discharges to the Twin Falls hydropower dam pool on the Snake River. From April through October Vinyard Creek receives irrigation drainage water, primarily from one main drain. During 1986 a water quality survey was conducted on Vinyard Creek to assess water quality conditions and beneficial use impairments due to agricultural pollutants.

During the 1986 irrigation season, Vinyard Creek transported an estimated 780 tons of sediment to the Snake River. Most of this sediment entered Vinyard Creek as a result of row crop irrigation, particularly during pre-irrigation in the spring and during the first irrigation of beans after cultivation in July. A substantial portion of this sediment load is likely deposited in lower Vinyard Creek in a backwater reach created by the elevated water level of the Twin Falls dam pool. This sediment reduces spawning and rearing habitat for resident salmonids (cutthroat trout, rainbow trout, and a cutthroat-rainbow hybrid).

Instream inorganic nitrogen and total phosphorus levels met or exceeded limits to prevent nuisance plant growth prior to the irrigation season. During the irrigation season, organic nitrogen, total phosphorus, and dissolved orthophosphate levels all increased. Much of this nutrient load could be attributed to irrigation drainage water since organic nitrogen and total phosphorus were positively correlated with suspended sediment. However, runoff from confined animal feeding operations (CAFOs) also contributed nutrients to the main drain. Elevated instream nitrate levels were due to springs feeding the creek with 2 to 4 mg/l nitrate nitrogen. Nitrate levels decreased with the onset of irrigation as agricultural return flows diluted creek flows.

Fecal coliform densities that exceeded the primary contact recreation standard were observed in Vinyard Creek during the irrigation season. Fecal coliform densities were poorly correlated with suspended sediment levels, and could be traced to runoff from CAFO corrals on the main drain. Ratios of fecal coliform bacteria to fecal streptococcus bacteria confirm that livestock was the predominant source of this contamination.

Macroinvertebrate collections from Vinyard Creek also indicate degraded water quality conditions. A substantial portion of the invertebrate taxa collected from Vinyard Creek could be categorized as "pollution-tolerant"

taxa. A comparison of benthic communities above and below the main drain confluence indicated fewer taxa, fewer individuals, and fewer "clean water species below this agricultural return.

The data indicate that beneficial uses of Vinyard Creek including cold water biota, salmonid spawning, and primary contact recreation are being impaired or threatened by agricultural pollutants. Levels of suspended sediment, total phosphorus, and organic nitrogen could be reduced in Vinyard Creek by implementation of agricultural best management practices on surface irrigated cropland that drains into the main drain. Overall productivity of the creek would likely not decrease since nutrient levels exceed eutrophication limits during the non-irrigation period. Implementation of the best management practices should receive priority on surface irrigated fields with crops with high erosion potentials (e.g., beans). Best management practices addressing animal waste management and rerouting of the main drain away from CAFO corrals should substantially reduce fecal contamination of Vinyard Creek, and thereby protect the primary contact recreation beneficial use and public health.

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INTRODUCTION

Water quality of the Snake River from Milner Dam to Buhl, Idaho is severely impacted by sediment and other pollutants associated with runoff from irrigated cropland (IDHW-DOE, ISCC, and U.S. EPA 1983). Tributary streams such as Vinyard Creek, in addition to agricultural return drains, convey nutrient, bacteria, and sediment rich irrigation tailwater to the Snake River. Also, runoff and discharges from confined animal feeding operations (CAFOs) contribute bacteria and soluble and particulate nutrients and organics to surface waters in this reach. These pollutants impact the beneficial uses of all affected stream segments. Additionally, the suspended sediment and nutrients in transport in surface waters during the year, and particularly during the irrigation season, represent lost crop productivity due to inadequate or improper agricultural best management practices (BMPs) to reduce soil erosion.

The Idaho Agricultural Pollution Abatement Plan (IDHW-DOE, ISCC, and U.S. EPA 1983) was developed and implemented to solve water quality problems attributable to agricultural activities. This plan focuses on reducing agricultural nonpoint source pollution impacts on surface waters of Idaho through implementation of agricultural BMPs (e.g., sedimentation ponds, filter strips, minimum tillage, irrigation water management, livestock waste management systems, etc.) in impacted drainages. The Soil Conservation Service (SCS), Soil Conservation Districts (SCDs), Idaho Fish and Game Department, and the IDHW-Division of Environmental Quality (IDHW-DEQ) worked together to identify impacted streams and to prioritize stream segments for BMP treatment under the plan.

Vinyard Creek has been identified by the Agricultural Pollution Abatement Plan as a stream impacted by agricultural pollutants arising from irrigated cropland. This implies that water quality problems in Vinyard Creek can be reduced or solved by BMP implementation in the Vinyard Creek watershed. The agricultural pollutants present in Vinyard Creek threaten beneficial uses such as salmonid spawning, and primary and secondary contact recreation. In addition, although rearing habitat is not an identified criteria to support the cold water biota designated use, it is evident that sediment accumulations below the main drain confluence have eliminated most rearing habitat in that section of Vinyard Creek.

PAST WATER QUALITY STUDIES

The IDHW-DEQ conducted a preliminary water quality study on Vinyard Creek during August, September, and October of 1985. This study was designed to help support the planning efforts of the North Side SCD (NSSCD), since it was awarded a Planning Grant through the State Agricultural Pollution Abatement Program in early 1985.

The survey indicated that agricultural pollutants were degrading Vinyard Creek water quality and impairing beneficial uses. Elevated suspended sediment and nutrient levels were attributed to eroding cropland in the watershed. Elevated bacteria densities were considered a result of CAFO discharges or runoff from corral areas. This research supported the NSSCD in its grant application for a BMP Implementation Grant. Also, it became evident that baseline data for a full water year were needed to document water quality conditions prior to BMP implementation, particularly to assess water quality impacts due to pre-irrigation of bean fields.

The Idaho Department of Fish and Game has made several assessments of the fish populations in Vinyard Creek (Bell 1988). Their data indicate that Vinyard Creek is utilized as spawning and rearing habitat by cutthroat trout and rainbow trout. This reach of the Snake River also has a unique cutthroat-rainbow hybrid which utilizes Vinyard Creek and other nearby areas for fall spawning. Idaho Department of Fish and Game indicates that Vinyard Creek is heavily utilized by this strain, and that juveniles also use the creek as rearing habitat. Preferred spawning and rearing habitat is located primarily in the upper reaches of the creek. The streambed downstream of the main drain confluence has been severely impacted by sediment accumulations. Based upon the output of the NSSCD's Planning Grant Project, the NSSCD applied for and received a BMP Implementation Grant for a local water and soil conservation resource management program in 1986. The IDHW-DEQ conducted an intensive water quality survey in 1986 on Vinyard Creek. This survey permitted additional baseline data to be collected over an entire water year, and the research was completed prior to any significant implementation of BMPs on cropland in the Vinyard Creek drainage.

OBJECTIVES

The objectives of this intensive water quality survey on Vinyard Creek were as follows:

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

b) Identify and characterize the major agricultural nonpoint pollution sources that impair water quality.

c) Expand the existing water quality data base to include a complete water year to assess pre and post irrigation season water quality.

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

DRAINAGE BASIN DESCRIPTION

Vinyard Creek is a small stream (total length less than 2 km) which arises from a large spring source on the north side of the Snake River in Jerome County (Figure 1). These springs feed a small lake which overflows via a waterfall into a box canyon forming Vinyard Creek. The creek discharges into the Snake River at the Twin Falls hydropower dam pool. Vinyard Creek is directly impacted by agricultural return flows during the irrigation season in two locations. One agricultural drain discharges to Vinyard Lake (Figure 2). The pollutant load to Vinyard Creek from this source is minimal since the drain flows through a pasture and extensive wetlands before it discharges to the lake, and the lake also acts as a large settling pond. The primary source is a drain which discharges to Vinyard Creek about 3/4 of a kilometer below the falls. Most of the subbasins in the Vinyard Creek watershed discharge at some point into this main drain. Pollutants carried by this drain severely impact water quality throughout the remainder of the creek to its confluence with the Snake River. Depending upon the elevation of the Twin Falls hydropower dam pool, an estuary-like area forms at the confluence of Vinyard Creek and the Snake River. Because of the reduced stream velocities in this reach, a substantial portion of the sediment load is deposited.

The Vinyard Creek watershed is totally irrigated agriculture under both furrow (40%) and sprinkler (60%) irrigation. The NSSCD estimates that 7,947 acres of the 9,890 acres in the watershed are critical acres in need of BMP treatment (NSSCD 1986). Main crops grown in the Vinyard Creek watershed include hay, row crops (beans, potatoes, peas, beets, corn, and onions), and small grains.

Soils in the watershed are primarily silt loams (76% of the total) and sandy loams (24%). While these soils are highly productive, they are also very erosive. The NSSCD estimates erosion rates as high as 20 tons/acre on surface irrigated lands, and 13 tons/acre under sprinklers (NSSCD 1986).

Confined animal feeding operations in the watershed are limited to small feedlot operations of less than 100 head. There are 17 small feedlots in the drainage, and no dairies.

Climate of the Vinyard Creek watershed is semiarid with cold winters and hot dry summers. Annual precipitation is about 20 cm, which primarily occurs as snow. Air temperatures range from 25°F to 90°F, and the growing season is about 130 days.

MONITORING STATIONS

This study was conducted throughout 1986 to assess Vinyard Creek water quality during a complete water year. This study was initiated in March to assess pre-irrigation and early irrigation water quality impacts, and continued through November to document post-irrigation season water quality. Water quality was monitored at four locations in the Vinyard Creek drainage (Table 1, Figure 2). Stations in the canyon were located on Vinyard Creek above and below the confluence of the main drain, and a monitoring station was located on the main drain upstream of this confluence. The remaining station was located outside of the canyon on the main drain below the confluence of two drains which convey irrigation tailwater from primarily furrow irrigated subbasins.

MATERIALS AND METHODS

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

Water samples were collected along transects at well mixed locations at each station and composited in a churn splitter for representative subsampling. Water samples for chemical analysis were collected in 1 liter cubitainers. Samples for nutrient analysis were preserved in the field with 2 ml H_2SO_4. Water samples for dissolved orthophosphate analysis were field filtered using 0.45µm 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. Filters were checked by the Bureau of Laboratories, Boise, prior to use to insure they were phosphorus free. Samples were placed on ice and cooled to 4°C. Chemical analyses were performed by the Idaho Department of Health and Welfare, Bureau of Laboratories, Boise, following Standard Methods (American Public Health Association 1985).

Grab water samples for bacteriological analysis were collected in sterile 250 ml Nalgene polyethylene bottles near the center of well-mixed locations at each station. These samples were cooled to 4°C and delivered to the Twin Falls Branch of the IDHW-Bureau of Laboratories. Analysis of bacteriological samples followed Standard Methods (American Public Health Association 1985).

Macroinvertebrates were collected at the two Vinyard Creek stations in July and October, 1986, with a modified Hess sampler (surface area of $0.10m^2$). 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 all four monitoring stations in May, July, and September 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 cross-composite collected for routine water chemistry samples. Duplicate bacteria samples were collected as close together in the stream as possible.

Three sets of spiked samples were collected during the study from each station 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, total Kjeldahl nitrogen, total phosphorus, orthophosphate, and suspended sediment. Celite was used for suspended sediment 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 then determined by subtracting background concentrations (as determined from duplicate or routine samples) from known spike values.

DATA ANALYSIS

Statistical tests used for data analysis followed Zar (1984) and Sokal and Rohlf (1969). A paired-sample t-test was used to evaluate differences in specific contaminant levels between various monitoring stations. This test was applied to data that had been transformed by a logarithmic transformation. Correlations between independent variables at each sampling station were examined using Spearman's rank correlation coefficient test.

RESULTS AND DISCUSSION

STREAM FLOW

Being a spring-fed creek, stream flows would be expected to be somewhat constant. At the upstream Vinyard Creek station (S-2), flow ranged from about 10 cfs in May to about 20 cfs in September and October. Mean flow for the study period at this station was 16.1 cfs (Table 2). United States Geological Survey data for station #13089500 near S-2 indicate that daily flows in this reach were relatively constant during the 1985-1986 water year, and that flows gradually increased from February base flows of about 12 cfs to peak flows of 19 cfs in September (Table 3). Increasing stream flows throughout the summer months probably reflects increased spring flows due to groundwater recharge by irrigation water.

Below the main drain confluence at S-1, flows did fluctuate considerably in response to irrigation water management. Flows ranged from 14.8 cfs in March before the irrigation season, to about 30 cfs during the peak irrigation months of June, July, and August. Mean flow at S-1 during the study was 24.9 cfs (Table 2).

Flows in the main drain at S-4 were significantly greater than flows measured at S-3 (two-sample *t*-test, $p < 0.05$). Mean flows for the study period at S-4 and S-3 were 26.3 cfs and 7.1 cfs, respectively (Table 2).

Much of the flow observed at S-4 is diverted to feed laterals which eventually terminate in lava fields at the north side of the watershed; one diversion eventually drains into Vinyard Lake (Figure 2). As discussed later, these diversions from the main drain below the furrow irrigated subbasins considerably reduce the load of sediment and other pollutants that might reach Vinyard Creek from this highly erodible cropland.

SUSPENDED SEDIMENT

Particles (mineral or organic) that require little energy to transport once they are entrained in the water column comprise the suspended sediment load of a river (Morisawa 1968). Suspended sediment adversely impacts aquatic ecosystems by reducing light penetration and primary production, and by damaging sensitive tissues of aquatic organisms (e.g., gill tissues) through physical abrasion. In addition, as this material is deposited on the streambed, it physically smothers incubating fish eggs, larvae, and fish food organisms. Stream bottoms once diverse with habitat for aquatic organisms, become uniform, physically unstable substrates. Spawning and rearing habitat for salmonids is reduced or eliminated.

During this study, suspended sediment levels at S-1 were significantly greater than at S-2 (two-sample *t*-test, $p < 0.05$), which reflects the input of sediment via the main drain downstream of S-2. Mean annual concentrations for S-2 and S-1 were 11.2 mg/l and 49.0 mg/l, respectively. Pre-irrigation concentrations in March at both stations were 2.0 mg/l; the data indicate that both stations are impacted by irrigation tailwater. As expected, the data indicate that the primary return flow source impacting Vinyard Creek water quality is the main drain.

Flow and suspended sediment levels were found to be poorly correlated. For example, at S-3 where these two parameters appear most correlated (Figure 3), the Spearman rank correlation coefficient (r_s) for these parameters over the irrigation season was only 0.53. These poor correlations are probably the result of variable sediment loadings from the subbasins, crop and irrigation water management, and/or sediment deposition in diversions or sedimentation ponds. However, as would be expected, suspended sediment levels and turbidity were positively correlated. Correlation coefficients (r_s) for these parameters at S-3 and S-4 were 0.91 and 0.88, respectively.

Suspended sediment levels in the main drain exceeded those measured instream. Mean values for the study were 170.0 mg/l and 179.3 mg/l for

S-3 and S-4, respectively. Measured concentrations were not significantly different between these stations (two-sample t-test, $p < 0.05$). Concentrations as high as 350 mg/l were measured on several dates at S-3; a concentration of 1060 mg/l was measured at S-4 in late July.

Plots of suspended sediment levels during the study at the four monitoring stations reveal patterns that can be explained by crop and irrigation water management (Figures 3-6). Explanation of these patterns can only be approximate due to the sampling interval. Obviously, more frequent sampling would permit greater refinement of these plots. However, the data do illustrate key water quality impact periods which can be related to agricultural practices causing the impact, and therefore may be used to identify agricultural practices that are in need of BMP treatment.

Although elements of this pattern are apparent at all sites, the most complete pattern is evident at S-3 and will be used for illustrative purposes (see Figure 3). Key features of this plot are as follows:

Date	Explanation
5/7	Pre-irrigation and preparation of ground for planting; pre-irrigation of beets and potatoes.
6/10	Pre-irrigation of beans; some irrigation of grains and beets. Flows have increased because hay is being cut.
6/25	Suspended sediment is low because primarily grains and hay are being irrigated.
7/23	First irrigation of beans after cultivation. This results in massive erosion (see Figure 6). Second hay cutting results in higher stream flows.
9/8	Sediment levels are low since beans are not being irrigated; grains are not being irrigated.
9/8 to 9/22	Flows have increased during third cutting of hay; canals are being flushed.

9/22 Suspended sediment levels increase due to pre-irrigation of fall grains and preparation of sugar beet fields for harvest.

These plots indicate that the key to reducing suspended sediment loading of Vinyard Creek is to manage row crop irrigation, particularly during pre-irrigation in spring and during the first irrigation of beans after cultivation in July. BMPs implemented on these crops designed to be particularly effective during these periods are critical to reduce suspended sediment levels in Vinyard Creek.

An estimate of suspended sediment loading of Vinyard Creek by irrigation tailwater may be calculated using flow and concentration data from the various stations. 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. Interval length ranged from 13 to 20 days depending upon sampling frequency. Pre-irrigation data were assumed to be representative of ambient water quality conditions and loads. The calculated loadings are rough estimates of total loads because a number of factors such as sampling frequency, time of day when samples were collected, etc., affect the accuracy of interval loading figures. Also because of limited pre-irrigation data (i.e., March samples) 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 total sediment load to the Vinyard Creek system during the 1986 irrigation season was 920 tons, with about 90% of this (or 820 tons) entering from the main drain (Figure 7). Most of the load transported by the main drain (99.5%) may be attributed to agricultural inputs during the irrigation season. The remainder is carried to Vinyard Creek by spring flows (< 0.5 cfs) which feed the main drain in the canyon. In addition, about 97 tons of sediment enter the Vinyard Creek system from the upstream lake. About 85.7% of this sediment load may be attributed to agricultural inputs.

The sediment load transported by the main drain below the furrow irrigated subbasins at S-4 is significantly greater than the load transported by the main drain in the canyon at S-3 (Figure 7). Although suspended sediment levels were not significantly different between the two stations, the substantial difference in flow accounts for the greater load at S-4 (Table 4). Of the estimated 3626 tons transported through the main drain at S-4 during the 1986 irrigation season, only 22% eventually enters Vinyard Creek. Much of this load is deposited in the channel at diversions below S-4, in laterals that terminate in fractured lava rock on the north side of the irrigation tract, and in a large sediment pond located on a farm a short distance above where the main drain drops into the canyon (see Figure 2).

It is likely that much of the load transported past S-1 is deposited in lower Vinyard Creek in a backwater or estuary-like area created by the Twin Falls dam pool. Fluctuating water levels during the study revealed extensive sediment deposits in this reach of Vinyard Creek (Figure 8).

Implementation of BMPs to reduce soil erosion on critical acres within the furrow-irrigated subbasins would be expected to substantially reduce sediment loadings to the main drain and Vinyard Creek. Also, additional sedimentation ponds on the main drain before it enters the canyon would also help to reduce sediment loading of Vinyard Creek and resulting water quality impacts. The primary focus of the NSSCD should be towards keeping soil on farmers fields rather than reducing the sediment load of irrigation tailwater. However, additional sedimentation ponds on the main drain could possibly serve as an interim measure to reduce sediment loading of Vinyard Creek and to improve water quality, while contracts are being written and BMPs implemented to reduce soil erosion.

NUTRIENTS

Nutrients essential for aquatic plant growth include nitrogen (N) and phosphorus (P). These two nutrients frequently limit plant growth due to a limited supply in contrast to a large demand. Primary productivity is stimulated and plant biomass increases when ample supply of these nutrients exists. Dense plant growth may adversely impact aquatic life during periods of dieback when decomposing plants consume dissolved oxygen. Also, in slack water areas where reaeration is minimal, nighttime dissolved oxygen levels 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 eutrophication (IDHW 1980). Usually nitrate nitrogen levels are compared to this criterion since ammonia and nitrite are quickly oxidized instream to nitrate and are therefore at low concentrations.

Vinyard Creek nitrate nitrogen levels generally exceeded the 0.3 mg/l criterion throughout the study. The annual mean calculated for S-1 of 2.27 mg/l is slightly less than that calculated for S-2 (2.44 mg/l), and reflects dilution of Vinyard Creek water at S-1 with irrigation tailwater (Table 2). The data indicate that most of the nitrate entering the Vinyard Creek system arises from groundwater. Instream nitrate nitrogen levels are generally highest prior to the irrigation season; peak concentrations during the irrigation season occur when irrigation return flows are reduced. For example, at S-1, concentrations decrease from 2.76 mg/l in March to 1.93 mg/l in May as irrigation begins (Figure 9). Throughout the remainder of the irrigation season, nitrate levels at S-1 are generally inversely related to the portion of flow at S-1 attributable to irrigation return flow.

Irrigation tailwater typically has low nitrate levels in contrast to groundwater in irrigated basins in southcentral Idaho (Clark 1986; Litke 1988). Although some of the nitrate in groundwater arises from leaching of nitrogen fertilizers, a substantial portion of this nitrate may also arise from alfalfa and other leguminous crop plow out. In the Rock Creek watershed, leguminous crop plow out is considered a major nitrate source to the groundwater (Clark 1986).

Mean annual nitrate nitrogen levels in the main drain were 0.44 mg/l and 0.078 mg/l for S-3 and S-4, respectively (Table 2). The higher levels at S-3 probably reflect groundwater accrual to the drain in the Vinyard Creek canyon. A flow of about 0.5 cfs, attributable to groundwater accrual, was measured at S-3 in March prior to the irrigation season. As at S-1, flow and nitrate nitrogen levels at S-3 are inversely related (Figure 10). In addition, small feedlots below S-4 on the main drain may supply nitrate to the drain. Clark (1986) has shown runoff from CAFOs to contain considerable amount of inorganic and organic nitrogen.

Organic Nitrogen

Major sources of organic nitrogen (total Kjeldahl nitrogen-TKN) in Vinyard Creek are nitrogenous compounds associated with sediment, and CAFO discharges or runoff. As would be expected, lowest mean annual TKN level was calculated for the upstream station, S-2 (0.18 mg/l, Table 2). Concentrations increased downstream at S-1, below the main drain confluence, where the mean annual concentration was 0.35 mg/l.

Measured levels were highest in the main drain, and significantly increased from S-4 to S-3 (two-sample *t*-test, $p < 0.05$) with calculated annual means of 0.61 mg/l and 0.82 mg/l, respectively (Table 2). The increased levels at S-3 are likely due to two CAFOs above the canyon where the main drain passes directly through corrals.

TKN and suspended sediment levels were found to be positively correlated. At S-4 (Figure 11) the Spearman rank correlation coefficient (r_s) calculated for these data was 0.91. At S-3, this coefficient decreases to 0.77 which is probably due to more of the TKN in transport arising from CAFO runoff rather than irrigation tailwater.

The sedimentation pond on the main drain serves to settle sediment and its associated TKN; the CAFOs contribute additional TKN to the runoff water before the drain enters the canyon.

Total Phosphorus

Primary productivity of aquatic systems is frequently limited by phosphorus availability (Wetzel 1983). Uncontaminated surface waters typically have total phosphorus concentrations of 0.01 to 0.05 mg/l, with dissolved orthophosphate representing usually less than 5 percent of the total (Tarapchak et al. 1982; Prepas and Rigler 1982).

A 0.1 mg/l total phosphorus concentration is usually considered the limit to control primary productivity and to prevent nuisance algae and aquatic plant growth (Mackenthum 1973). Where streams discharge to impoundments, a more restrictive limit of 0.05 mg/l is often applied (U.S. EPA 1977).

Pre-irrigation total phosphorus levels of 0.1 mg/l at both S-1 and S-2 indicate that ample phosphorus is likely present year-round in Vinyard Creek to support primary production. Instream concentrations were highest during the irrigation season below the drain confluence. Mean annual concentrations at S-1 and S-2 were 0.12 mg/l and 0.09 mg/l, respectively, with values as high as 0.2 mg/l measured at S-1 during irrigation (Table 2).

Total phosphorus levels were higher in the main drain than in Vinyard Creek, with mean annual concentrations ranging from 0.24 to 0.31 mg/l at S-4 and S-3, respectively (Table 2). Although measured concentrations at

S-3 frequently exceeded those at S-4, the means are not significantly different (two-sample *t*-test, $p < 0.05$).

Total phosphorus levels were generally positively correlated with suspended sediment levels, indicating that most phosphorus in the Vinyard Creek system was associated with eroded sediment (Figure 12). The lowest correlation was calculated for S-2 ($r_s = 0.48$), which received the lowest sediment load.

Dissolved Orthophosphate

Instream dissolved orthophosphate levels increased from pre-irrigation levels of between 0.002 to 0.008 mg/l to as high as 0.04 at S-1 during the irrigation season. Mean annual instream levels ranged from 0.007 to 0.019 mg/l at S-2 and S-1, respectively (Table 2).

Drain concentrations were considerably higher than instream levels, which would indicate dissolved orthophosphate was being leached from fertilized cropland by irrigation runoff. Mean annual values for S-3 and S-4 were 0.048 and 0.013 mg/l, respectively (Table 2). Orthophosphate levels were significantly higher at S-3 in comparison to S-4 (two-sample *t*-test, $p < 0.05$), and may reflect nutrient loading of the main drain by CAFOs downstream of S-4. Data presented by Clark (1986) for runoff from a CAFO in the Rock Creek drainage indicated that dissolved orthophosphate represented about 80% of the total phosphorus reaching surface waters from this facility. It is interesting to note that this facility was empty when this analysis was made by Clark (1986).

Nutrient Loadings

As with suspended sediment, nutrient loadings were calculated using flow and concentration data. During the summer of 1986, irrigation tailwater transported about 3.4 tons of organic nitrogen to Vinyard Creek via the main drain (Figure 13). About 92% of this load may be attributed to agricultural contributions. Although the load in transport at S-4 is substantially greater than this (10.2 tons), much of this material is deposited with the sediment trapped by downstream diversions and sedimentation ponds. The greater load at S-4 is primarily due to higher flows at S-4 than at S-3 (Table 4).

The organic nitrogen load entering the creek via Vinyard Lake that could be attributed to agricultural inputs was minimal. Of the 1.4 tons of organic nitrogen transported at S-2 during the irrigation season, less that 5% could be attributed to agricultural inputs (Figure 13). Apparently the wetlands and lake served to reduce any substantial impact from the drain discharging to Vinyard Lake. Most of the organic nitrogen in transport at S-2 is likely living and dead algae and aquatic macrophytes, as well as dissolved organic nitrogen released extracellularly by plants.

Vinyard Creek transported about 5.2 tons of TKN to the Snake River during the irrigation season, with about 73% of this load attributable to agricultural inputs (Figure 13). Much of this material is likely deposited with sediment in lower Vinyard Creek, although some also reaches the Twin Falls impoundment. Regardless, this nutrient is oxidized instream to nitrate to support primary production in Vinyard Creek and the downstream reservoir.

Most of the nitrate entering Vinyard Creek arises from spring flows (Figure 14). Irrigation tailwater with lower nitrate nitrogen levels than the creek, accounted for only about 1 ton of nitrate reaching Vinyard Creek while the creek exported about 32.4 tons to the Snake River during the same period. Loadings calculated for both main drain stations are about equal; flows and nitrate nitrogen concentrations were significantly different between the two stations (Table 4). The higher nitrate levels at S-3 probably reflect CAFO runoff and groundwater accrual in the canyon.

Some nitrate also enters the creek with spring flows between S-2 and S-1. Flow data indicate that Vinyard Creek gains an additional 1-3 cfs of flow between these two stations. This groundwater, with elevated nitrate levels, would add to the load calculated for S-1.

About 1.3 tons of total phosphorus was transported to Vinyard Creek during the irrigation season by the main drain (Figure 15). Total phosphorus load in the main drain was substantially higher at S-4 than S-3, but much of this material was likely deposited downstream of S-4 along with a large portion of the sediment load observed at S-4. Although total phosphorus levels were higher at S-3 than S-4, the higher flows at S-4 resulted in greater loadings (Table 4).

Vinyard Creek transported about 1.8 tons of total phosphorus to the Snake River during the 1986 agricultural season. About 55% of this load may be attributed to irrigation tailwater. Therefore, about half of the total phosphorus load transported to the Snake River arises from sources other than inputs during the agricultural season. These sources might include phosphorus in the form of organic phosphates and cellular constituents of plants and animals (living and dead) which enter Vinyard Creek from Vinyard Lake.

The main drain also contributed about 0.2 tons of dissolved orthophosphate to Vinyard Creek during the irrigation season (Figure 16). Most of the dissolved orthophosphate load in Vinyard Creek (about 70% to 80%) arises from agricultural inputs. Much of this material is probably leached from fertilized cropland. Although flows were significantly higher at S-4 than S-3, the loads at both stations are about equal due to the higher concentrations at S-3 (Table 4). Elevated levels at S-3 are likely due to runoff from upstream CAFOs.

Vinyard Creek transported about 0.3 tons of dissolved orthophosphate to the Snake River during the irrigation season. Of this amount, about 78% may be attributed to irrigation tailwater.

Although most phosphorus entering Vinyard Creek and transported to the Snake River was associated with suspended sediment, a substantial portion of this was as dissolved orthophosphate. Meybeck (1981) noted that particulate phosphorus forms comprise about 95% of the total phosphorus present in natural stream systems. In Vinyard Creek, dissolved orthophosphate represented 9.2% to 16.6% of total phosphorus, and in the main drain dissolved orthophosphate accounted for 4.6% to 16.4% of the total. The greatest proportion of dissolved orthophosphate was observed at S-3 and S-1. Although elevated dissolved orthophosphate levels at S-3 may have been due in part to upstream CAFO runoff, these data generally support the conclusion that dissolved orthophosphate levels are usually higher in agricultural watersheds due to leaching of this nutrient from fertilized fields.

The data collected during 1986 indicate that ample nutrients are present in the Vinyard Creek system to support plant growth. Even though a substantial load of nutrients entered the creek with irrigation tailwater, pre-irrigation nitrate nitrogen and total phosphorus levels which exceed eutrophication standards indicate that the system would be productive regardless of this additional nutrient loading. Nutrients in agricultural return flows primarily impact lower Vinyard Creek and the Twin Falls hydropower dam impoundment. Even with BMP implementation, Vinyard Creek will likely remain a productive system, but the load of nutrients transported to the Snake River and resulting eutrophication problems in the Twin Falls impoundment would be reduced. BMPs implemented to reduce erosion and suspended sediment levels would primarily result in reduced levels of TKN and total phosphorus in lower Vinyard Creek and the

Snake River. The nutrient loadings calculated for the 1986 irrigation season should be used for comparison to assess the effectiveness of a BMP implementation project in the Vinyard Creek watershed.

BACTERIA

Contamination of water with fecal material is indicated when coliform bacteria (i.e., gram negative, lactose fermenting, enteric rods) are present. 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 are strains of Streptococcus faecalis. These organisms do not survive in water as long as fecal coliforms, so their presence indicates a recent pollution event (Atlas 1984).

The probable source of fecal contamination may be assessed by calculating the ratio of fecal coliforms to fecal streptococci (FC/FS ratio) in a water sample. 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).

Primary contact recreation (or swimming) is a protected beneficial use for Vinyard Creek. To support this use, water quality standards state that the geometric mean for fecal coliforms shall not exceed 50/100 ml. Furthermore, fecal coliform densities shall not exceed 500/100 ml at any one time (IDHW 1985).

Annual instream geometric mean fecal coliform densities ranged from 39.7/100 ml at S-2 to 477.4/100 ml at S-1 (Table 5). At both instream stations, pre-irrigation densities were 1/100 ml. At S-1 the geometric mean standard was exceeded for most of the study period (Figure 17). Densities ranged from 360 to 910/100 ml, and about 70% of the samples collected during the irrigation season exceeded the instantaneous maximum limit.

At S-2, densities also increased during the irrigation season, but the geometric standard was exceeded only in June and July (Figure 18). Fecal coliform densities at S-1 were significantly greater than at S-2 (two-sample *t*-test, $p < 0.05$), and reflect the impact of main drain CAFOs on Vinyard Creek water quality.

Bacteria densities at the main drain stations greatly exceeded those measured instream (Table 5). Annual geometric mean fecal coliform densities ranged from 1165.4/100 ml at S-4 to 2627.5/100 ml at S-3. Densities varied considerably between both stations and between sampling dates (Figures 19 and 20). Maximum densities in the main drain were observed at S-3 which suggest that upstream CAFOs may be the source. Fecal coliform densities as high as 15,000/100 ml were measured at S-3 in June, 1986.

Agricultural pollution impact studies on Rock Creek (Clark 1986) and Mud Creek and Deep Creek (Litke 1988), have indicated that in agricultural impacted streams fecal coliform densities are usually correlated with suspended sediment levels. Therefore, implementation of BMPs to reduce soil erosion are also expected to help reduce bacteria loading of surface waters.

Rank correlations between suspended sediment levels and fecal coliform densities in Vinyard Creek are poor at most stations except S-4. At S-4 the correlation coefficient (r_s) was 0.65, so much of the variability in bacteria densities could be explained by suspended sediment levels. However, at S-3 where the geometric mean fecal coliform density was considerably higher than that calculated at S-4 (Table 5), the correlation coefficient was only 0.18. Variability in bacteria densities at this station was likely due to intermittent corral runoff from upstream CAFOs. Correlation coefficients at S-1 and S-2 were 0..51 and -0.04, respectively.

The data indicate that eliminating corral runoff from CAFOs located between S-3 and S-4 would substantially reduce bacteria loading of Vinyard Creek. In addition, this would also help reduce nutrient loading of the creek. Eliminating corral runoff could be accomplished by re-routing the main drain around existing corrals, or by moving the corrals to alternative locations. BMP treatment to reduce soil erosion would help to reduce bacteria levels, but such treatment alone without addressing CAFO runoff would not protect the primary contact recreation beneficial use.

Fecal coliform to fecal streptococcus ratios calculated for the period of study support the conclusions above regarding the impact of CAFOs on Vinyard Creek water quality. Calculated ratios were similar for all stations, and range from 0.25 to 0.45. These ratios indicate the source of bacteria to be primarily livestock waste.

MACROINVERTEBRATES

Benthic macroinvertebrates are well-suited for assessing water quality conditions because a) they live in the stream and their presence reflects an integration of chemical/physical conditions through time that are not assessable by "grab" samples, b) most species are not very mobile and therefore reflect water quality conditions near the point of collection, and c) most species have life cycles of a year or less so their presence reflects recent stream conditions (Platts et al. 1983, Rosenberg et al. 1986). Sensitive species and life stages respond quickly to pollutants and environmental stress while overall communities generally respond more slowly. Although stream benthic communities are composed primarily of insects (Minshall 1969, Hynes 1970), other groups such as annelids, flatworms, crustaceans, and molluscs are often present depending upon water quality conditions.

A number of approaches have been utilized in the literature to interpret benthic data. Invertebrate densities, taxa richness, and species diversity indexes (which incorporate both taxa richness and densities) have been used. In general, clean water would be expected to support a diverse benthic community composed primarily of 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 (Ephemeroptera-Plecoptera-Trichoptera) value or index is one measure that is used to assess benthic invertebrate communities. 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 and therefore composed of "clean water" species. 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 (CTQ_p) 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 (CTQ_a). The Biotic Condition Index is equal to $CTQ_p/CTQ_a \times 100$. 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

Macroinvertebrate samples were collected essentially during the irrigation season in July and early October, so pre- and post-irrigation season comparisons can not be made. However, a total of 22 taxa were collected from Vinyard Creek, with the Molluscs (Bivalvia and Gastropoda), Trichoptera, and Diptera best represented with 5, 4, and 4 taxa, respectively (Table 6). The actual number of Diptera taxa is probably greater than 4 since many species are likely "lumped" into the Chironomidae.

In terms of densities, the data indicate the benthic community to be dominated by generally pollution-tolerant (i.e., high tolerance quotient) taxa such as Hydropsyche sp., Baetis tricaudatus, Chironomidae, Hyalella azteca, and Mollusca. For example, at S-2 in July, over 50% of the individuals collected belong to three taxa including Hydropsyche sp., Hyalella azteca, and Fluminicola virens (a gastropod mollusc)(Table 7). In October at S-1, about 70% of the individuals present were Hydropsyche larvae (Table 8).

The July invertebrate data indicate, as would be expected, that irrigation tailwater was impacting station S-1. Fewer individuals representing fewer taxa, were collected at S-1 than S-2 (Table 7). Also, a greater percentage of taxa collected at S-1 were pollution-tolerant forms. Of the 11 taxa represented, 5 taxa were gastropods with tolerance quotients of 108. EPT index values of 2 and 6 at stations S-1 and S-2, respectively, also indicate better conditions at S-2 since more "clean-water" species were present.

The October data indicate a reduction in taxa richness at both stations

(Table 8). However, the most significant decline in taxa richness, EPT value, and number of individuals occurred at S-2. At this station which receives little irrigation return flow, densities declined from 1643 to 876/m^2, the total number of taxa dropped from 16 to 9, and the EPT value decreased from 6 to 3. In comparison, at S-1 which is most heavily impacted by the main drain, densities increased in October in comparison to July (396 to 543/m^2), and the EPT value remained constant. The reason for this apparently significant impact on S-2 is unclear.

Biotic Condition Index

The actual community tolerance quotients (CTQ_a) calculated for each station indicate that the benthos of Vinyard Creek is composed of primarily pollution-tolerant taxa (Table 9). In July, CTQ_a were 92.7 and 90.4 at S-1 and S-2, respectively. In October, the CTQ_a at S-1 increased to 100 indicating a greater proportion of the taxa present at that time were pollution-tolerant forms. At S-2, even though densities, taxa richness, and the EPT value declined, many of the taxa that were lost were pollution-tolerant forms. Because of this, the CTQ_a decreased slightly from 90.4 to 76.7.

The calculated BCI values are all less than 100 (Table 9) and indicate that a more tolerant benthic community is present than expected. At S-1, the BCI value decreased from July to October reflecting the continual input of irrigation tailwater and increased number of pollution-tolerant forms. The BCI value increased at S-2 between July and October (55.3 to 65.2) indicating an improvement in the benthic community. However, even though this index shows a slight improvement in the benthic community as irrigation tapers off in October, other parameters previously discussed indicate that some factor or factors had a substantial negative impact on the benthic community during this period.

Also, unexpectedly the BCI value is lower at S-2 than at S-1 for both collections. For example, in July these values were 86.3 and 55.3 for S-1 and S-2, respectively. Since it is apparent that S-2 is not greatly impacted by irrigation tailwater, some other factor or factors must impact this community such that more tolerant taxa are present than what would be expected based upon the parameters assessed by this index. The anomalous reduction in density, taxa richness, and EPT value at S-2 in October in comparison to July, and the low BCI values for both collections at a station with apparently "good" water quality warrants further study.

Functional Feeding Group Analysis

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

Generally, the benthic community of Vinyard Creek was dominated by collector-filterers (e.g., Hydropsyche sp., Simulium sp.), scrapers (e.g., Paragyractis sp. and molluscs), and collector-gatherers (e.g., Baetis tricaudatus)(Table 10). For example, about 70% of the organisms collected at S-1 in July could be classified as collector-filterers. Similarly, about 50% of the invertebrates collected in October at S-2 were collector-filterers. These organisms collect algae, detritus, and invertebrates from the water column. With the abundant nutrients available in Vinyard Creek, a substantial portion of the food resources of this functional feeding group is likely algae (as living cells or detritus).

QUALITY ASSURANCE

During the study, quality assurance samples (duplicates and spikes) were collected to evaluate data quality. These samples were used to determine if laboratory 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 set of data.

Precision

Precision is a measure of the agreement between duplicate measurements of the same parameter under the same environmental conditions (Bauer 1986). The average relative range is used to describe the precision for duplicate samples. Precision was generally good for suspended sediment, nitrate, total Kjeldahl nitrogen, and total phosphorus (Table 11). Precision was not very good for dissolved orthophosphate and turbidity, and poor for fecal coliform bacteria.

Poor agreement between duplicate coliform bacteria samples has been noted in other surveys (e.g., Bauer 1986, Clark 1986, Litke 1988). This variability and therefore low precision may be due to difficulty in collecting homogeneous duplicate field samples, or to difficulty in obtaining similar representative subsamples for plating in the laboratory (Bauer 1986).

Accuracy

Accuracy is a measure of the agreement between a given measurement and the true value for that parameter. Accuracy may be 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. Average percent recoveries are calculated for comparison when a number of spiked samples are analyzed for a given parameter.

Generally, mean percent recovery was excellent for suspended sediment (95.1% ± 2.8%) and dissolved orthophosphate (95.3% ± 5.6%)(Table 12). Recovery was good for nitrate (112.2% ± 10.3%), total Kjeldahl nitrogen (111.0% ± 6.8%), and total phosphorus (105.0% ± 5.1%). Recovery for ammonia was good, but there was high variability between replicate spikes. Average percent recovery for this parameter was 98.8% with a calculated 95% confidence interval of 26.2%.

CONCLUSIONS

Vinyard Creek water quality is being impaired by agricultural nonpoint sources and several beneficial uses are threatened. These beneficial uses include cold water biota, salmonid spawning, and primary contact recreation. Primary contaminants include suspended sediment, nutrients, and bacteria. Pollutant sources include return flows from irrigated cropland, and runoff from confined animal feeding operations.

Suspended sediment levels increased substantially in Vinyard Creek during the irrigation season. Fluctuations in suspended sediment levels and stream flow could be traced to irrigation practices and crop management. Soil erosion in the Vinyard Creek watershed results primarily from furrow irrigation of row crops such as beans, beets, and potatoes from April through September. The key to reducing suspended sediment loading of Vinyard Creek is to better manage row crop irrigation, particularly during pre-irrigation in the spring and during the first irrigation of beans after cultivation in July.

Most of the impact due to suspended sediment in Vinyard Creek occurs below its confluence with the main drain. The excess sediment in lower Vinyard Creek results in a loss of habitat for fish spawning and rearing, and impacts the benthic invertebrate community which represents the food of resident fish populations. The available spawning and rearing habitat for salmonids (cutthroat trout, rainbow trout, and a cutthroat-rainbow hybrid) is therefore considerably reduced and limited to areas upstream of the main drain confluence.

Nutrient levels (nitrogen, phosphorus) in Vinyard Creek prior to the irrigation season met or exceeded concentrations which stimulate aquatic plant growth. During the irrigation season, instream levels of organic nitrogen, total phosphorus and dissolved orthophosphate all increased. Sources of these nutrients included irrigation tailwater and runoff from CAFOs. Instream nitrate nitrogen levels were dependent upon ground water inputs to the creek. Generally, instream nitrate levels were lowest below the main drain confluence where stream water was diluted with irrigation water. Elevated levels of inorganic nitrogen in ground water may be due to alfalfa and other leguminous crop plowout, as well as leaching of nitrogen fertilizers.

Nutrient levels in the main drain generally increase between S-4 and S-3. This increase is due to nutrient-rich runoff from corrals of CAFOs below S-4 to the main drain. The main drain flows through the corrals of several of these operations. Spring seeps which feed the main drain in the canyon also contributed to higher nitrate levels at S-3 than at S-4.

During the irrigation season, levels of organic nitrogen and total phosphorus were positively correlated with suspended sediment levels. Irrigation season loads of these three parameters decrease considerably between stations S-4 and S-3 on the main drain. This was due to a number of diversions from the main drain and a sedimentation pond below S-4. An agricultural BMP implementation project to reduce soil erosion and to manage animal wastes would be expected to reduce instream levels of these parameters. However, since instream pre-irrigation levels of nitrate and total phosphorus were at or above concentrations to prevent excessive plant growth, a BMP implementation project would not likely reduce instream productivity.

Fecal coliform densities at S-1 exceeded the primary contact standard throughout the irrigation season. At S-2, this standard was exceeded in June and July. On the main drain, bacteria densities were significantly greater at S-3, probably due to runoff from upstream CAFOs. Fecal coliform to fecal strep ratios calculated for the survey stations indicated the source of these bacteria to be livestock. Bacteria densities were not generally correlated with suspended sediment levels. A BMP implementation project to reduce suspended sediment levels would therefore not likely protect the primary contact recreation beneficial use. Rather, BMPs to manage animal waste, and particularly to re-route the main drain around corrals of upstream CAFOs, would protect this use.

Macroinvertebrate collections from Vinyard Creek indicated that degraded water quality conditions existed as a substantial portion of the invertebrate fauna was composed of pollution-tolerant taxa. This impact was most pronounced below the main drain confluence where fewer taxa, fewer individuals, and a greater number of pollution-tolerant taxa were collected in contrast to the upstream station. Biological indexes used to examine the invertebrate data indicate that the communities sampled at both stations were composed of a greater number of pollution-tolerant taxa than expected based upon certain chemical and physical characteristics of the sites. Biological data indicated that Vinyard Creek should be managed to improve water quality and improve instream habitat.

RECOMMENDATIONS

The data indicate that degraded water quality condition existed in Vinyard Creek during the irrigation season, particularly downstream of the confluence of the main drain. In addition, corral wastes and runoff from several confined animal feeding operations (CAFOs) on the main drain are transported to Vinyard Creek during the irrigation season.

The North Side Soil Conservation District (SCD) is currently contracting best management practices (BMPs) for implementation in the Vinyard Creek watershed. These BMPs should focus on reducing soil erosion and on controling animal wastes and CAFO runoff. BMPs implemented to reduce soil erosion would reduce suspended sediment and nutrient levels in Vinyard Creek and the Snake River. Similarly, BMPs directed at managing animal wastes and towards re-routing the main drain away from corrals of upstream CAFOs would also reduce nutrient loading of Vinyard Creek in addition to reducing bacteria loading. A reduction of bacteria loading or contamination of the main drain would reduce the probability of public health problems during the irrigation season and ultimately protect the primary contact beneficial use in Vinyard Creek.

Because of funding limitations, BMP implementation should focus on critical acres that are surface irrigated and drain towards the main drain or the small drain which feeds Vinyard Lake. BMP treatment should focus on fields with crops that contribute disproportionately to the sediment load entering the main drain (e.g., bean fields). Other sensitive areas in the watershed that are prone to erosion should also be treated to retain the soil and maintain productivity of the land, but such treatment will not improve Vinyard Creek water quality.

BMP treatment on critical acres will ultimately lead to less sediment entering the main drain and Vinyard Creek. Vinyard Creek, however, is a unique system that lends itself to various management options that can be quickly implemented to reduce water quality impacts due to agriculture. These short term options can be implemented while BMPs are being contracted and installed. Two small drains feed the Vinyard Creek system. The main drain had a mean flow of 7.1 cfs during the 1986 irrigation season; the drain feeding Vinyard Lake is substantially smaller. One sediment pond is currently on the main drain, below station S-4. A short term management option would be to construct additional sedimentation ponds on both drains to reduce the suspended sediment loading of the Vinyard Creek system. This would reduce organic nitrogen and total phosphorus loadings as well since both are correlated with suspended sediment. If this short term option were implemented in combination with re-routing the main drain away from CAFO corral areas, Vinyard Creek water quality should rapidly improve. This would only be an interim measure since the ultimate goal of all involved agencies is to improve Vinyard Creek water quality by keeping the soil on the land, and not by treating sediment-laden irrigation tailwater. As BMPs installed on critical acres become effective, the proposed sedimentation ponds could be phased out without a concommitant reduction in Vinyard Creek water quality.

Implementation of agricultural BMPs in the Vinyard Creek watershed should help to control sediment, nutrient, and bacteria loading of Vinyard Creek. Through time, water quality would be expected to improve, and beneficial uses would 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 for evaluating the effectiveness of the North Side SCD BMP implementation project.

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Table 1. Summary of Vinyard Creek survey stations, 1986.

Station	Description	Latitude	Longitude	River Mile	Elevation	STORET #
S-1	Vinyard Creek below drain confluence	42 35 10	114 20 46	324.30/619.30/.20	3520	2060234
S-2	Vinyard Creek above drain confluence	42 35 14	114 20 46	324.30/619.30/.30	3550	2060235
S-3	Drain above confluence with Vinyard Creek	42 35 14	114 20 48	324.30/619.30/.30	3540	2060236
S-4	Drain below confluence of major furrow-irrigated sub-basins	42 34 48	114 17 55	324.30/619.30/3.70	3900	2060237

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

Parameter	S-1	S-2	S-3	S-4
Temperature (oC)	14.1 (11.0-16.5)	14.5 (11.0-17.0)	13.4 (6.0-20.0)	14.9 (0.2-21.5)
Flow (cfs)	24.9 (14.8-31.5)	16.1 (9.8-19.9)	7.1 (0.9-14.1)	26.3 (0.5-45.8)
Turbidity (NTU's)	9.0 (0.5-20.0)	1.3 (0.4-3.0)	29.9 (1.2-66.0)	43.5 (2.0-368.0)
Conductivity (umhos/cm at 25 oC)	664.7 (558-711)	706.8 (654-727)	462.7 (400-671)	403.5 (351-504)
Dissolved oxygen (mg/l)	7.3 (4.8-8.8)	7.4 (4.7-8.4)	7.2 (5.8-9.0)	7.3 (5.1-10.4)
Dissolved oxygen (% saturation)	70.9 (47.0-81.5)	72.4 (47.0-84.0)	68.2 (51.7-84.7)	71.0 (53.6-79.5)
pH	8.6 (8.1-9.1)	8.5 (7.8-8.9)	8.6 (8.1-9.0)	8.8 (8.4-9.3)
TKN (mg/l)	0.35 (0.11-0.51)	0.18 (0.05-0.31)	0.82 (0.21-1.34)	0.61 (0.2-1.67)
NO2+NO3-N (mg/l)	2.27 (1.1-3.7)	2.44 (1.2-3.3)	0.44 (0.12-2.0)	0.078 (0.007-0.19)
Dissolved PO4-P (mg/l)	0.019 (0.008-0.042)	0.007 (0.002-0.017)	0.048 (0.014-0.101)	0.013 (0.003-0.029)
Total P (mg/l)	0.12 (0.05-0.20)	0.09 (0.03-0.1)	0.31 (0.1-0.6)	0.24 (0.02-1.06)
Volatile Solids (mg/l)	4.5 (2-8)	3.8 (2-10)	11.1 (2-20)	10.9 (2-38)

Table 2. Continued.

Parameter	S-1	S-2	S-3	S-4
Suspended Sediment (mg/l)	49 (2-116)	11 (2-24)	170 (8-362)	179 (2-1060)
Fecal Coliform (#/100 ml)	477.4 (1-910)	39.7 (1-160)	2627.5 (40-15,000)	1165.4 (50-4,800)
Fecal Strep (#/100 ml)	3015.8 (107-12,000)	296.5 (22-580)	8976.4 (400-37,000)	3948.9 (290-11,000)
FC/FS Ratio	0.3 (0.009-1.1)	0.25 (0.002-1.23)	0.45 (0.032-1.43)	0.27 (0.026-0.67)

Table 3. USGS flow record for the Vinyard Creek monitoring station (#13089500) for the October 1985 - September 1986 water year. This station is about 10 m downstream of survey station S-2.

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

STATION NUMBER 13089500 10S 18E 04AAD1S DEVILS WASHBOWL SP NR KIMBERLY SPRING SOURCE AGENCY USGS
LATITUDE 423518 LONGITUDE 1142045 GEOLOGIC UNIT 110SKRV DATUM 3540.00 STATE 16 COUNTY 053

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	16	16	15	14	12	12	14	14	13	14	16	18
2	16	16	15	14	12	12	14	14	13	15	16	17
3	16	16	15	14	12	12	14	14	13	15	16	17
4	16	16	15	14	12	12	14	14	13	15	16	17
5	16	16	15	14	12	12	14	14	13	15	16	17
6	16	16	15	14	12	12	14	14	13	15	16	18
7	16	16	15	14	12	12	14	14	14	15	16	17
8	16	16	15	14	12	12	14	14	14	15	16	18
9	16	16	15	14	12	12	14	14	14	15	16	18
10	16	16	15	13	12	13	14	14	14	15	16	18
11	16	16	15	13	12	13	14	14	14	15	16	18
12	16	16	15	13	12	13	14	14	14	15	16	18
13	16	16	15	13	12	13	14	14	14	15	16	18
14	16	16	15	13	12	13	14	14	14	15	16	18
15	16	16	15	13	12	13	14	14	14	15	16	18
16	16	15	15	13	12	13	14	13	14	15	17	18
17	16	15	15	13	12	13	14	13	14	15	17	18
18	16	15	15	13	12	13	14	13	14	16	17	18
19	16	15	14	13	12	13	14	13	14	16	17	18
20	16	15	14	13	12	13	14	13	14	16	17	18
21	16	15	14	13	12	13	14	13	14	16	17	18
22	16	15	14	13	12	13	14	13	14	16	17	18
23	16	15	14	13	12	13	14	13	14	16	17	18
24	16	15	14	13	12	13	14	13	14	16	17	18
25	16	15	14	13	12	13	14	13	14	16	17	18
26	16	15	14	12	12	13	14	13	14	16	17	19
27	16	15	14	12	12	13	15	13	14	16	17	18
28	16	15	14	12	12	14	15	13	14	16	17	18
29	16	15	14	12	---	14	14	13	14	16	17	18
30	16	15	14	12	---	14	14	13	14	16	17	18
31	16	---	14	12	---	14	---	13	---	16	18	---
TOTAL	496	465	452	406	336	398	422	418	414	478	513	536
MEAN	16.0	15.5	14.6	13.1	12.0	12.8	14.1	13.5	13.8	15.4	16.5	17.9
MAX	16	16	15	14	12	14	15	14	14	16	18	19
MIN	16	15	14	12	12	12	14	13	13	14	16	17
AC-FT	984	922	897	805	666	789	837	829	821	948	1020	1060

Table 4. Mean flow, concentrations, and daily loadings, and total irrigation season loads, for the indicated Vinyard Creek survey stations and chemical parameters, during the 1986 irrigation season (April 15 to October 31).

	S-1	S-2	S-3	S-4
Mean flow (cfs)	26.1	16.2	7.6	28.4
		Suspended Sediment		
Mean concentration (mg/l)	55.3	12.0	181.6	191.3
Mean daily load (lbs/d)	7,394.9	932.1	7,540.7	35,003.8
Total Irrigation season load (tons)	780.5	96.9	820.5	3,626.5
		Total Kjeldahl Nitrogen		
Mean concentration (mg/l)	0.38	0.18	0.86	0.63
Mean daily load (lbs/d)	53.8	13.1	33.1	102.5
Total Irrigation season load (tons)	5.2	1.4	3.4	10.2
		Nitrate Nitrogen		
Mean concentration (mg/l)	2.2	2.4	0.3	0.08
Mean daily load (lbs/d)	308.05	212.1	10.9	12.5
Total Irrigation season load (tons)	32.4	21.1	1.09	1.17

Table 4. Continued.

	S-1	S-2	S-3	S-4
Mean flow* (cfs)	26.1	16.2	7.6	28.4
		Total Phosphorus		
Mean concentration (mg/l)	0.127	0.089	0.32	0.25
Mean daily load (lbs/d)	17.7	7.8	12.6	43.6
Total Irrigation season load (tons)	1.8	0.76	1.3	4.4
		Dissolved Orthophosphorus		
Mean concentration (mg/l)	0.02	0.007	0.05	0.013
Mean daily load (lbs/d)	2.99	0.74	2.2	2.06
Total Irrigation season load (tons)	0.3	0.07	0.22	0.2

*Mean flow is repeated here to facilitate between-station comparisons.

Table 5. Fecal coliform and fecal streptococcus bacteria densities (number/100 ml) in Vinyard Creek and the main drain, 1986. Means listed are annual geometric means.

		Fecal Coliform			Fecal Strep			
Station	n	Minimum	Maximum	Mean	Minimum	Maximum	Mean	FC/FS Ratio
S-1	15	1	910	477.4	107	12000	3015.8	0.29
S-2	15	1	160	39.7	22	580	296.5	0.25
S-3	14	40	15000	2627.5	400	37000	8976.4	0.45
S-4	14	50	4800	1165.4	290	11000	3948.9	0.27

Table 6. Species list of invertebrates collected in Vinyard Creek, 1986. Taxa richness, mean tolerance values, and EPT values for the two sampling dates are listed for comparison.

	7-July	10-Oct
Trichoptera		
Hydropsyche sp.	X	X
Hydroptila sp.	X	
Polycentropus sp.	X	
Rhyacophila sp.	X	X
Ephemeroptera		
Baetis tricaudatus	X	X
Ephemerella inermis	X	
Tricorythodes minutus	X	X
Diptera		
Antocha sp.	X	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
Crustacea		
Amphipoda		
Gammarus sp.		X
Hyalella azteca	X	
Bivalvia		
Piscidium sp.	X	
Sphaerium sp.	X	X
Gastropoda		
Fluminicola virens	X	X
Fontellicella sp.	X	
Physa sp.	X	

Table 6. Continued.

Turbellaria		
Planariidae	X	
Total number of taxa	21	13
Mean tolerance quotient	88.3	80.76
EPT Value	7	4

Table 7. Mean densities (number/m2), tolerance quotients (TQ), functional feeding groups (FFG), and EPT values of macroinvertebrates collected in Vinyard Creek, July 23, 1986. Tolerance quotients are from Winget and Mangum (1979).

TAXON	S-1 Density	S-2 Density	TQ	FFG
Trichoptera				
Hydropsyche sp.	250.0	430.0	108	C-F
Hydroptilla sp.		10.0	108	P-H,SC
Polycentropus sp.		43.3	108	PR
Rhyacophila sp.		3.3	18	PR
Ephemeroptera				
Baetis tricaudatus		86.7	72	C-G,SC
Ephemerella inermis	3.3		48	SC,C-G
Tricorythodes minutus		100.0	108	C-G
Diptera				
Antocha sp.		103.3	24	C-G
Chironomidae		113.3	108	C-G,PR
Simulium sp.		53.3	108	C-F
Hexatoma sp.	3.3		36	PR
Lepidoptera				
Paraguractis sp.		53.3	72	SC
Coleoptera				
Optioservus sp.	10.0	113.3	108	SC,C-G
Odonata				
Ischnura sp.	6.7	16.6	72	PR
Crustacea				
Amphipoda				
Hyalella azteca	23.3	203.3	108	C-G
Bivalvia				
Piscidium sp.	6.6	13.3	108	C-F
Sphaerium sp.	13.3		108	C-F
Gastropoda				
Fluminicola virens	66.7	296.7	108	SC
Fontellicella sp.	3.3		108	SC
Physa sp.	10.0		108	SC
Turbellaria				
Planariidae		3.3	108	PR,C-G

Table 7. Continued.

	S-1	S-2
Total number/m2	396.5	1643.0
Total number of taxa	11.0	16.0
EPT Value	2.0	6.0

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

Table 8. Mean densities (number/m2), tolerance quotients (TQ), functional feeding groups (FFG), and EPT values of macroinvertebrates collected in Vinyard Creek, October 10, 1986. Tolerance quotients are from Winget and Mangum (1979).

TAXON	S-1 Density	S-2 Density	TQ	FFG
Trichoptera				
Hydropsyche sp.	380.0	430.0	108	C-F
Rhyacophila sp.		10.0	18	PR
Ephemeroptera				
Baetis tricaudatus		120.0	72	C-G,SC
Tricorythodes minutus	6.7		108	C-G
Diptera				
Antocha sp.		76.7	24	C-G
Chironomidae		66.7	108	C-G,PR
Simulium sp.		10.0	108	C-F
Lepidoptera				
Paragyractis sp.	20.0	140.0	72	SC
Coleoptera				
Optioservus sp.	23.3	16.7	108	SC,C-G
Odonata				
Ischnura sp.	20.0	6.7	72	PR
Crustacea				
Amphipoda				
Gammarus sp.	3.3		108	C-G
Hyalella azteca	20.0		108	C-G
Bivalvia				
Sphaerium sp.	3.3		108	C-F
Gastropoda				
Fluminicola virens	66.7		108	SC

Table 8. Continued.

	S-1	S-2
Total number/m2	543.3	876.8
Total number of taxa	9.0	9.0
EPT Value	2.0	3.0

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

Table 9. Density of macroinvertebrates (number/m2), number of taxa collected, community tolerance quotients (CTQ), Biotic Condition Index, and EPT values for the Vinyard Creek stations on the dates indicated.

	S-1	S-2
	23-Jul-86	
Density (#/m2)	396.5	1643
Number of taxa	11	16
Number of taxa with TQ= 108	8	11
% of taxa with TQ= 108	72.7	68.7
CTQp	80	50
CTQa	92.7	90.4
Biotic Condition Index	86.3	55.3
EPT Value	2	6
	10-Oct-86	
Density (#/m2)	543.3	876.8
Number of taxa	9	9
Number of taxa with TQ= 108	7	4
% of taxa with TQ= 108	77.8	44.4
CTQp	80	50
CTQa	100	76.7
Biotic Condition Index	80	65.2
EPT Value	2	3

Table 10. Functional feeding groups of macroinvertebrates collected at the Vinyard Creek stations on the dates listed, 1986. Values listed are individuals/m2.

Functional Feeding Group	S-1	S-2
	23-Jul-86	
Collector/gatherer	23.3	606.6
Scraper	93.3	463.3
Collector/filterer	269.9	496.6
Piercer/herbivore	--	10.0
Predator	--	66.5
	10-Oct-86	
Collector/gatherer	30.0	263.4
Scraper	110.0	156.7
Collector/filterer	383.3	440.0
Predator	20.0	16.7

Table 11. Precision of duplicate samples from Vinyard Creek, 1986.

STORET #	Parameter	n	Average Relative Range (%)
80154	Suspended sediment	12	8.2
00630	NO2+NO3-N	12	7.0
00625	Total Kjeldahl nitrogen	12	9.3
00665	Total phosphorus	12	6.1
00671	Dissolved PO4-P	12	33.7
00095	Specific conductance	12	6.0
00076	Turbidity	12	33.0
31616	Fecal Coliforms	12	43.2
31679	Fecal Strep	12	15.2

Table 12. Average percent recovery for spiked samples from Vinyard Creek, 1986.

STORET #	Parameter	Average Percent Recovery	95% Confidence Interval
80154	Suspended sediment	95.1	2.8
00610	NH3-N	98.8	26.2
00630	NO2+NO3-N	112.2	10.3
00625	Total Kjeldahl nitrogen	111.0	6.8
00665	Total phosphorus	105.0	5.1
00671	Dissolved PO4-P	95.3	5.6

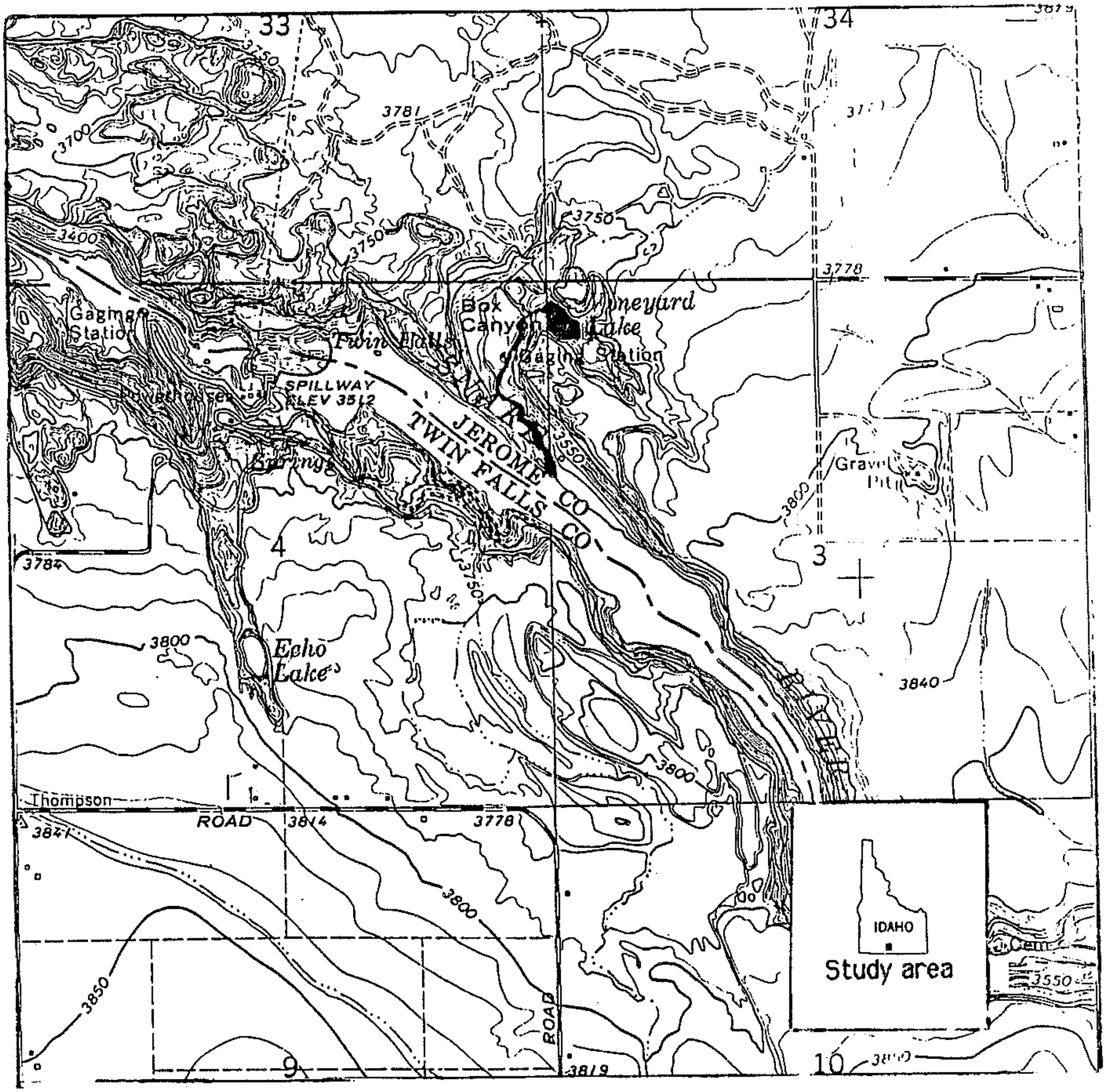

Figure 1. Location of the Vinyard Creek watershed, Jerome County, Idaho. Map source U.S.G.S. Kimberly Quadrangle, 1:24,000 scale.

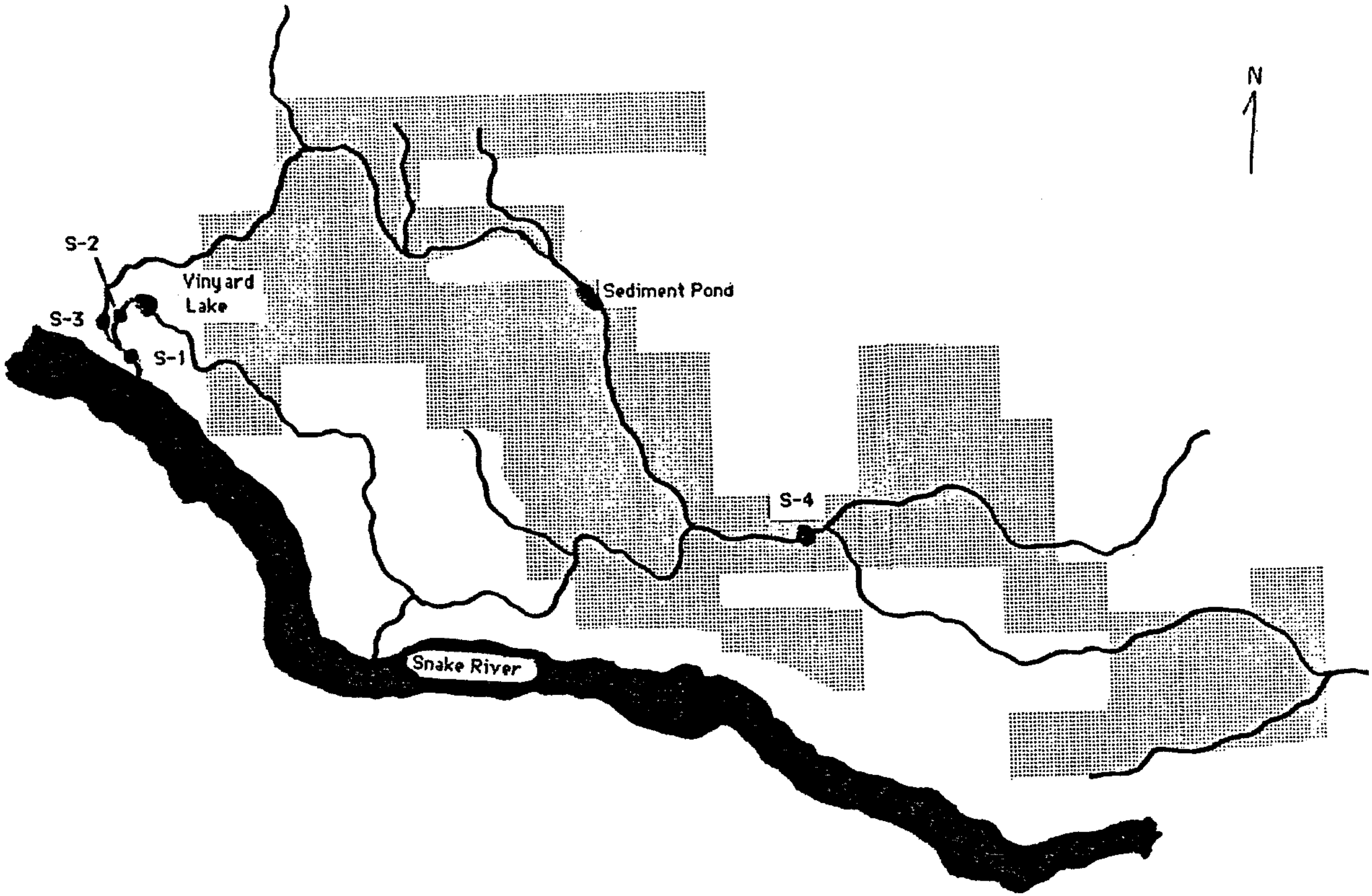

Figure 2. Locations of the Vinyard Creek water quality monitoring stations, 1986. Shaded areas represent farmland that is surface irrigated. Map was redrawn from NSSCD pre-application for an implementation grant under the Idaho Agricultural Pollution Abatement Program (NSSCD 1986). Map scale: 1 inch = 0.5 mile.

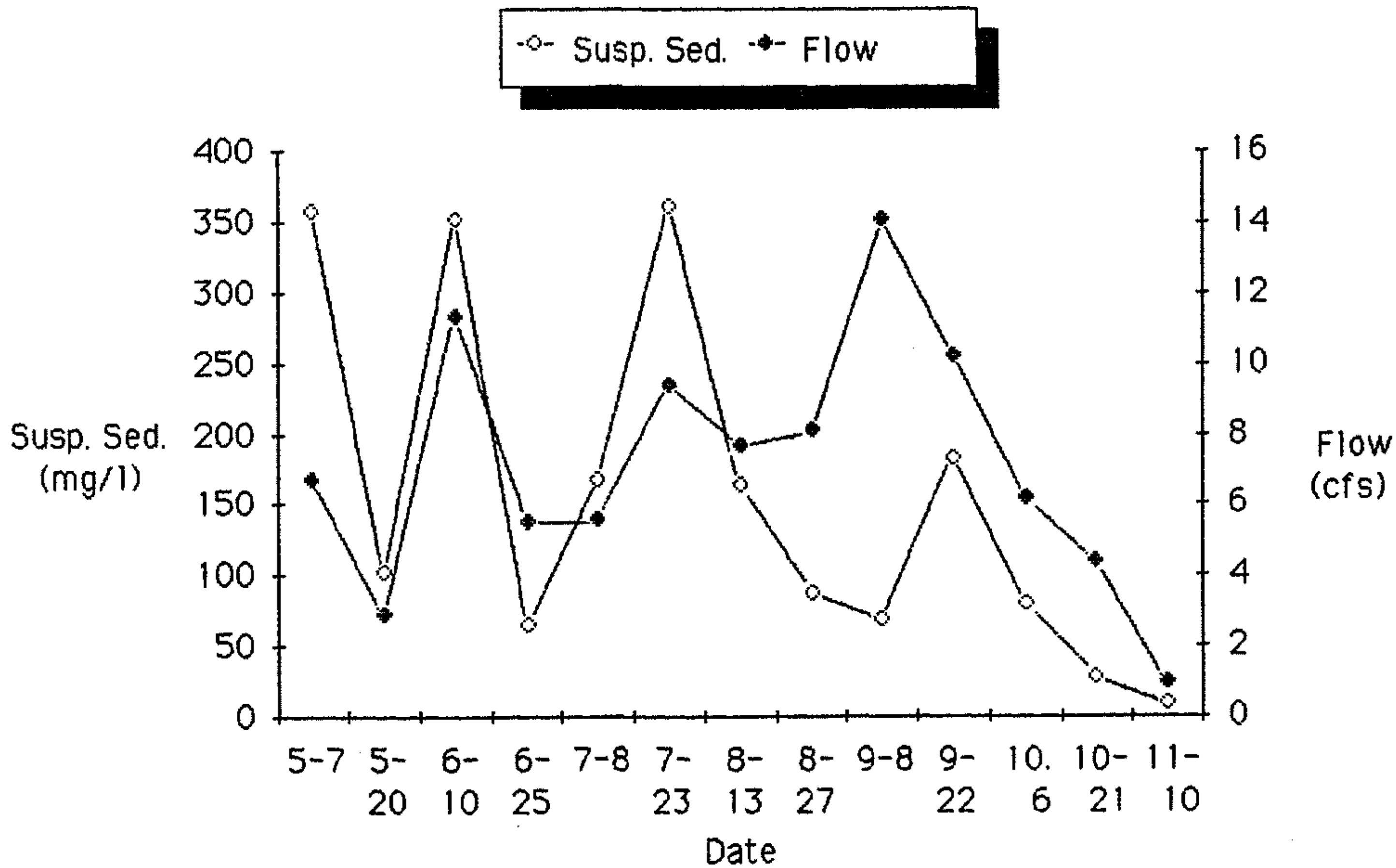

Figure 3. Suspended sediment levels and flow at Vinyard Creek station S-3, 1986.

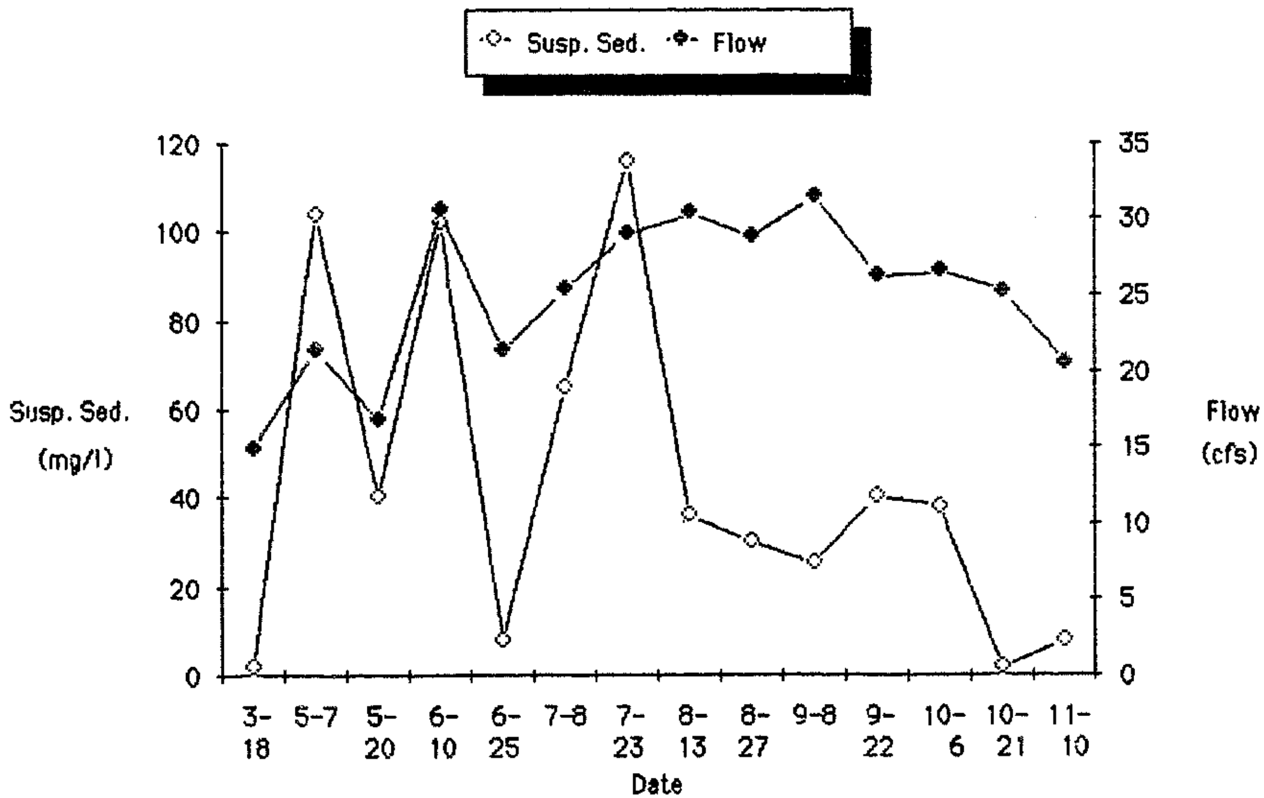

Figure 4. Suspended sediment levels and flow at Vinyard Creek station S-1, 1986.

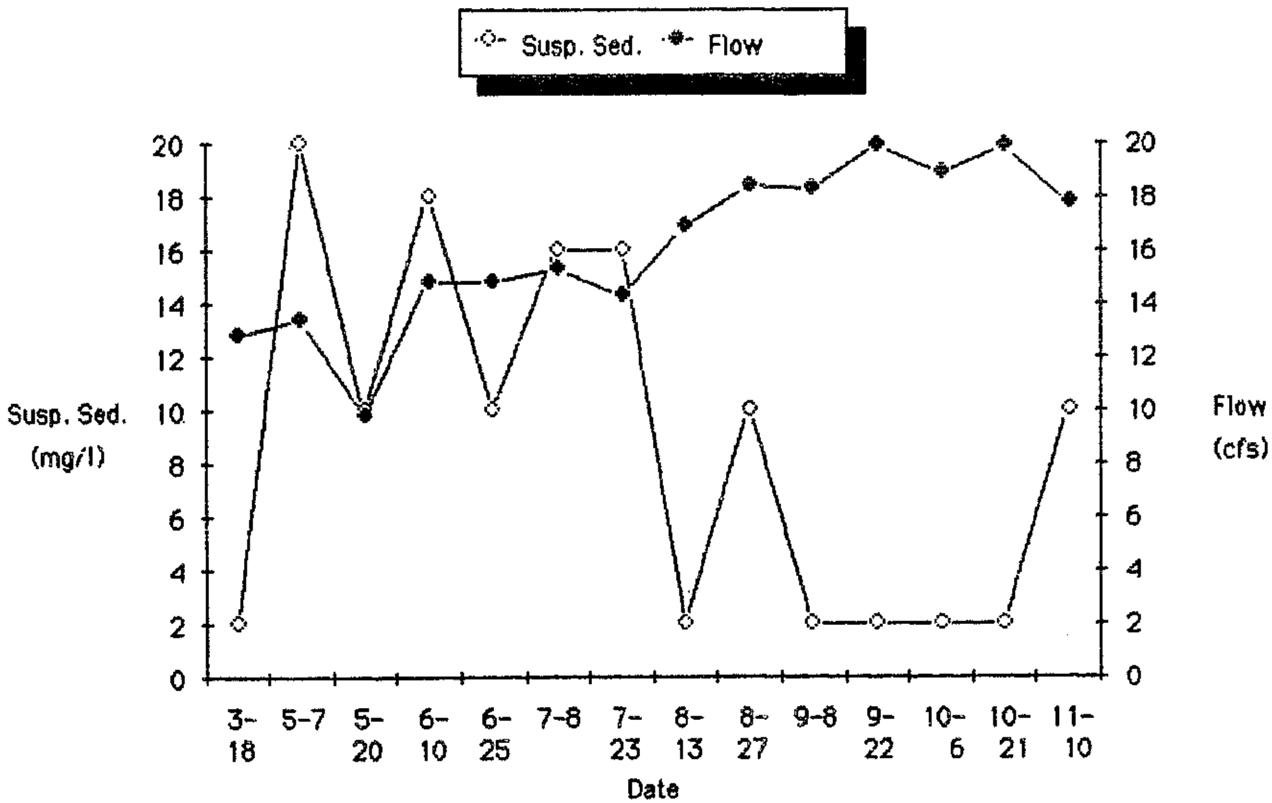

Figure 5. Suspended sediment levels and flow at Vinyard Creek station S-2, 1986.

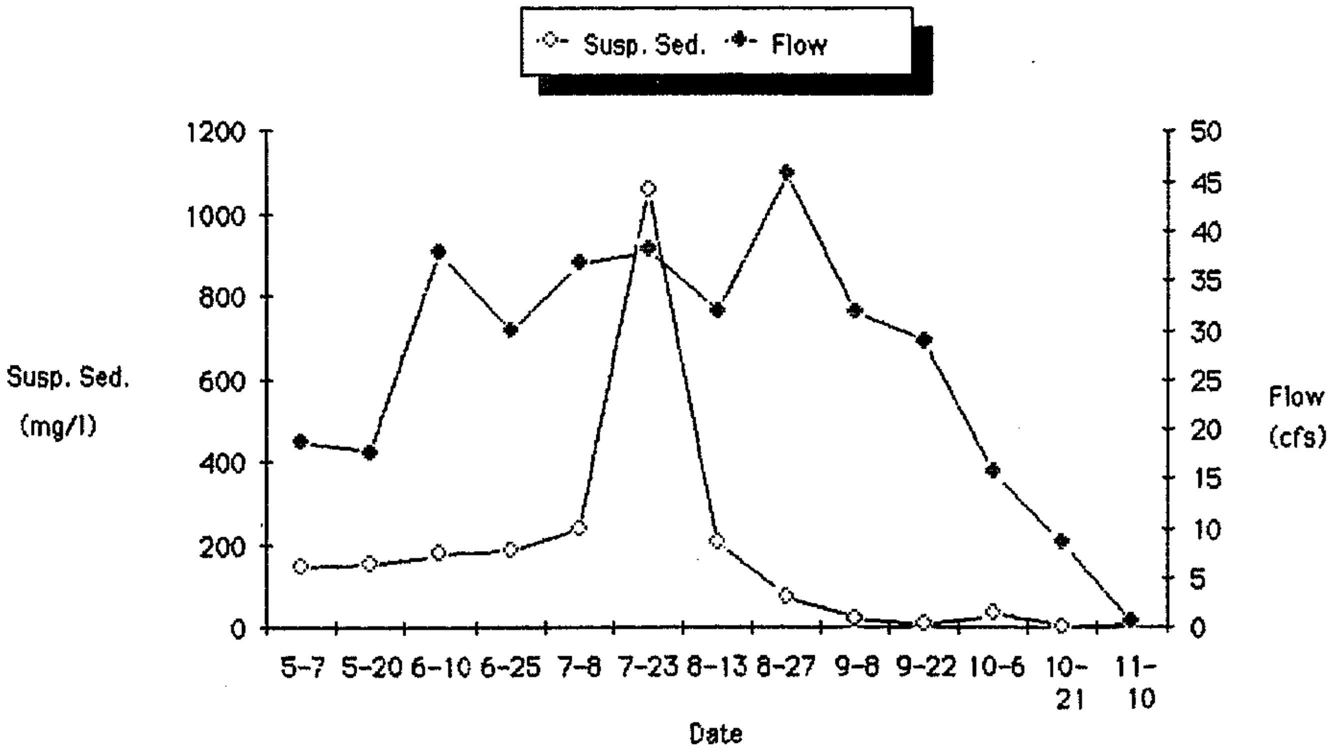

Figure 6. Suspended sediment levels and flow at Vinyard Creek station S-4, 1986.

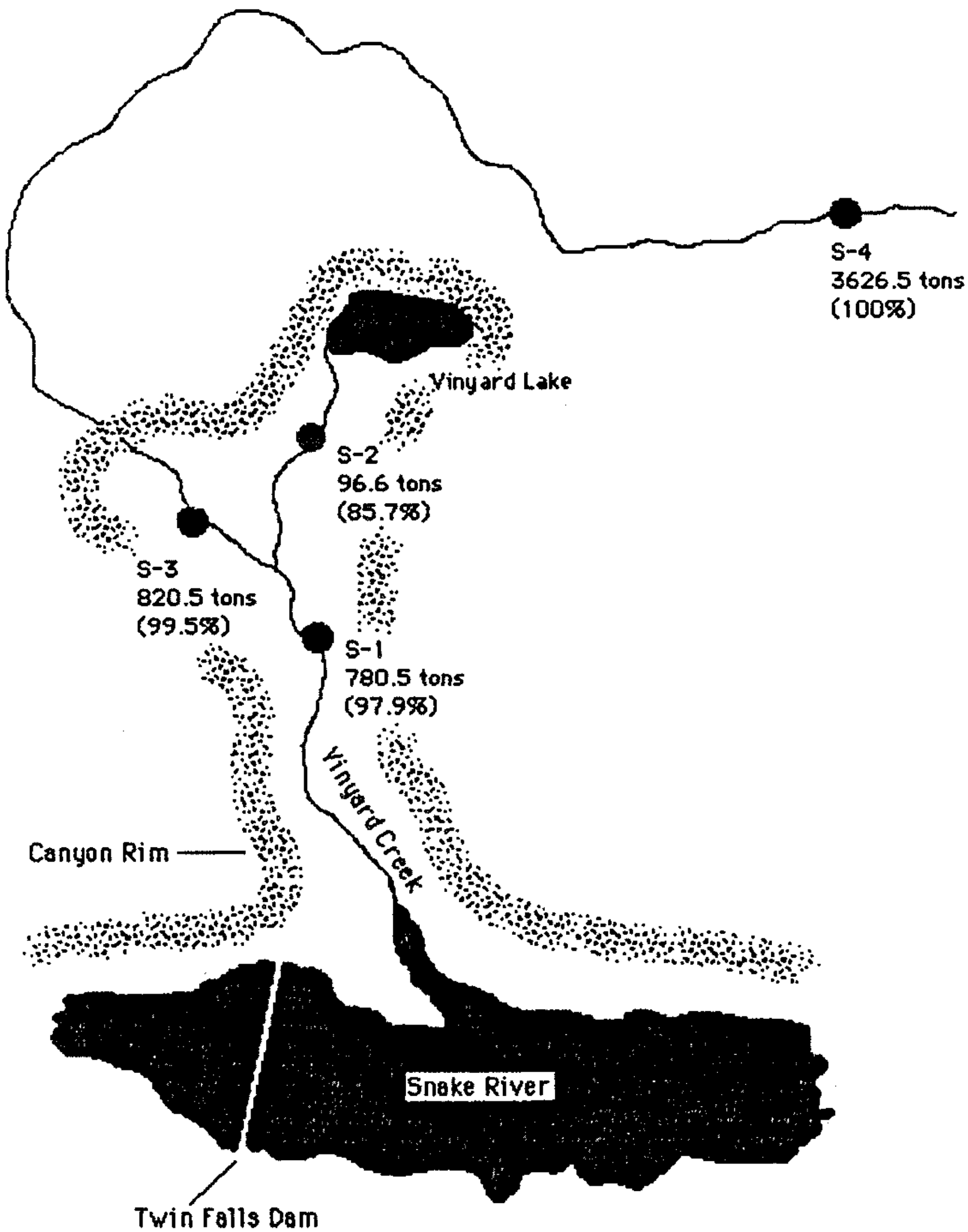

Figure 7. Irrigation season suspended sediment loads and percentages of loadings due to agricultural inputs for the Vinyard Creek survey stations, 1986.

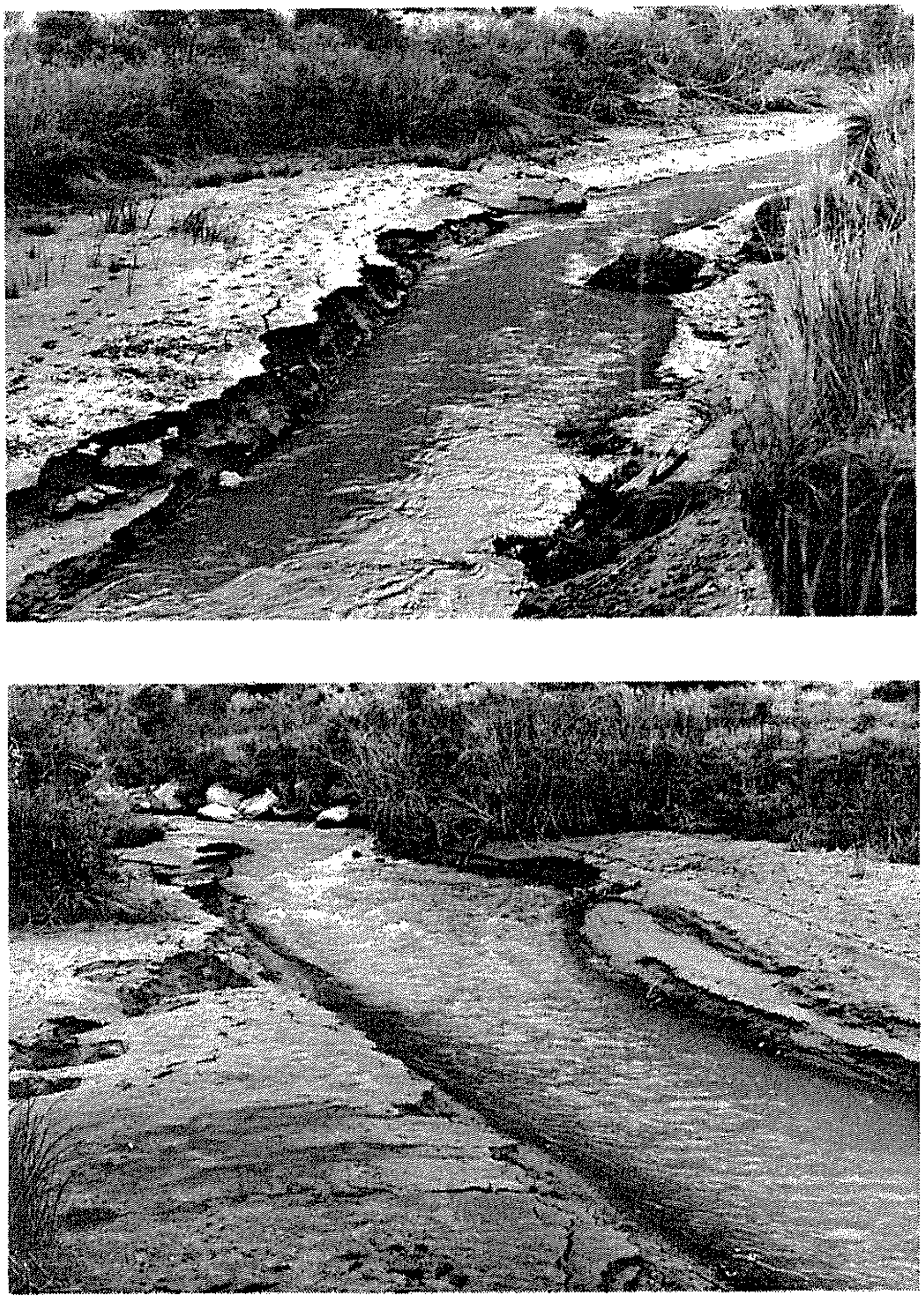

Figure 8. Vinyard Creek near its confluence with the Snake River on July 23, 1986. On this date the elevation of the Twin Falls hydropower dam pool was lower than normal. The resulting lower water level exposed the extensive sediment deposits in lower Vinyard Creek.

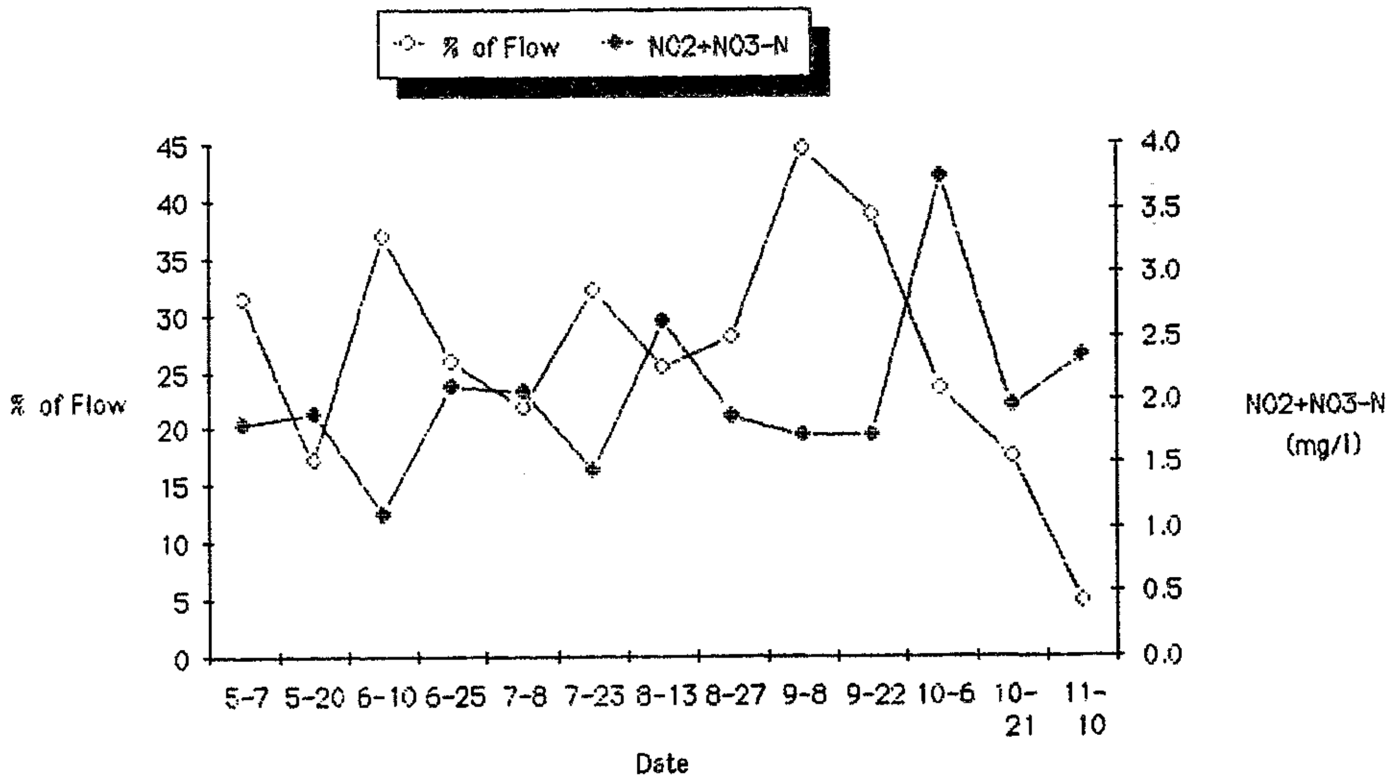

Figure 9. NO2+NO3-N levels at Vinyard Creek survey station S-1, and percentage of flow at S-1 attributable to S-3 input, 1986.

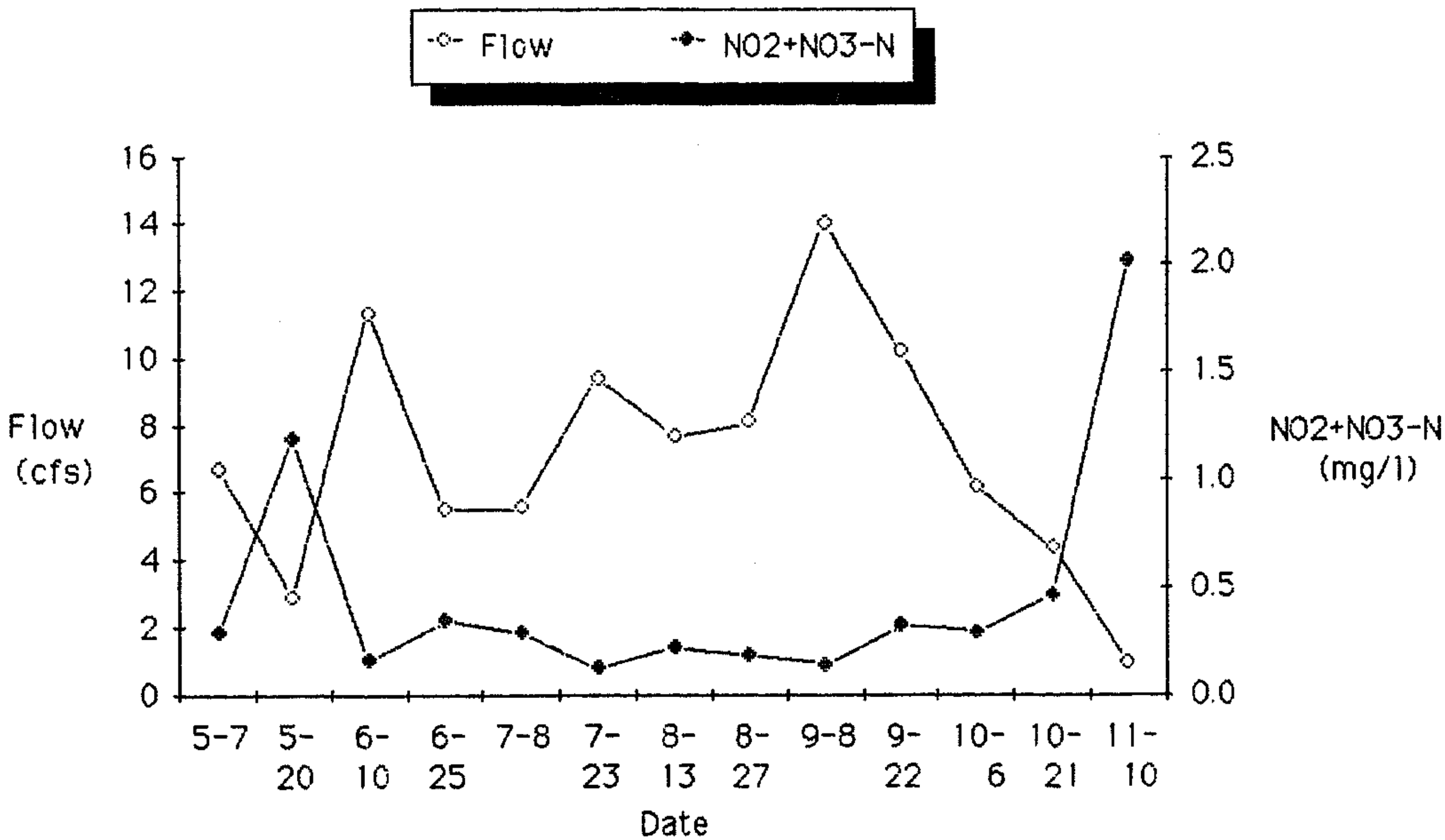

Figure 10. Flow and nitrate nitrogen levels at Vinyard Creek survey station S-3 during 1986.

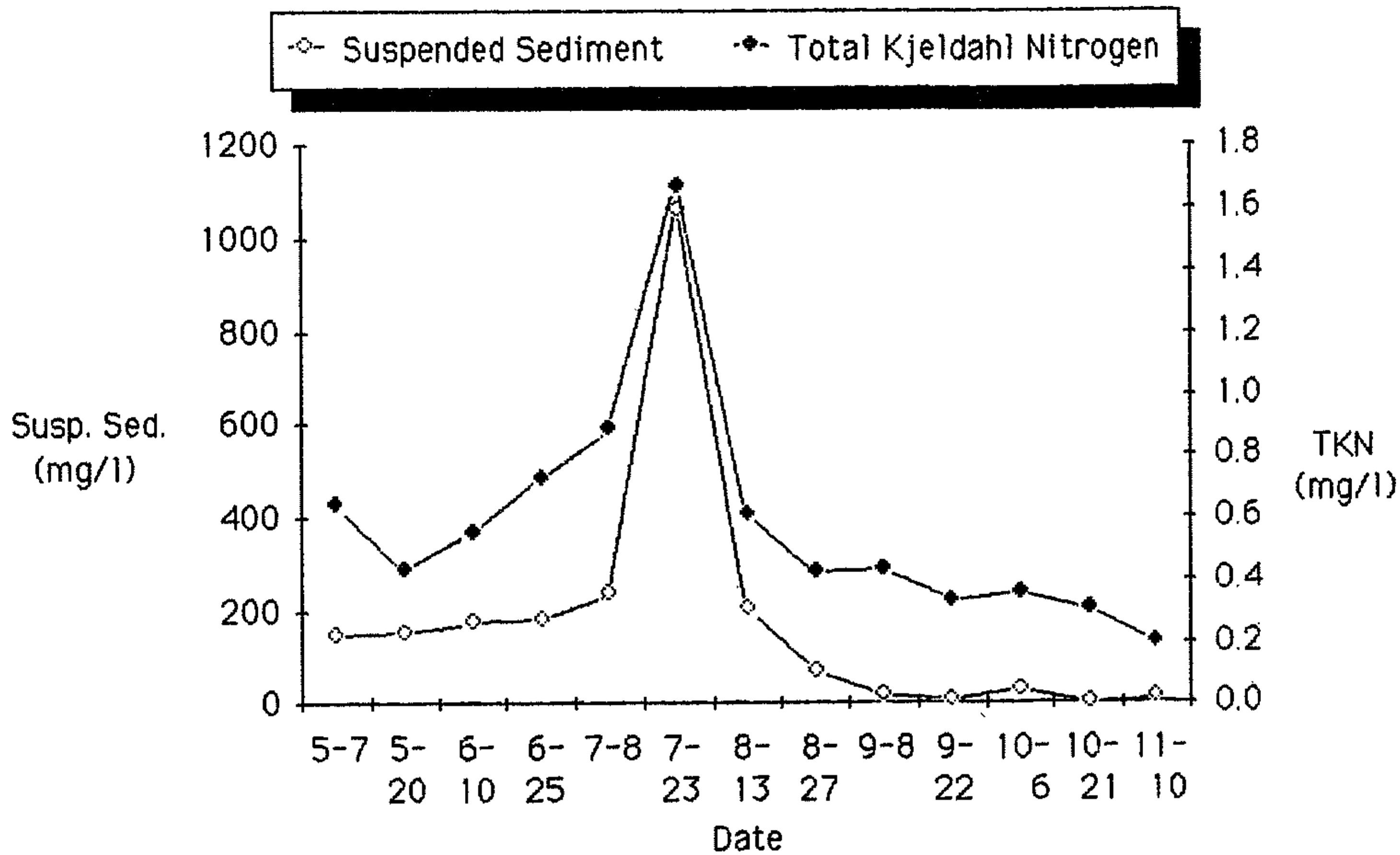

Figure 11. Suspended sediment and total Kjeldahl nitrogen levels at Vinyard Creek survey station S-4 during 1986.

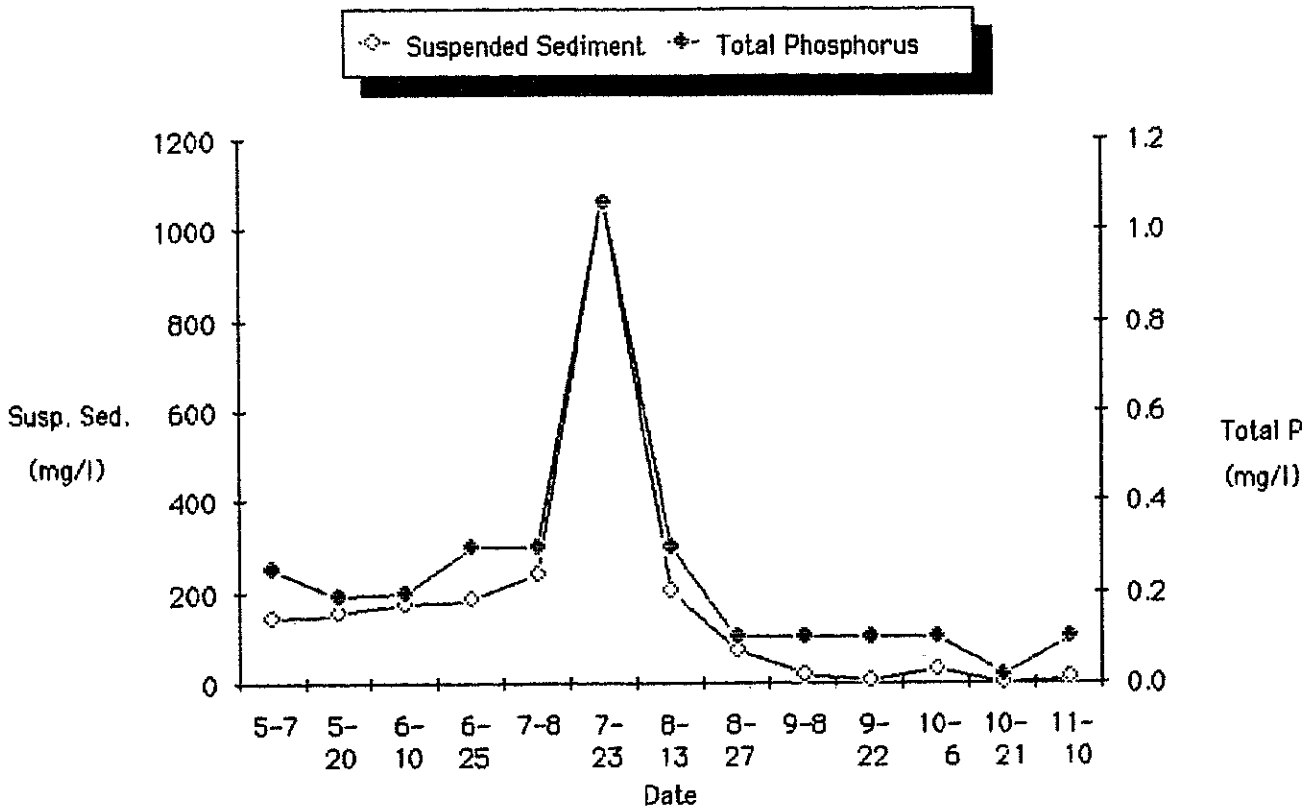

Figure 12. Suspended sediment and total phosphorus levels at Vinyard Creek survey station S-4 during 1986. Spearman rank correlation coefficient for these parameters = 0.91.

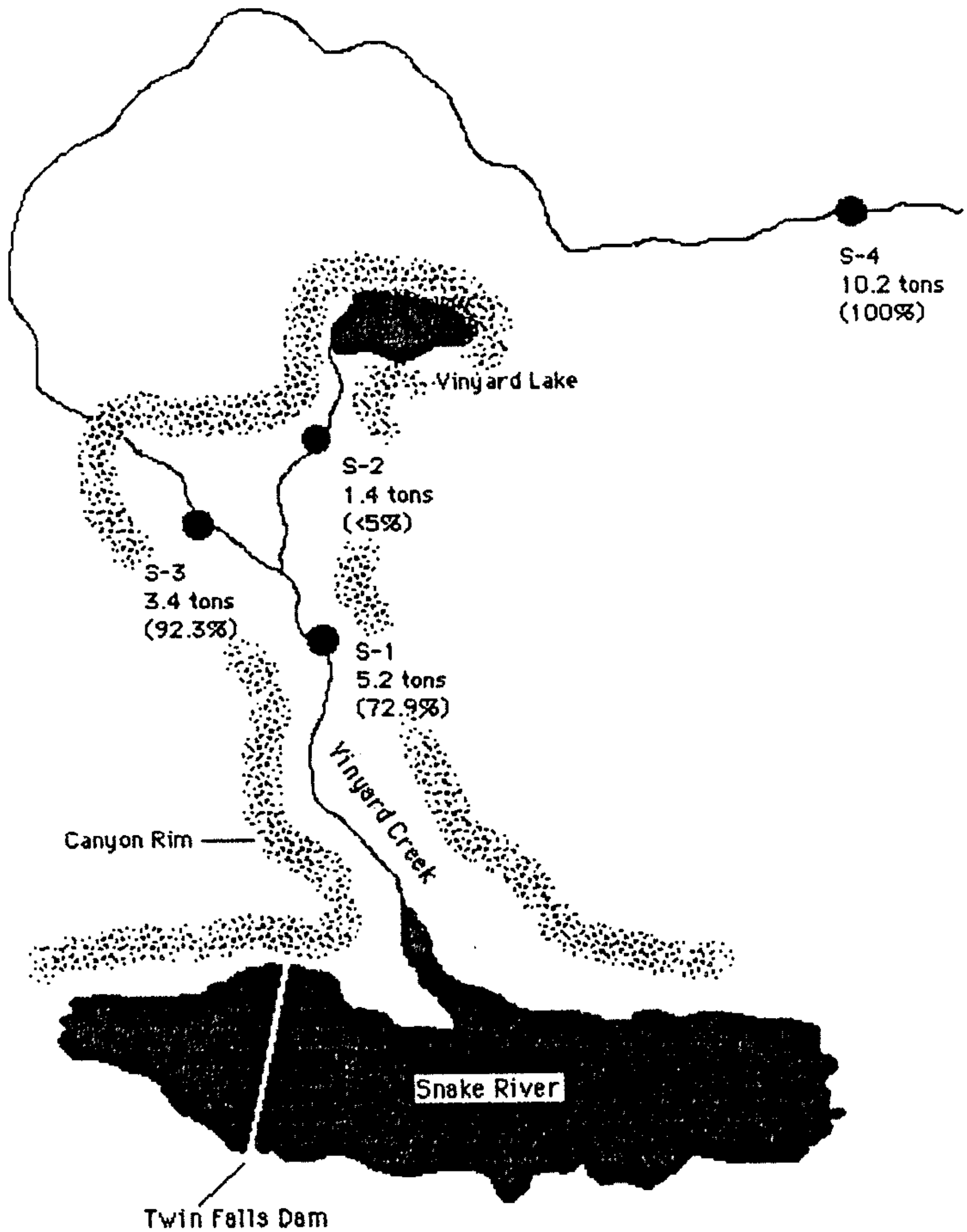

Figure 13. Irrigation season total Kjeldahl nitrogen loads and percentages of loadings due to agricultural inputs for the Vinyard Creek survey stations, 1986.

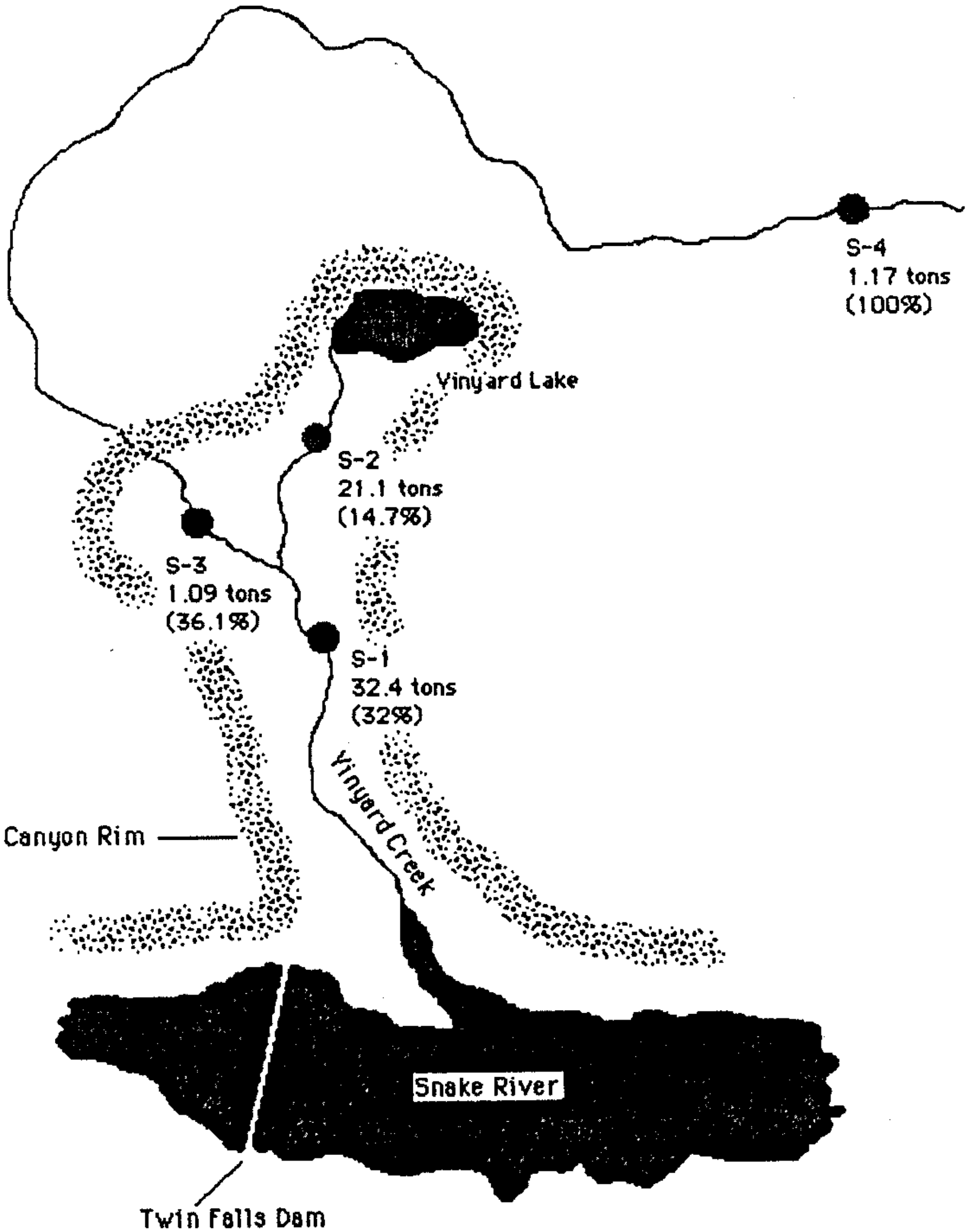

Figure 14. Irrigation season NO2+NO3-N loads and percentages of loadings due to agricultural inputs for the Vinyard Creek survey stations, 1986.

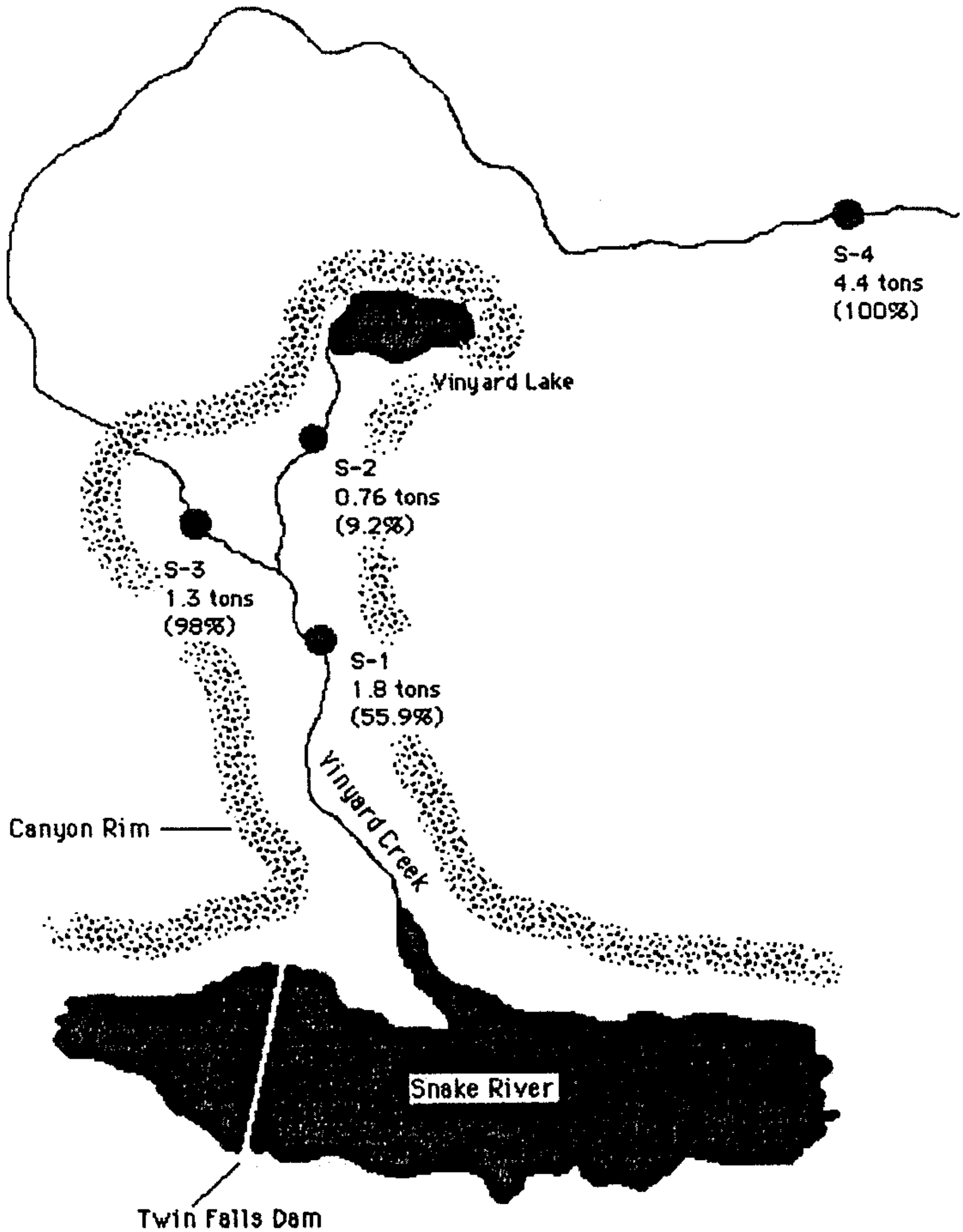

Figure 15. Irrigation season Total phosphorus loads and percentages of loadings due to agricultural inputs for the Vinyard Creek survey stations, 1986.

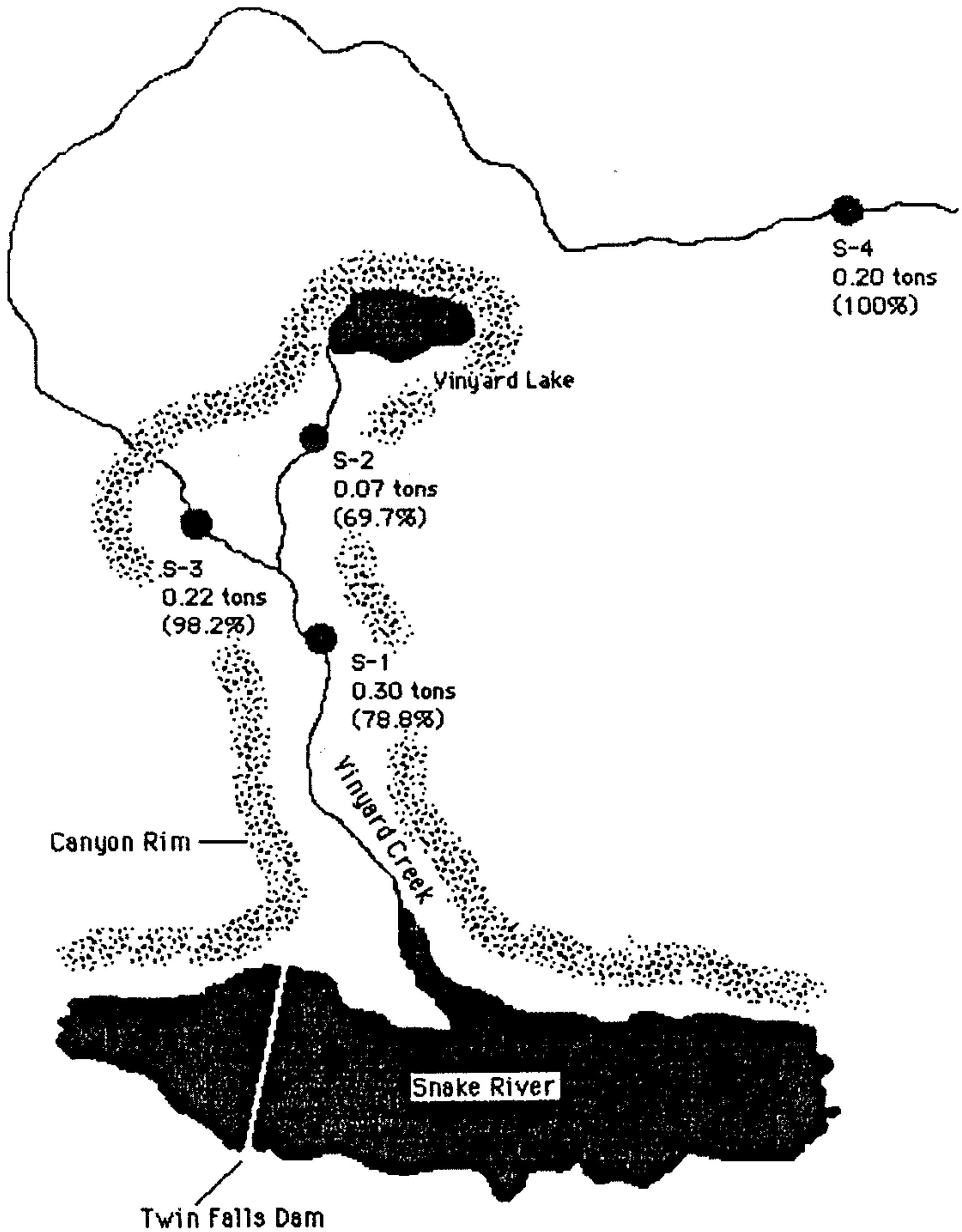

Figure 16. Irrigation season dissolved orthophosphorus loads and percentages of loadings due to agricultural inputs for the Vinyard Creek survey stations, 1986.

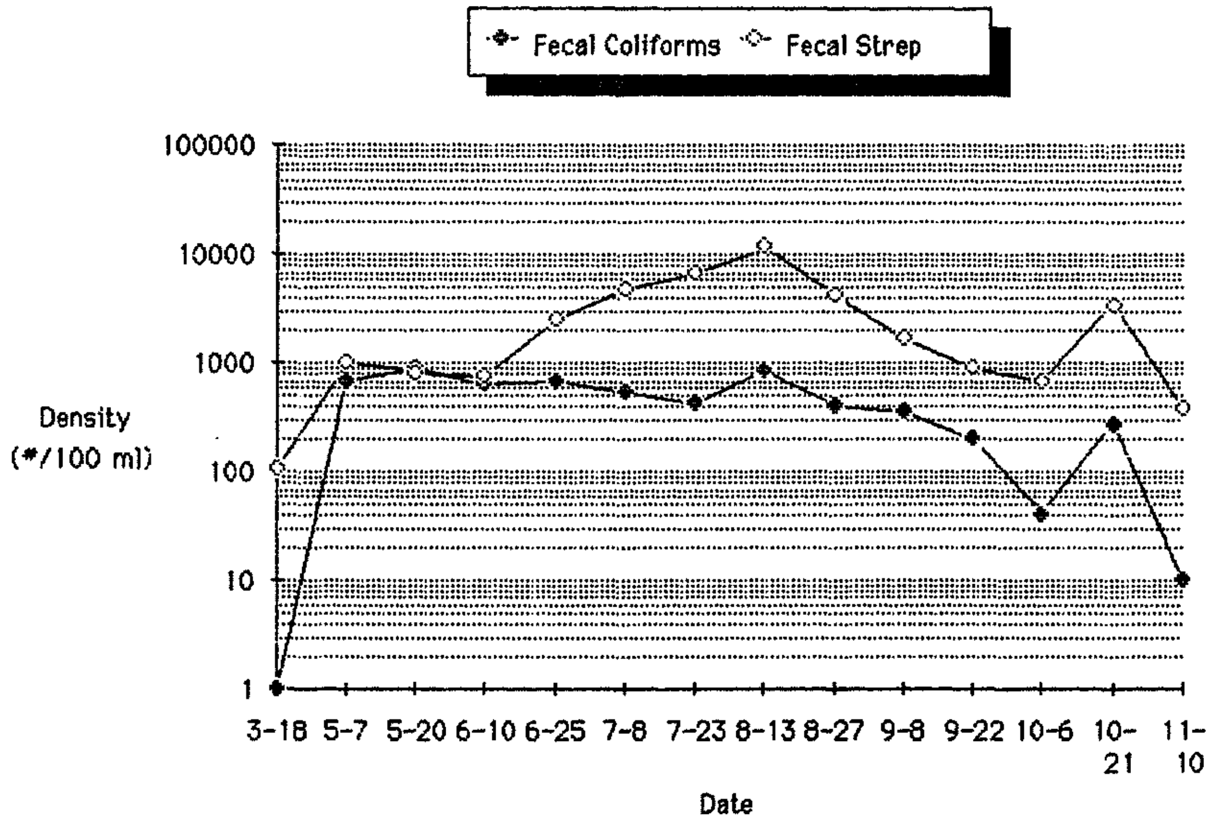

Figure 17. Bacteria densities at Vinyard Creek survey station S-1 during 1986.

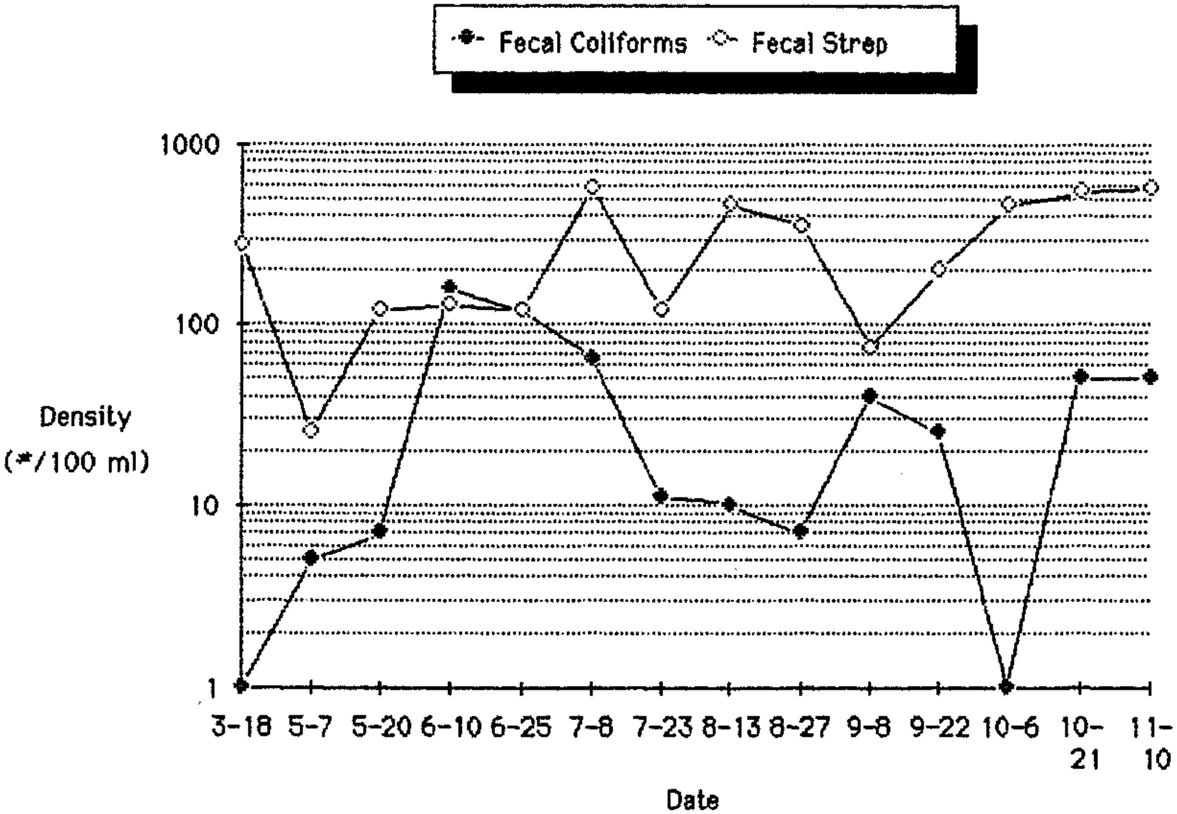

Figure 18. Bacteria densities at Vinyard Creek survey station S-2 during 1986.

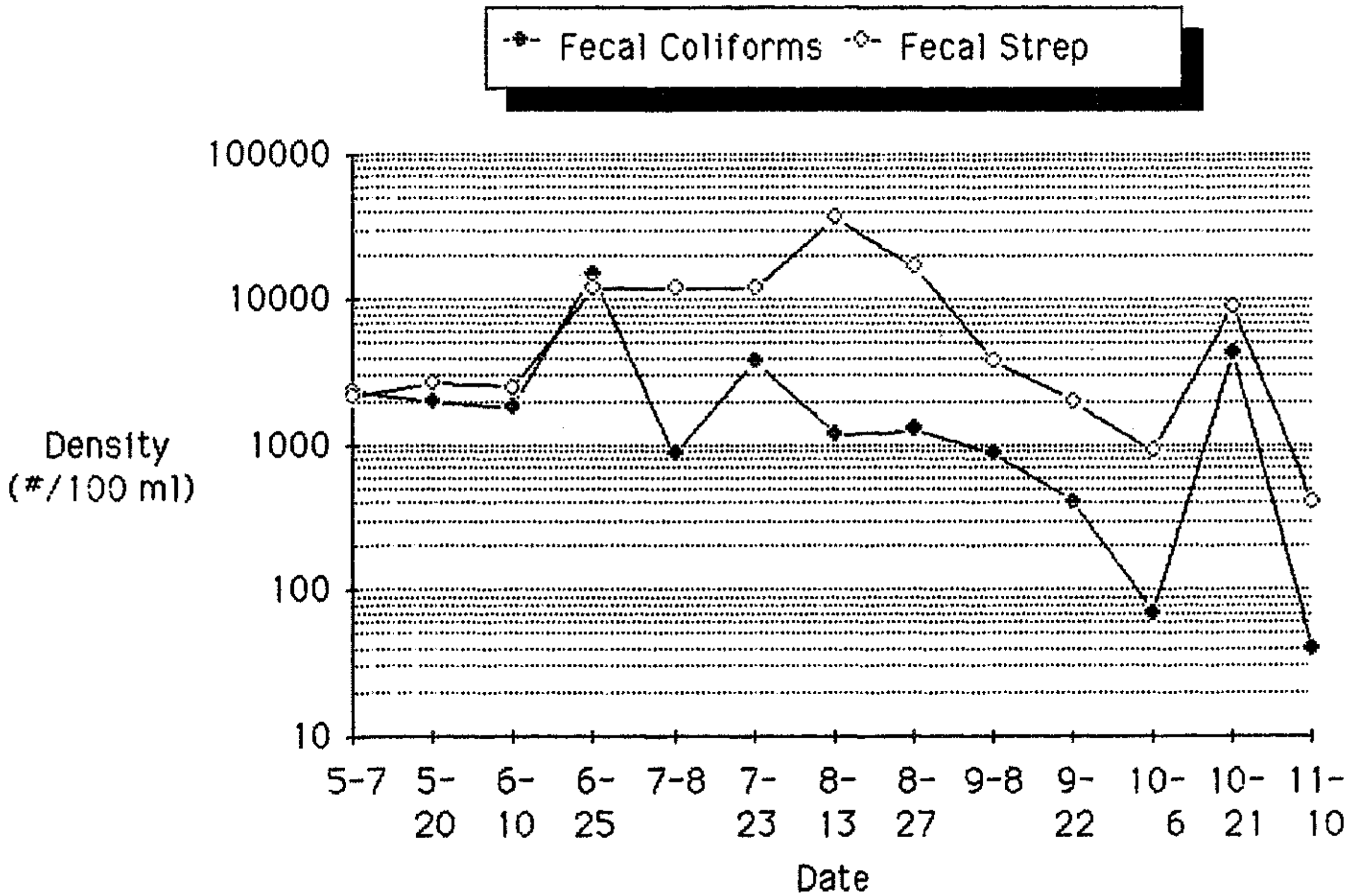

Figure 19. Bacteria densities at Vinyard Creek survey station S-3 during 1986.

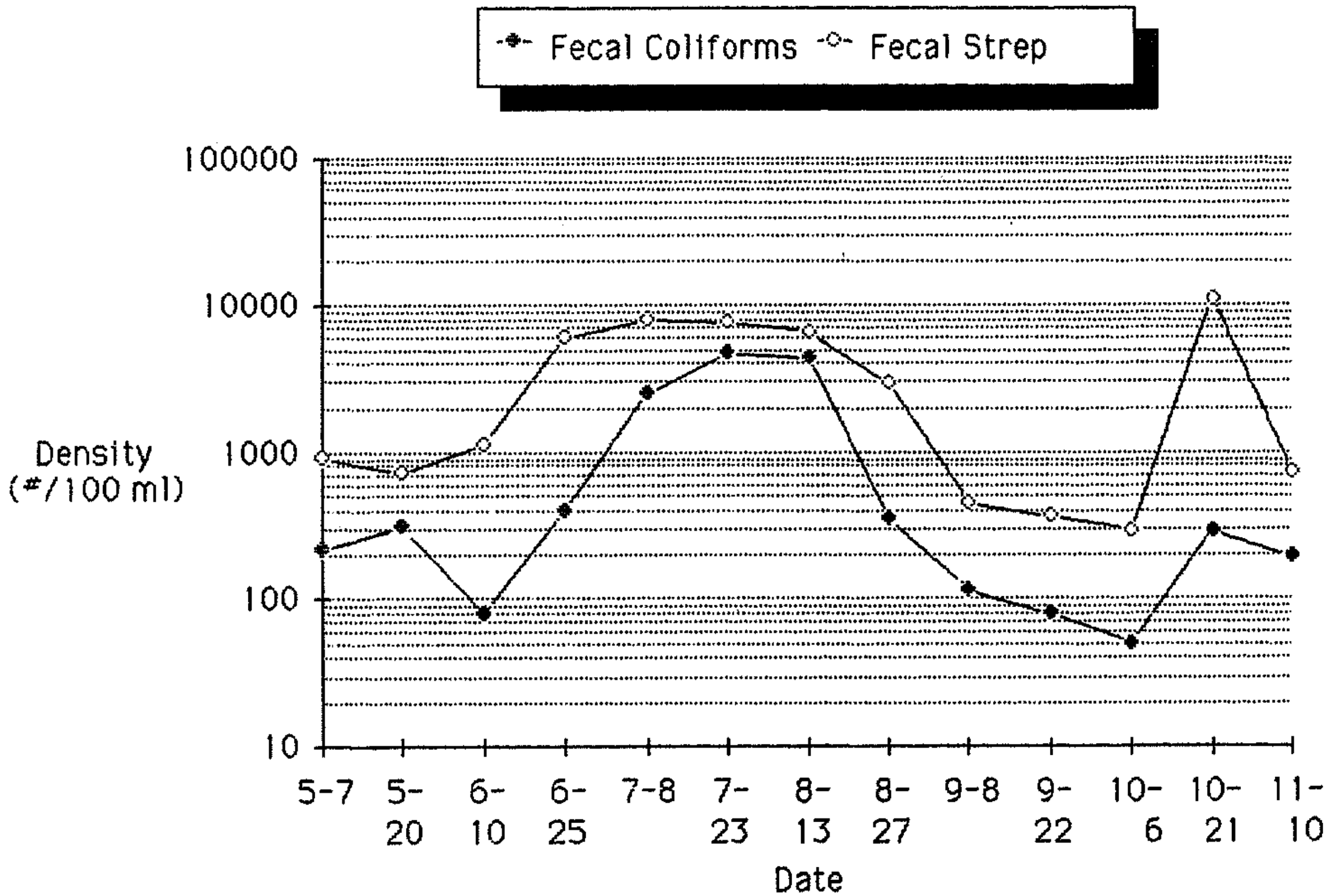

Figure 20. Bacteria densities at Vinyard Creek survey station S-4 during 1986.