WATER QUALITY STATUS REPORT

Assessment of Nonirrigated Cropland Runoff

HANGMAN CREEK

(Benewah County)

1981-1982

Idaho Department of Health and Welfare
Division of Environment
Boise, Idaho 83720

February, 1983

Report No. WQ-51

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February, 1983

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SUMMARY

1. Hangman Creek drains a forest and cropland watershed of approximately 83,000 acres, of which 33,000 acres is in dry cropland production. Major crops include wheat, peas, lentils, and barley. Soils are highly erosive; critical cropland has an annual average erosion rate between 40 and 50 tons/acre.

2. Four ambient stations on Hangman Creek and twelve stations on tributaries were monitored between February 1981 and June 1982 to determine baseline water quality status, and to identify subwatersheds which contribute to the water quality problem. Monitoring efforts were directed at sampling peak runoff periods for suspended sediment, nutrients, and bacteria.

3. Precipitation patterns are highly variable within this small watershed due to changes in elevation and topography. Annual average precipitation at the local weather bureau station over a four year period (1979-1982) was 28 inches. Data collected at three sites, by volunteers within the watershed, showed daily variation up to one-half inch. Major runoff events generally occur between January and March and are attributed to a rain on snow event caused by warm Chinook winds from the Pacific coast. A peak flow of over 3,000 cfs was measured at the gaging station in February 1982 at the Idaho-Washington state line. Average daily stream flow was 626 cfs in February 1982, which decreased to an average daily flow of 25 cfs in May.

4. Peak sediment discharge was measured in the watershed between February 1 and the first week in March. (A major runoff event in January from the 25th to the 27th was not sampled.) Sediment discharge in Hangman Creek and the tributaries was sampled during a 10-day storm event in February and a 5-day storm event in March. The 5-day storm event in March was much lower in intensity and produced an average about one-third the discharge and approximately 10 percent of the sediment load as the February storm.

   Total sediment load at the mouths of tributaries during the February storm varied from 1,893 tons in Sheep Creek to 6,389 tons in Mission Creek. The highest sediment load, 43,891 tons, was recorded in Hangman Creek at De Smet. The sediment load downstream at State Line was lower, 27,982 tons. This indicates that approximately 16,000 tons of sediment were deposited in the Hangman Creek channel--a distance of only eight river miles--during the 10-day storm.

   A general trend in increasing sediment concentrations was observed in the tributaries as one proceeds downstream in the watershed. This reflects the general land use change toward

increases in cropland acreages in the tributaries. Based on sediment discharge, priorities for BMP implementation programs should include Mission Creek, Lolo Creek, Upper Hangman Creek, Andrews Springs Creek, and Smith Creek.

5. Baseline conditions (as measured in 1982) for suspended sediment concentrations were established for tributary stations using sediment rating curves. This information can be used to determine the success of BMP implementation programs. Sampling for sediment and flow can be repeated at a station after an implementation program is completed. The post-implementation data can then be compared to the baseline sediment rating curve.

6. Average phosphorus concentrations at the monitoring sites ranged from 0.16 mg/l in Upper Hangman to 1.32 mg/l at the Clay Pit site. A peak concentration of 6.2 mg/l was recorded in the watershed from a tributary during the February storm. It was estimated that 60,000 pounds of phosphorus were lost from the watershed during the February storm as measured in Hangman Creek at the state line. Tributaries that contributed large amounts of phosphorus include Mission Creek (12,000 pounds), Lolo Creek (11,800 pounds), Andrews Springs Creek (7,800 pounds), and Smith Creek (5,700 pounds).

   Average inorganic nitrogen concentrations ranged from 0.23 mg/l in Hangman Creek above Sanders to 6.8 mg/l at the Clay Pit site. Peak concentrations of inorganic nitrogen (primarily nitrates) in the 12 to 13 mg/l range were recorded in the tributaries. These concentrations are well above expected background levels of 0.1 to 0.3 mg/l, and can be attributed to runoff and percolation of agricultural fertilizers. It was estimated that the nitrogen and phosphorus lost from Hangman Creek at State Line during the 10-day storm event in February had an equivalent fertilizer value of approximately $80,000.

7. High bacterial numbers were found in Hangman Creek in the upper watershed. Fecal coliform bacteria concentrations exceeded the 800/100 ml standard for individual samples 36 percent of the time in Hangman Creek above Sanders, and 25 percent of the time below Sanders. Bacterial sources in this area include livestock grazing and individual septic system drainage. Comparison of fecal coliform bacteria to fecal streptococcus bacteria indicate that this bacterial contamination is primarily from human sources. The most likely cause of this problem is inadequate or poorly maintained individual sewage disposal systems.

8. Dissolved oxygen concentrations were well above minimum standards indicating that future fisheries use will not be hampered by inadequate dissolved oxygen levels.

9. Dissolved solids levels are naturally low in Hangman Creek. This results in some violations of the minimum pH standard, however, this is considered a normal situation for north Idaho waters and is not caused by pollution sources. Water in Hangman Creek is in the "very soft" to "soft" category in regards to minerals. Hardness values range from 16 units (equivalent to mg/l of calcium carbonate) above Sanders to 46 units at the State Line.

10. Total iron was fairly high in Hangman Creek. Concentrations of iron throughout the year exceed the maximum criteria of 0.3 mg/l for domestic water supplies. During storm events total iron reached extremely high concentrations. However, iron measured during storm events is probably part of sediment particles. This iron is considered a natural component of the water and soil and is not related to pollution. However, reducing the sediment washed into the creek will reduce iron associated with soil particles.

HANGMAN CREEK WATER QUALITY REPORT

INTRODUCTION

Objectives

Idaho Water Quality Standards and Wastewater Treatment Requirements (IDHW, 1980) designate the waters of Hangman Creek as:

1. Protected for general use as an agricultural water supply.
2. Protected for future use as a cold water biota.
3. Protected for general use as a secondary contact recreation.

See Appendix A.

In view of the protected uses of Hangman Creek and its identification as an area of severe erosion, the specific objectives of this water quality survey were:

1. To define the baseline water quality status of Hangman Creek. This will allow a comparison of water quality in Hangman Creek to water quality standards and comparison to other stream segments.

2. To illustrate the effect of different land use patterns--woodland, cropland on cut-over soils, and cropland on prairie soils--on water quality and erosion rates.

3. To locate the critical erosion areas or subbasins within Hangman Creek and characterize the extent of the water quality degradation.

Background

The Idaho Agricultural Pollution Abatement Plan (1979) identified the waters of Hangman Creek as severely affected by sediment due to erosion. Approximately 40 percent of the watershed is cultivated for dryland farming. Soils of the watershed directly adjacent to the creeks are often poorly drained and flooded during early spring. Soils of the rolling hills and mountains are classified as highly erosive. Soil loss within the watershed often reaches 50 tons/acre. Early spring rain on snow covered and unprotected frozen ground compounds the problems associated with soil type and farming practices. Due to unusual weather patterns in this area, rainfall in excess of 1½ inches over a five-day period is not uncommon.

Fred Wetter (1980), a retired Soil Conservationist, identified seven major problems contributing to degradation of water quality. These problems are: crop rotation, tillage, runoff disposal, field layout, land clearing, road systems, and stream bank erosion.

Under a 208 Planning for Implementation Grant from the IDHW-DOE, the Benewah Soil and Water Conservation District is designing water pollution abatement plans for the watershed based on Best Management Practices. To provide water quality information, the IDHW-DOE began studying Hangman Creek in February of 1981.

Drainage Description

Headwaters of Hangman Creek originate in northern Idaho in the mountains east of the Palouse country of Benewah County. Flowing northwest, Hangman Creek (Figure 1) crosses the Idaho-Washington border near Tensed, Idaho, and enters the Spokane River at Spokane, Washington. The Spokane River is part of the Columbia River System.

The Hangman Creek valley is surrounded on the north, east, and south by mountains 3,900 to 4,950 feet high. The stream elevation drops 330 feet between the town of Sanders and the Idaho-Washington border. Annual precipitation averages 20 inches at the border, over 25 inches at Tensed, and nearly 45 inches above 4,000 feet (Wetter, 1980).

Three major soil divisions are found within the watershed. (Figure 2) Type 1 soil is located on flood plains and low stream terraces. Due to its proximity to the creeks, it is frequently flooded in early spring. This mainly level silt loam makes good cropland, though limited in areas by high water table and poor drainage. Type 2 soil occurs on undulating to steep loess-covered hills. Readily eroded, this silt loam requires

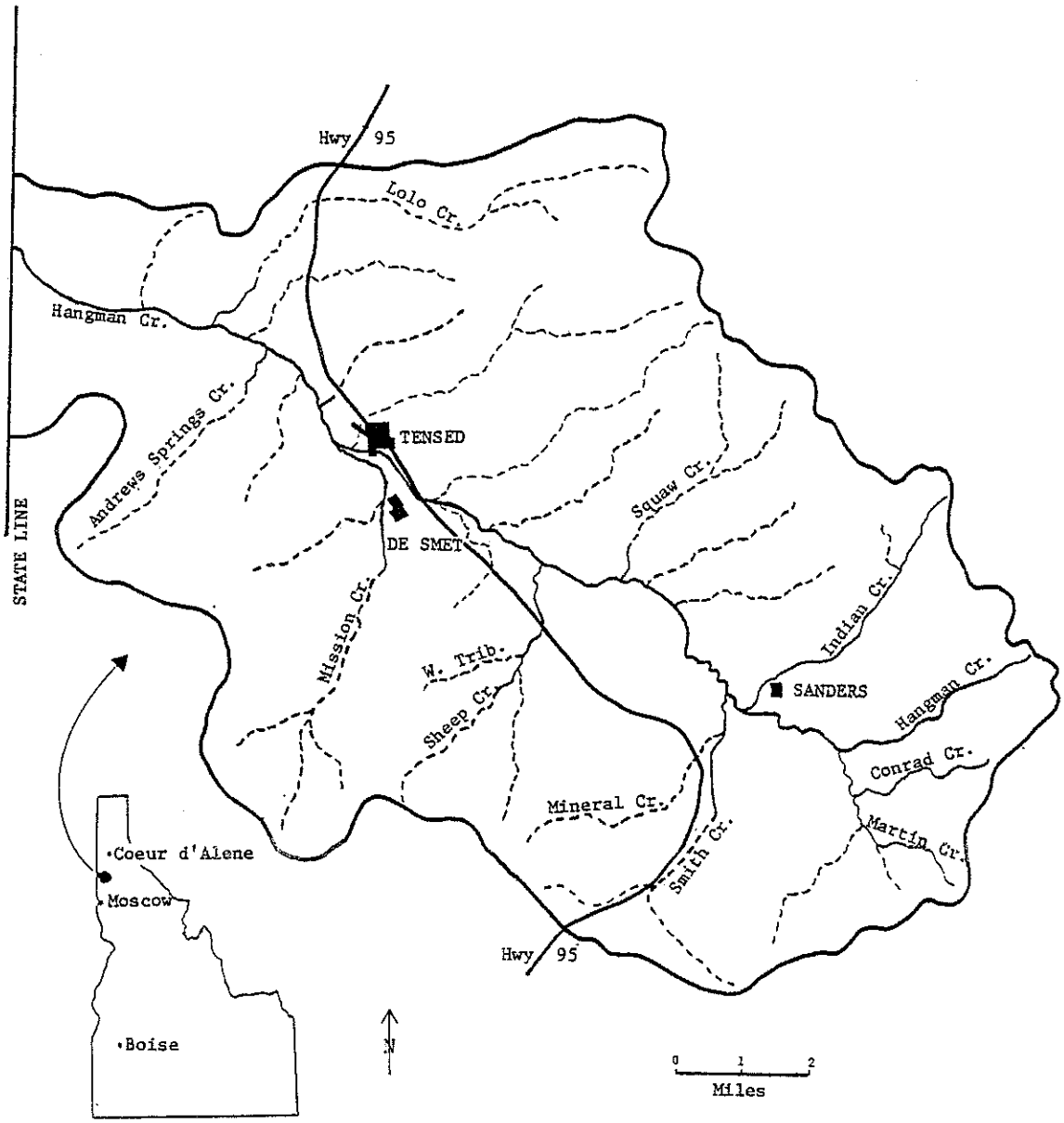


Figure 1. Hangman Creek Watershed.

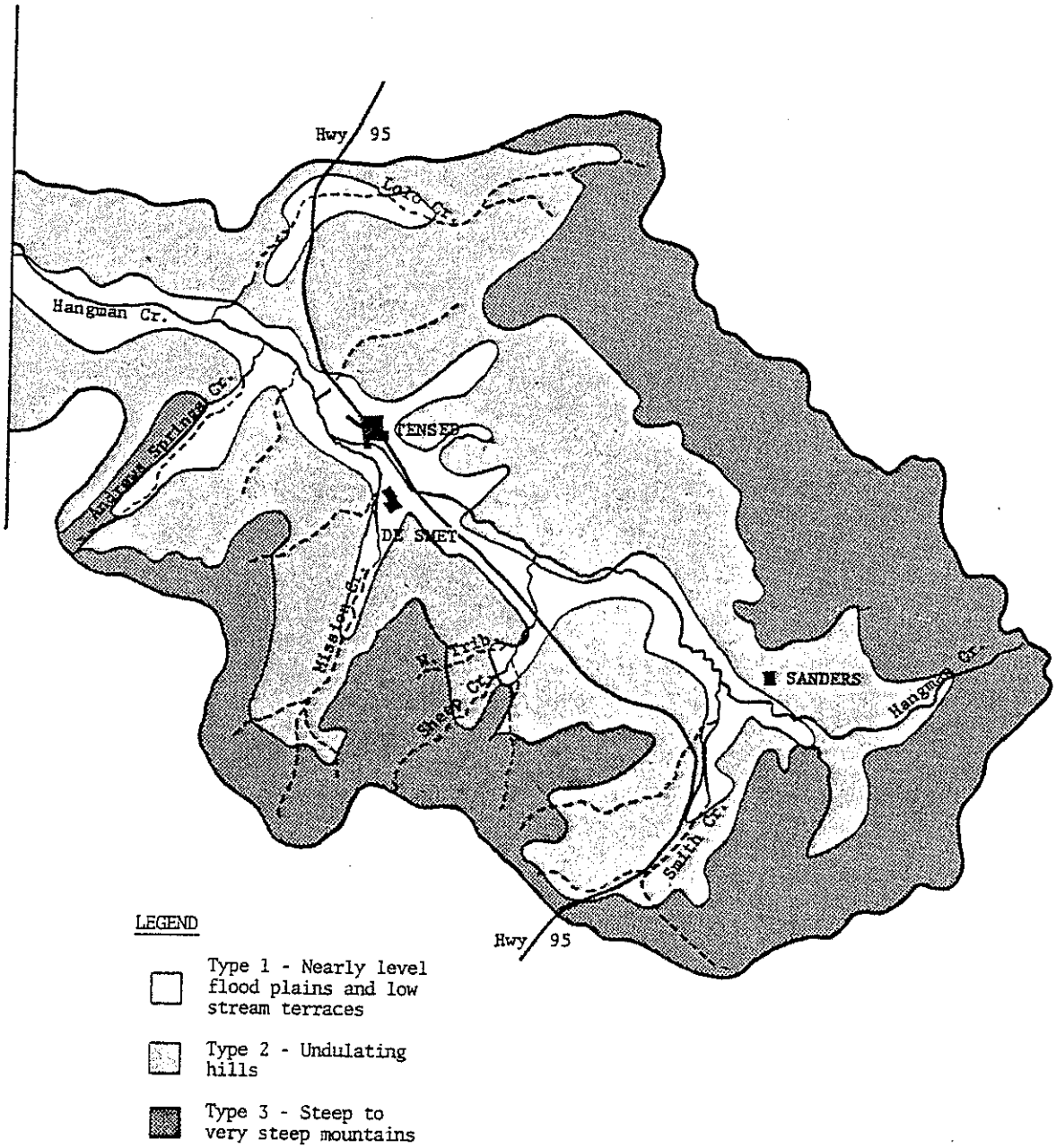


Figure 2. General Soils Map of Hangman Creek Watershed. From SCS Soil Survey.

conservation practices for erosion control. Minimum tillage, strip cropping and high crop residue are recommended. Type 3 soil is found on steep mountainous slopes. These gravelly loam and silt loam soils are not recommended for cultivation due to high erosion potentials. For further description of soil types see USDA (1981) Soil Survey of Benewah County Area, Idaho.

Hangman Creek watershed covers approximately 50,000 acres of forest land and 33,000 acres of agricultural land (Figure 3). Major crops include wheat, peas, lentils, and barley. Of the agricultural land, approximately 45 percent is prairie soil and 55 percent is cut-over (once forested) soil. The prairie soils have good water carrying capabilities. Cut-over soils have increased clay content. Within a foot or two of the surface, water and root penetration are nearly eliminated. Excessive tillage often occurs on these fragile soils. Such tillage eliminates residue and breaks clods, both of which greatly reduce soil water-holding capacity and resistance to erosion.

As of 1980, the population of Hangman Creek watershed was 620. Less than 200 reside in the three small communities of Tensed, DeSmet, and Sanders. There are 57 farmers in the watershed, 49 residing in Idaho. The majority of the watershed lies within the Coeur d'Alene Indian Reservation. Considerable acreage is privately owned or deeded. The remainder is under the management of the Tribal Council. For further description of the watershed, see the Hangman Creek Conservation Inventory (1980), by Fred Wetter.

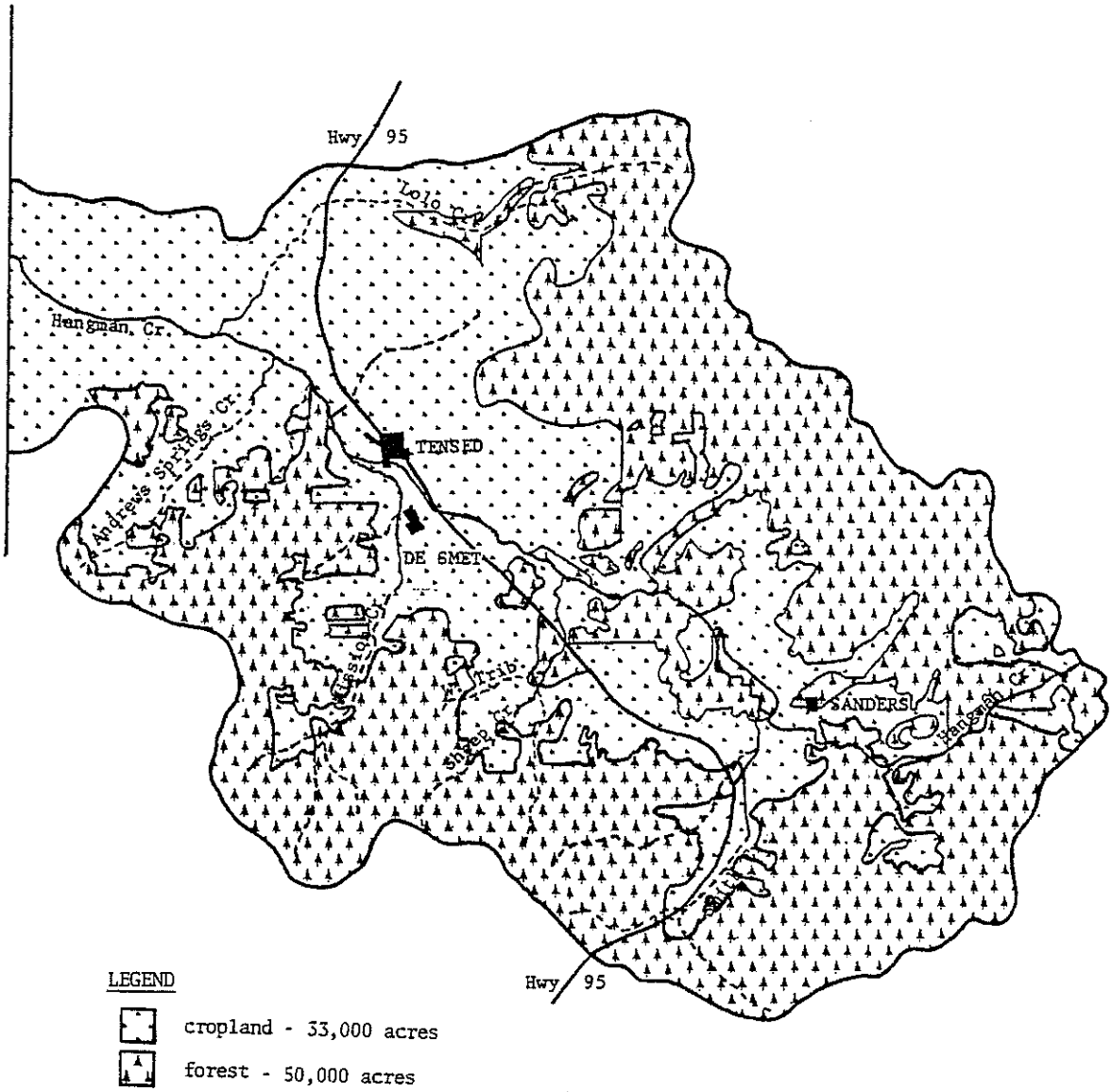


Figure 3. General Land Use Map of Hangman Creek Watershed.

MATERIALS AND METHODS

Survey Design

Four ambient stations on Hangman Creek and twelve intensive stations on tributaries were monitored between February 1981 and June 1982 (Figure 4). Table 1 describes each sampling station and the number of samples collected from each station. More exact descriptions of sampling stations are listed in Appendix B.

TABLE 1 - NUMBER OF SAMPLES COLLECTED AT EACH STATION. NOT ALL PARAMETERS WERE MONITORED DURING EACH SAMPLING.

STATION	LOCATION OF STATION	NUMBER OF SAMPLES COLLECTED
A	Hangman Creek above Sanders-(A)	25
B	Hangman Creek below Sanders-(A)	24
1	Smith Creek near mouth-(I)	15
3	Western Tributary of Sheep Creek-(I)	15
2	Sheep Creek near mouth-(I)	14
C	Hangman Creek at De Smet-(A)	23
4	Upper Mission Creek-(I)	12
5	Mission Creek near mouth-(I)	15
10	Clay Pit Tributary-(I)	14
6	State Park Tributary-(I)	10
7	Upper Andrews Springs Creek-(I)	11
8	Middle Andrews Springs Creek-(I)	12
9	Andrews Springs Creek near mouth-(I)	14
11	Upper Lolo Creek	11
12	Lolo Creek near mouth-(I)	13
D	Hangman Creek near Idaho/WA State Line-(A)	36

A Indicates ambient stations.
I Indicates intensive stations.

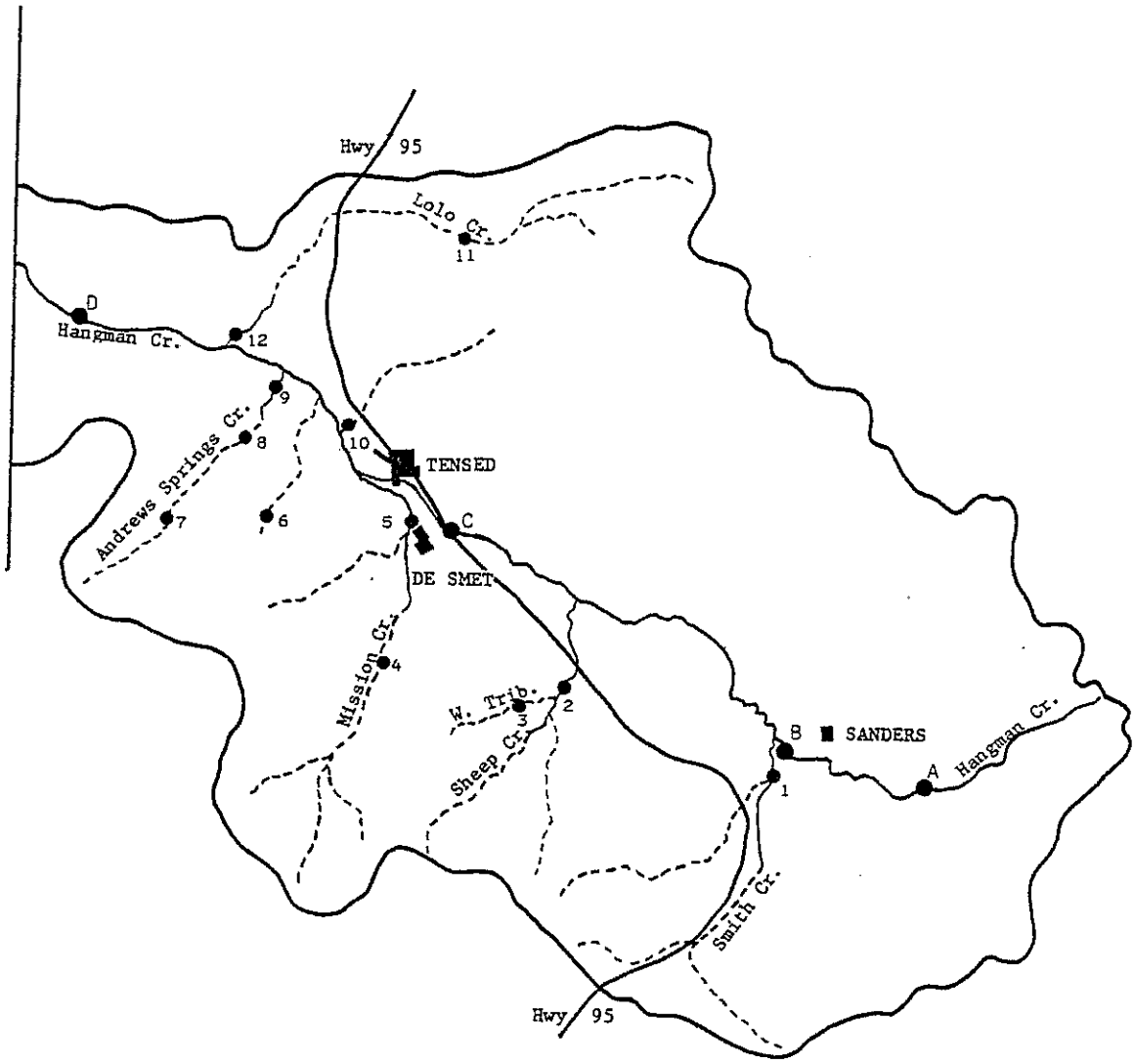


Figure 4. Sampling Station Locations, Hangman Creek.
Ambient A-D, Intensive 1-12.

Ambient stations were monitored at least bimonthly to determine base line water quality parameters. Intensive stations were sampled only during the major runoff events since they are dry from June to December. Sediment and nutrient samples were obtained during storm events in February and March of 1982. All stations were sampled at least four times during each storm.

Parameters

Sampling at ambient stations on Hangman Creek included field measurements, bacteria, nutrients, suspended sediment, minerals, and total metals. Intensive stations on the tributaries were monitored for field parameters, nutrients, and suspended sediment. For a complete listing of parameters sampled, see Appendix C.

Field Procedure

Field parameters (temperature, conductivity, dissolved oxygen, pH, and flow) were measured according to the IDHW-DOE Technical Procedures Manual (Ralston, 1976). All other parameters were analyzed according to EPA, Methods for Chemical Analysis of Water and Wastes (EPA, 1979). Discharge was measured in the field with a Gurley current meter or a Marsh-McBirney electromagnetic current meter. When conditions (equipment failure or high stream flow) prevented the use of meters, the following method was used to indirectly determine discharge:

1. A cross section of the stream channel was measured during low flow and a diagram constructed from which area of the channel could be calculated.

2. Depth of the water was either measured or determined indirectly by subtracting the distance between the top of the bridge and the water surface from the total distance between the top of the bridge and the stream channel bottom.

3. Velocity was calculated by timing a float a pre-measured distance.

In instances where neither direct nor indirect measurement procedures were possible, flow was calculated by regression analysis with the USGS gage data as discussed in the results.

Discharge near the Idaho-Washington border was recorded by a continuous recording gage operated under contract by USGS.

RESULTS AND DISCUSSION

Stream Flow

Hangman Creek, while not intermittent, has very low base flows during the summer. All tributaries monitored during this study were intermittent streams. Flows within the watershed vary widely in response to rainfall and snow melt. Most precipitation occurs during winter months when cultivated ground has little cover. The majority of the erosion and sediment production takes place at that time.

Flow characteristics of Hangman Creek are shown as hydrographs, WY81 (Figure 5) and WY82 (Figure 6). These figures display weekly average mean discharges for the USGS gaging station on Hangman Creek near the Idaho-Washington state line. Discharges during water year 1981 (Figure 5) averaged much lower than discharges during water year 1982 (Figure 6). Further comparison of detailed flow and precipitation data is listed in Table 2.

Total precipitation fluctuates approximately 5½ inches from year to year according to the United States Weather Bureau. Of the four years for which we have data, total water year precipitation ranged between 25.52 and 30.19 inches. For further precipitation information, see Appendix D.

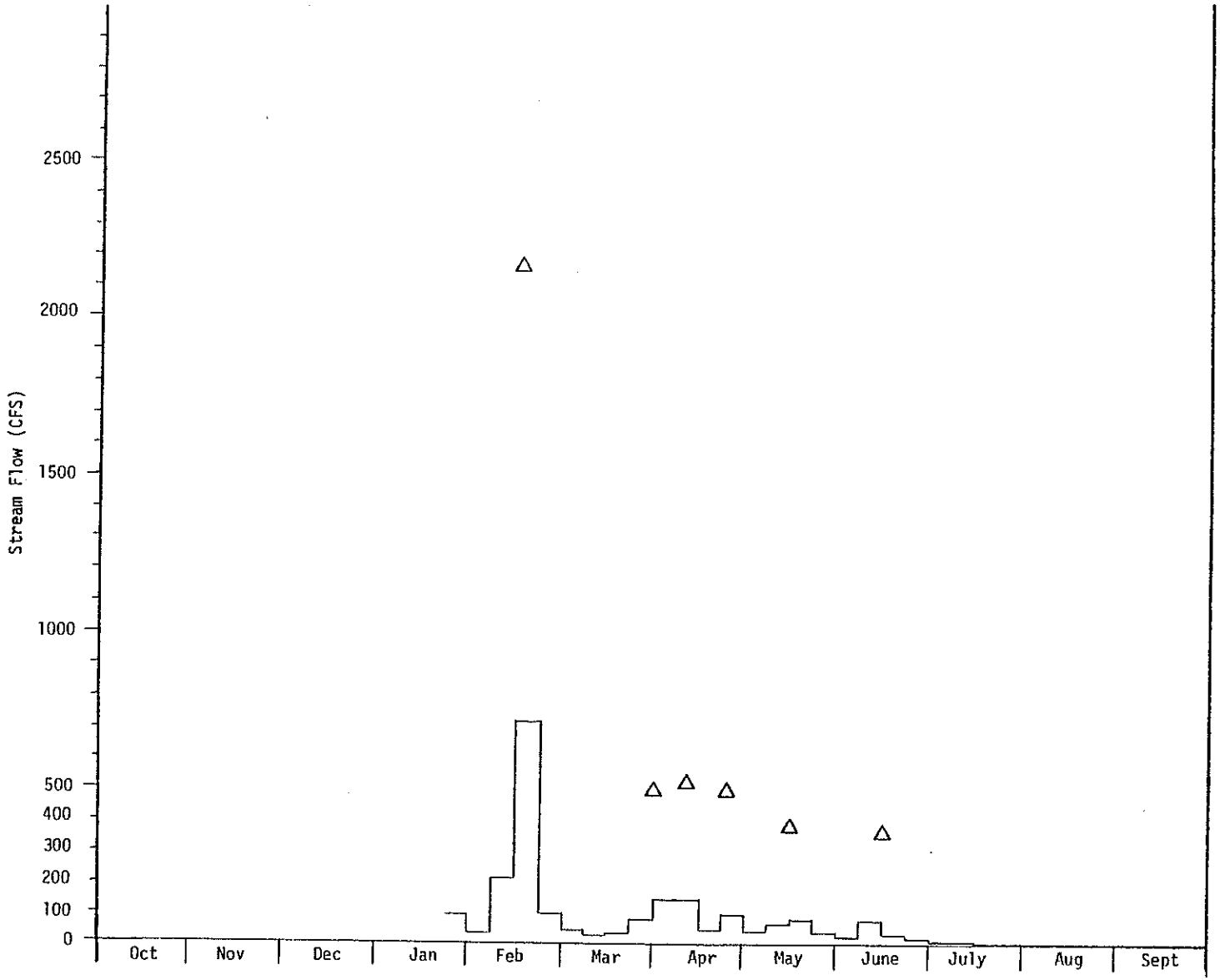


Figure 5. Hangman Creek near Idaho/Washington State Line. Water Year 1981 hydrograph of weekly mean discharge. USGS provisional records. Equipment became operational on January 29, 1981. △ indicates peak flow.

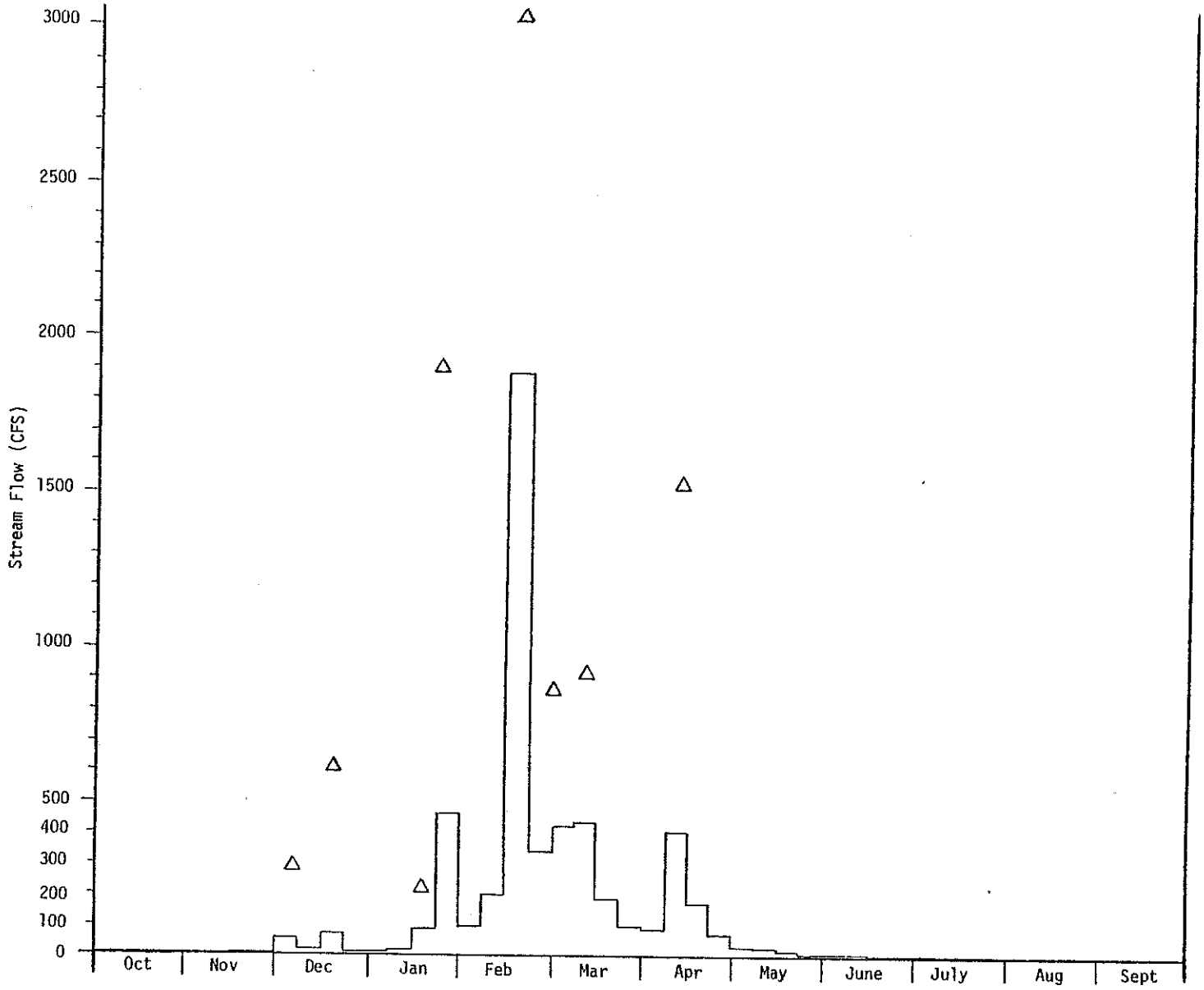


Figure 6. Hangman Creek near Idaho/Washington State Line. Water Year 1982 hydrograph of weekly mean discharge. USGS provisional records. △ indicates peak flow.

TABLE 2 - COMPARISON OF FLOW AND PRECIPITATION DURING 1981 AND 1982 WATER YEARS. (")-INDICATES TOTAL PRECIPITATION FOR THE SPECIFIED TIME PERIOD.

	1981 Water Year	1982 Water Year
Monthly Average Mean Daily Flow in cfs		
January	* (1.24")	153 (5.57")
February	241 (3.37")	626 (5.53")
March	49 (2.29")	290 (1.74")
April	117 (2.36")	183 (2.76")
Major Storm Event	Feb. 13-22	Feb. 14-23
Average Mean Daily Flow in cfs	667 (3.16")	1531 (6.03")
Both storm events lasted 10 days		
	Feb. 16	Feb. 19
Peak Flow in cfs	2190	3080
Daily Mean in cfs	1730	2712

*No data available. USGS gaging station became operational January 29, 1981.

According to local resident George "Bud" Mills, Hangman Creek near the state line floods its banks once or twice a year. He also stated that the January 23-25, 1982, storm event was unusual in its intensity for that time of year. Although water from the January storm had receeded by our February 3 sampling, debris indicated that flood water had covered roads in the Mission and Sheep Creek subwatersheds and the access road to the USGS gage at the state line. (The wooden bridge at that sampling station had been replaced with a concrete structure during late summer of 1981.)

These areas of the watershed were also flooded during the February 14-23, 1982, storm event. Discharge at the state line reached a peak of 3080 cfs on February 19. Flow was still so high at the February 21 sampling that the access road was covered with 1-1½ feet of water.

Although variations in discharge occur from year to year, flows during both water years show a similar runoff pattern. Lowest flows occurred between July and November of 1982. Discharges averaged between 0.25 and 4.0 cfs for these five months. Early winter rain and snowfall cause a slight increase in flow. Snowpack increases during the winter until warming Chinook winds and rains in January and February rapidly melt snow and create major runoff events. Major runoff events of both years took place in February. Greatest erosion and sediment production occurred during these events. Spring snowmelt and rains maintain discharge above base flow through June.

1. Water Budgets for Subwatersheds

Figure 7 illustrates the four ambient sampling stations on the main channel of Hangman Creek and the area of the watershed that drains into each station. Figure 8 shows the boundary and farthest downstream sampling station of the seven subwatersheds monitored during this study.

Acres draining into each sampling station were planimetered from SCS maps supplied by the Benewah Soil and Water Conservation District in St. Maries, Idaho. Boundaries were estimated from USGS topographic maps. Total acres and cropland acres draining

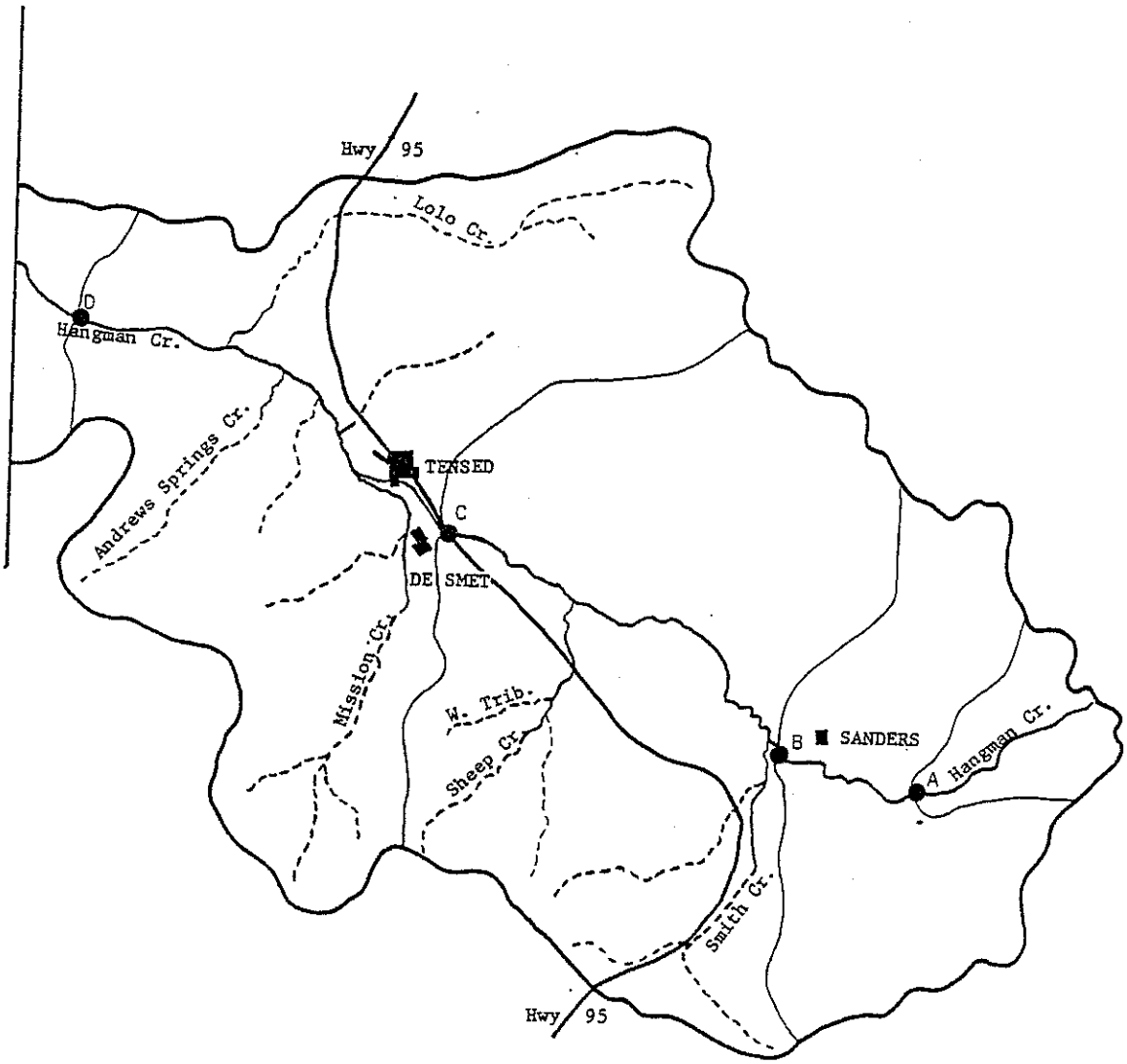


Figure 7. Drainage Areas for Ambient Stations, Hangman Creek. See Appendix E for Acres.

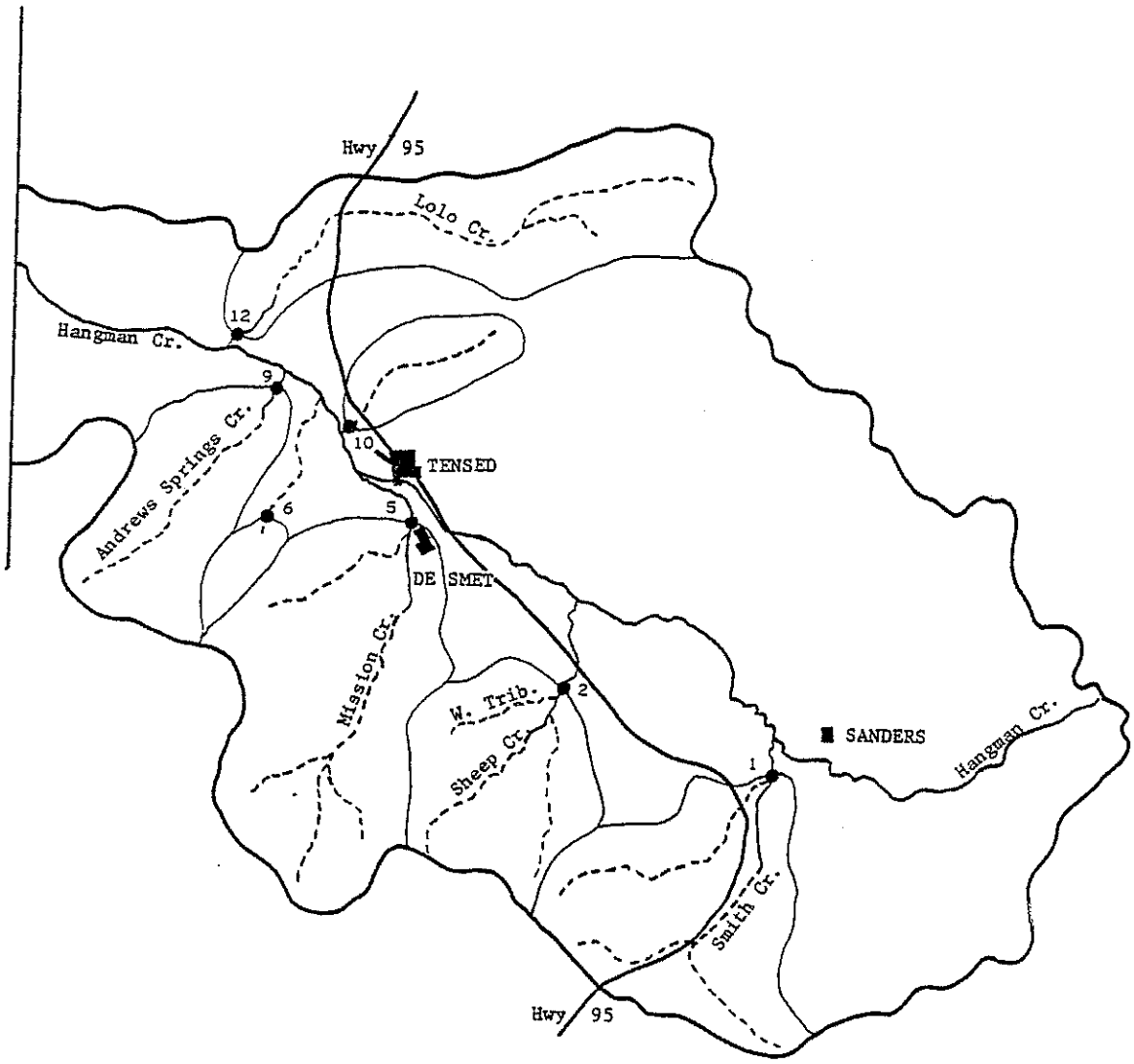


Figure 8. Drainage Areas for Intensive Stations on Tributaries. See Appendix E for Acres.

into a sampling station were planimetered. Forested acres were determined by subtracting cropland acres from total acres in the drainage. To give a more accurate estimate of sediment contributing land, five percent (SCS estimate*) of the forested acres in each drainage was added to the cropland acres for that drainage. Table 3 lists the sampling stations, the total acres, and the calculated sediment-contributing acres draining into each sampling station. For calculations of sediment-contributing acres, see Appendix E.

*Based on estimate by SCS personnel of forest logging road contribution.

TABLE 3 - TOTAL ACRES DRAINING AND TOTAL SEDIMENT-CONTRIBUTING ACRES DRAINING INTO EACH SAMPLING STATION.

SAMPLE SITE	TOTAL ACRES DRAINED	SEDIMENT-CONTRIBUTING ACRES
A - Hangman Creek above Sanders	3,168	1,095
B - Hangman Creek below Sanders	13,450	3,561
C - Hangman Creek at DeSmet	41,150	15,172
D - Hangman Creek Idaho/Washington border	72,000	33,715
1 - Smith Creek near mouth	5,952	1,514
2 - Sheep Creek Sections 31-32	4,320	1,554
5 - Mission Creek at DeSmet	7,616	2,235
6 - Small Tributary 1½ miles west of DeSmet	576	29
9 - Andrews Springs Creek near mouth	3,840	2,502
10- Tributary at Section 10 Clay Pit and Fertilizer Plant	1,536	1,536
12- Lolo Creek near mouth	5,760	4,041
TOTAL ACRES during monitoring (B+1+2+5+6+9+10+12)	43,050	16,972
TOTAL ACRES not accounted for during monitoring	28,950	16,743

Figure 9 is a diagram of the Water Budget of Hangman Creek watershed during the storm season of 1982. Percentages indicate contribution by each subwatershed to the total water budget. Percentage discharge for each of the three storm months (February, March, April) was calculated, and then averaged.

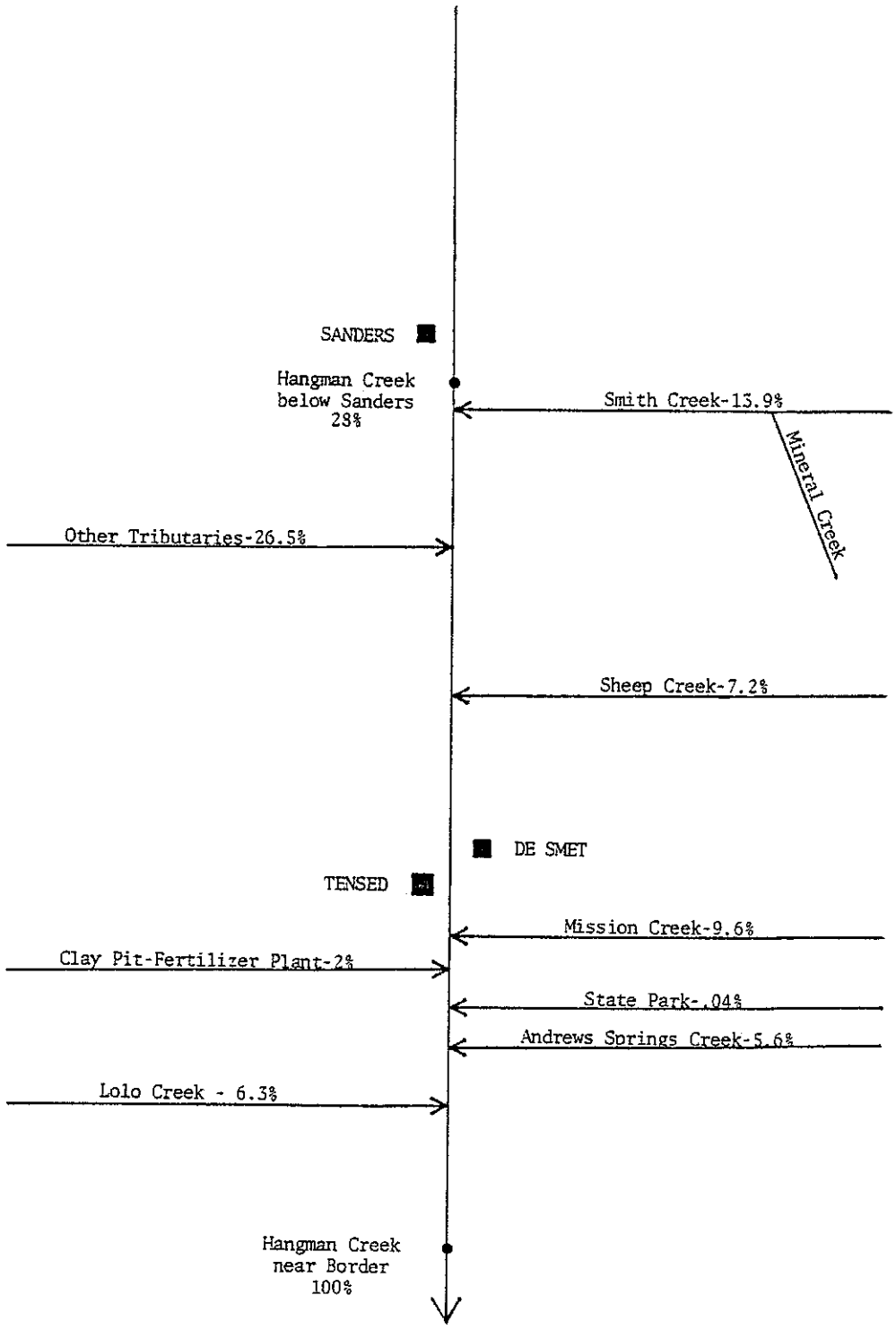


Figure 9. Water Budget for the 1982 Storm Season (February, March, April), Hangman Creek.

Suspended Sediment

1. Water Year Basis

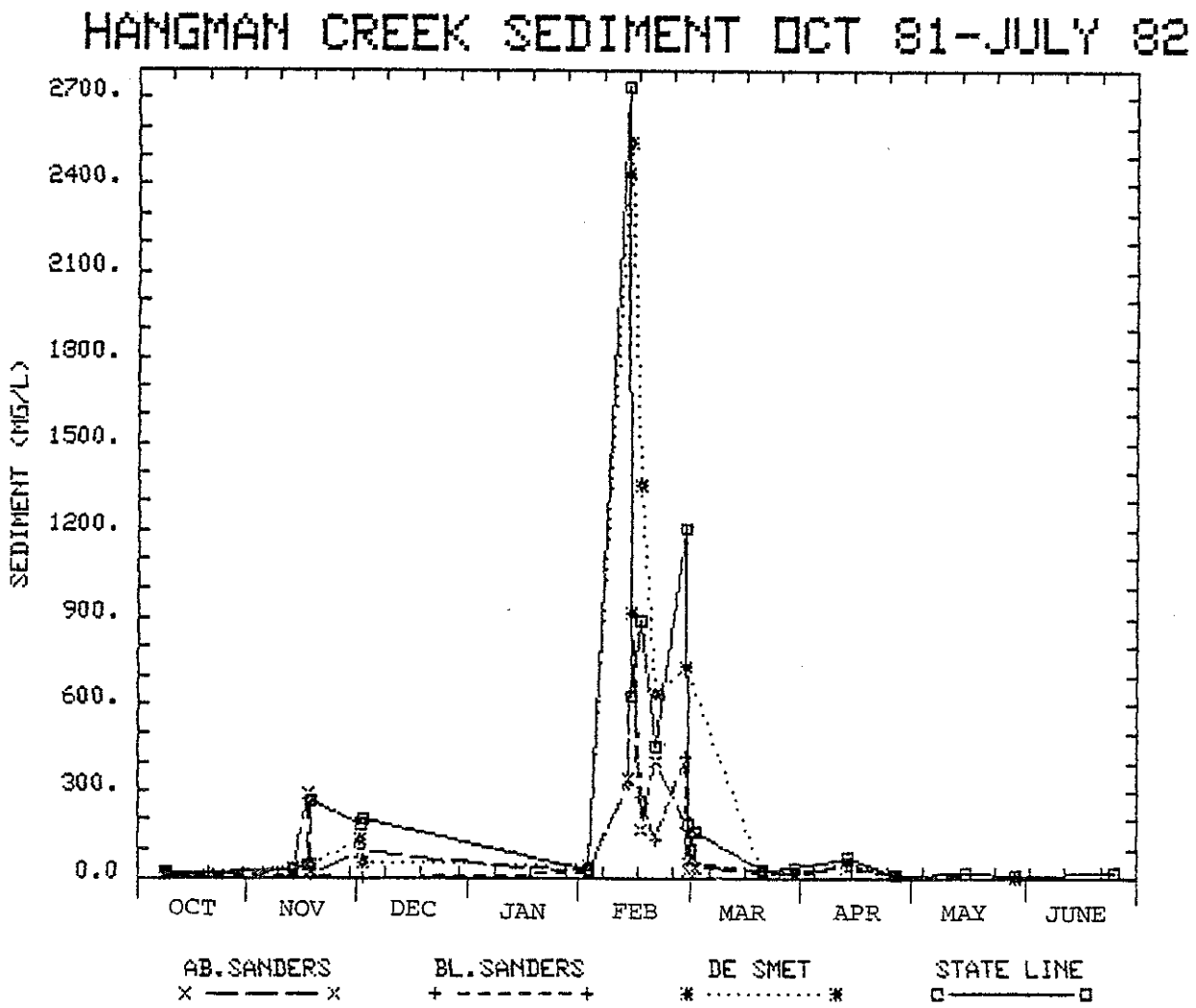
Suspended sediment concentrations follow the pattern for discharge. Peak suspended sediment concentrations occur over a short period in the water year when precipitation, melting snow, and frozen ground create conditions for maximum sediment runoff. In 1982, the majority of high sediment values occurred between the first of February and the first week in March as shown in Figure 10.

Following this storm period (February and March), suspended sediment concentrations drop off rapidly and are low the remainder of the year. The sediment is not only transported out of the watershed but is also deposited at any low gradient channel reaches and in low lying fields. The deposited sediment destroys habitat for aquatic life and serves as a reservoir of sediment to be moved during the next high flow period.

2. Storm Events

Sufficient data was collected during two storm events (February 14-23, 1982 and March 1-5, 1982) to calculate sediment loading in tons for tributary stations. This data is shown in Tables 4 and 5. Average flow and sediment concentration are shown for

Figure 10. Suspended Sediment Concentration at Hangman Creek Ambient Stations, October, 1981 to July, 1982.



information purposes and were not used to calculate sediment load.

The suspended sediment load was calculated by using daily flow-sediment pairs. Linear regression equations were used to calculate missing data pairs as shown in Appendix F. Missing tributary flows were calculated by regression with the USGS gaging station. Missing tributary sediment concentrations were calculated by regression with tributary flows.

Total sediment load at the mouths of tributaries for the ten-day storm in February varied from 1,893 tons in Sheep Creek to 6,389 tons in Mission Creek (Table 4). The highest sediment load, 43,891 tons, was recorded in Hangman Creek at DeSmet. The sediment load at Hangman Creek near the state line was lower, 27,982 tons, indicating that approximately 16,000 tons of sediment were deposited in the Hangman Creek channel, a distance of only eight river miles, during the ten-day storm.

The five-day storm event in March was much lower in intensity and produced about one-third of the discharge compared to the February storm. Sediment loading for the March storm was less than ten percent of the loading calculated for most tributaries during the February storm (compare Table 5 to Table 4).

Table 4. Suspended Sediment Produced During 10 Day Storm, February 14-23, 1982.

Station	Average Flow (cfs)	Average Suspended Sediment (mg/l)	Total Suspended Sediment Load (tons)	Critical Land (acres)**	Total Delivered Sediment (tons/acre)
Hangman Creek above Sanders	37	367	388	1095	0.35
Hangman Creek below Sanders	354	449	5124	3561	1.44
Smith Creek near mouth	190	582	3399	1514	2.24
Western Tributary of Sheep Creek	38	1589	2118	--	--
Sheep Creek near mouth	104	647	1893	1554	1.22
Hangman Creek at De Smet	1062	1394	43981	15172	2.9
Upper Mission Creek	86	686	1718	--	--
Mission Creek near mouth	145	1450	6389	2235	2.86
Clay Pit Tributary	35	2461	2314	1536	1.51
State Park Tributary	0.94	59	2.5	29	0.09
Upper Andrews Springs Creek	43	673	941	--	--
Middle Andrews Springs Creek	34	1332	1475	--	--
Andrews Springs Creek near mouth	105	1234	4171	2502	1.67
Upper Lolo Creek	55	919	1593	--	--
Lolo Creek near mouth	80	2031	5183	4041	1.28
Hangman Creek near Idaho/WA State Line	1531	683	27982	33715	0.83

** See Appendix E for calculations.

Table 5. Suspended Sediment Produced During 5 Day Storm, March 1-5, 1982.

Station	Average Flow (cfs)	Average Suspended Sediment (mg/l)	Total Suspended Sediment Load (tons)	Critical Land (acres)**	Total Delivered Sediment (tons/acre)
Hangman Creek above Sanders	17	83	20	1095	0.02
Hangman Creek below Sanders	128	149	260	3561	0.07
Smith Creek near mouth	88	183	246	1514	0.16
Western Tributary of Sheep Creek	14	519	124	--	--
Sheep Creek near mouth	46	312	231	1554	0.15
Hangman Creek at De Smet	423	481	2960	15172	0.2
Upper Mission Creek	33	284	127	--	--
Mission Creek near mouth	48	308	198	2235	0.09
Clay Pit Tributary	15	786	210	1536	0.14
State Park Tributary	0.2	6.2	0.013	29	0.0005
Upper Andrews Springs Creek	8.4	119	14	--	--
Middle Andrews Springs Creek	12	255	46	--	--
Andrews Springs Creek near mouth	23	275	94	2502	0.04
Upper Lolo Creek	14	300	62	--	--
Lolo Creek near mouth	35	597	337	4041	0.08
Hangman Creek near Idaho/WA State Line	493	256	1876	33715	0.06

** See Appendix E for calculations.

Total delivered sediment in tons/acre is shown in Tables 4 and 5 and is based on calculated critical acres. This figure should be used with caution in comparison to erosion rates. Most of the sediment from a field is deposited at the toe of the slope and does not enter the stream. SCS personnel indicate erosion rates are commonly 40-50 tons/acre/year on cropland in this drainage.

3. Land Use

Data for suspended sediment in tributaries for the storm events can be used to compare land uses in the watershed. Major land uses that can be compared include:

a. Woodland--undisturbed, state park lands.
b. Woodland--used for timber production.
c. Cropland--derived from cut-over forest soils.
d. Cropland--Palouse prairie soils.

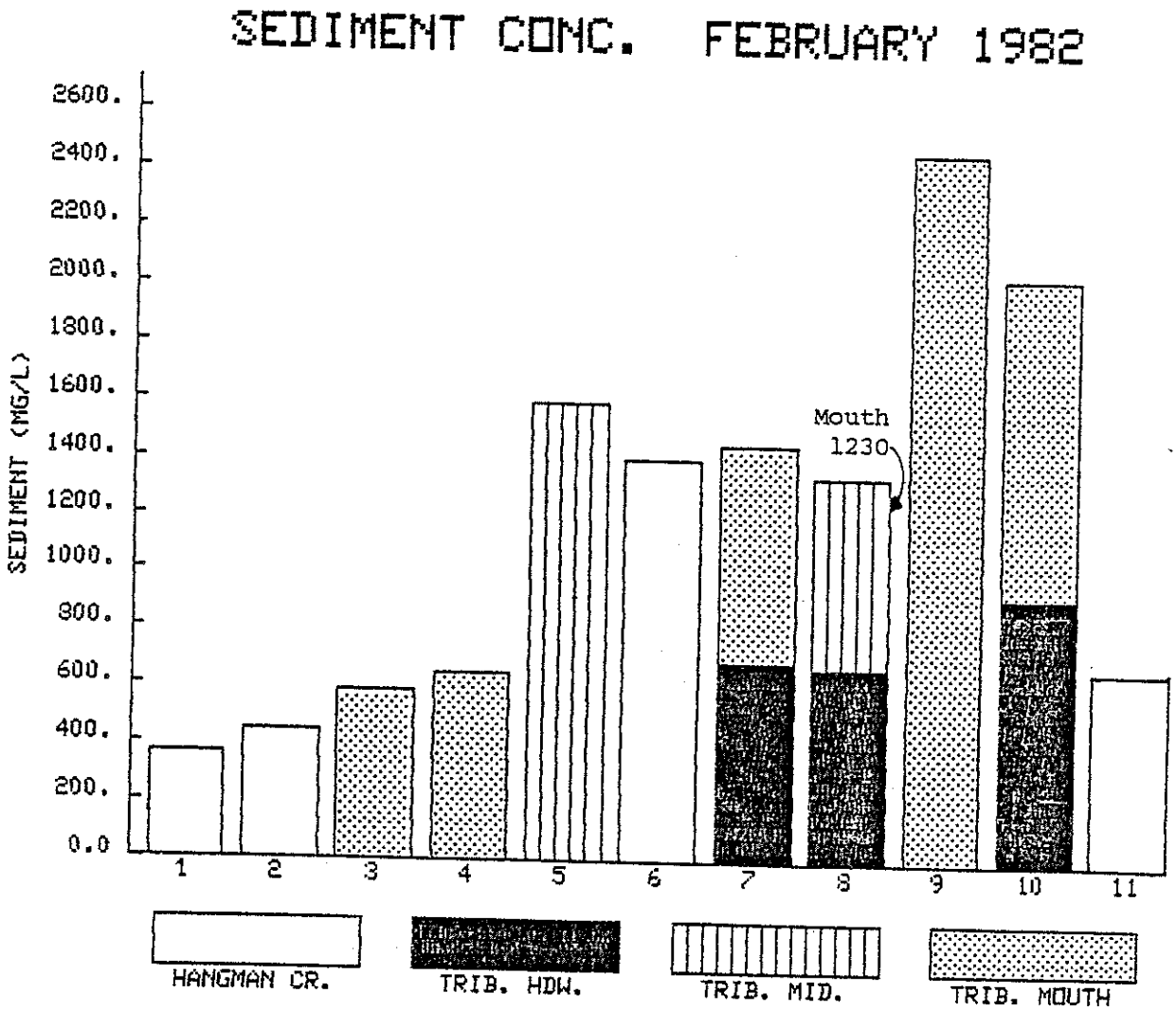
It should be noted that most stations do not strictly reflect one land use or the other--as shown in the land use map, Figure 3.

The relation between sediment and land uses is shown in Figures 11 and 12 for the February storm and Figures 13 and 14 for the March storm. The small tributary that drains the McCroskey State Park,

which is pristine woodland, had concentrations too low for comparison on the graphs, however, the data is shown in Tables 4 and 5. Other woodland produces fairly high sediment values as shown by the station at Hangman Creek above Sanders and at Andrews Springs Creek headwaters (note: headwaters indicate top of the drainage, not actual headwaters). Both cropland categories are higher than woodland as shown in the figures. Further comparison of cut-over soils versus Palouse prairie soils cannot be made since most stations have mixed land uses.

Although general land use comparisons are valuable, it must be remembered that these are broad categories and a specific activity in a drainage will have a considerable impact on sediment production. For example, an upper drainage in Smith Creek was logged prior to the February storm. This likely contributed a significant portion of the sediment recorded at the Smith Creek mouth station. However, the monitoring plan did not segregate out the sediment runoff due to this activity.

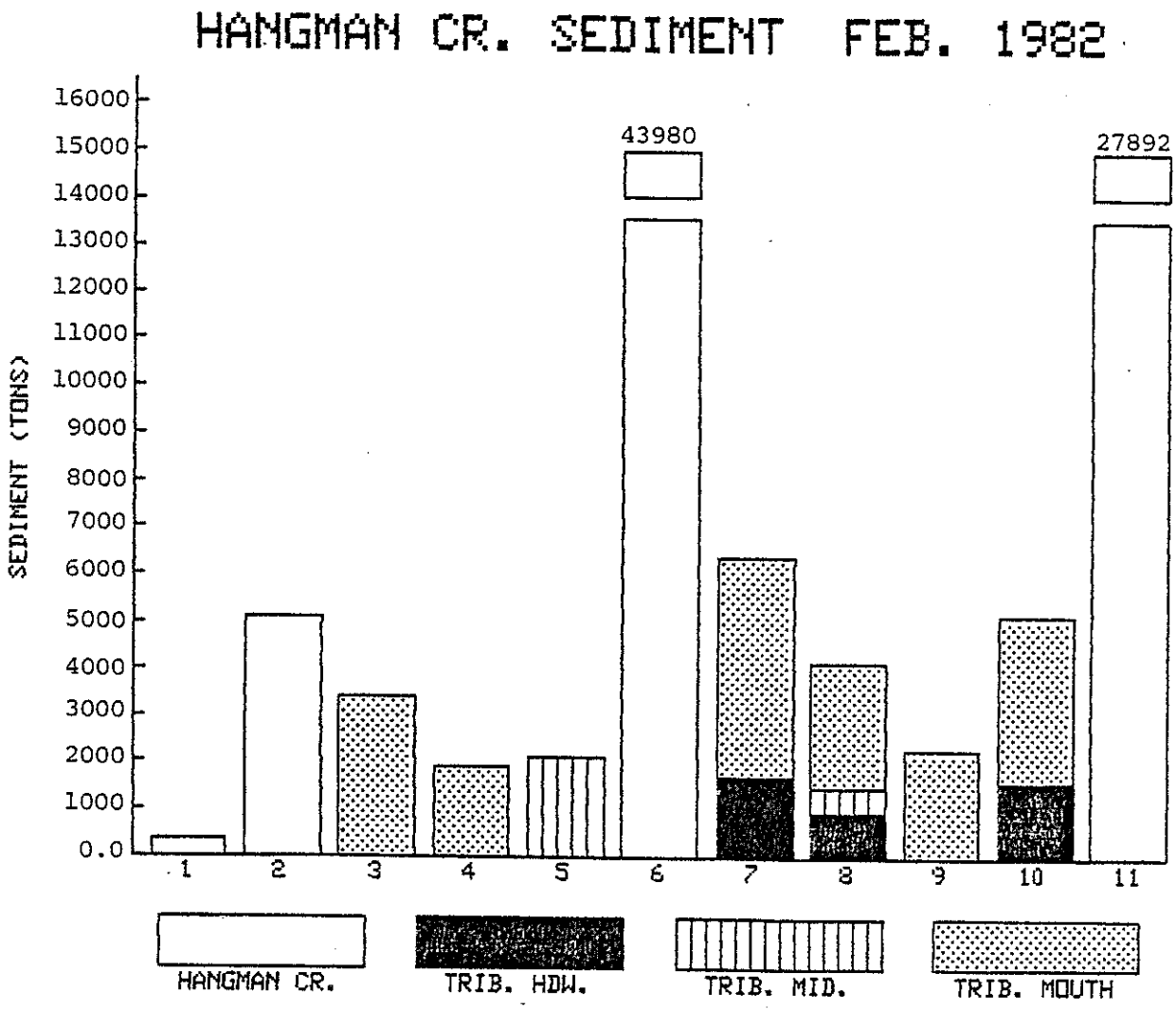
Figure 11. Average Suspended Sediment Concentration in Hangman Creek, February Storm, 1982.



1. HC above Sanders ---------- woodland, logging activity
2. HC below Sanders ---------- woodland, cut-over forest soils
3. Smith Cr. Mouth ---------- cut-over forest soils
4. Sheep Cr. Mouth ---------- woodland, cut-over forest soils
5. West Trib. Sheep Cr. -------- cut-over forest soils
6. HC at De Smet ---------- mixed land use
7. Mission Cr. Hdw. ---------- woodland, cut-over forest soils
   Mission Cr. Mouth ---------- Palouse prarie soils
8. Andrews Springs Cr. Hdw. ---- woodland
   Andrews Springs Cr. Mid. ---- cut-over forest, Palouse prairie soils
   Andrews Springs Cr. Mouth --- Palouse prairie soils
9. Clay Pit ---------- fertilizer plant, Palouse prairie soils
10. Lolo Cr. Hdw. ---------- woodland, cut-over forest soils
    Lolo Cr. Mouth ---------- Palouse prairie soils
11. HC at State Line ---------- mixed land use

Small Tributary below State Park is not included in graph as the sediment and nutrient figures from this pristine woodland are too low to compare.

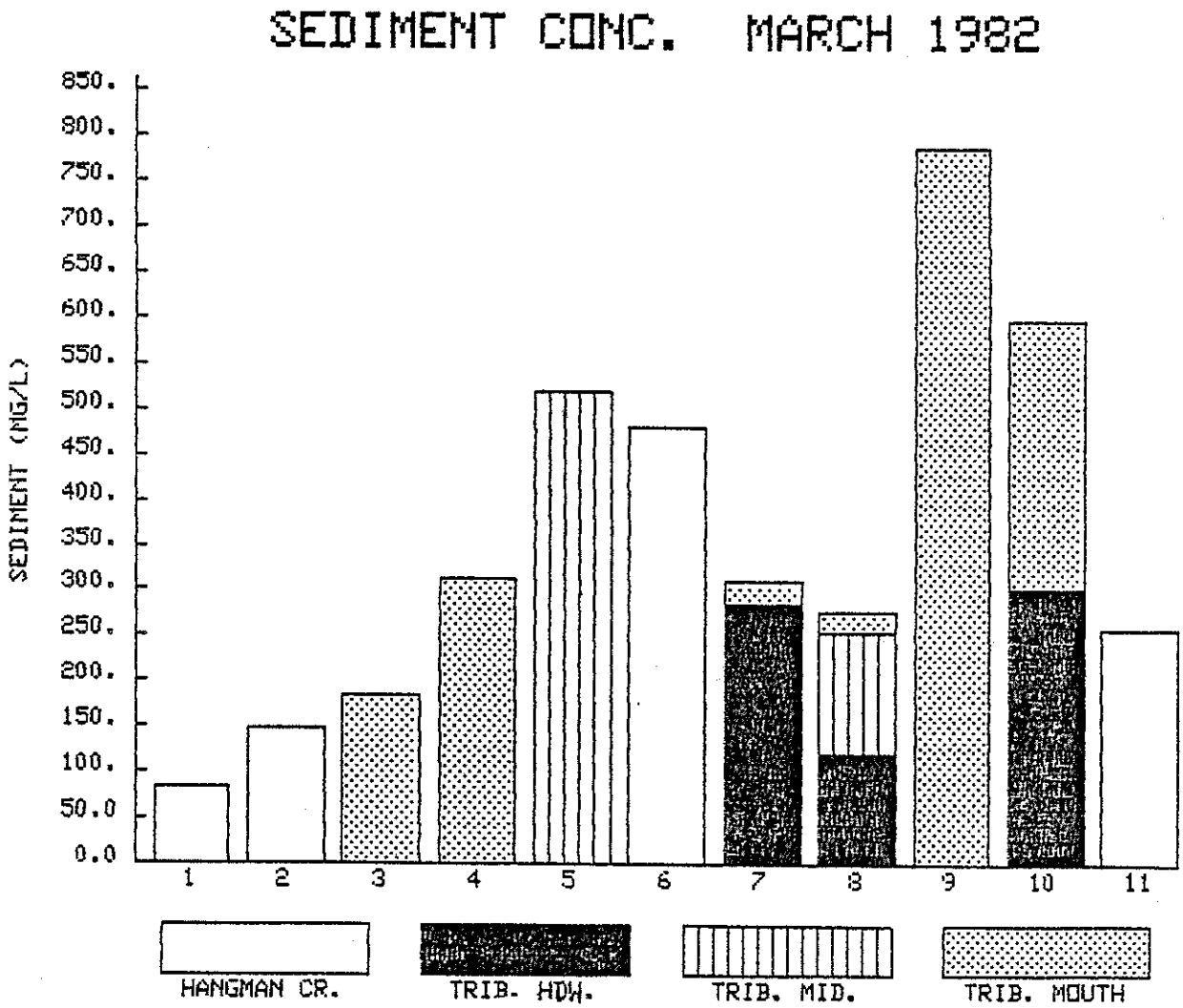
Figure 12. Total Suspended Sediment Load in Hangman Creek, 10 Day February Storm, 1982.



1. HC above Sanders ---------- woodland, logging activity
2. HC below Sanders ---------- woodland, cut-over forest soils
3. Smith Cr. Mouth ---------- cut-over forest soils
4. Sheep Cr. Mouth ---------- woodland, cut-over forest soils
5. West Trib. Sheep Cr. -------- cut-over forest soils
6. HC at De Smet ---------- mixed land use
7. Mission Cr. Hdw. ---------- woodland, cut-over forest soils
   Mission Cr. Mouth ---------- Palouse prarie soils
8. Andrews Springs Cr. Hdw. ---- woodland
   Andrews Springs Cr. Mid. ---- cut-over forest, Palouse prairie soils
   Andrews Springs Cr. Mouth --- Palouse prairie soils
9. Clay Pit ---------- fertilizer plant, Palouse prairie soils
10. Lolo Cr. Hdw. ---------- woodland, cut-over forest soils
    Lolo Cr. Mouth ---------- Palouse prairie soils
11. HC at State Line ---------- mixed land use

Small Tributary below State Park is not included in graph as the sediment and nutrient figures from this pristine woodland are too low to compare.

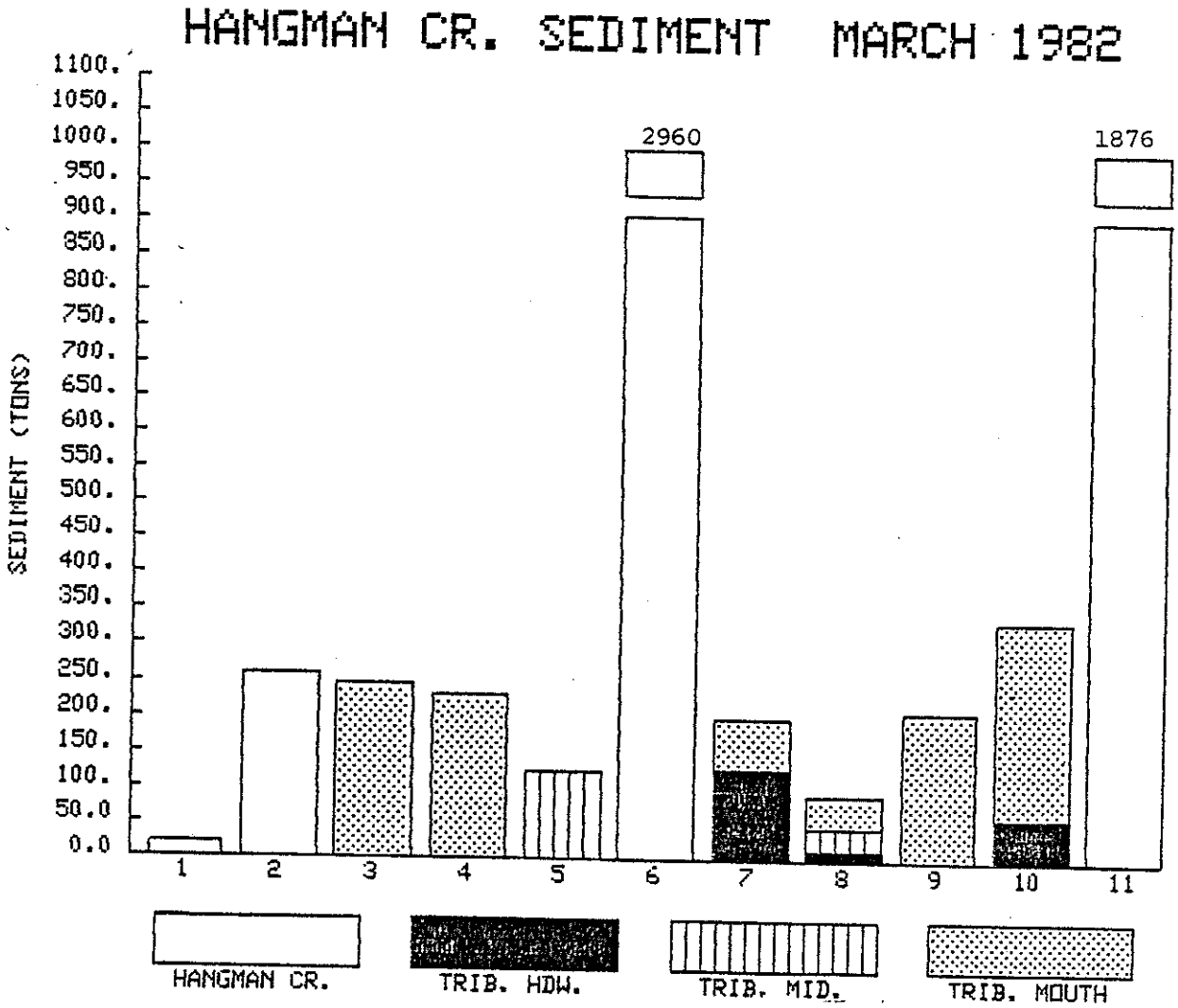
Figure 13. Average Suspended Sediment Concentration in Hangman Creek, March Storm, 1982.



1. HC above Sanders ---------- woodland, logging activity
2. HC below Sanders ---------- woodland, cut-over forest soils
3. Smith Cr. Mouth ---------- cut-over forest soils
4. Sheep Cr. Mouth ---------- woodland, cut-over forest soils
5. West Trib. Sheep Cr. -------- cut-over forest soils
6. HC at De Smet ---------- mixed land use
7. Mission Cr. Hdw. ---------- woodland, cut-over forest soils
   Mission Cr. Mouth ---------- Palouse prarie soils
8. Andrews Springs Cr. Hdw. ---- woodland
   Andrews Springs Cr. Mid. ---- cut-over forest, Palouse prairie soils
   Andrews Springs Cr. Mouth --- Palouse prairie soils
9. Clay Pit ---------- fertilizer plant, Palouse prairie soils
10. Lolo Cr. Hdw. ---------- woodland, cut-over forest soils
    Lolo Cr. Mouth ---------- Palouse prairie soils
11. HC at State Line ---------- mixed land use

Small Tributary below State Park is not included in graph as the sediment and nutrient figures from this pristine woodland are too low to compare.

Figure 14. Total Suspended Sediment Load in Hangman Creek, 5 Day March Storm, 1982.



1. HC above Sanders ---------- woodland, logging activity
2. HC below Sanders ---------- woodland, cut-over forest soils
3. Smith Cr. Mouth ---------- cut-over forest soils
4. Sheep Cr. Mouth ---------- woodland, cut-over forest soils
5. West Trib. Sheep Cr. -------- cut-over forest soils
6. HC at De Smet ---------- mixed land use
7. Mission Cr. Hdw. ---------- woodland, cut-over forest soils
   Mission Cr. Mouth ---------- Palouse prarie soils
8. Andrews Springs Cr. Hdw. ---- woodland
   Andrews Springs Cr. Mid. ---- cut-over forest, Palouse prairie soils
   Andrews Springs Cr. Mouth --- Palouse prairie soils
9. Clay Pit ---------- fertilizer plant, Palouse prairie soils
10. Lolo Cr. Hdw. ---------- woodland, cut-over forest soils
    Lolo Cr. Mouth ---------- Palouse prairie soils
11. HC at State Line ---------- mixed land use

Small Tributary below State Park is not included in graph as the sediment and nutrient figures from this pristine woodland are too low to compare.

The small tributary referred to as "clay pit" on the Sediment Figures, 11 through 14, had the highest suspended sediment concentrations. This drainage was comprised almost entirely of Palouse soil cropland, and included drainage from a clay pit operation. The clay from the pit remains in suspension which kept suspended sediment concentrations high. This impact was rather obvious in the field because the water was colored an orange-brown tint.

4. Critical Areas

One of the survey objectives was to help the Benewah SCD identify critical areas within the Hangman Creek watershed. The data can be used in several ways to achieve this. One method is to compare tributaries by using suspended sediment concentrations only. This compares stream segments without regard to size of the watershed or magnitude of discharge. The other method is to compare sediment load in tons which combines both factors of flow and concentration.

In reviewing sediment concentration data as shown in Tables 4 and 5 and Figures 11 and 13, one can see a general increase in concentration in tributaries as one proceeds downstream. This reflects the general land use change toward increases in cropland acreage in the tributaries. Based on sediment

concentration, it appears priority for land management changes should be placed on:

a. Lolo Creek and surrounding area,
b. West tributary of Sheep Creek,
c. Mission Creek, and
d. Andrew Springs Creek.

If a priority were to be based on tons of sediment delivered to the creek, then the list would change to include Upper Hangman and Smith Creek as follows:

a. Mission Creek.
b. Lolo Creek.
c. Upper Hangman Creek.
d. Andrews Springs Creek.
e. Smith Creek.

5. Suspended Sediment Baseline: Sediment Rating Curves

The baseline condition for suspended sediment can be established for each of the tributaries that were monitored by using a sediment rating curve procedure. A sediment rating curve is the mathematical relationship between suspended sediment concentration and stream discharge. The curves reflect the suspended sediment condition for the watershed as was present

in 1982. Future changes in the watershed, for example, installation of BMPs, would change the relationship and can be used to determine success of a program.

A sediment rating curve is a plot of the linear regression of discharge and suspended sediment concentration. These plots and the regression equations are in Appendix G. All the curves had highly significant correlation values. The standard procedure for rating curves uses a logarithmic relationship, however, we obtained higher correlation coefficients using a normal arithmetic plot. A logarithmic plot would reduce the scatter of points shown on the graphs in Appendix G, but does not improve the correlation between flow and sediment values.

NUTRIENTS

The major nutrients of concern in water are forms of nitrogen and phosphorus. These nutrients in high concentrations cause excessive nuisance algae or aquatic plant growth. If excessive, the algae or plant growth will interfere with recreational use, will be offensive to sight and smell, may clog pipes and ditches, and may reduce night-time dissolved oxygen to harmful levels.

Phosphorus

Total phosphorus measures the phosphorus dissolved in the water plus the phosphorus contained in soil particles suspended in the water column. Ortho-phosphate measures only the dissolved phosphorus. Comparing the two forms indicates how much of the phosphorus is washed into streams with the sediment.

1. Comparison to Criteria

The instream criteria for total phosphorus in running water is 0.1 mg/l (EPA, 1976) and is based on stimulation of algae growth. This criteria is considered conservative since many investigators have proposed that only a portion of the total phosphorus is "biologically" available for use by algae or aquatic plants. Dorich, et. al., 1980, found that only about 20 percent of the total sediment phosphorus found in agricultural runoff was available for growth of algae. A more site-specific

criteria is to compare the concentration of phosphorus in a protected watershed, which may be considered as background, to other stations. For Hangman Creek, the state park tributary, which can be used as background, had an average concentration of 0.3 mg/1.

Total phosphorus data for Hangman Creek is summarized in Table 6. Average concentrations at the stations ranged from 0.16 mg/1 in Upper Hangman to 1.32 mg/1 at the Clay Pit site. Maximum total phosphorus levels were recorded during peak runoff in the February 1982 storm. As can be seen from the table, low levels were generally found in the upper watershed. High concentrations occurred in tributaries closer to the mouth of Hangman Creek.

2. Transport During Storm Events

A large amount of phosphorus associated with sediment particles is washed out of the watershed during storm events. The phosphorus load in pounds was estimated for the 10-day storm event in February 1982 and the 5-day storm event in March 1982. Phosphorus load was calculated in the same manner as described for sediment load during the storm events (see Appendix H).

Table 6. Summary of Nutrient Data For Hangman Creek, 1981-1982.

Station		Inorganic Nitrogen* (mg/l)	Ortho-Phosphate (mg/l)	Total Phosphorus (mg/l)
Hangman Creek above Sanders	Mean	0.23	0.11	0.17
	Range	0.02-0.61	0.01-0.73	0.02-1.06
	Number	19-20	19	24
Hangman Creek below Sanders	Mean	0.42	0.11	0.16
	Range	0.01-1.6	0.01-0.56	0.02-0.82
	Number	18-19	18	24
Smith Creek near Mouth	Mean	0.83	0.27	0.23
	Range	0.02-2.81	0.02-1.40	0.03-1.06
	Number	9-11	11	15
Western Tributary of Sheep Creek	Mean	1.62	0.24	0.74
	Range	0.11-4.79	0.03-1.23	0.05-3.75
	Number	7-9	9	14
Sheep Creek near Mouth	Mean	0.75	0.24	0.32
	Range	0.04-1.73	0.03-1.40	0.02-0.98
	Number	6-8	8	13
Hangman Creek at De Smet	Mean	0.75	0.16	0.21
	Range	0.002-2.70	0.01-1.39	0.03-0.82
	Number	20-21	20	23
Upper Mission Creek	Mean	0.99	0.37	0.38
	Range	0.55-2.21	0.03-1.87	0.03-1.06
	Number	7-9	9	11
Mission Creek near Mouth	Mean	1.56	0.50	0.70
	Range	0.16-3.05	0.04-2.12	0.02-2.28
	Number	7-9	8	14
Clay Pit Tributary	Mean	6.80	0.99	1.32
	Range	2.71-12.75	0.03-6.85	0.03-6.19
	Number	8-10	10	14
State Park Tributary	Mean	0.10	0.23	0.30
	Range	0.002-0.17	0.03-0.82	0.02-0.57
	Number	6-8	8	9
Upper Andrews Springs Creek	Mean	4.01	0.22	0.42
	Range	0.03-13.41	0.03-0.90	0.05-1.47
	Number	7-10	10	11
Middle Andrews Springs Creek	Mean	3.45	0.42	0.63
	Range	1.65-4.66	0.04-1.79	0.03-3.1
	Number	9-11	10	12
Andrews Springs Creek near Mouth	Mean	3.58	0.22	0.72
	Range	1.75-5.33	0.07-0.57	0.02-3.1
	Number	8-10	10	14
Upper Lolo Creek	Mean	2.20	0.17	0.58
	Range	0.67-3.57	0.02-0.90	0.02-2.45
	Number	8-10	10	11
Lolo Creek near Mouth	Mean	3.68	0.55	1.12
	Range	1.66-4.98	0.02-2.45	0.02-5.87
	Number	7-9	9	13
Hangman Creek near Idaho/WA State Line	Mean	1.53	0.18	0.38
	Range	0.01-5.53	0.01-0.90	0.01-2.61
	Number	28-29	24	32

*Inorganic Nitrogen = Nitrite (NO_2) + Nitrate (NO_3) + Ammonia (NH_3)

Phosphorus load data is summarized in Table 7 for the February storm and Table 8 for the March storm. As can be seen in comparing the tables, most of the phosphorus was lost during the February storm. Approximately 60,000 pounds of phosphorus were lost from the watershed in the February storm as recorded at the State Line station.

Tributaries that contributed large amounts of phosphorus to Hangman Creek in February are those listed as critical areas in the sediment discussion. These include Mission Creek (12,000 pounds), Lolo Creek (11,800 pounds), Andrew Springs Creek (7,800 pounds), and Smith Creek (4,700 pounds). The western tributary of Sheep Creek transported a large amount of phosphorus for its size--4,500 pounds. This can be compared to Upper Hangman Creek (above Sanders) which had similar flows, but transported only 18 percent as much phosphorus.

Nitrogen

In comparison to phosphorus, inorganic nitrogen is not associated with soil particles, but is carried dissolved in the water column. Inorganic nitrogen is the sum of nitrite (NO_2), nitrate (NO_3) and ammonia (NH_3). Although nitrogen fertilizer may be applied as ammonia or urea, these compounds are readily oxidized to nitrate and then are available for transport in surface water or percolate into the shallow ground water layer. The shallow ground water also provides flow to surface streams, thus acting as a reservoir of nitrates for the creeks.

Table 7. Total Phosphorus Produced During 10 Day Storm, February 14-23, 1982.

Station	Average Flow (cfs)	Average Total Phosphorus (mg/l)	Total Phosphorus Load (pounds)	Critical Land (acres)**	Total Delivered Phosphorus (pounds/acre)
Hangman Creek above Sanders	37	0.30	831	1095	0.76
Hangman Creek below Sanders	354	0.45	9318	3561	2.62
Smith Creek near mouth	190	0.48	5706	1514	3.77
Western Tributary of Sheep Creek	38	1.71	4525	--	--
Sheep Creek near mouth	104	0.54	3467	1554	2.23
Hangman Creek at De Smet	1062	0.55	35161	15172	2.32
Upper Mission Creek	86	0.73	3827	--	--
Mission Creek near mouth	145	1.40	12037	2235	5.39
Clay Pit Tributary	35	--	--	1536	--
State Park Tributary	0.94	0.56	44	29	1.51
Upper Andrews Springs Creek	43	1.03	3187	--	--
Middle Andrews Springs Creek	34	0.91	1815	--	--
Andrews Springs Creek near mouth	105	1.22	7822	2502	3.13
Upper Lolo Creek	55	0.97	3215	--	--
Lolo Creek near mouth	80	2.39	11808	4041	2.92
Hangman Creek near Idaho/WA State Line	1531	0.75	60679	33715	1.8

** See Appendix E for calculations.

Table 8. Total Phosphorus Produced During 5 Day Storm, March 1-5, 1982.

Station	Average Flow (cfs)	Average Total Phosphorus (mg/l)	Total Phosphorus Load (pounds)	Critical Land (acres)**	Total Delivered Phosphorus (pounds/acre)
Hangman Creek above Sanders	17	0.08	39	1095	0.04
Hangman Creek below Sanders	128	0.14	470	3561	0.13
Smith Creek near mouth	88	0.17	438	1514	0.29
Western Tributary of Sheep Creek	14	0.53	242	--	--
Sheep Creek near mouth	46	0.33	465	1554	0.30
Hangman Creek at De Smet	423	0.31	4022	15172	0.27
Upper Mission Creek	33	0.29	259	--	--
Mission Creek near mouth	48	0.45	580	2235	0.26
Clay Pit Tributary	15	--	--	1536	--
State Park Tributary	0.2	0.18	0.8	29	0.03
Upper Andrews Springs Creek	8.4	0.38	88	--	--
Middle Andrews Springs Creek	12	0.45	159	--	--
Andrews Springs Creek near mouth	23	0.47	310	2502	0.12
Upper Lolo Creek	14	0.43	176	--	--
Lolo Creek near mouth	35	0.66	689	4041	0.17
Hangman Creek near Idaho/WA State Line	493	0.33	4389	33715	0.13

** See Appendix E for calculations.

The instream criteria for inorganic nitrogen is 0.3 mg/l (IDHW-DOE, 1980). This criteria is exceeded throughout the Hangman Creek drainage as can be seen in Table 6. The criteria of 0.3 mg/l is reasonable for Hangman Creek since the State Park site recorded lower concentrations at an average of 0.1 mg/l. Average inorganic nitrogen concentrations ranged from 0.23 mg/l in Hangman Creek above Sanders to 6.8 mg/l in the Clay Pit tributary. Peak concentrations were recorded at Upper Andrews Spring Creek (13.4 mg/l) and at the Clay Pit site (12.8 mg/l). The elevated concentrations in the Clay Pit tributary may be attributed to runoff from a fertilizer plant which is located near the mouth of this tributary.

Nutrient Value

The pounds of phosphorus and nitrogen which are transported out of the watershed not only enrich the receiving stream, but also are lost for production of crops. It was estimated that approximately $35,000 worth of phosphorus and $46,000 worth of nitrogen were lost from Hangman Creek at State Line during the 10-day storm event in February. This represents a significant amount of nutrients and production costs which may partially be saved by reducing runoff from fields in the drainage through installation of BMPs. See Appendix I for further information.

Bacteria

Fecal coliform and fecal streptococcus bacteria are found in the intestinal tract of warm-blooded animals and are therefore used as indicators of fecal contamination. Hangman Creek is protected for secondary contact recreation, which includes activities like wading and floating. The standards specify that fecal coliform numbers not exceed a geometric mean of 200/100 ml or exceed 800/100 ml at any time.

Results of bacterial sampling are shown in Table 9. Bacterial numbers are highest at the top of the drainage and decrease toward the State Line. The standards for geometric mean and individual samples are exceeded at the stations above and below Sanders.

There is no specific standard for fecal streptococcus bacteria. However, this species can be used as an indicator of the sources of contamination. Animal feces contain a greater number of streptococci, such that the ratio of fecal coliforms to fecal streptococcus is always less than 0.7. Human feces contain a greater number of coliforms, causing the FC/FS ratio to exceed 4.0 (Clausen, et. al., 1977). As can be seen in Table 9, fecal streptococci numbers are fairly low in comparison to fecal coliforms and the ratios all exceed 4. On this basis, the bacterial numbers appear to be due primarily to human sources rather than to livestock. The authors (Clausen, et. al., 1977) warn, however, that the ratios may be altered by bacterial die-off and should be applied only to recent contamination.

Table 9. Fecal Coliform Bacteria in Hangman Creek, 1981-1982.

Station	Number of Samples	Fecal Coliform /100 ml (log mean)	Minimum-Maximum /100 ml	% Violation*
Hangman Creek above Sanders	14	334	5-8300	36%
Hangman Creek below Sanders	12	226	15-8500	25%
Hangman Creek at De Smet	14	169	18-2800	7%
Hangman Creek near Idaho/WA State Line	17	43	7-260	0%

* % violation based on 800/100 ml. water quality standard..

Possible bacterial sources in the Sanders area include livestock grazing and septic tank drainage. SCS personnel estimate there were approximately 600 head of cattle in the area. The population in the Sanders area is estimated at approximately 75. The data indicate that drainage from septic systems is impacting the creek. Therefore, the adequacy of individual septic systems in the area should be examined. In addition, efforts should be made in the farm planning process to reduce use of the riparian area by livestock.

Other Parameters

In addition to parameters which were expected to be impacted in an agricultural watershed, several other water quality parameters were sampled on a reduced basis to establish the baseline condition in regards to possible future uses of fish and aquatic life. This includes dissolved oxygen, pH, dissolved solids, minerals, and heavy metals.

1. Dissolved Oxygen

   No problems with dissolved oxygen were detected. Dissolved oxygen concentrations were well above the minimum standard of 6 mg/1 (see Table 10) at all stations.

2. pH

The Idaho water quality standards specify that pH be within the range of 6.5 to 9.0 for cold water biota. As can be seen in Table 10, the lower range for pH in Hangman Creek and tributaries is at or below the minimum standard of 6.5. This is likely a normal condition for surface water in the Idaho Panhandle, and is due to the low concentration of dissolved solids found in the area. The low dissolved solids are a poor buffer and allow low pH levels to develop. Therefore, these minimum pH levels are not considered a problem which can be corrected through pollution abatement procedures. However, this data reinforces the concern about low soil pH levels found in the area.

3. Dissolved Solids

Dissolved solids include minerals and other ions which are carried in solution. Dissolved solids levels are low in the Hangman Creek watershed as shown by conductivity levels in Table 10. Conductivity is generally 0.5 to 0.7 of the total dissolved solids concentration.

Another indicator of the dissolved solids concentration is hardness. This term relates to the ability of water to precipitate soap and is due to the presence of calcium and magnesium in

Table 10. Summary of Dissolved Oxygen, pH, and Conductivity in Hangman Creek, 1981-1982.

Station	Number of Samples	Mean Dissolved Oxygen (mg/l)	pH Range	Mean Conductivity (micromho)
Hangman Creek above Sanders	20-22	12.1	6.7-9.5	32
Hangman Creek below Sanders	19-21	12.3	6.4-7.9	37
Smith Creek near mouth	9-12	12.2	6.5-7.7	45
Western Tributary of Sheep Creek	8-10	12.1	6.2-7.8	59
Sheep Creek near mouth	7-9	12.4	6.3-7.4	33
Hangman Creek at De Smet	20-22	12.8	6.7-8.9	55
Upper Mission Creek	8-10	12.3	6.5-7.7	40
Mission Creek near mouth	7-10	12.5	6.5-8.3	52
Clay Pit Tributary	9-10	11.5	6.5-8.4	109
State Park Tributary	7-9	12.4	6.4-8.3	44
Upper Andrews Springs Creek	7-10	12.4	6.5-7.3	103
Middle Andrews Springs Creek	7-10	12.8	6.4-7.3	90
Andrews Springs Creek near mouth	7-10	12.9	6.0-7.3	94
Upper Lolo Creek	7-9	11.9	6.7-8.4	58
Lolo Creek near mouth	6-9	12.8	6.3-8.0	83
Hangman Creek near Idaho/WA State Line	21-23	12.0	6.5-8.7	82

the water. Based on a scale used by USGS (1970) the water in Hangman Creek is considered "very soft" to "soft." Hardness values range from an average of 16 units in Hangman Creek above Sanders to 46 units at the State Line. The breakpoint between soft and moderately hard water is at 60 units.

4. Metals

Samples were collected for heavy metals at the four Hangman Creek stations. Total cadmium, chromium, copper, lead, and zinc were all well below recommended criteria for aquatic life and are not a problem.

Samples were also collected for total iron. Results shown in Table 11 indicate that iron levels are high, and concentrations do exceed recommended criteria for domestic water supplies and aquatic life. Maximum criteria recommended by EPA (1976) are 300 μg/l for domestic water supplies and 1,000 μg/l for freshwater aquatic life. The high concentrations at State Line during February occur during high flows when sediment concentrations are high. This indicates that the iron is probably complexed with soil particles. Therefore, this iron may not be as detrimental as it appears since it is probably tied up with the sediment and is not biologically active.

Table 11. Total iron in mg/l in Hangman Creek.

Date	Hangman Creek above Sanders	Hangman Creek below Sanders	Hangman Creek at De Smet	Hangman Creek at State Line
November 17, 1980	710	900	1,850	1,300
February 25, 1981	1,230	1,280	1,800	2,370
April 1, 1981	1,690	--	4,740	1,030
May 27, 1981	900	810	840	1,880
July 7, 1981	590	880	750	1,040
September 8, 1981	720	--	430	1,050
October 8, 1981	910	840	1,460	560
November 13, 1981	1,680	880	1,350	750
December 2, 1981	5,550	10,200	22,500	2,430
February 3, 1982	440	430	580	790
February 15, 1982	--	--	--	41,000
February 17, 1982	--	--	--	27,000
February 21, 1982	--	--	--	16,200
March 1, 1982	--	--	--	6,840
March 23, 1982	720	900	940	1,430
April 29, 1982	250	280	450	530
June 2, 1982	250	350	400	450
Mean	1,203	1,613	2,930	6,275

Water Quality Index Rating

A Water Quality Index is used to summarize all the various parameters and allows for easy comparison of one stream to another. EPA Region X has developed a Water Quality Index which reduces the data to one number. This index is an aggregation of a standard set of parameters and associated criteria which provides a means for comparing water quality status with respect to fishable/swimmable water quality goals.

The Water Quality Index spans a scale from zero to 100, with zero indicating no evidence of pollution to 100 indicating severe pollution. The overall index for Hangman Creek was 49 which is considered poor water quality. WQI values for Hangman Creek are shown below. Other nearby streams are shown for comparison.

STATION	WQI	RATING
Hangman Creek above Sanders	49	Poor
Hangman Creek below Sanders	44	Poor
Hangman Creek at De Smet	48	Poor
Hangman Creek at State Line	46	Poor
S.F. Palouse River near Moscow	88	Very Poor
Palouse River at Potlatch	33	Fair
St. Joe River at St. Maries	13	Good

CONCLUSIONS AND RECOMMENDATIONS

Excessive concentrations of sediment and nutrients are washed into Hangman Creek from dry cropland in the watershed. Peak sediment discharge occurs during a rain-on-snow storm event in late winter when the weather changes to cause rapid snow melt. High phosphorus and nitrogen concentrations in the tributaries are associated with sediment runoff and percolation of agricultural fertilizers. The occurrence and composition of indicator bacteria indicate human sources of contamination in the Sanders area.

The following recommendations are made:

1. The Agricultural Cost-Share program that has been initiated in the Sheep-Mission Creek area be expanded to include cropland in the remaining tributaries.

2. Priorities for implementing the cost-share programs include a review of the water quality data in this report. Based on sediment and phosphorus loading, priority should be placed on tributaries in the following order: Mission Creek, Lolo Creek, Upper Hangman Creek, Andrews Springs Creek, and Smith Creek.

3. The benefits derived from the implementation program will occur primarily downstream in the lower Hangman-Spokane River area. Therefore, a major effort should be made by federal agencies to implement cost-share programs in the Hangman Creek watershed in Washington. Without this effort, the benefits from Idaho's program will not be realized.

4. The Panhandle District Health Department, in cooperation with IDHW-DOE, should survey the adequacy of individual sewage systems in the Sanders area and make appropriate corrective measures.

5. Following completion of the state cost-share program, the suspended sediment monitoring should be repeated at the specific stations affected to evaluate the success of the program. The sediment rating curves shown in this report can be used for comparison.

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APPENDIX A

Idaho Water Quality Standards and Wastewater Treatment Requirements (1980) designate the waters of Hangman Creek as: (1-2110.01)

1. Protected for general use as an agricultural water supply. Waters which are suitable or intended to be made suitable for the irrigation of crops or as drinking water for livestock. (1-2100.01)

2. Protected for future use as a cold water biota. Waters which are suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species which have optimal growing temperatures below 18°C. (1-2100.03)

   Waters designated for cold water biota are to exhibit the following characteristics:

   a. Dissolved oxygen concentrations exceeding 6 mg/l at all times.

   b. Hydrogen on concentration (pH) values within the range of 6.5 and 9.0.

   c. Water temperatures of 22°C or less with a maximum daily average of no greater than 19°C.

   d. The total concentration of dissolved gas not exceeding one hundred ten percent (110%) of saturation at atmospheric pressure at the point of sample collection.

   e. Mean concentration of unionized ammonia at a level of 0.04 mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period if water quality characteristics are near optimal for the protected use. In all other cases, the mean concentration of unionized ammonia is to be 0.02 mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period. (1-2250.04)

3. Protected for general use as a secondary contact recreation. Surface waters which are suitable or intended to be made suitable for recreational uses on or about the water and which are not included in the primary contact category. These waters may be used for fishing, boating, wading, and other activities where ingestion of raw water is not probable. (1-2100.07)

Waters designated for secondary contact recreation are not to contain fecal coliform bacteria significant to the public health in concentrations exceeding:

a. 800/100 ml at any time; and

b. 400/100 ml in more than ten percent (10%) of the total samples taken over a thirty (30) day period; and

c. A geomteric mean of 200/100 ml based on a minimum of five (5) samples taken over a thirty (30) day period. (1-2250.02)

Appendix B

SURVEY STATIONS, STORET DESCRIPTION

Station #	Description	Latitude	Longitude	River Mile*	Elevation	Storet #
Ambient						
A	Hangman Creek above town of Sanders	47°06'00"	116°45'10"	643.0/72.4/74.2	2880	2000170
B	Hangman Creek below town of Sanders	47°07'10"	116°48'20"	643.0/72.4/71.4	2640	2000171
C	Hangman Creek at De Smet, Highway 95	47°09'00"	116°54'30"	643.0/72.4/65.4	2550	2000172
D	Hangman Creek at USGS gaging station near Idaho/Washington state line	47°12'10"	117°02'25"	643.0/72.4/57.4	2500	2000173
Intensive						
1	Smith Creek near mouth	47°05'55"	116°48'45"		2640	2000177
3	West Tributary of Sheep Creek	47°06'50"	116°53'00"		2630	2000178
2	Sheep Creek, Sections 31/32	47°08'18"	116°52'25"		2570	2000189
4	Mission Creek at bridge, Section 26/35	47°07'15"	116°55'40"		2600	2000179
5	Mission Creek near town of De Smet	47°08'55"	116°55'10"		2550	2000180
6	Tributary below state park, 1½ miles west of De Smet	47°08'55"	116°56'50"		2720	2000181
7	Andrews Springs Creek below headwaters, Section 17/20	47°08'50"	116°59'40"		2640	2000182
8	Andrews Springs Creek, Section 9	47°10'00"	116°58'10"		2580	2000183
9	Andrews Springs Creek near mouth, Section 3	47°10'40"	116°57'20"		2540	2000184
10	Small tributary draining clay pit and fertilizer plant, Section 10	47°10'10"	116°56'30"		2550	2000186
11	Lolo Creek, Section 36	47°12'25"	116°54'10"		2680	2000187
12	Lolo Creek near mouth, Section 4	47°11'15"	116°58'10"		2530	2000188

*Columbia River/Spokane River/Hangman Creek

APPENDIX C

Water Quality Parameters

A = Ambient station sampled
I = Intensive station sampled

		Storet Code
Flow		
A-I	flow, instantaneous in CFS	00061
Temperature		
A-I	temperature Deg-C	00010
Oxygen		
A-I	dissolved oxygen mg/l	000299/000300
pH		
A-I	field	00400
Bacteria		
A	fecal coliform	31616
A	fecal streptococci	31679
Nutrients		
A-I	COD	00335/00340
A-I	total ammonia as N	00610
A-I	total NO_2 + NO_3 as N	00630
A-I	total Kjeldahl nitrogen	00625
A-I	total phosphorus as P	00665
A-I	orthophsophate as P	70507
Solids		
A-I	turbidity NTU	00076
A-I	dissolved solids as filterable residue	70300
A-I	suspended sediment as nonfilterable residue	80154
A-I	specific conductance micromhos/cm	00095

APPENDIX C (Continued)

Minerals - Common Ions		Storet Code
A	hardness as $CaCO_3$	00900
A	total alkalinity as $CaCO_3$	00410
A	bicarbonate alkalinity as $CaCO_3$	00425
A	carbonate alkalinity as $CaCO_3$	00430
A	calcium	00916
A	magnesium	00927
A	sodium	00929
A	potassium	00937
A	chloride	00940
A	floride	00951
A	sulphate as SO_4	00945
A	silica as SiO_2	00956

Total Metals - Inorganic Toxicity		
A	arsenic, total	01002
A	boron, total	01022
A	cadmium, total	01027
A	chromium, total	01034
A	copper, total	01042
A	iron, total	01045
A	lead, total	01051
A	mercury, total	71900
A	zinc, total	01092

APPENDIX D

PRECIPITATION

The names of several people willing to collect precipitation data were supplied to the Division of Environment by the Benewah Soil and Water Conservation District personnel. Three of the area farmers were contacted and subsequently equipped with rain gages and instructions. These individuals measured precipitation on a daily basis (or as often as farming activities permitted) during the major part of the 1982 water year. During storm events, early morning phone conversations provided precipitation and stream flow information. In this way the DOE was able to coordinate sampling with different phases of storm event hydrographs. Without the voluntary assistance of these individuals, this sampling project would have been much less successful.

Precipitation data was obtained at the following locations: (See map.)

Sanders (1) - Johnny Berreth lives on Hangman Creek east of the town of Sanders and upstream to the Hangman Creek (above Sanders) sampling station. Precipitation measurements were taken between 10 and 12 a.m. Average annual precipitation near Hangman Creek headwaters ranges between 40 and 45 inches. (USWB)

Sheep (2) - Al DeShields lives next to Highway 95, north of the Sheep Creek bridge. Precipitation was measured between 8 and 9 a.m. Annual precipitation in that area averages 25 inches. (USWB)

Tensed (3) - The United States Weather Bureau station is located in Tensed. Measurements were taken at 9 p.m. Annual precipitation averages 25 inches.

Border (4) - George "Bud" Mills lives next to Hangman Creek between Lolo Creek (near mouth) and Hangman Creek (near Idaho/Washington state line) sampling stations. Precipitation measurements were taken between 6 and 6:30 a.m. Annual precipitation near the state line averages 20 to 25 inches. (USWB)

Most storm events in the Hangman Creek drainage are widespread--encompassing the entire watershed. (See tables and map.) During spring and summer, the majority of the precipitation that falls soaks immediately into the ground to be used by crops. Although fields are bare after fall harvest, precipitation is low and any that falls also soaks into the ground. Major storm events do not usually occur until late winter or early spring. Figures 5 and 6 are hydrographs showing the average weekly stream flow for Hangman Creek near the state line during 1981 and 1982 water years.

Total precipitation in December and January of both years was equal to or exceeded February precipitation. During the winter, however, most of the precipitation is snow. As the hydrographs indicate, major runoff events did not occur in 1982 until late January and middle February. Warming Chinook wind and rain on snow caused stream flow to reach a high of 1930 cfs the last week in January. The same type of warming trend the third week of February produced a peak of 3080 cfs and a weekly average of 1885 cfs. Frozen ground during the February event prevented any water infiltration. All the water produced by rainfall (between 2.47 and 5.13 inches) and snowmelt turned into runoff. Tremendous amounts of sediment and fertilizer nutrients were mobilized during this event. See Appendices G, H, and I for details.

Water Year Precipitation Totals

1979 Water Year	1980 Water Year	1981 Water Year	1982 Water Year
30.26"*	25.52"	25.8"	30.19"

*Includes precipitation estimates for October, November and December.

For more detailed information refer to Climatological Data, Idaho, NOAA.

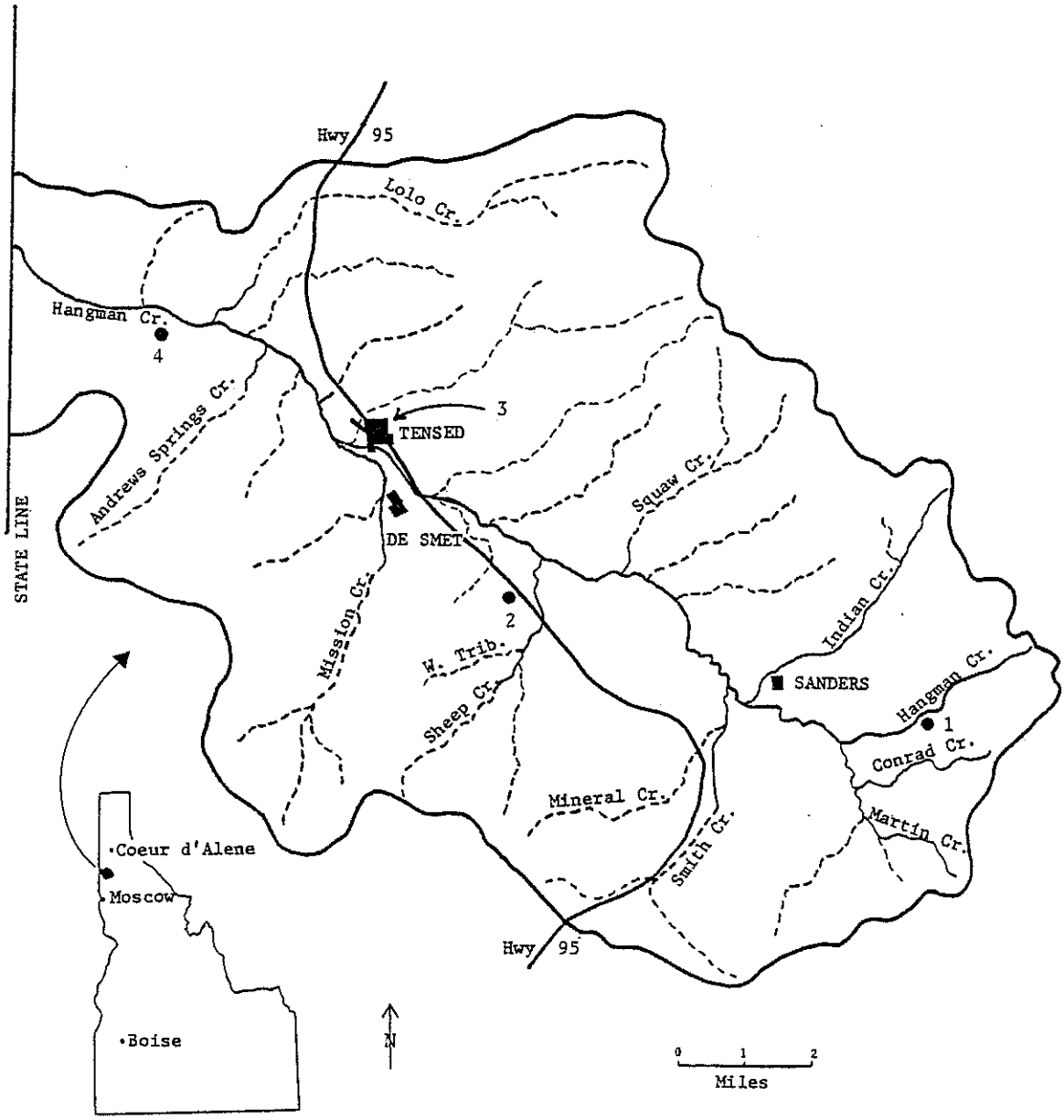


Figure D-1. Location of Precipitation Stations.

INCHES OF PRECIPITATION MEASURED IN HANGMAN CREEK WATERSHED DURING 1982 STORM SEASON

Date	Sanders*	Sheep*	Tensed*	Border*
February				
2	--	2.00	--	--
13	1.85	1.75	1.00	0.34
14			2.00	0.30
15	1.00		1.80	0.27
16		0.44	0.05	0.29
17	0.45	0.36	--	0.17
18	0.88	0.37	0.15	0.50
19	--	0.50	0.13	0.58
20	0.55	0.54	--	0.02
21	0.40	0.43	--	--
26	--	--	--	0.10
Total	5.13	6.39	5.13	2.57
March				
1	snow	0.84	0.19	0.25
2			0.10	0.26
3	1.50		0.24	0.29
4		0.59	--	0.19
7	--	0.57	--	--
8	--	--	0.05	--
9	--	--	0.41	0.49
10	--	--	--	0.41
11	--	0.15	0.10	
12	0.50	--	--	
13	--	0.50	--	
14	--		0.09	
15	0.20	0.24	--	0.59
19	--	0.21	0.16	--
23	0.60	--	--	--
26	--	--	0.06	--
27	0.20	--	0.25	0.48
28	0.20	--	0.04	--
29	0.10	0.23	T	0.04
30	--	--	T	0.25
31	--	--	0.05	
Total	3.30	3.31	1.74	3.25
April				
1	--	0.48	T	0.25
2	--		T	--
3	0.30		0.05	0.15
4	--		T	0.12
5	--		T	--
7	--	--	1.00	--
8	--	--	0.40	--
9	--	--	0.60	--
10	--	--	0.04	--
11	0.50	1.35	T	0.59
12	0.47		0.40	0.61
13	0.25	--	0.20	0.12
14	--	0.38	T	0.48
15	0.35	--	0.02	0.04
18	0.30	--	T	--
28	0.20	0.29	0.05	0.35
Total	2.37	2.50	2.76	2.71

*Location described in preceeding text.
T indicates trace of precipitation.

Table D-1. Precipitation Data for Rain Gages.

PRECIPITATION* AND STREAM FLOW**
HANGMAN CREEK - 1981-1982 WATER YEARS

Month	1981 Total Precipitation (inches)	1981 Average Daily Stream Flow (cfs)	1982 Total Precipitation (inches)	1982 Average Daily Stream Flow (cfs)
October	0.76	***	2.64	2.1
November	1.64	***	2.34	4.7
December	5.68	***	5.97	42.4
January	1.24	***	5.57	153.0
February	3.37	241.0	5.13	626.0
March	2.29	49.0	1.74	290.0
April	2.36	117.0	2.76	183.0
May	2.75	64.0	0.57	25.0
June	2.87	37.0	0.51	5.4
July	1.14	3.2	1.61	2.2
August	0.14	0.6	0.39	0.7
September	1.29	0.2	0.96	1.0
Total Precipitation	25.53		30.19	

* Precipitation from USWB station at Tensed.
** Stream Flow from USGS gaging station on Hangman Creek near Idaho/Washington state line.
*** USGS gaging station became operational January 29, 1981.

Table D-2. Precipitation and Flow Data Comparisons.

APPENDIX E

TABLE E-1: CALCULATION OF TOTAL SEDIMENT-CONTRIBUTING ACRES DRAINING INTO SAMPLING STATIONS.

SAMPLE SITE	TOTAL	CROPS	FOREST	X .05 =	FOREST CONTRIBUTING	TOTAL ACRES CONTRIBUTING SEDIMENT
A	3,168	986	2,182		109	1,095
B	13,450	3,040	10,410		521	3,561
C	41,150	13,805	27,345		1,367	15,172
D	72,000	31,700	40,300		2,015	33,715
1	5,952	1,280	4,672		234	1,514
2	4,320	1,408	2,912		145	1,554
5	7,616	1,956	5,664		283	2,235
6	576	0	576		29	29
9	3,840	2,432	1,408		70	2,502
10	1,536	1,536	0		0	1,536
12	5,760	3,950	1,810		91	4,041

TABLE E-2: WATER BUDGET COMPARED TO ACRES.

Sediment producing acres, subwatershed acres and percentages each contributes to total. ( ) indicates Sample Station Code

Tributary	Percentage of Water Budget	Sediment Producing Acres	Total Watershed Acres
Hangman Creek near Idaho-Washington Border (D)	100%	33,715 = 100%	72,000 = 100%
Hangman Creek below Sanders (B)	28%	3,561 = 10.6%	13,450 = 18.7%
Other tributaries not sampled	27%	16,743 = 49.7%	28,950 = 40.2%
Smith Creek (1)	13.9%	1,514 = 4.5%	5,952 = 8.3%
Mission Creek (5)	9.6%	2,235 = 6.6%	7,616 = 10.6%
Sheep Creek (2)	7.2%	1,554 = 4.6%	4,320 = 6%
Lolo Creek (12)	6%	4,041 = 12%	5,760 = 8%
Andrews Springs Creek (9)	5.6%	2,502 = 7.4%	3,840 = 5.3%
Fertilizer Plant & Clay Pit (10)	2%	1,536 = 4.6%	1,536 = 2.1%
State Park (6)	.04%	29 = 0.09%	576 = 0.8%

APPENDIX F

Calculation of suspended sediment loading during February and March storms.

On days when samples were not taken, flows were estimated by regression analysis with the USGS gaging station.

Suspended sediment was then estimated by regression analysis with flow in cfs.

APPENDIX F (Continued)

HANGMAN CREEK ABOVE SANDERS

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	32@	340@	29.38
15	39	920	96.88
16	41@	372@	41.18
17	48	163	21.12
18	27@	243@	17.71
19	52@	474@	66.55
20	44@	400@	47.52
21	44@	407	48.35
22	23@	206@	12.79
23	16@	141@	6.09
Average	36.6	366.6	
Total			387.58
Tons/Acre for 10 days = 0.35			
March Storm Event			
1	21	191	10.83
2	22	27	1.60
3	11	32	0.95
4	17	34	1.56
5	15@	132@	5.35
Average	17.2	83.2	
Total			20.29
Tons/Acre for 5 days = 0.02			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 0.6300 Log (X) - 1.02561
   r = .948** n = 22

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   Y = 9.2512 X - 6.92213
   r = .578** n = 20

APPENDIX F (Continued)

HANGMAN CREEK BELOW SANDERS

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	291@	325	255.35
15	513	918	1,271.52
16	410@	583@	645.38
17	300	285	230.85
18	234@	318@	200.91
19	577@	884@	1,377.18
20	459@	656@	812.98
21	451@	131	159.52
22	189@	251@	128.09
23	114@	138@	42.47
Average	353.8	448.9	
Total			5,124.24
Tons/Acre for 10 days = 1.44			
March Storm Event			
1	138@	421	153.51
2	194	67	35.09
3	101	82	22.36
4	104	56	15.72
5	103@	121@	33.65
Average	128	149.4	
Total			260.34
Tons/Acre for 5 days = 0.07			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = .86748 Log (X) - .49999
   r = .974* n = 20

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   Y = 1.50278 X - 33.4022
   r = .929** n = 19

APPENDIX F (Continued)

SMITH CREEK NEAR MOUTH

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	152@	889	364.85
15	220	734	436.00
16	213@	661@	380.14
17	265	872	623.92
18	122	353@	116.28
19	298@	948	762.76
20	238@	745	478.74
21	234@	218	137.73
22	100@	279@	75.33
23	60@	143@	23.17
Average	190.2	584.2	
Total			3,398.90
Tons/Acre for 10 days = 2.24			
March Storm Event			
1	120	467	151.31
2	99	94	25.13
3	81	134	29.31
4	86	93	21.59
5	55@	126@	18.71
Average	88.2	182.8	
Total			246.05
Tons/Acre for 5 days = 0.16			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (y)/Gage CFS (X)
   Log (Y) = .85282 Log (X) - 1.04556
   r = .957** n = 12

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   Y = 3.38147 X - 59.5827
   r = .956** n = 11

APPENDIX F (Continued)

WEST TRIBUTARY SHEEP CREEK

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	29@	3,946	308.97
15	26	1,568	110.07
16	52@	2,055@	288.52
17	21/22	671/442	33.09
18	21@	804@	45.59
19	90@	3,588@	871.88
20	62@	2,458@	441.47
21	60@	139	22.52
22	15@	562@	22.76
23	6.3@	211@	3.59
Average	38.33	1,588.8	
Total			2,118.46
March Storm Event			
1	15/26	1012/742	49.73
2	11	94	2.79
3	23	871	54.09
4	10	568	15.34
5	5.4@	175@	2:55
Average	14.08	519	
Total			124.49

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 1.4167 Log (X) - 6.69931
   r = .918** n = 11

2. Tributary Suspended Sediment in mg/l (Y)/Tribuary CFS (X)
   Y = 40.337 X - 42.84521
   r = .821** n = 13

APPENDIX F (Continued)

SHEEP CREEK NEAR MOUTH

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	86@	2,290	531.74
15	116@	993	311.01
16	122@	542@	178.53
17	120/110	442/381	127.31
18	68@	315@	57.83
19	175@	759@	358.63
20	138@	608@	226.54
21	135@	137	49.94
22	55@	258@	38.31
23	32@	156@	13.48
Average	104.2	646.8	
Total			1,893.32
Tons/Acre for 10 days = 1.22			
March Storm Event			
1	64/65	892/535	125.31
2	39	88	9.27
3	55	396	58.81
4	44	219	26.02
5	29@	142@	11.12
Average	46.4	311.8	
Total			230.52
Tons/Acre for 5 days = 0.15			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 0.90464 Log (X) - 1.98761
   r = 0.968** n = 9

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   Log (Y) = 0.93152 Log (X) + 1.82091
   r = 0.917** n = 11

APPENDIX F (Continued)

HANGMAN CREEK AT DE SMET

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	896@	2,443	5,910.11
15	937	2,548	6,446.19
16	1,304@	1,448@	5,098.12
17	1,121@	1,355	4,101.18
18	704@	786@	1,494.03
19	1,894@	2,100@	10,739.00
20	1,475@	1,637@	6,519.35
21	1,408	634	2,410.21
22	560@	627@	948.02
23	321@	363@	314.61
Average	1,062	1,394.1	
Total			43,980.80
Tons/Acre for 10 days = 2.90			
March Storm Event			
1	635	735	1,260.16
2	389@	438@	460.03
3	376@	424@	430.44
4	427@	480@	553.39
5	289@	328@	255.94
Average	423.2	481	
Total			2,959.96
Tons/Acre for 5 days = 0.20			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 0.94883 \text{ Log}(X) + 0.04550$

   $r = 0.976^{**}$ $n = 19$

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)

   $Y = 1.1037 X + 9.11334$

   $r = 0.701^{**}$ $n = 17$

APPENDIX F (Continued)

UPPER MISSION CREEK

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	72@	1,312	255.05
15	95@	1,280	328.32
16	99@	672@	179.63
17	103/96	711/558	171.45
18	58@	405@	63.42
19	137@	919@	339.94
20	110@	744@	220.97
21	109@	331	97.41
22	48@	340@	44.06
23	30@	223@	18.06
Average	85.8	686.1	
Total			1,718.32
March Storm Event			
1	30/32	460/416	36.66
2	35@	255@	24.10
3	34@	249@	22.86
4	38@	275@	28.22
5	27@	203@	14.80
Average	33	284	
Total			126.63

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   $\text{Log}(Y) = 0.81609 \text{ Log}(X) - 1.53205$
   $r = 0.981^{**}$ $n = 7$

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   $Y = 6.5125 X + 27.17252$
   $r = .887^{**}$ $n = 9$

APPENDIX F (Continued)

MISSION CREEK NEAR MOUTH

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	119@	2,746	882.29
15	114	1,602	493.10
16	180@	1,782@	886.05
17	226/161	1,937/1,863	990.09
18	91@	858@	210.81
19	237@	2,374@	1,519.12
20	207@	2,063@	1,153.01
21	202@	224	122.17
22	70@	640@	120.96
23	38@	307@	31.50
Average	145.1	1,449.6	
Total			6,389.10
Tons/Acre for 10 days = 2.86			
March Storm Event			
1	49/45	765/680	91.69
2	33	114	10.16
3	58	312	48.86
4	67	129	23.34
5	34@	266@	24.42
Average	47.8	308.7	
Total			198.46
Tons/Acre for 5 days = 0.09			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 1.05485 Log (X) - 2.72906
   r = 0.976** n = 11

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   Y = 10.386 X - 87.40698
   r = 0.920** n = 13

APPENDIX F (Continued)

STATE PARK TRIBUTARY

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	0.62@	66	0.11
15	0.97	48	0.13
16	1.34@	80@	0.29
17	0.84	74	0.17
18	0.38@	23@	0.02
19	2.87@	171@	1.33
20	1.72@	103@	0.48
21	0.39	9.2@	0.01
22	0.24@	14@	0.01
23	0.075@	4.6@	0.001
Average	0.94	59.3	
Total			2.54
Tons/Acre for 10 days = 0.09			
March Storm Event			
1	0.32	6.0	0.005
2	0.11@	6.7@	0.002
3	0.10@	6.1@	0.002
4	0.14@	8.5@	0.003
5	0.061@	3.8@	0.0006
Average	0.2	6.2	
Total			0.013
Tons/Acre for 5 days = 0.0005			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 1.94637 \text{ Log}(X) - 14.3315$

   $r = 0.870^{**}$ $n = 9$

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)

   $Y = 59.5029 X + 0.16338$

   $r = 0.861^{**}$ $n = 8$

APPENDIX F (Continued)

UPPER ANDREWS SPRINGS CREEK

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	31@	1,810	151.50
15	50	714	96.39
16	54@	790@	115.18
17	30	469	37.99
18	21@	298@	16.90
19	93@	1,372@	334.51
20	64@	939@	162.26
21	63@	39	6.63
22	15@	209@	8.46
23	6.7@	85@	1.54
Average	42.8	672.5	
Total			941.36
March Storm Event			
1	9.1@	161	3.96
2	8.8@	117@	2.78
3	8.4@	111@	2.52
4	10@	135@	3.65
5	5.7@	70@	1.08
Average	8.4	118.8	
Total			13.98

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 1.4129 \text{ Log}(X) - 6.63175$

   $r = 0.956^{**}$ $n = 8$

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)

   $Y = 14.906 X - 14.53903$

   $r = 0.995^{**}$ $n = 8$

MIDDLE ANDREWS SPRINGS CREEK

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	29@	3,070	240.38
15	41	1,886	208.78
16	44@	1,499@	178.08
17	35	1,352	127.76
18	23@	682@	42.35
19	65@	2,316@	406.46
20	50@	1,732@	233.82
21	28	121	9.15
22	18@	487@	23.67
23	10@	175@	4.73
Average	34.3	1,332	
Total			1,475.18
March Storm Event			
1	20/14	441/242	16.48
2	12@	254@	8.23
3	12@	254@	8.23
4	13@	293@	10.28
5	8.9@	133@	3.20
Average	12.4	255.1	
Total			46.42

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 1.0047 Log (X) - 3.76588
   r = 0.974** n = 10

2. Tributary Suspended Sediment mg/l (Y)/Tributary CFS (X)
   Y = 38.906 X - 213.2431
   r = 0.861** n = 11

ANDREWS SPRINGS CREEK NEAR MOUTH

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	75@	3,106	628.97
15	174	2,426	1,139.73
16	120@	1,159@	375.52
17	99@	1,230	328.78
18	55@	484@	71.87
19	193@	1,917@	998.95
20	140@	1,367@	516.73
21	131	189	66.85
22	41@	388@	37.42
23	20@	120@	6.48
Average	104.8	1,233.6	
Total			4,171.29
Tons/Acre for 10 days = 1.67			
March Storm Event			
1	27@	552	40.24
2	16	91	3.93
3	26	523	36.71
4	27	108	7.87
5	18@	99@	4.81
Average	22.8	274.6	
Total			93.57
Tons/Acre for 10 days = 0.04			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 1.20233 Log (X) - 4.24356
   r = 0.987** n = 11

2. Tributary Suspended Sediment in mg/l (Y)/Tribuary CFS (X)
   Y = 10.3894 X - 87.9108
   r = 0.920** n = 11

CLAY PIT TRIBUTARY

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	16	9,400	406.08
15	29	1,946	152.37
16	44@	1,856@	220.49
17	46	3,976	493.82
18	18@	888@	43.16
19	76@	2,913@	597.75
20	53@	2,164@	309.67
21	52@	439	61.64
22	13@	679@	23.83
23	5.8@	349@	5.47
Average	35.28	2,461.0	
Total			2,314.27
Tons/Acre for 10 days = 1.51			
March Storm Event			
1	21	2,256	127.92
2	8	212	4.58
3	25	949	64.06
4	16	206	8.90
5	5.0@	309@	4.17
Average	15.0	786.4	
Total			209.62
Tons/Acre for 5 days = 0.14			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tribuary CFS (Y)/Gage CFS (X)
   Log (Y) = 1:37482 Log (X) - 6.53417
   r = 0.814** n = 13

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   Log (Y) = 0.82503 Log (X) + 4.4040
   r = 0.810** n = 13

UPPER LOLO CREEK

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	41@	2,072	229.37
15	76	1,164	238.85
16	66@	1,021@	181.94
17	50	699	94.37
18	30@	481@	38.96
19	105@	1,606@	455.30
20	77@	1,186@	246.57
21	75@	385	77.96
22	23@	376@	23.35
23	11@	196@	5.82
Average	55.4	918.9	
Total			1,592.50
March Storm Event			
1	18	568	27.6
2	14@	241@	9.11
3	14@	241@	9.11
4	16@	271@	11.71
5	9.8@	178@	4.71
Average	14.4	299.8	
Total			62.24

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   $\text{Log}(Y) = 1.2008 \text{ Log}(X) - 4.83237$
   $r = 0.978^{**}$ $n = 9$

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   $Y = 14.997 X + 30.85657$
   $r = 0.965^{**}$ $n = 9$

LOLO CREEK NEAR MOUTH

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	74	3,634	726.07
15	97	2,450	641.66
16	97@	2,486@	651.08
17	96	2,222	575.94
18	54@	1,258@	183.42
19	138@	3,656@	1,362.23
20	109@	2,828@	832.28
21	68	373	68.48
22	43@	944@	109.60
23	26@	459@	32.22
Average	80.2	2,031	
Total			5,182.98
Tons/Acre for 10 days = 1.28			
March Storm Event			
1	43	1,592	184.83
2	21	114	6.46
3	53	777	111.19
4	33	129	11.49
5	23@	373@	23.16
Average	34.6	597	
Total			337.14
Tons/Acre for 5 days = 0.08			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   $\text{Log}(Y) = 0.901545 \text{ Log}(X) - 2.19777$
   $r = 0.949^{**}$ $n = 13$

2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)
   $Y = 28.550 X - 283.45728$
   $r = 0.805^{**}$ $n = 13$

HANGMAN CREEK AT STATE LINE

SUSPENDED SEDIMENT

Date	Flow (cfs)	Suspended Sediment (mg/l)	Sediment Load (tons/day)
February Storm Event			
14	1,232	2,742	9,120.99
15	1,728	628	2,930.00
16	1,830	406@	2,006.05
17	1,560	942/839	3,750.79
18	956	298@	769.20
19	2,712	491@	3,597.95
20	2,084	432@	2,430.78
21	2,042	607/314	2,613.35
22	751	265@	537.34
23	418	200@	225.72
Average	1,531.3	682.7	
Total			27,982.17
Tons/Acre for 10 days = 0.83			
March Storm Event			
1	521	557/859	1,071.35
2	511	184	253.86
3	494	160/32	116.86
4	564	160/158	242.13
5	374	190@	191.86
Average	492.8	265.8	
Total			1,876.06
Tons/Acre for 5 days = 0.06			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. N/A

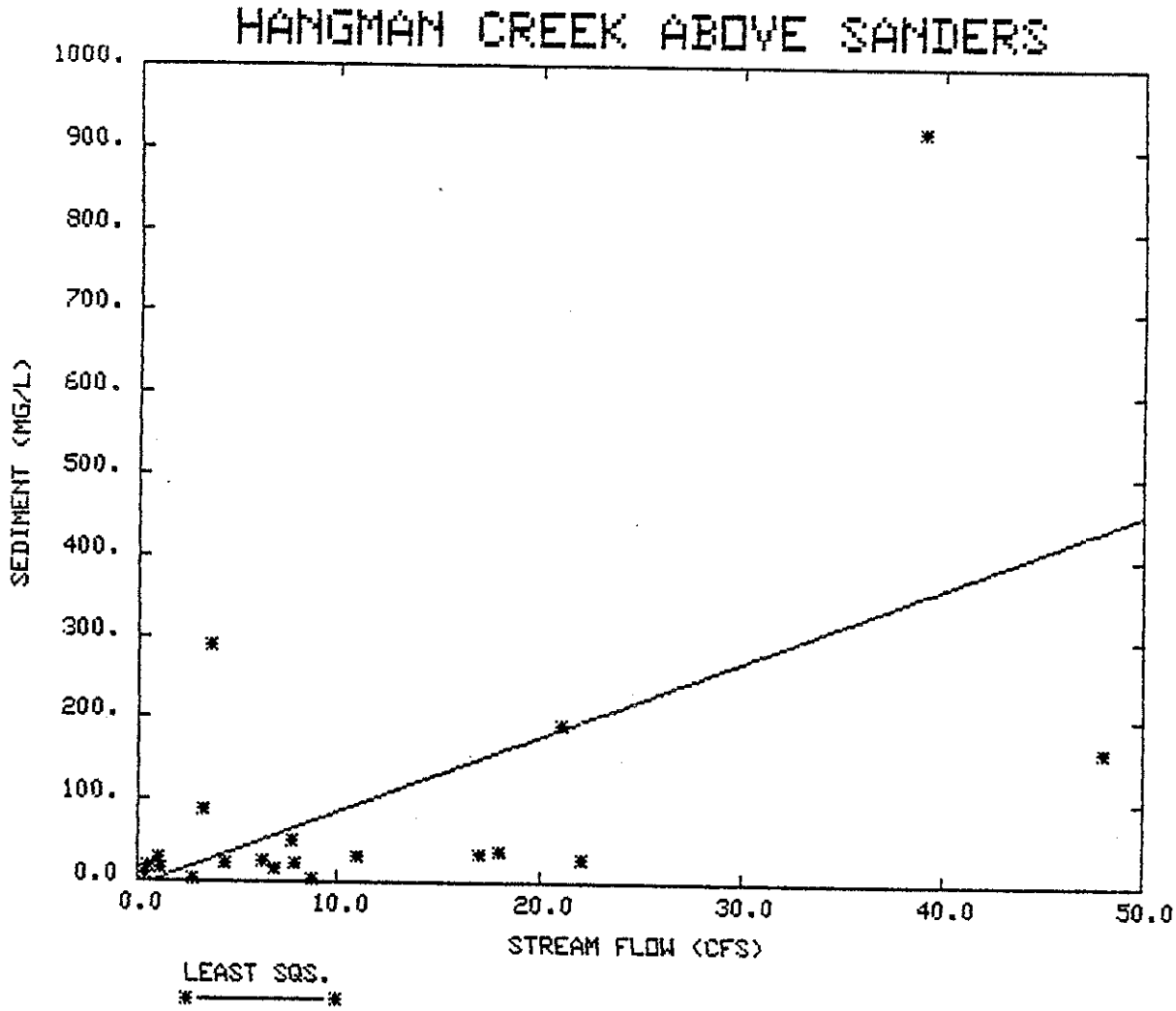
2. Tributary Suspended Sediment in mg/l (Y)/Tributary CFS (X)

$$\text{Log } (Y) = 0.47925 \text{ Log } (X) + 2.40671$$

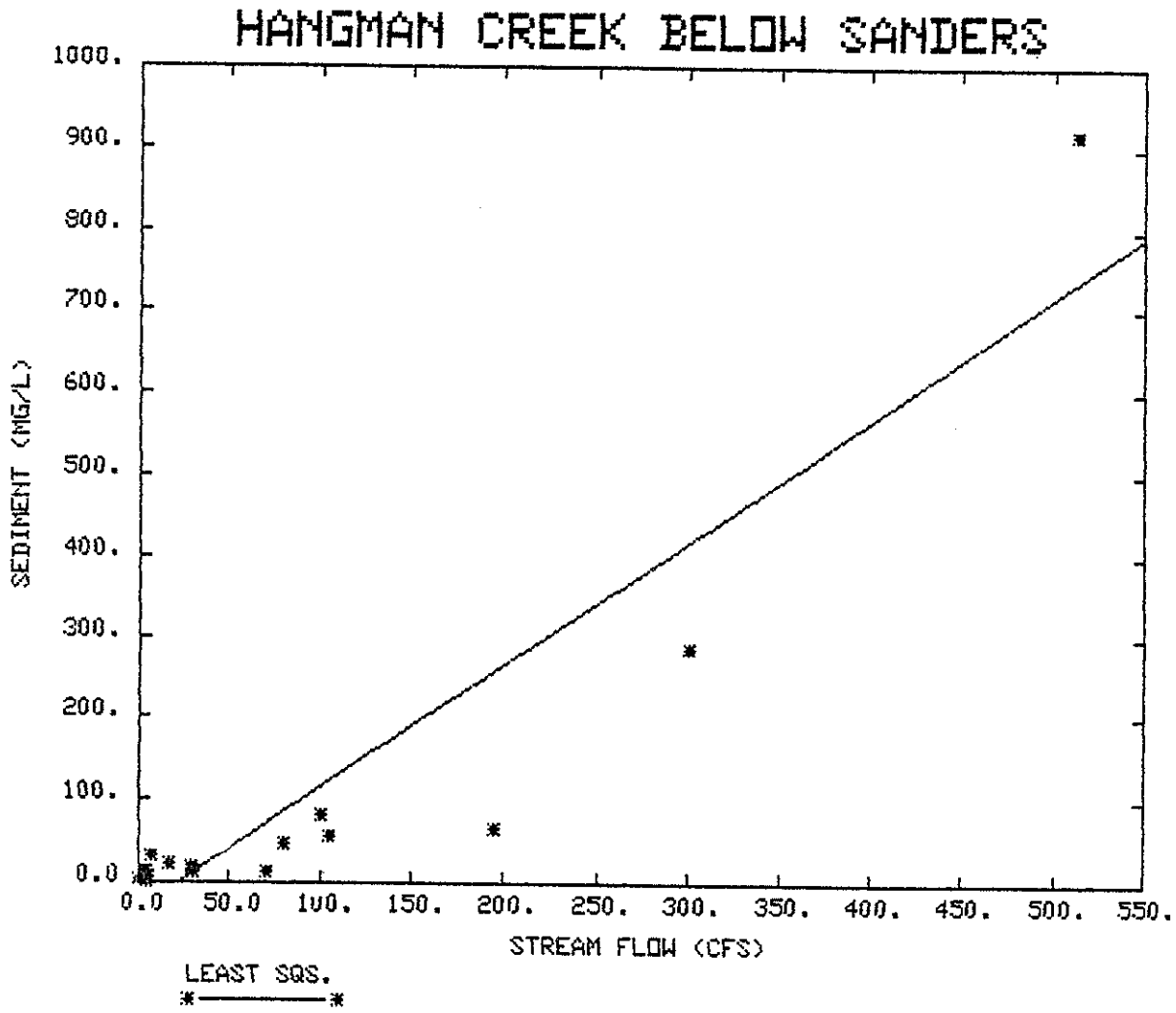
$$r = 0.738^{**} \quad n = 37$$

APPENDIX G

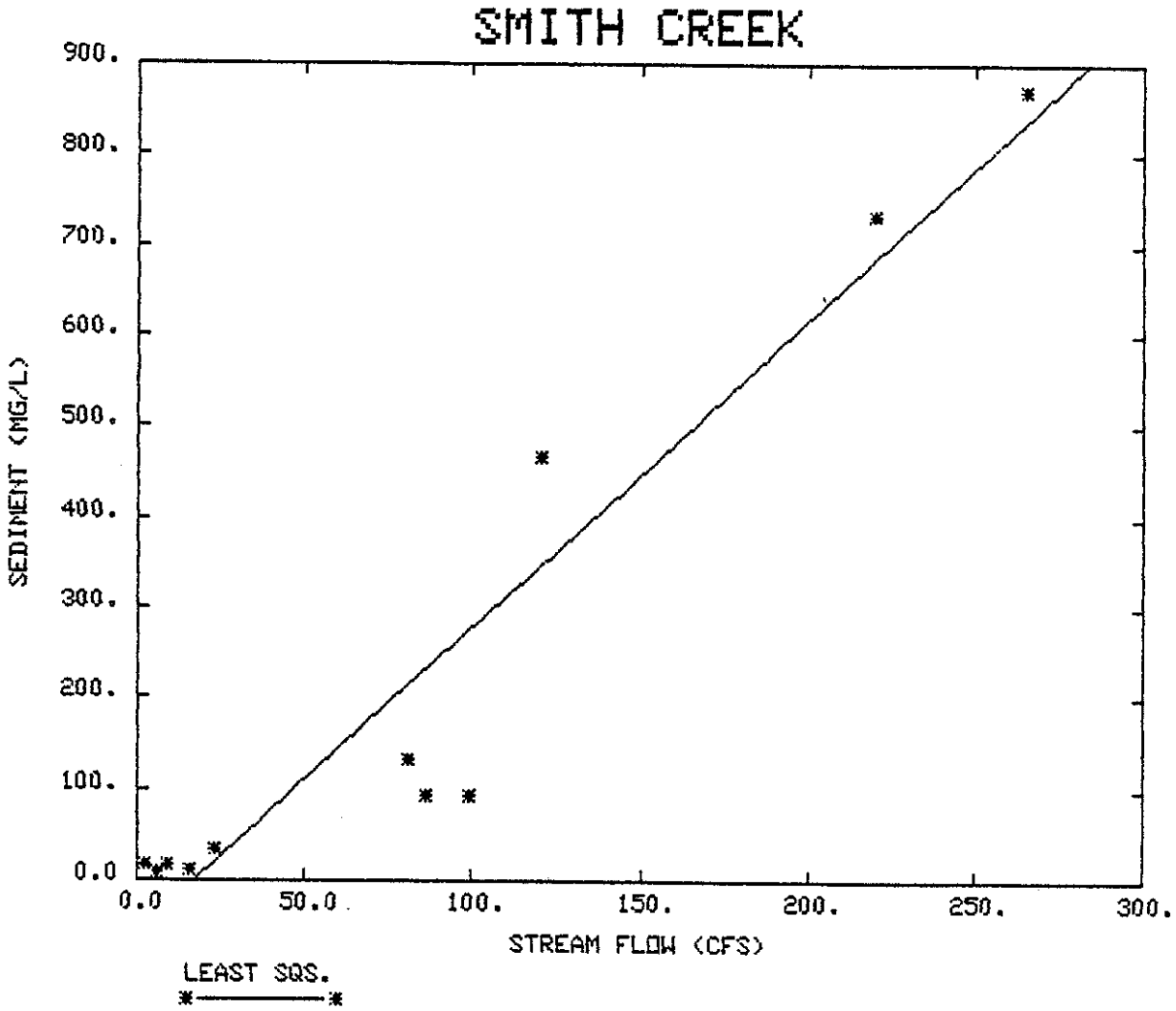
SEDIMENT RATING CURVES



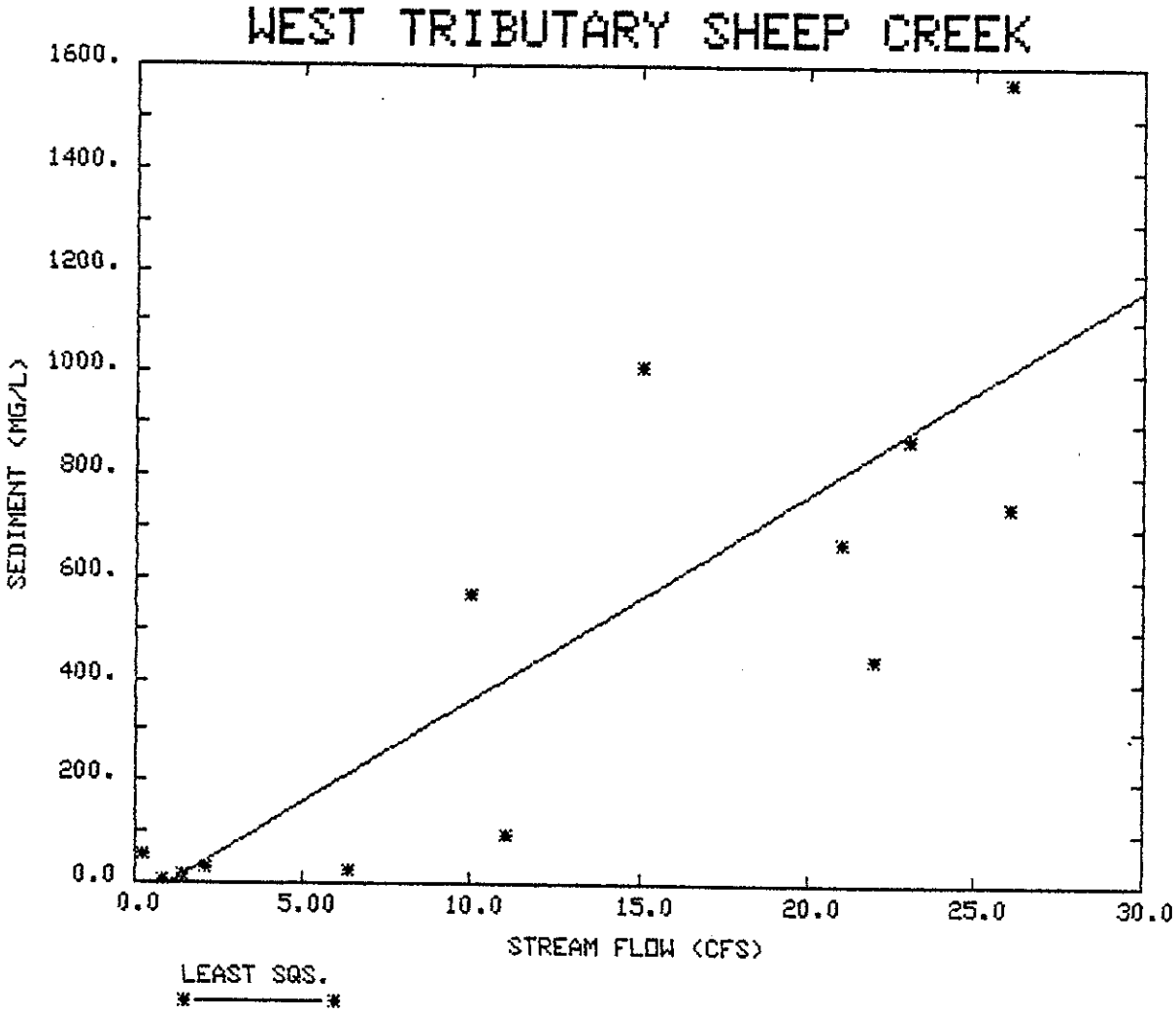
Y = 9.2512X - 6.92213
r = 0.578**



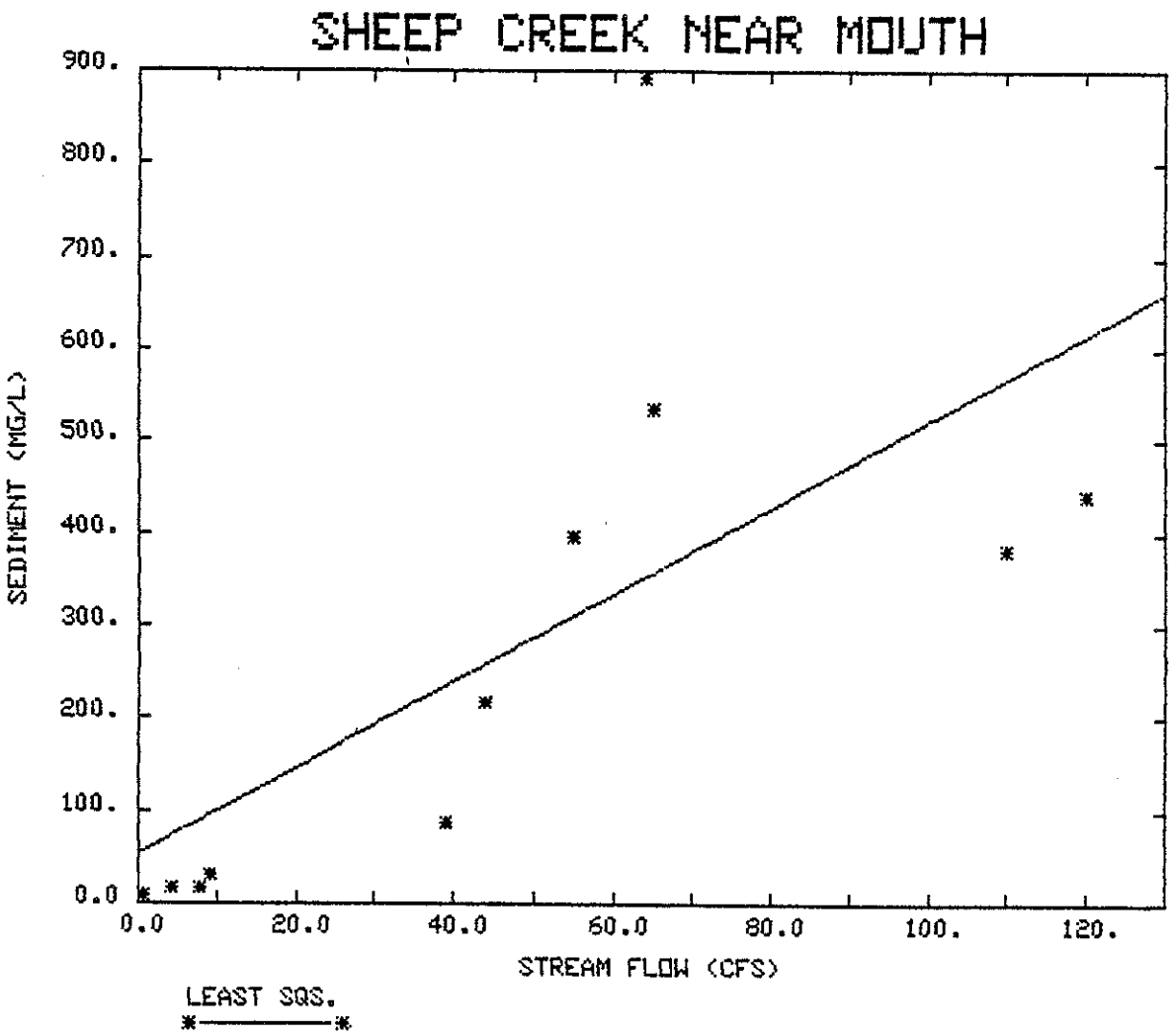
Y = 1.50278X - 33.4002
r = 0.929**



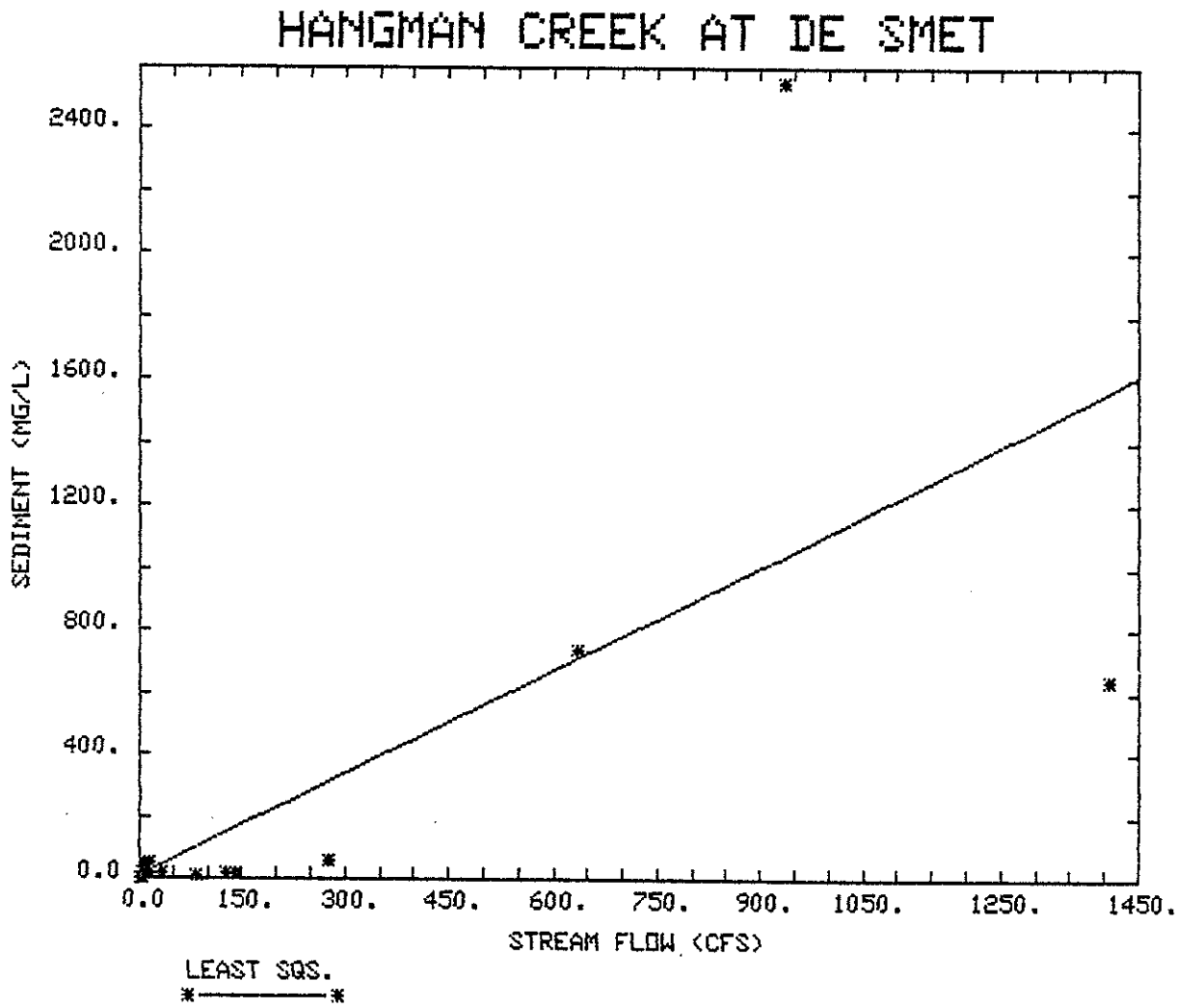
Y = 3.38147X - 59.5827
r = 0.956**



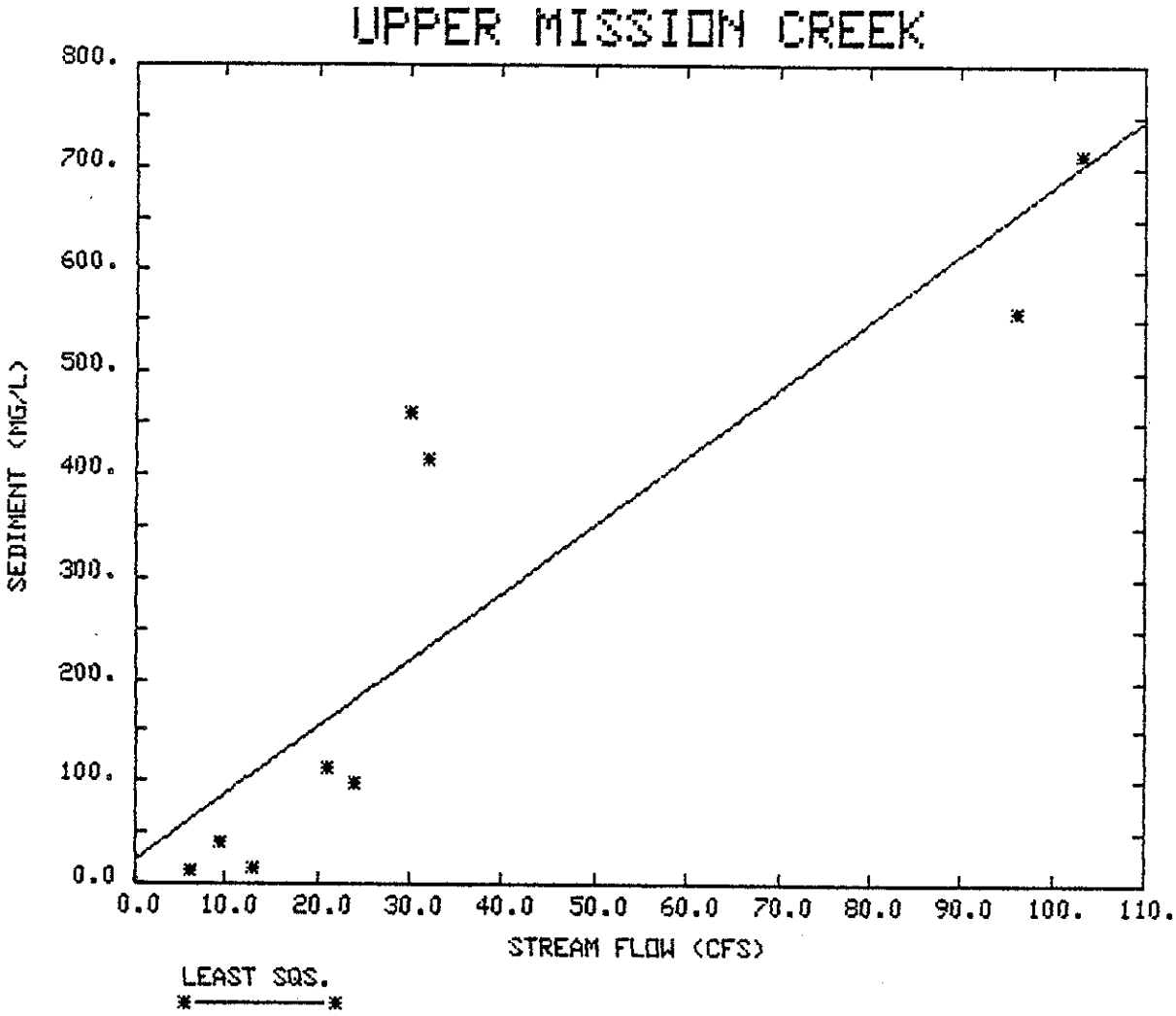
Y = 40.337X - 42.84521
r = 0.821**



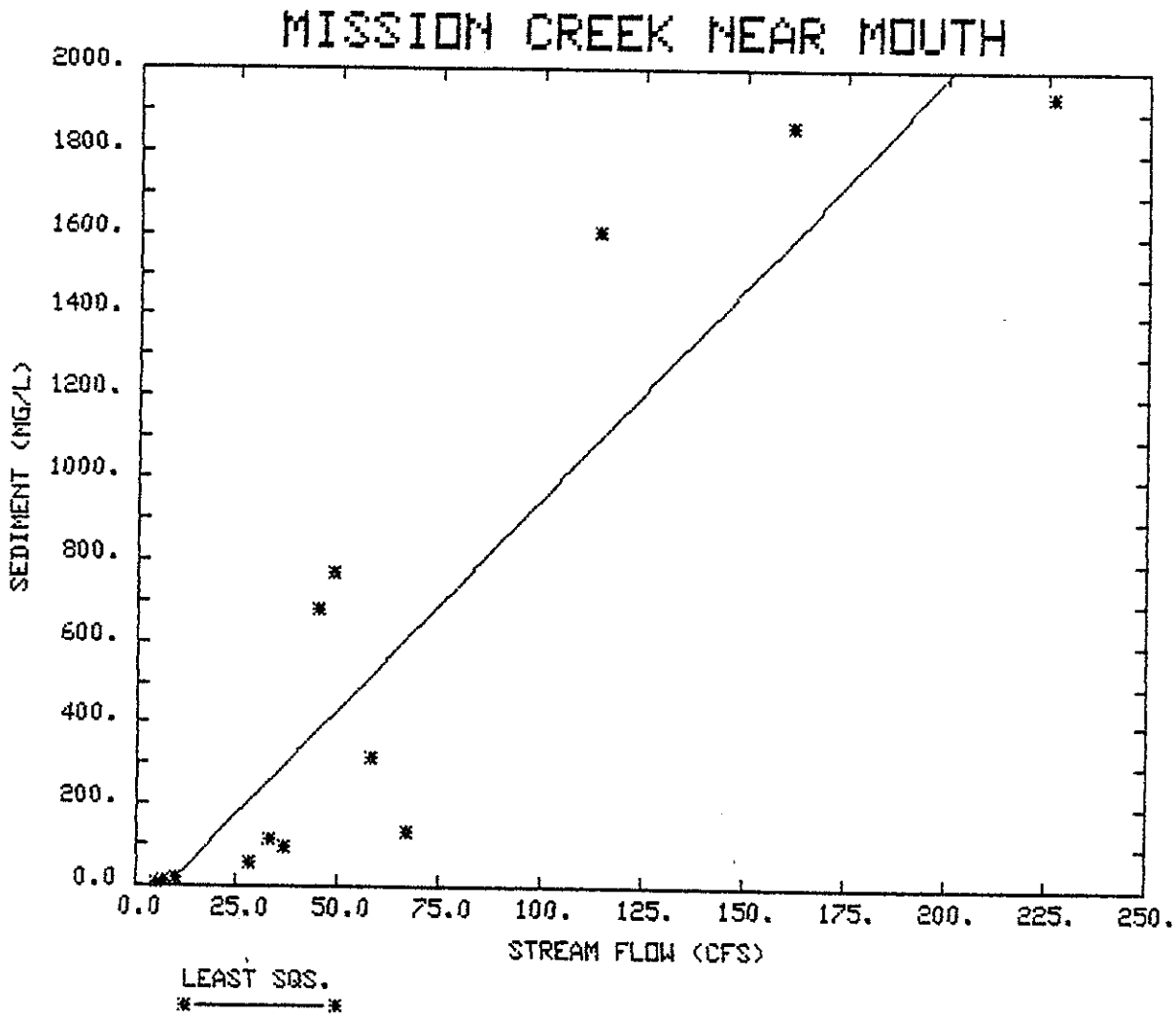
Log (Y) = 0.93152 Log(X) + 1.82091
r = 0.917**



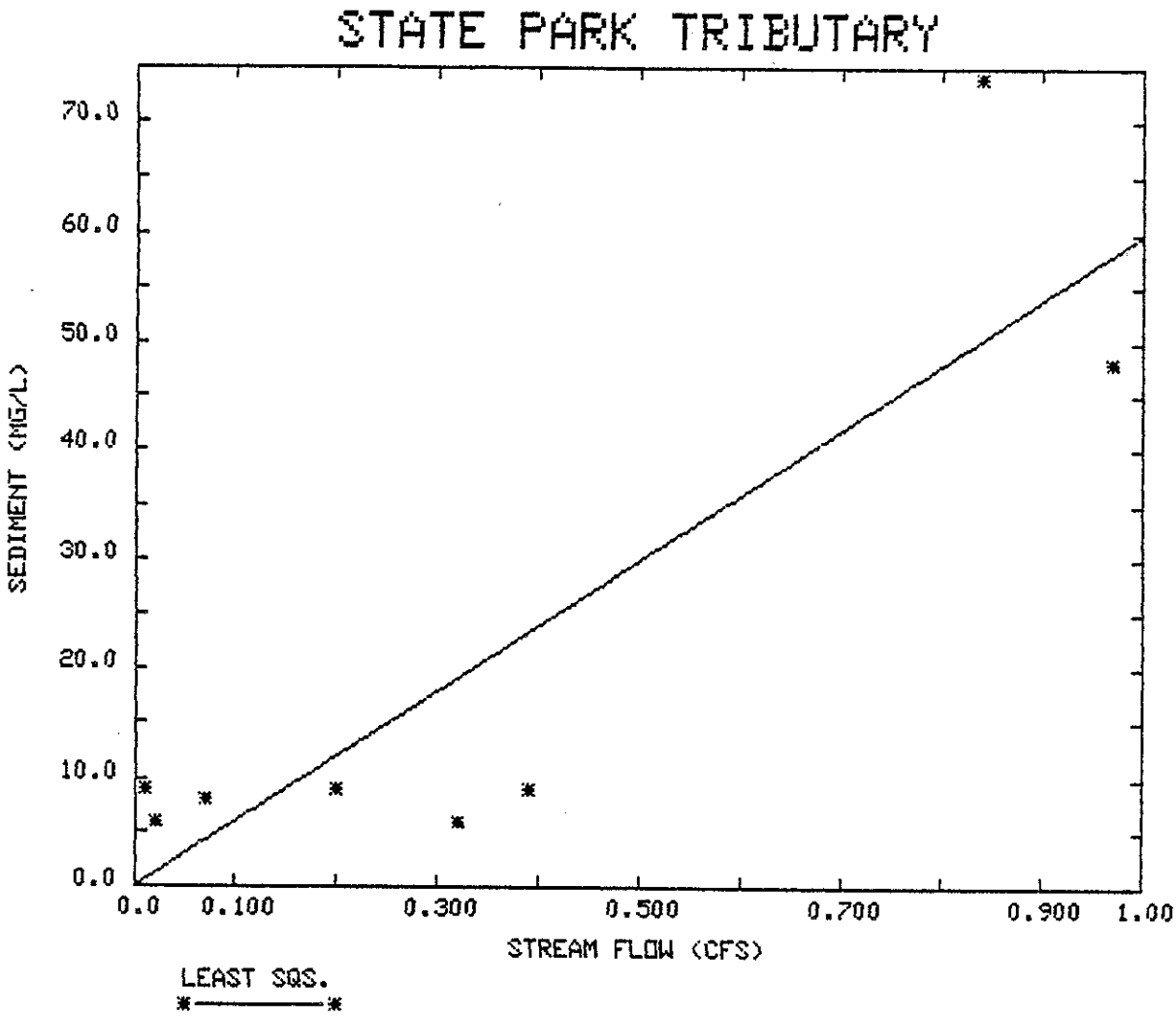
Y = 1.1037X + 9.11334
r = 0.701**



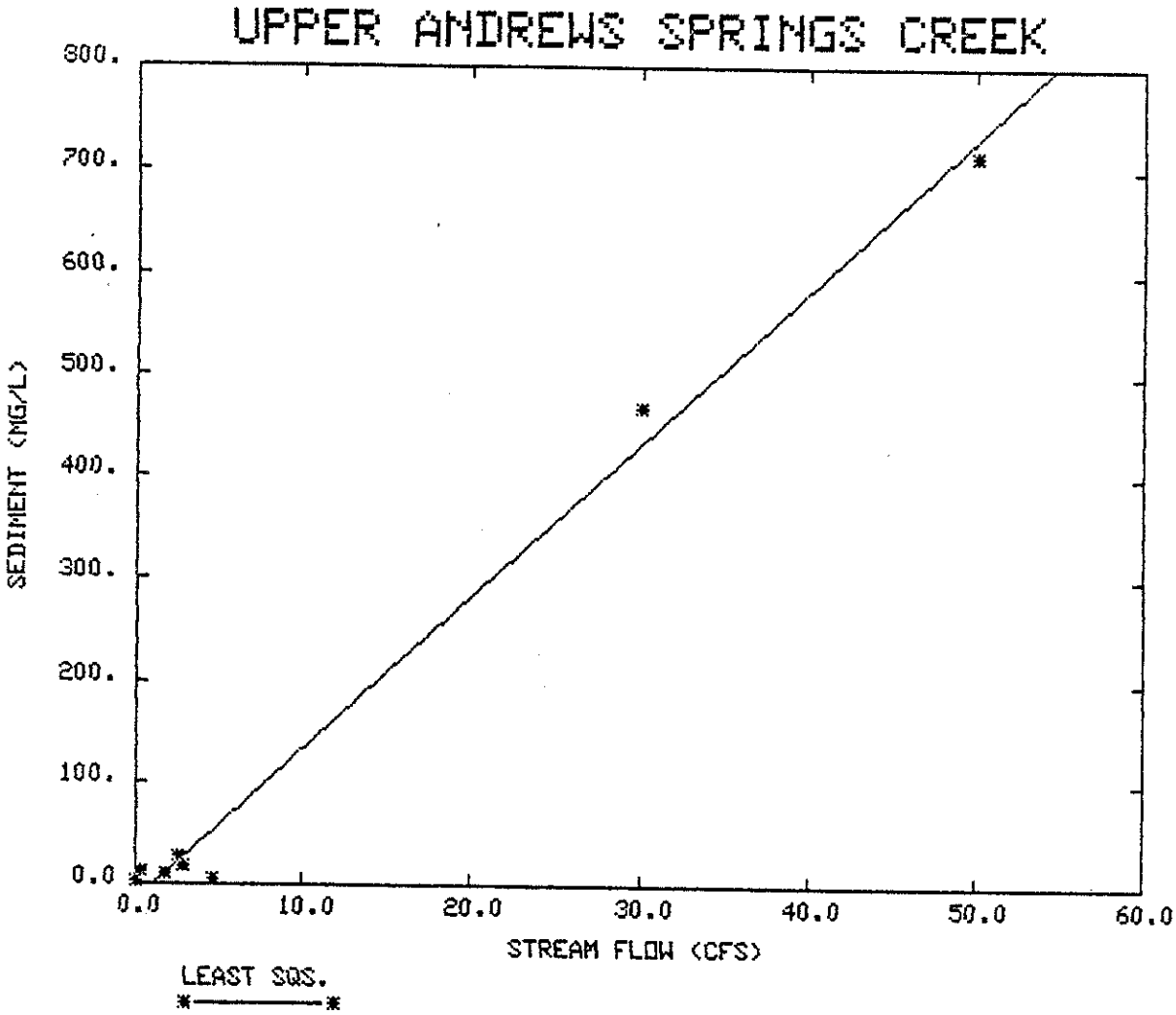
Y = 6.5125X + 27.17252
r = 0.887**



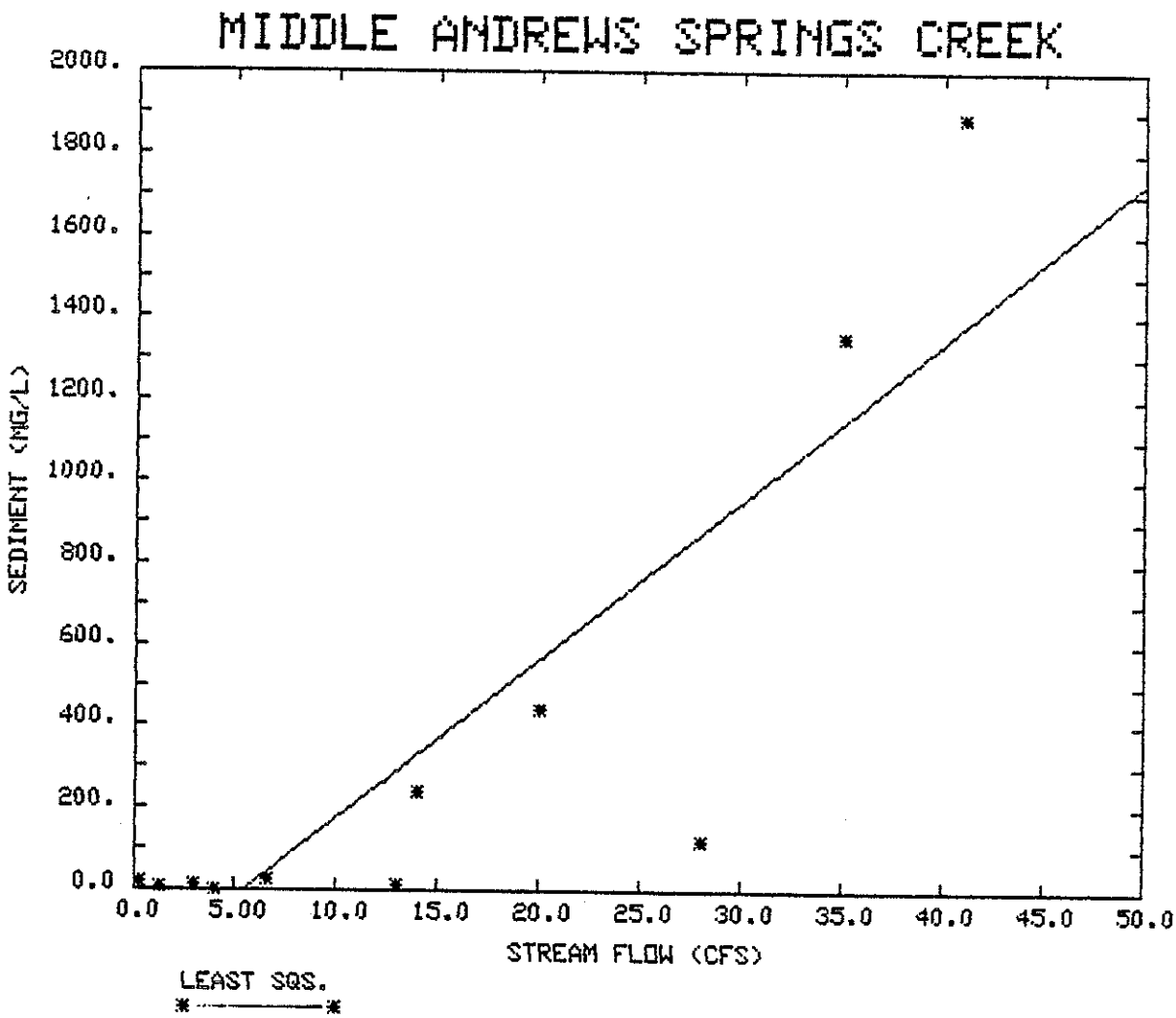
Y = 10.386X - 87.40698
r = 0.920**



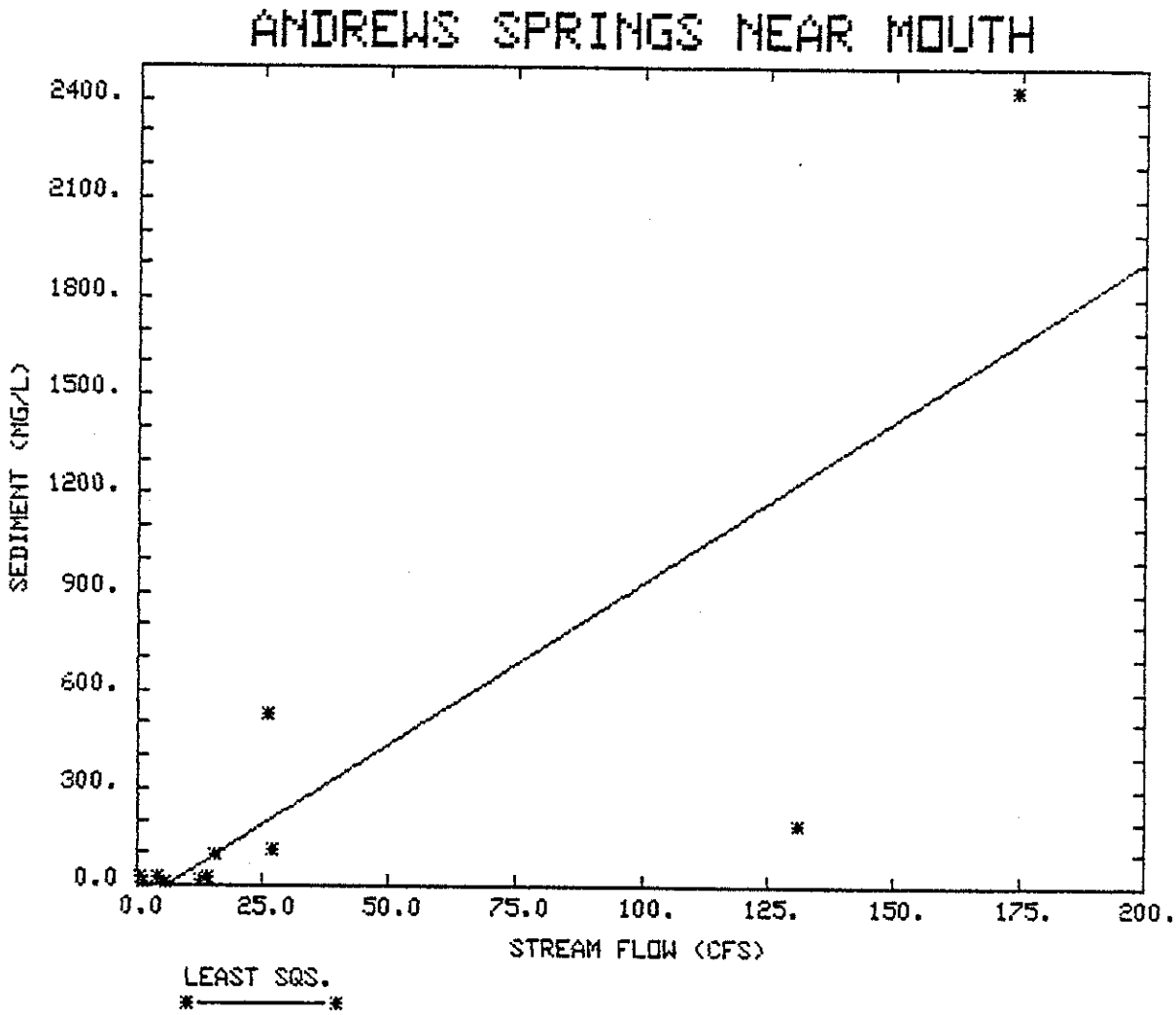
Y = 59.5029X + 0.16338
r = 0.861**



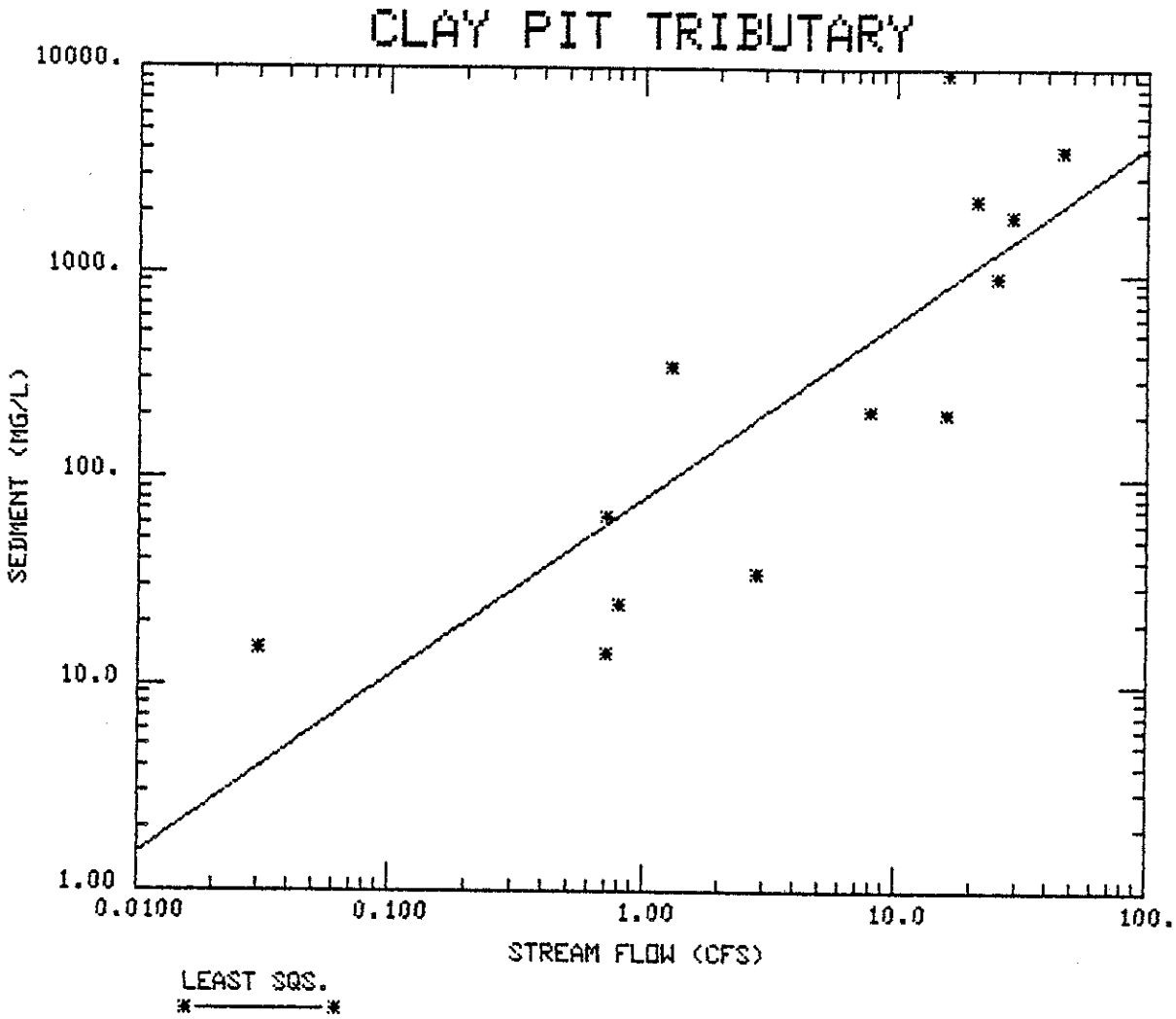
Y = 14.906X - 14.53903
r = 0.995**



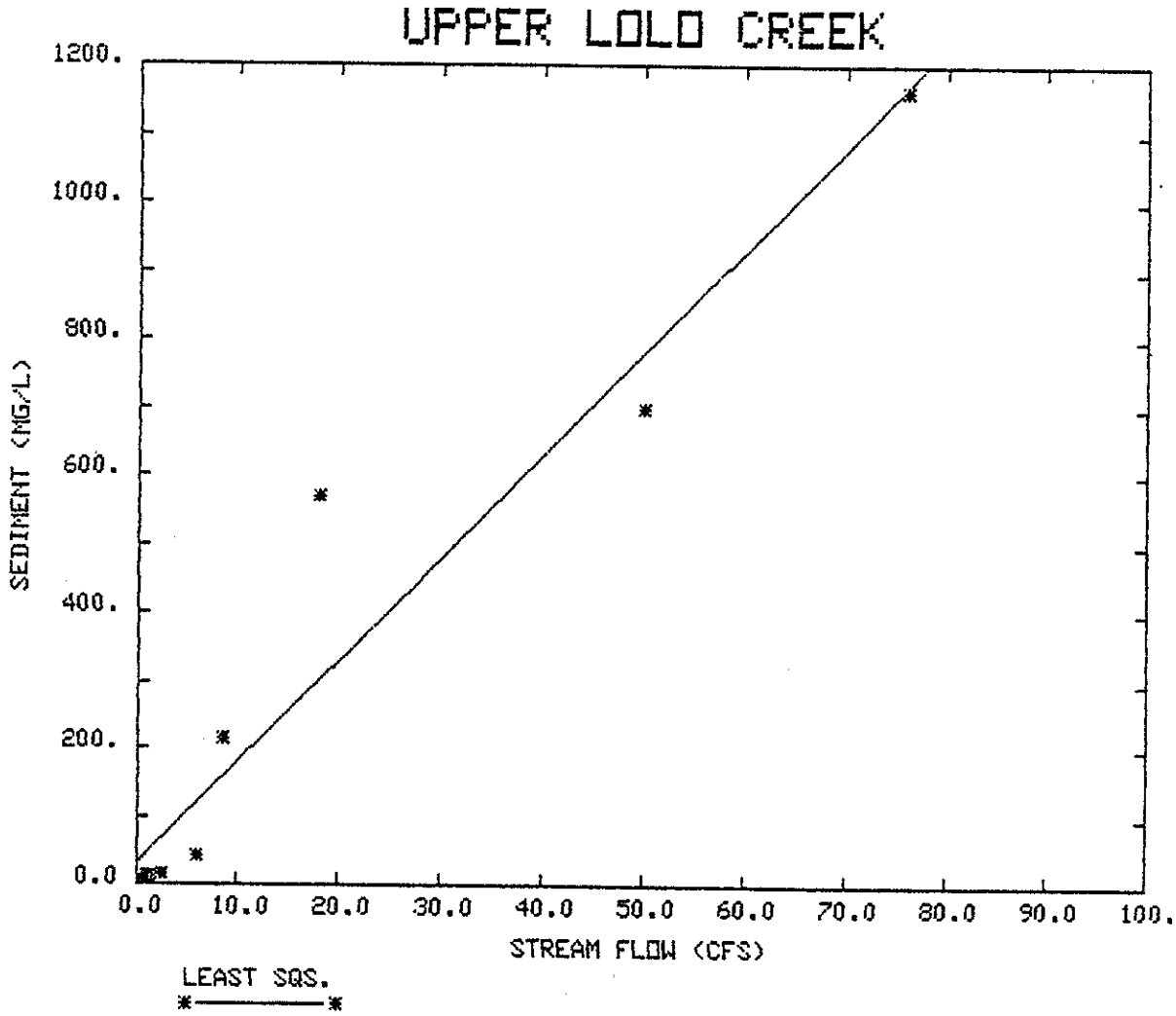
Y = 38.906X - 213.2431
r = 0.861**



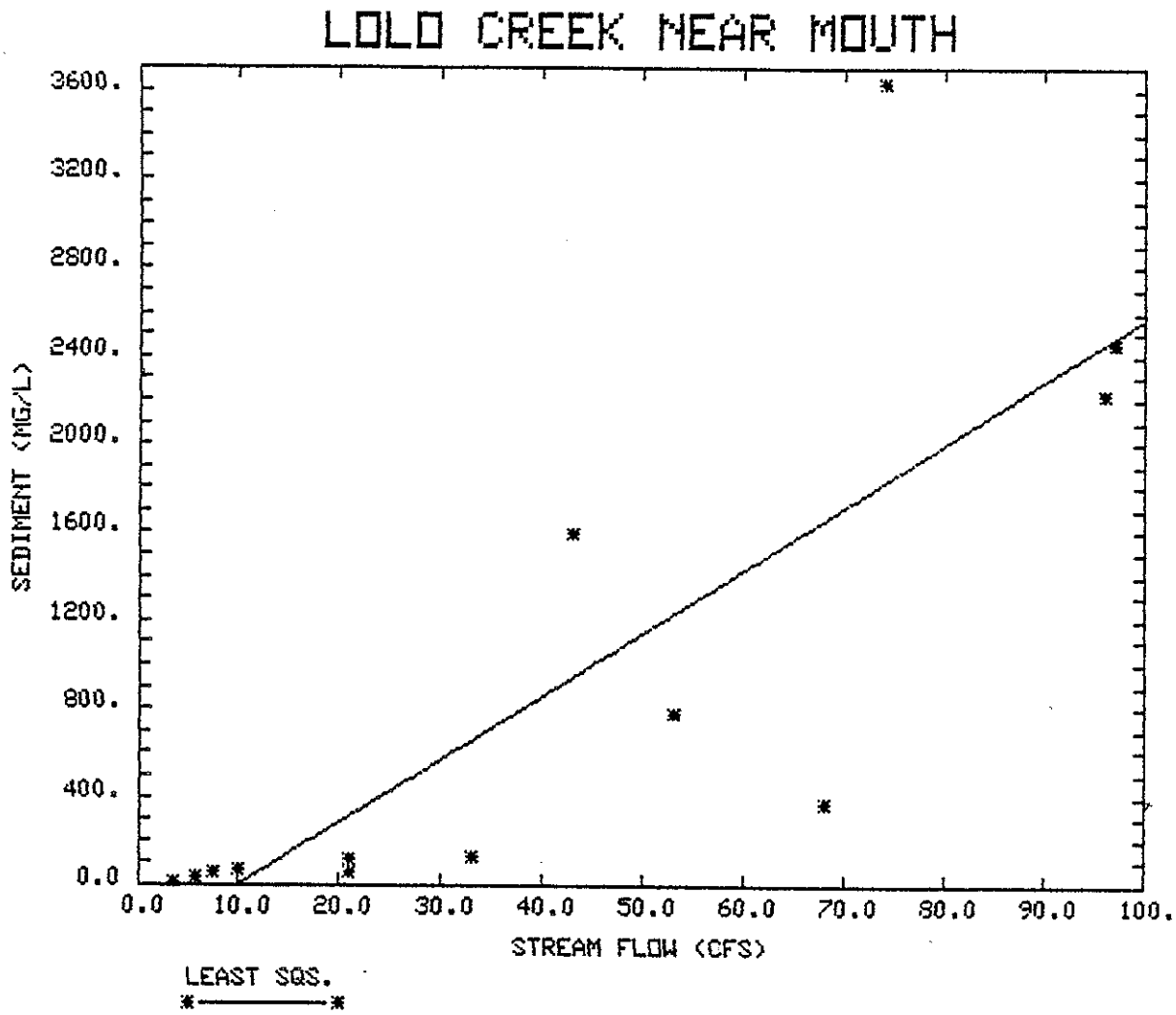
Y = 10.3894X - 87.9108
r = 0.920**



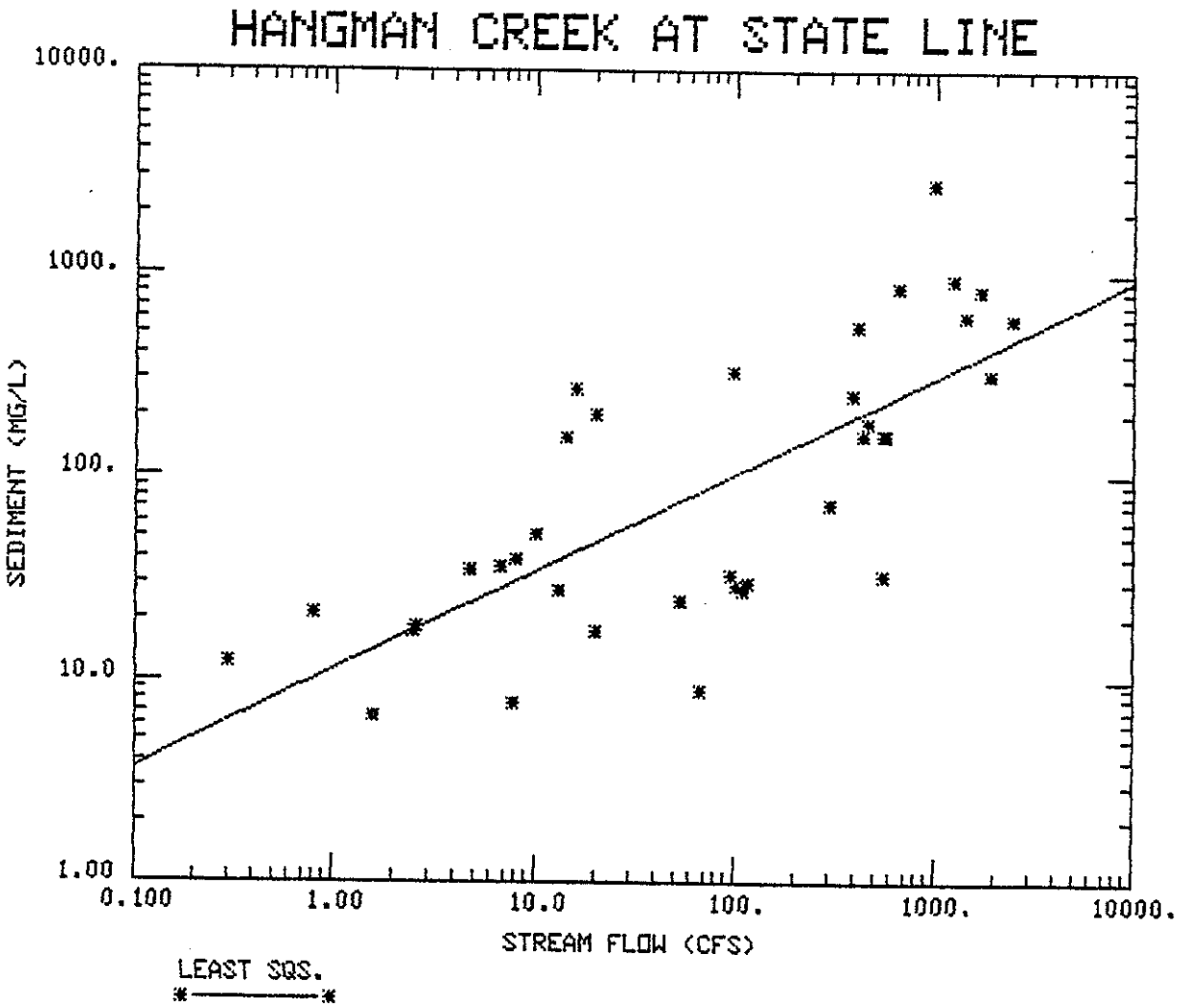
Log (Y) = 0.82503 Log (X) + 4.4040
r = 0.810**



Y = 14.997X + 30.85657
r = 0.965**



Y = 28.550X - 283.45728
r = 0.805**



Log (Y) = 0.47925 Log (X) + 2.40671
r = 0.738 **

APPENDIX H

Calculation of total phosphorus loading during February and March storms.

On days when samples were not taken, flows were estimated by regression analysis with the USGS gaging station.

Total phosphorus was then estimated by regression analysis with flow in cfs.

APPENDIX H (Continued)

HANGMAN CREEK ABOVE SANDERS

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	32@	1.06	182.83
15	39	0.49	103.00
16	41@	0.31@	68.51
17	48	0.41	106.08
18	27@	0.22@	32.02
19	52@	0.38@	106.51
20	44@	0.33@	78.26
21	44@	0.49	116.21
22	23@	0.19@	23.55
23	16@	0.16@	13.8
Average	36.6	0.304	
Total			830.76
Pounds/Acre for 10 days = 0.76			
March Storm Event			
1	21	0.1	11.32
2	22	0.07	8.30
3	11	0.03	1.78
4	17	0.07	6.41
5	15	0.14@	11.32
Average	17.2	0.082	
Total			39.13
Pounds/Acre for 5 days = 0.04			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 0.63 \text{ Log}(X) - 1.02561$

   $r = 0.948^{**}$ $n = 22$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)

   $Y = 0.00648 X + 0.04585$

   $r = 0.637^{**}$ $n = 20$

APPENDIX H (Continued)

HANGMAN CREEK BELOW SANDERS

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	291@	0.82	1,286.16
15	513	0.57	1,576.09
16	410@	0.58@	1,281.74
17	300	0.57	921.69
18	234@	0.29@	365.77
19	577@	0.65@	2,021.52
20	459@	0.53@	1,311.23
21	451@	0.08	194.47
22	189@	0.25@	254.68
23	114@	0.17@	104.46
Average	353.8	0.451	
Total			9,317.80
Pounds/Acre for 10 days = 2.62			
March Storm Event			
1	138@	0.23	171.08
2	194	0.10	104.57
3	101	0.03	16.33
4	104	0.16	89.69
5	103@	0.16@	88.83
Average	128	0.136@	
Total			470.49
Pounds/Acre for 5 days = 0.13			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 0.86748 \text{ Log}(X) - 0.50000$

   $r = 0.974^{*}$ $n = 20$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)

   $Y = 0.00103 X + 0.05290$

   $r = 0.789^{**}$ $n = 21$

APPENDIX H (Continued)

SMITH CREEK NEAR MOUTH

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	152@	0.41	335.90
15	220	0.33	391.31
16	213@	0.59@	677.36
17	265	1.06	1,514.05
18	122@	0.33@	217.00
19	298@	0.83@	1,333.16
20	238@	0.66@	846.66
21	234@	0.16	201.80
22	100@	0.26@	140.14
23	60@	0.15@	48.51
Average	190.2	0.478	
Total			5,705.90
Pounds/Acre for 10 days = 3.77			
March Storm Event			
1	120	0.33	213.44
2	99	0.13	69.37
3	81	0.13	56.76
4	86	0.13	60.26
5	55@	0.13@	38.54
Average	88.2	0.17	
Total			438.37
Pounds/Acre for 5 days = 0.29			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 0.85282 Log (X) - 1.04556
   r = 0.957** n = 12

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   Y = 0.00287 X -0.02326
   r = 0.857** n = 11

APPENDIX H (Continued)

WEST TRIBUTARY SHEEP CREEK

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	29@	3.75	586.16
15	26	1.63	228.43
16	52@	2.2@	616.62
17	21/22	0.9	106.72
18	21@	0.91@	103.00
19	90@	3.79@	1,838.53
20	62@	2.62@	875.55
21	60@	0.33	106.72
22	15@	0.66@	53.36
23	6.3@	0.29@	9.85
Average	38.33	1.708	
Total			4,524.94
March Storm Event			
1	15/26	1.11/0.68	101.31
2	11	0.33	19.57
3	23	0.75	92.98
4	10	0.39	21.02
5	5.4@	0.26@	7.57
Average	14.08	0.525	
Total			242.44

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   $\text{Log}(Y) = 1.4167 \text{ Log}(X) - 6.69931$
   $r = 0.918^{**}$ $n = 11$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   $Y = 0.04183 X + 0.02924$
   $r = 0.850^{**}$ $n = 12$

APPENDIX H (Continued)

SHEEP CREEK NEAR MOUTH

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	86@	0.16	74.17
15	116@	0.98	612.74
16	122@	0.71@	466.88
17	120/110	0.49	303.73
18	68@	0.43@	157.60
19	175@	0.99@	933.82
20	138@	0.80@	595.06
21	135@	0.24	174.64
22	55@	0.36@	106.72
23	32@	0.24@	41.40
Average	104.2	0.54	
Total			3,466.74
Pounds/Acre for 10 days = 2.23			
March Storm Event			
1	64/65	0.85/0.49	234.73
2	39	0.13	27.33
3	55	0.36	106.72
4	44	0.26	61.66
5	29@	0.22@	34.39
Average	46.4	0.328	
Total			464.83
Pounds/Acre for 5 days = 0.30			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   $\text{Log}(Y) = 0.90464 \text{ Log}(X) - 1.98761$
   $r = 0.968^{**}$ $n = 9$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   $Y = 0.00529 X + 0.06684$
   $r = 0.747^{*}$ $n = 10$

APPENDIX H (Continued)

HANGMAN CREEK AT DE SMET

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	896@	0.41	1,980.07
15	937	0.73	3,686.81
16	1,304@	0.62@	4,357.71
17	1,121@	0.82	4,945.60
18	704@	0.37@	1,403.99
19	1,894@	0.87@	8,881.54
20	1,475@	0.69@	5,485.67
21	1,408	0.41	3,111.54
22	560@	0.31@	935.70
23	321@	0.21@	363.34
Average	1,062	0.554	
Total			35,161.00
Pounds/Acre for 10 days = 2.32			
March Storm Event			
1	635	0.62	2,122.04
2	389@	0.24@	503.21
3	376@	0.24@	486.39
4	427@	0.26@	598.40
5	289@	0.20@	311.54
Average	423.2	0.312	
Total			4,021.59
Pounds/Acre for 5 days = 0.27			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 0.94833 \text{ Log}(X) + 0.04550$

   $r = 0.976^{**}$ $n = 19$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)

   $Y = 0.00042 X + 0.07995$

   $r = 0.786^{**}$ $n = 17$

APPENDIX H (Continued)

UPPER MISSION CREEK

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	72@	0.65	252.25
15	95@	1.06	542.77
16	99@	0.86@	458.90
17	103/96	0.90	485.10
18	58@	0.49@	153.18
19	137@	1.20@	886.12
20	110@	0.96@	569.18
21	109@	0.57	334.88
22	48@	0.41@	106.08
23	30@	0.24@	38.81
Average	85.8	0.734	
Total			3,827.28
March Storm Event			
1	30/32	0.62/0.03	55.14
2	35@	0.29@	54.71
3	34@	0.28@	51.31
4	38@	0.32@	65.54
5	27@	0.22@	32.02
Average	33	0.288	
Total			258.72

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 0.81609 \text{ Log}(X) - 1.53205$

   $r = 0.981^{**}$ $n = 7$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)

   $Y = 0.00896 X - 0.02473$

   $r = 0.843^{**}$ $n = 8$

APPENDIX H (Continued)

MISSION CREEK NEAR MOUTH

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	119@	2.28	1,462.42
15	114	1.79	1,099.88
16	180@	1.66@	1,610.53
17	226/161	1.79	1,862.08
18	91@	0.90@	441.44
19	237@	2.14@	2,733.70
20	207@	1.88@	2,097.57
21	202@	0.33	359.30
22	70@	0.73@	275.43
23	38@	0.46@	94.22
Average	145.1	1.396	
Total			12,036.60
Pounds/Acre for 10 days = 5.39			
March Storm Event			
1	49/45	1.24/0.75	253.33
2	33	0.20	35.57
3	58	0.42	131.30
4	67	0.23	83.06
5	34@	0.42@	76.97
Average	47.8	0.454	
Total			580.23
Pounds/Acre for 5 days = 0.26			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 1.05485 \text{ Log}(X) - 2.72906$

   $r = 0.976^{**}$ $n = 11$

2. Tributary Total Phsophorus in mg/l (Y)/Tributary CFS (X)

   $Y = 0.00845 X + 0.13458$

   $r = 0.818^{**}$ $n = 13$

APPENDIX H (Continued)

CLAY PIT TRIBUTARY

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	16	6.19	
15	29	1.14	
16	44@		
17	46	2.2	
18	18@		
19	76@		
20	53@		
21	52@	0.33	
22	13@		
23	5.8@		
Average	35.28		
Total			
March Storm Event			
1	21	1.89	
2	8	0.26	
3	25	0.68	
4	16	0.36	
5	5.0@		
Average	15.0		
Total			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 1.37482 Log (X) - 6.53417
   r = 0.814** n = 13

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   Correlation Not Significant

APPENDIX H (Continued)

STATE PARK TRIBUTARY

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	0.62@	0.49	1.64
15	0.97	0.57	2.98
16	1.34@	0.72@	5.20
17	0.84	0.49	2.22
18	0.38@	0.28@	0.57
19	2.87@	1.42@	21.97
20	1.72@	0.90@	8.34
21	0.39	0.32	0.67
22	0.24@	0.22@	0.28
23	0.075@	0.14@	0.06
Average	0.94	0.555	
Total			43.93
Pounds/Acre for 10 days = 1.51			
March Storm Event			
1	0.32	0.26	0.45
2	0.11@	0.16@	0.09
3	0.10@	0.16@	0.09
4	0.14@	0.17@	0.13
5	0.06@	0.14@	0.05
Average	0.2	0.178	
Total			0.80
Pounds/Acre for 5 days = 0.03			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 1.94637 \text{ Log}(X) - 14.3315$

   $r = 0.870^{**}$ $n = 9$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)

   $Y = 0.45649 X + 0.11002$

   $r = 0.858^{**}$ $n = 8$

APPENDIX H (Continued)

UPPER ANDREWS SPRINGS CREEK

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	31@	0.33	55.14
15	50	1.47	396.17
16	54@	1.52@	442.41
17	30	0.82	132.59
18	21@	0.66@	74.71
19	93@	2.55@	1,278.24
20	64@	1.79@	617.48
21	63@	0.41	139.22
22	15@	0.50@	40.43
23	6.7@	0.29@	10.47
Average	42.8	1.034	
Total			3,186.85
March Storm Event			
1	9.1@	0.59	28.94
2	8.8@	0.34@	16.13
3	8.4@	0.33@	14.94
4	10.0@	0.37@	19.94
5	5.7@	0.26@	7.99
Average	8.4@	0.378	
Total			87.94

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)

   $\text{Log}(Y) = 1.4129 \text{ Log}(X) - 6.63175$

   $r = 0.956^{**}$ $n = 8$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)

   $Y = 0.02625 X + 0.11019$

   $r = 0.986^{**}$ $n = 8$

APPENDIX H (Continued)

MIDDLE ANDREWS SPRINGS CREEK

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	29@	3.1	484.56
15	41	0.82	181.21
16	44@	0.84@	199.21
17	35	0.65	122.62
18	23@	0.53@	65.70
19	65@	1.15@	402.90
20	50@	0.92@	247.94
21	28	0.33	49.80
22	18@	0.45@	43.66
23	10@	0.33@	17.79
Average	34.3	0.912	
Total			1,815.41
March Storm Event			
1	20/14	0.75/0.88	70.72
2	12@	0.36@	23.28
3	12@	0.36@	23.28
4	13@	0.38@	26.63
5	8.9@	0.32@	15.35
Average	12.4	0.448	
Total			159.26

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   $\text{Log}(Y) = 1.0047 \text{ Log}(X) - 3.76588$
   $r = 0.974^{**}$ $n = 10$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   $Y = 0.01478 X + 0.18508$
   $r = 0.679^{*}$ $n = 11$

APPENDIX H (Continued)

ANDREWS SPRINGS CREEK NEAR MOUTH

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	75@	3.1	1,253.18
15	174	2.12	1,988.26
16	120@	1.08@	698.54
17	99@	1.3	693.69
18	55@	0.57@	168.98
19	193@	1.65@	1,716.45
20	140@	1.24@	935.70
21	131	0.33	233.01
22	41@	0.46@	101.66
23	20@	0.30@	32.34
Average	104.8	1.215	
Total			7,821.81
Pounds/Acre for 10 days = 3.13			
March Storm Event			
1	27@	0.95	138.25
2	16	0.23	19.84
3	26	0.59	82.68
4	27	0.29	42.20
5	18@	0.28@	27.17
Average	22.8	0.468	
Total			310.14
Pounds/Acre for 5 days = 0.12			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Lob (Y) = 1.20233 Log (X) - 4.24356
   r = 0.987** n = 11

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   Y = 0.00784 x + 0.14029
   r = 0.792** n = 11

APPENDIX H (Continued)

UPPER LOLO CREEK

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	41@	2.45	541.43
15	76	1.14	466.99
16	66@	1.02@	362.85
17	50	0.73	196.74
18	30@	0.56@	90.55
19	105@	1.53@	865.90
20	77@	1.16@	481.43
21	75@	0.33	133.40
22	23@	0.46@	57.03
23	11@	0.31@	18.38
Average	55.4	0.969	
Total			3,214.70
March Storm Event			
1	18	0.78	75.68
2	14@	0.35@	26.41
3	14@	0.35@	26.41
4	16@	0.37@	31.91
5	9.8@	0.29@	15.32
Average	14.4	0.428	
Total			175.72

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   $\text{Log}(Y) = 1.2008 \text{ Log}(X) - 4.83237$
   $r = 0.978^{**}$ $n = 9$

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   $Y = 0.01296 X + 0.16678$
   $r = 0.889^{**}$ $n = 9$

APPENDIX H (Continued)

LOLO CREEK NEAR MOUTH

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	74	5.87	2,341.31
15	97	2.28	1,192.05
16	97@	2.78@	1,453.47
17	96	2.04	1,055.58
18	54@	1.51@	439.50
19	138@	3.99@	2,967.84
20	109@	3.13@	1,838.91
21	68	0.41	150.27
22	43@	1.18@	273.49
23	26@	0.68@	95.30
Average	80.2	2.387	
Total			11,807.70
Pounds/Acre for 10 days = 2.92			
March Storm Event			
1	43	1.47	340.70
2	21	0.26	29.43
3	53	0.68	194.26
4	33	0.29	51.58
5	23@	0.59@	73.14
Average	34.6	0.656	
Total			689.11
Pounds/Acre for 5 days = 0.17			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. Tributary CFS (Y)/Gage CFS (X)
   Log (Y) = 0.90155 Log (X) - 2.19777
   r = 0.949** n = 13

2. Tributary Total Phosphorus in mg/l (Y)'Triburary CFS (X)
   Y = 0.02952 X - 0.08439
   r = .622* n = 13

APPENDIX H (Continued)

HANGMAN CREEK AT STATE LINE

TOTAL PHOSPHORUS, WY 1982

Date	Flow (cfs)	Total Phosphorus (mg/l)	Phosphorus Load (pounds/day)
February Storm Event			
14	1,232	2.61	17,331.70
15	1,728	0.98	9,127.64
16	1,830	0.45@	4,338.67
17	1,560	0.98	8,240.23
18	956	0.37@	1,960.55
19	2,712	0.50@	7,308.84
20	2,084	0.47@	5,279.40
21	2,042	0.49/0.41	4,952.87
22	751	0.35@	1,416.76
23	418	0.30@	675.91
Average	1,531.3	0.746	
Total			60,678.50
Pounds/Acre for 10 days = 1.80			
March Storm Event			
1	521	0.62/0.72	1,881.49
2	511	0.16	440.69
3	494	0.1/0.42	692.29
4	564	0.26/0.26	790.39
5	374	0.29@	584.60
Average	492.8	0.328	
Total			4,389.45
Pounds/Acre for 5 days = 0.13			

@ = value approximated from regression equation

REGRESSION EQUATIONS:

1. N/A

2. Tributary Total Phosphorus in mg/l (Y)/Tributary CFS (X)
   Log (Y) = 0.27812 Log (X) - 2.88763
   r = 0.544** n = 34

APPENDIX I

Estimate of fertilizer value lost during runoff. Shown only for sample dates.

APPENDIX I (Continued)

FERTILIZER PHOSPHORUS CONCENTRATION AND COST
HANGMAN CREEK AND TRIBUTARIES
STORM SEASON 1982

Station	Month	Phosphorus Load (pounds/day)**	Fertilizer P (pounds/day)***	Cost at 20¢/lb
Hangman Creek above Sanders	February*	830.76	1,902	$ 476
	March *	39.13	90	23
Hangman Creek below Sanders	February	9,317.8	21,338	5,335
	March	470.49	1,077	269
Smith Creek near mouth	February	5,705.9	13,067	3,267
	March	438.37	1,004	251
Western Tributary of Sheep Creek	February	4,524.94	10,362	2,591
	March	242.44	555	139
Sheep Creek near mouth	February	3,466.74	7,939	1,985
	March	464.83	1,064	1,064
Hangman Creek at De Smet	February	35,161.00	80,519	20,130
	March	4,021.49	9,209	2,302
Upper Mission Creek	February	3,827.28	8,764	2,191
	March	258.72	592	148
Mission Creek near mouth	February	12,036.6	27,564	6,891
	March	580.23	1,329	332
Clay Pit Tributary	February	Computation not possible, see Appendix H		
	March	" " " " " "		
State Park Tributary	February	43.93	101	25
	March	0.8	2	1
Upper Andrews Springs Creek	February	3,186.85	7,298	1,800
	March	87.94	201	50
Middle Andrews Springs Creek	February	1,815.41	4,157	1,039
	March	159.26	2,655	664
Andrews Springs Creek near mouth	February	7,821.81	17,912	4,478
	March	310.14	7,122	1,781
Upper Lolo Creek	February	3,214.7	7,362	1,841
	March	175.72	402	101
Lolo Creek near mouth	February	11,807.7	27,040	6,760
	March	689.11	1,578	395
Hangman Creek near ID/WA State Line	February	60,678.5	138,954	34,739
	March	4,389.45	10,052	2,513

*February storm event was calculated as 10 days.
March storm event was calculated as 5 days.

**See Appendix H.

***Phosphorus fertilizer is applied P_2O_5. The figure under Phosphorus load represents only elemental phosphorus. To convert elemental into fertilizer phosphorus, multiply the elemental value by 2.29.

APPENDIX I (Continued)

FERTILIZER NITROGEN CONCENTRATION AND COST
HANGMAN CREEK NEAR IDAHO/WASHINGTON STATE LINE
1981-1982 WATER YEARS

Date	Fertilizer N (mg/l)	Stream Flow (cfs)	Nitrogen Load (pounds/day)	Cost At 25¢/lb
1981				
Feb. 25	1.34	109.0	785.5	$ 196.38
Apr. 1	1.30	336.0	2,361.6	590.40
July 1	0.089	9.0	4.3	1.07
Sept. 8	0.14	0.3	0.2	.06
Oct. 8	0.034	4.0	0.8	.19
Nov. 13	0.22	4.0	4.8	1.20
17	0.76	10.0	40.8	10.20
18	3.45	15.0	278.9	69.73
Dec. 2	2.42	32.0	417.1	104.26
3	2.12	23.0	263.3	65.83
1982				
Feb. 3	4.02	108.0	2,337.8	584.45
14	3.23	1,232.0	21,448.8	5,362.19
15	2.25	1,728.0	20,975.0	5,243.74
17	2.53	1,560.0	21,290.1	5,322.52
21	1.38	2,042.0	15,232.9	3,808.21
Mar. 1	3.00	521.0	8,416.1	2,104.04
3	2.05	494.0	5,453.1	1,363.28
4	2.20	564.0	6,672.7	1,668.18
23	1.50	108.0	874.9	218.73
Apr. 1	1.05	98.0	554.1	138.53
16	0.78	286.0	1,197.8	229.44
29	0.61	68.0	222.8	55.71
May 19	0.48	20.0	51.3	12.83
June 2	0.58	8.2	25.8	6.44
30	0.34	0.8	1.5	.36

NOTE: Fertilizer Nitrogen is considered sum of nitrite, nitrate and ammonia.