ANNUAL REPORT

DEVELOPMENT OF A SEDIMENT GENERATION AND ROUTING MODEL FOR IRRIGATION RETURN FLOW

Funded through the

ROCK CREEK RURAL CLEAN
WATER PROJECT
COMPREHENSIVE MONITORING
AND EVALUATION PROGRAM

for

Idaho Department
of
Health and Welfare
Division of Environment

by

C. E. Brockway, Ph.D, P.E.
F. J. Watts, Ph.D, P.E.
C. W. Robison
R. P. Sterling

University of Idaho
Department of Agricultural Engineering
Department of Civil Engineering
and
Idaho Water and Energy Resources
Research Institute, Kimberly Idaho

November 1, 1982

ACKNOWLEDGEMENTS

The following agencies and business contributed valuable assistance in the preperation of this report.

Snake River Conservation Research Center, Agricultural Research Service, USDA.

Twin Falls and Snake River Soil Conservation Districts.

University of Idaho, Cooperative Extension Service, Twin Falls County

CH2M HILL, Boise, Idaho

Thanks are due Donna Anthis in the preparation of the written portion of this report, and special thanks to Victor Watkins in the collection and reduction of the data and in the preparation of the figures.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Background

The Idaho Water and Energy Resources Research Institute (IWERRI) contracted with the Idaho Department of Health and Welfare Division of Environment (DOE) to develop an operational package of computer models for predicting changes in water quality of streams receiving irrigation return flows.

The model package is expected to be used as an operational planning tool for evaluating the potential of proposed water quality improvement projects. There are currently no operational simulation models intended for use with surface irrigation return flow. The project is part of the Comprehensive Monitoring and Evaluation Program of the Rock Creek Rural Clean Water Project and is funded from that project. This report outlines the work performed through the University of Idaho Kimberly Research and Extension Center from November 1981 to September 1982.

Objectives

The primary purpose of this project is to develop a sediment modeling package for use with surface irrigation return flow. A primary goal is to develop operational computer tools requiring minimal data input for predicting water quality with respect to sediment. The following objectives were defined:

1. The model package should be capable of predicting potential improvement in water quality due to Best Management Practice (BMP) implementation.

2. It should assist watershed planners in deciding which BMP Implementation scheme is best for the watershed, and define high priority sub-basins in the watershed for implementation of BMP's.

3. The package should be able to predict water quality changes in streams receiving irrigation return flow, and predict possible adverse effects in the streams due to a certain mix of BMP implementation schemes.

4. The model should be based on physical processes and usable for other surface-irrigated watersheds.

Procedure

In accordance with objectives and time frame, it was concluded that the model package would consist mainly of previously developed routines. Because there were no acceptable models dealing with furrow irrigated lands, emphasis was placed on development of a soil erosion model for furrow irrigated lands. The rest of the models, irrigation, treatment and routing, will be made compatable with each other after selection and testing. Initial testing is to be pursued with data from the LQ Drain Project 1976-1980 (Brockway, et al., 1981). To meet objective 4, two sub-basins from different watersheds were selected for calibration and verification.

Study Area Description

Watersheds

The study area is comprised of two watersheds, Rock Creek watershed south of Twin Falls, Idaho and Cedar Draw watershed west of Filer, Idaho and to the east of Buhl, Idaho as shown in figure 1. They are located approximately three miles apart and are separated by the LQ Drain watershed.

The Rock Creek watershed encompasses approximately 45000 acres with varied land use. Predominant land use is row-crop farming with furrow irrigation; however, significant urbanization is occuring. Cedar Draw watershed covers approximately 24000 acres with similar land use except urban sprawl is not as prevalent.

The calibration sub-basin was chosen from the Rock Creek watershed and the verification sub-basin was chosen from the Cedar Draw watershed. The major criteria used in the selection of sub-basins was the ease of delineation of the hydrologic boundaries, physical differences, and the priority of the area for implementation of BMP's.

Calibration Sub-Basin

Figure 2 shows the sub-basin from the Rock Creek watershed chosen for calibration. It encompasses 3800 acres and is bounded by the Low Line Canal on the south and by Rock Creek on the north. Two major drains service the area and flow seperately into Rock Creek. The land can be classified as a mildly sloping with Portneuf Silt Loam soil. The crop distribution is changing from a row-crop rotation to pasture, alfalfa and minor row-crops. An 18-hole golf course operated by the city of Twin Falls is located within the sub-basin.

Five monitoring stations were established for collection of the calibration data (Figure 2). Stations UI-001 and UI-002 are located

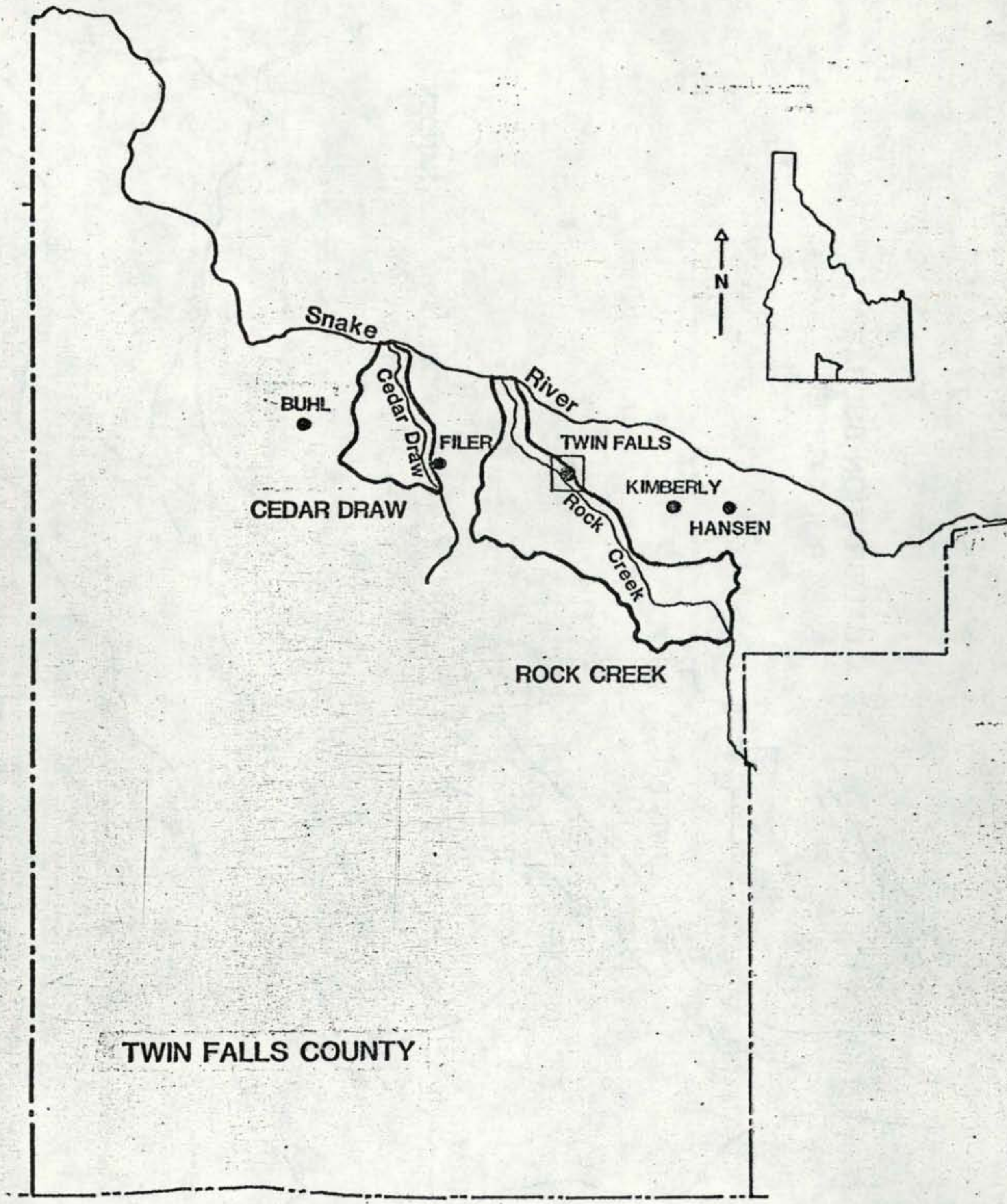

Figure 1. Study Area Location Map.

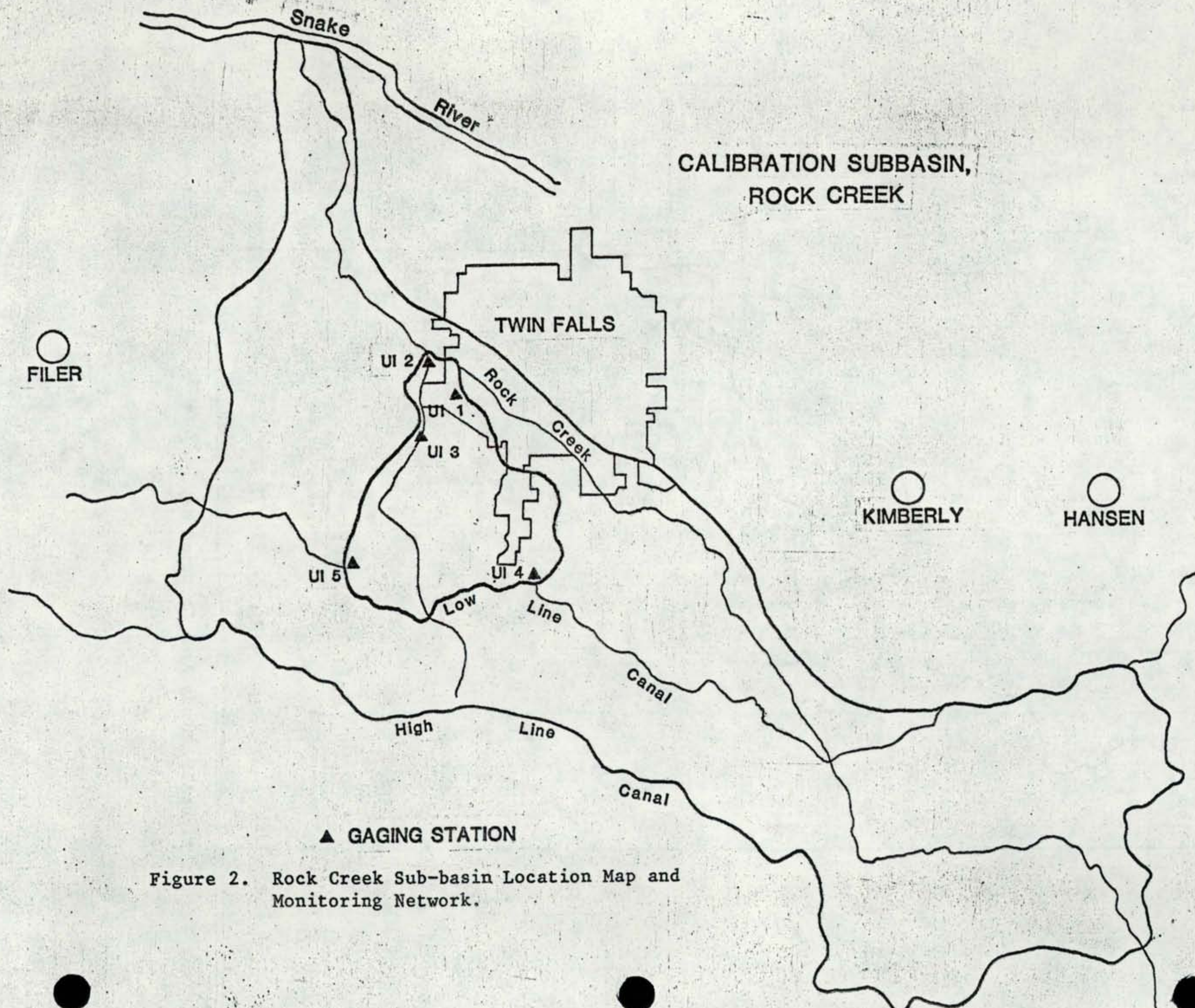

Figure 2. Rock Creek Sub-basin Location Map and Monitoring Network.

near the mouths of the two drains. Stations UI-004 and UI-005 monitor the inputs to the sub-basin from the Low Line Canal. Station UI-003 monitors a drain which enters on the west boundary of the sub-basin.

Verification Sub-Basin

The sub-basin from the Cedar Draw watershed, which has a state funded rural clean water program, is shown in figure 3. The sub-basin covers some 4500 acres and is drained by one drain known as the 'LF'. The LF drain starts out as a surface drain and splits into two service laterals for the Twin Falls Canal Company. The laterals then begin to function as drains and rejoin approximately two miles upstream of their confluence with Cedar Draw. The land has varied slopes with a crop distribution of beans, sugar beets, small grains, corn and alfalfa which is consistant throughout the area.

The monitoring network in the verification basin consists of five stations as shown in figure 3. Input station UI-104 is located at the origin of the LF Drain at the Low Line Canal. Other input station, UI-105 measures flow in a lateral which supplies irrigation water to the west side of the basin. Stations UI-103 and UI-102 are located along the drains halfway between the mouth and the head. Station UI-101 was placed near the mouth of the drain and is the most important station for verification.

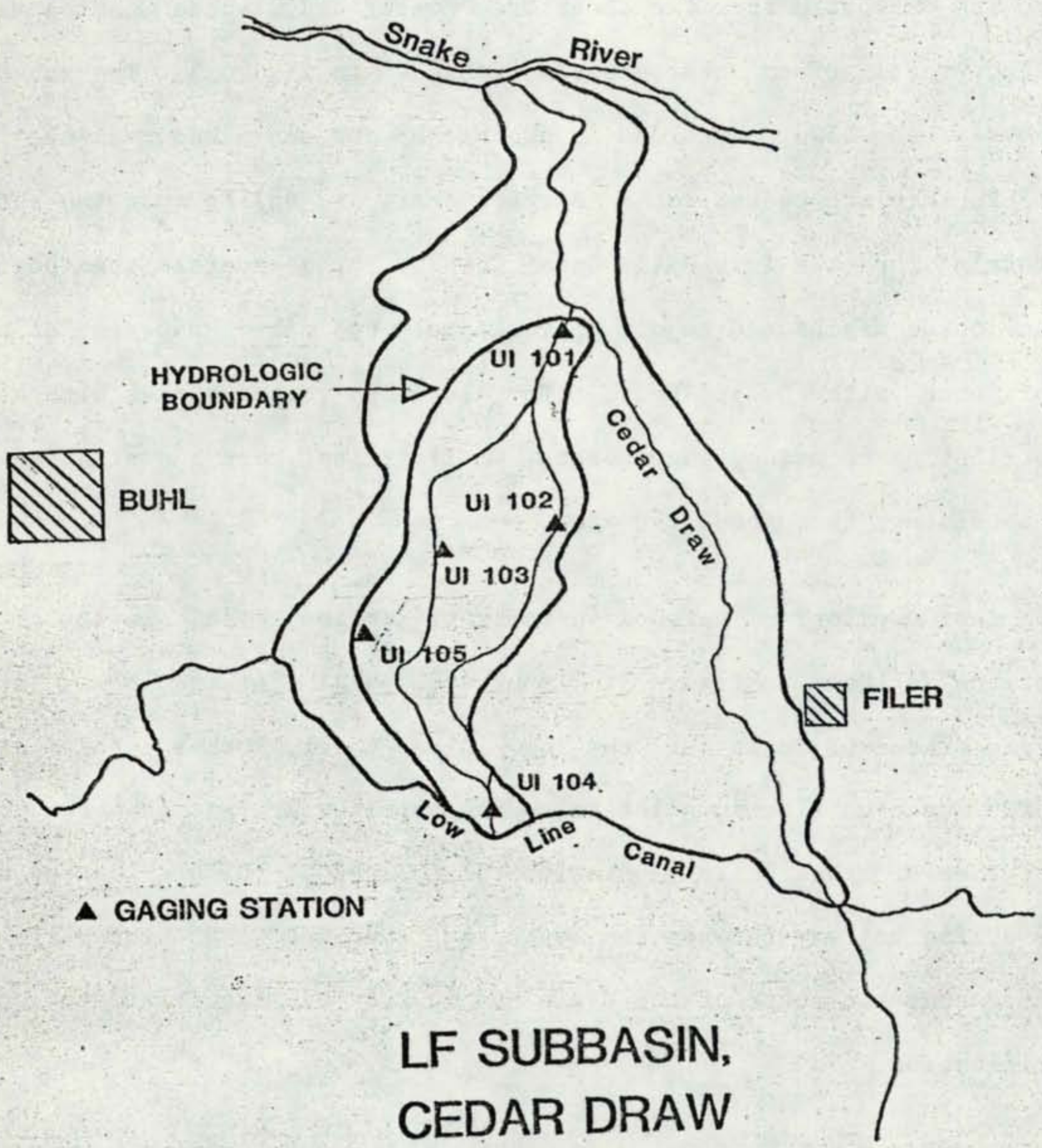

Figure 3. Cedar Draw Sub-basin Location Map and Monitoring Network.

PROJECT STATUS

Input, calibration, and verification data has been collected during the past year. The models have been selected and some intial testing performed. The suitability of the various models and of the initial study plans and methodology developed with the cooperators have been evaluated.

Data collection

Input Data

The input data requirements have been discussed with the co-operators. Methods for the data collection have been finalized. The topographical data will be taken from the two-foot contour maps supplied by the Soil Conservation Service (SCS). Cropping and BMP information will come from the Agricultural Stablization and Conservation Service and the SCS via the Economic Research Service.

Some data required for the routing model have been obtained from flood insurance studies performed by CH2M Hill Engineering (_____, 1981).

Calibration Data

Water quality data have been collected for calibration of the modeling package from the Rock Creek sub-basin since May. Figure 4 shows the accumulated flow and suspended sediment at station UI-001.

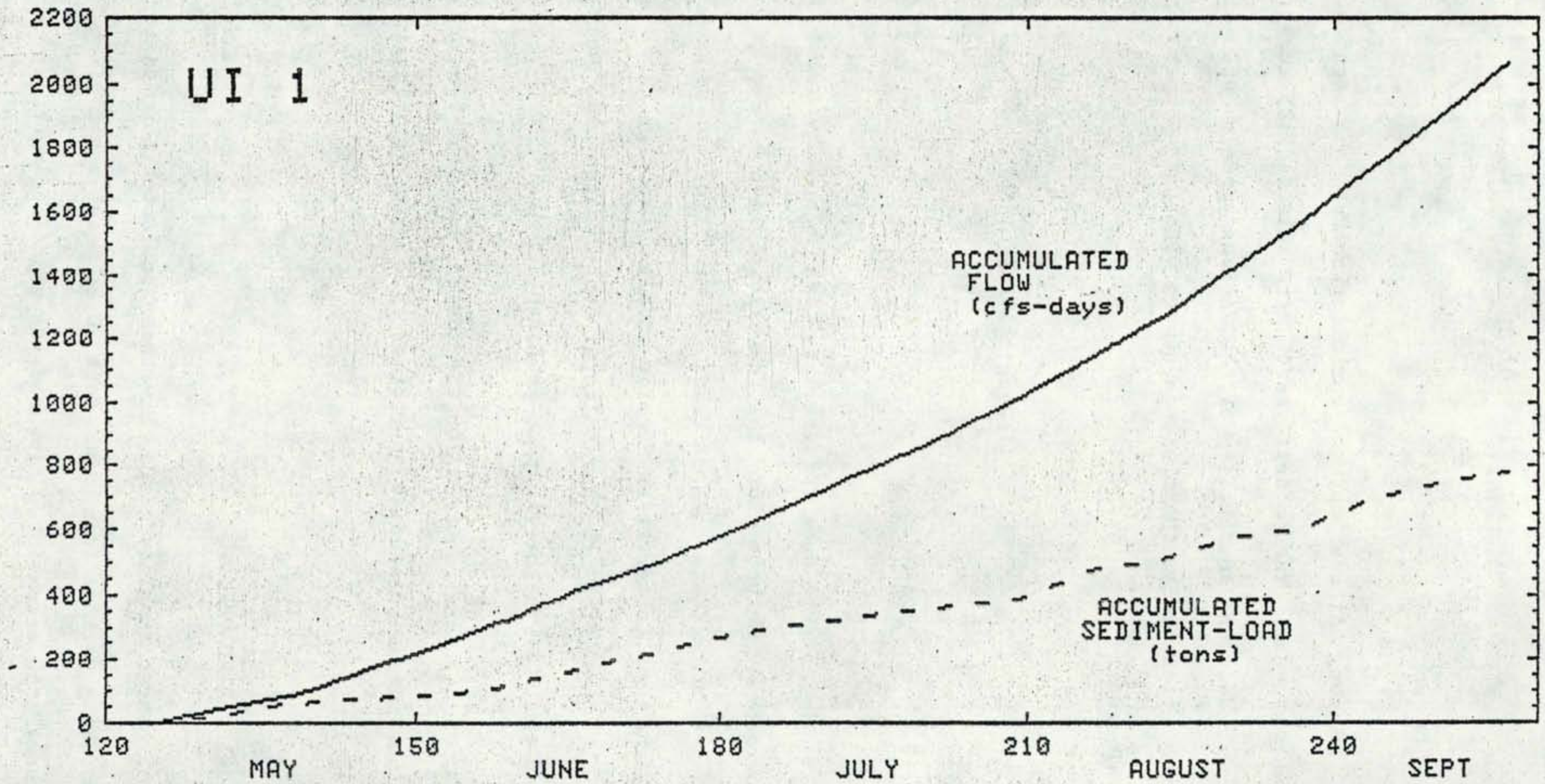

Figure 4. Accumulated Sediment Load and Flow for Station UI 1.

Over 2060 cfs-days of water passed the station carrying 780 tons of suspended sediment. At this station the flow varies from 2.5 cfs to 25 cfs with the suspended sediment load varying between 1.8 pounds per minute to 23 pounds per minute (Figure 5). There is no apparent relationship between suspended sediment and flow at this location as shown in figure 6.

At station UI-002 the accumulated flow and suspended sediment load was 2780 cfs-days and 950 tons respectively (Figure 7). The seasonal variation in the flow rate and the suspened sediment was 13 cfs and 25 pounds per minute as shown in figure 8.

Station UI-003 located on a drain entering the sub-basin shows a suspended sediment spike at the end of July (Figure 9). Over 810 cfs-days of water passed UI-003 carrying with it 450 tons of sediment (Figure 10). The 3 cfs variation in flow was small; however, the suspended sediment load variation was large, 33 pounds per minute, as shown in figure 9.

Verification Data

The verification data base from the Cedar Draw sub-basin is shown in figures 11 through 21. Inputs to the sub-basin are shown in figures 11 through 14. The water and suspended sediment loads passing station UI-104 and UI-105 were 9000 cfs-days with 3525 tons and 1850 cfs-days with 900 tons respectively (Figures 11 and 12). The seasonal fluctuations at UI-104 and UI-105 are shown figures 13 and 14.

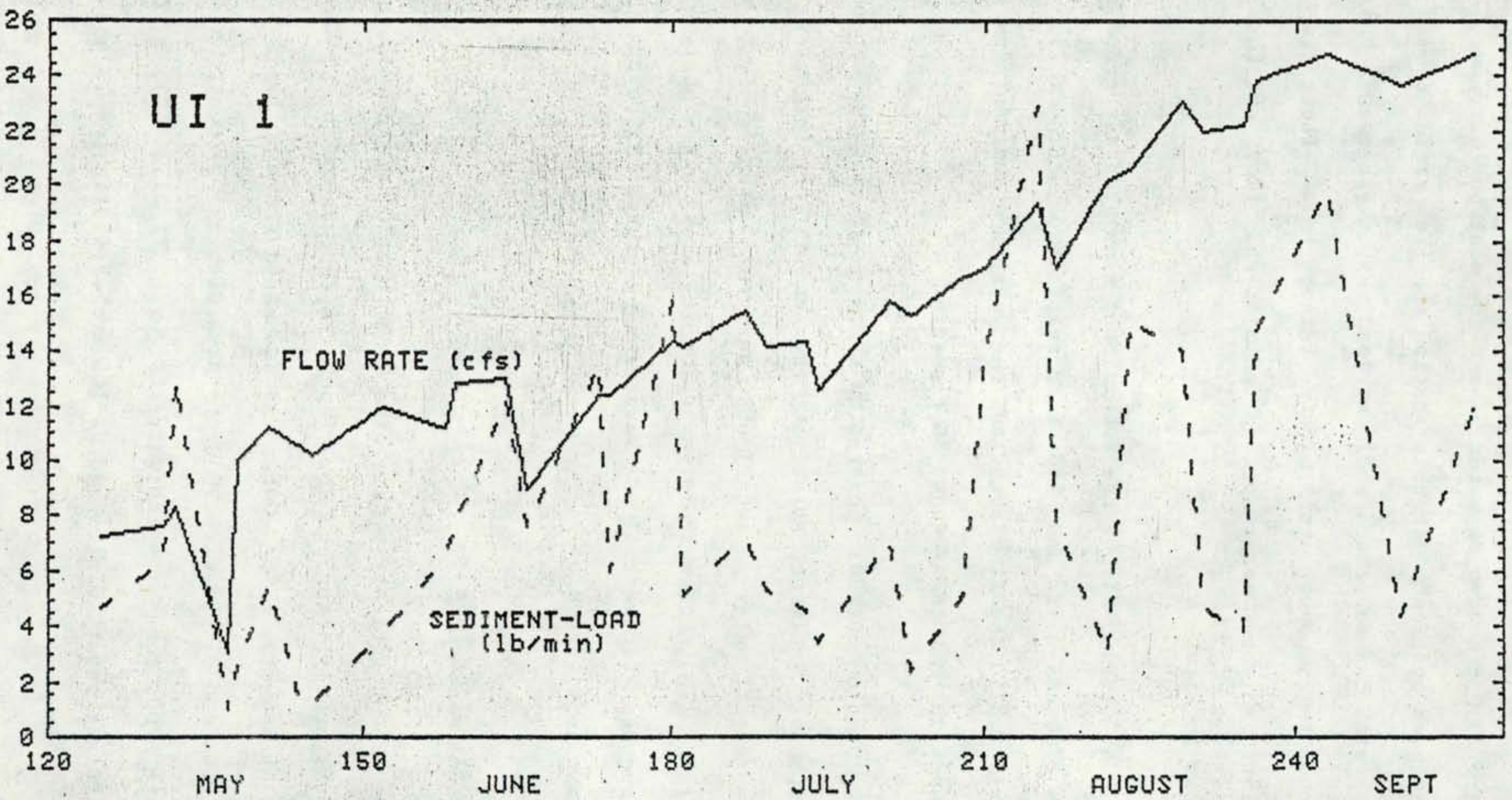

Figure 5. Hydrograph and Sediment Load for Station UI 1.

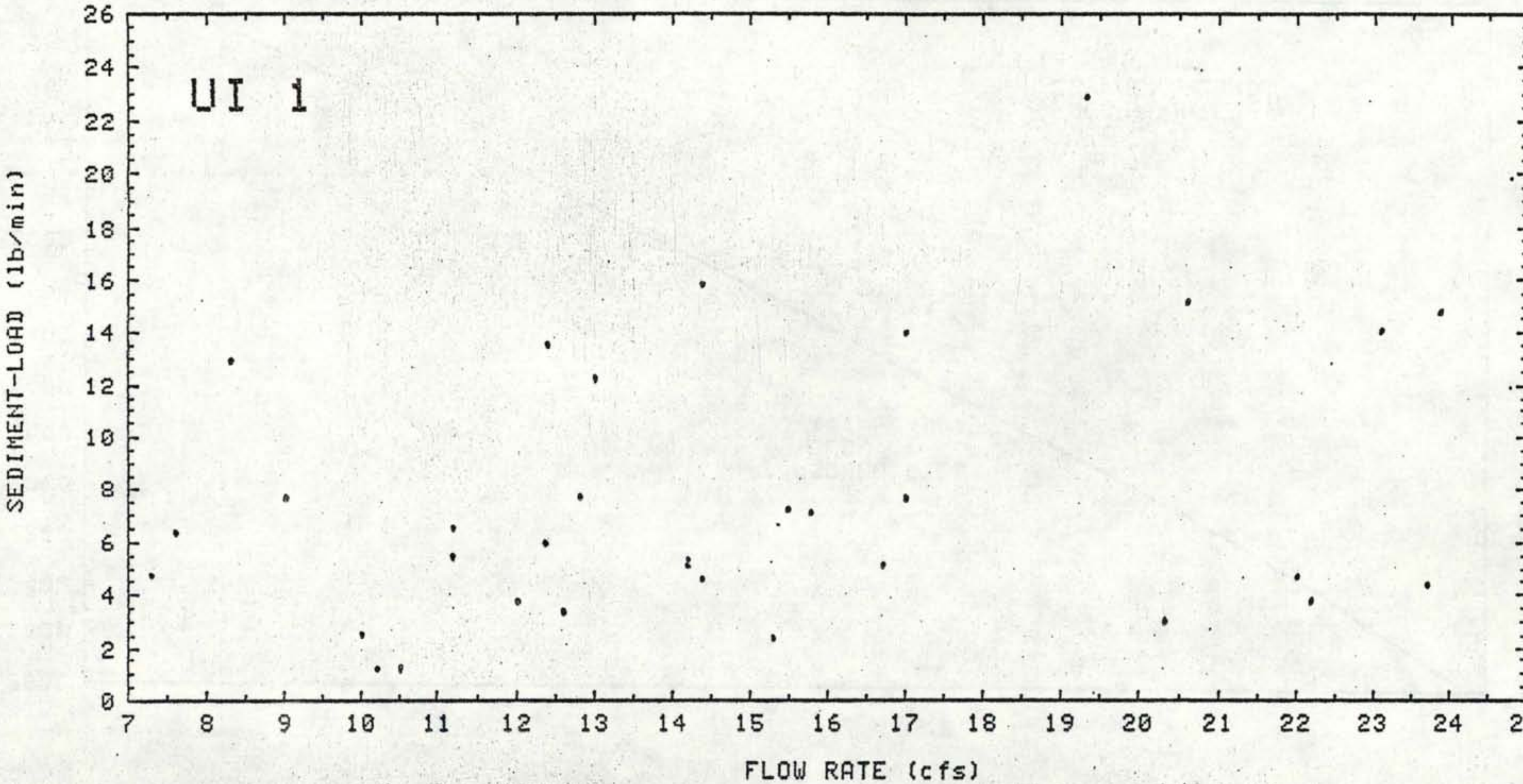

Figure 6. Suspended Sediment Load versus Flowrate for Station UI 1.

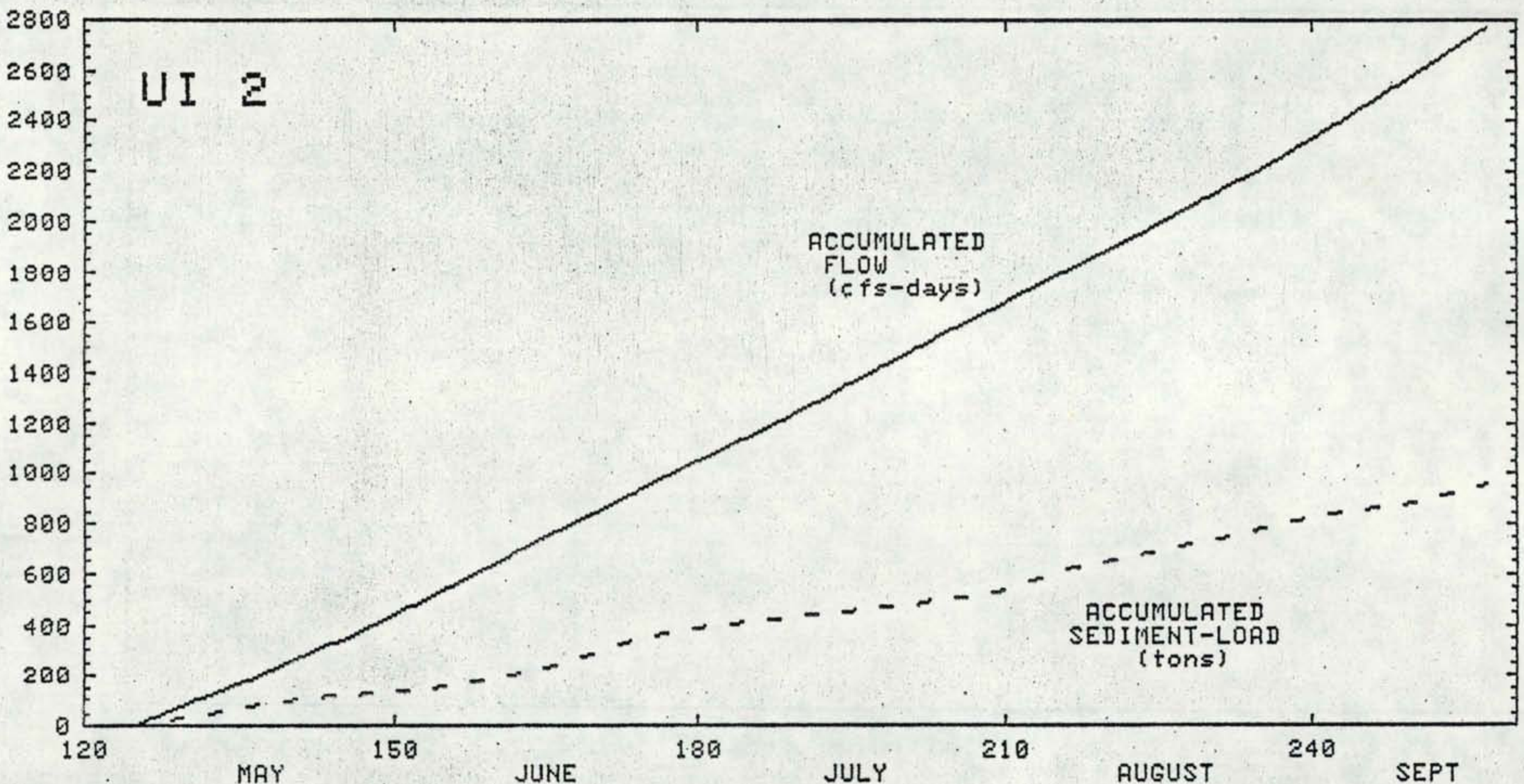

Figure 7. Accumulated Sediment Load and Flow for Station UI 2.

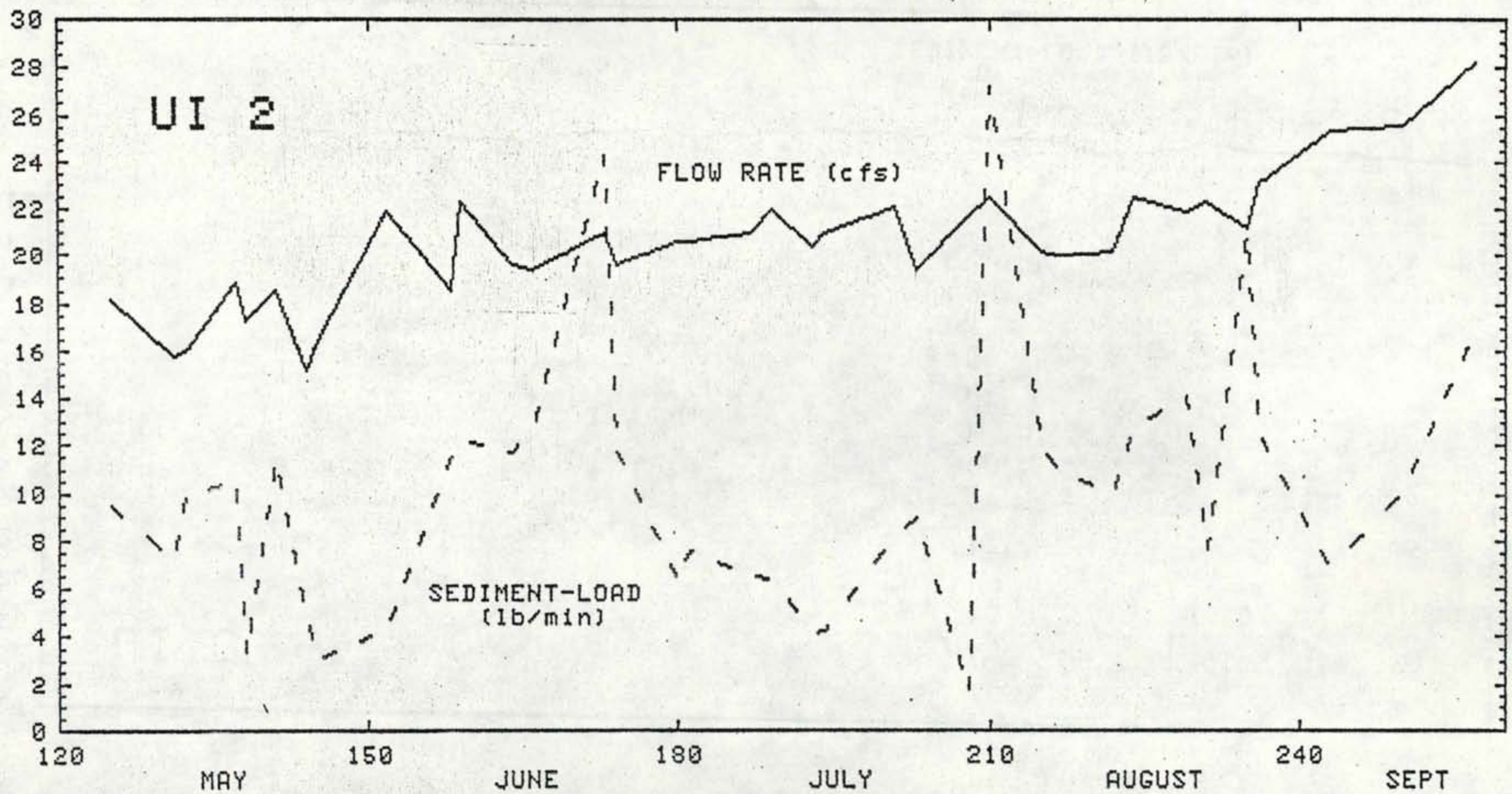

Figure 8. Hydrograph and Sediment Load for Station UI 2.

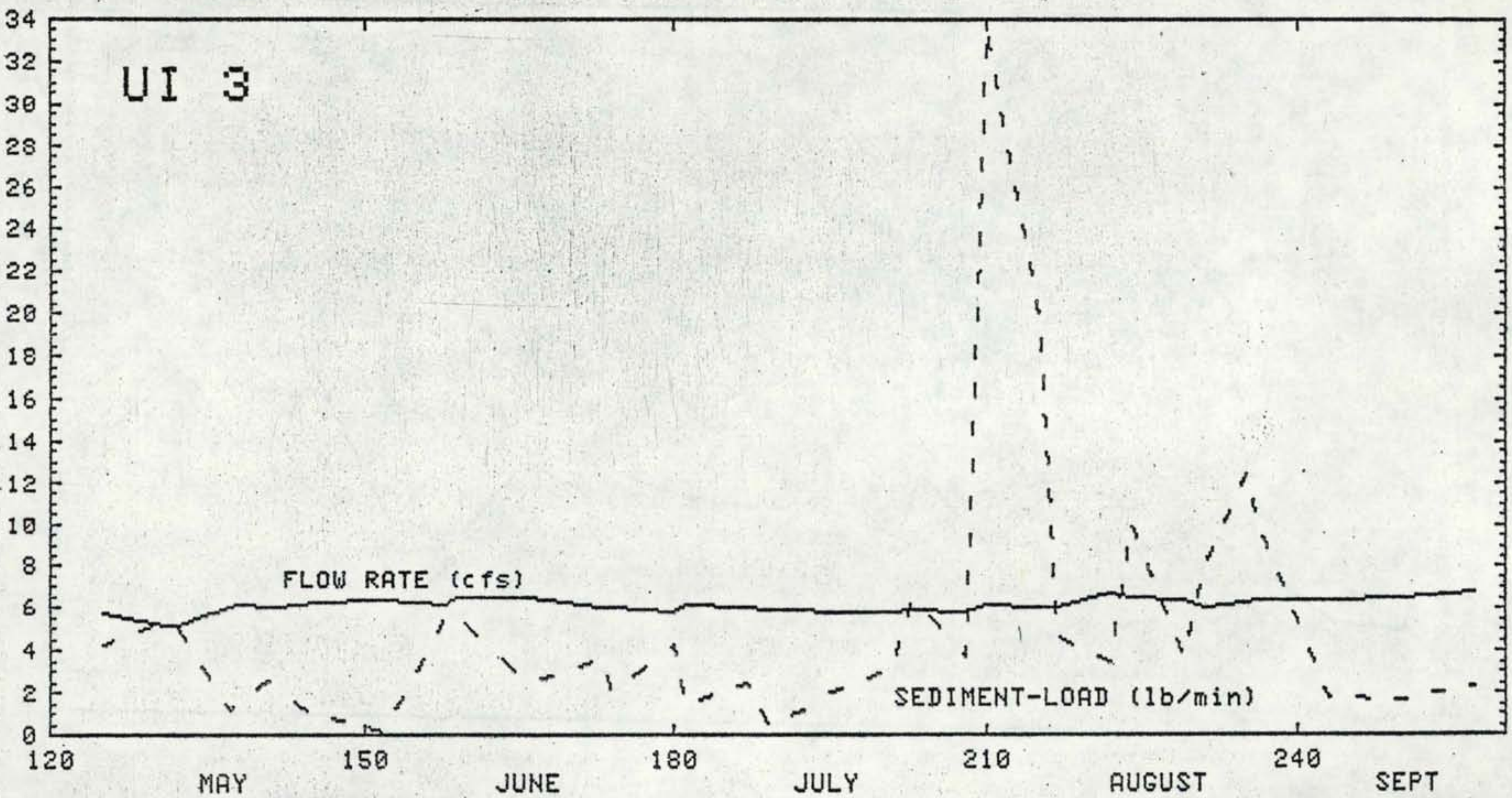

Figure 9. Hydrograph and Sediment Load for Station UI 3.

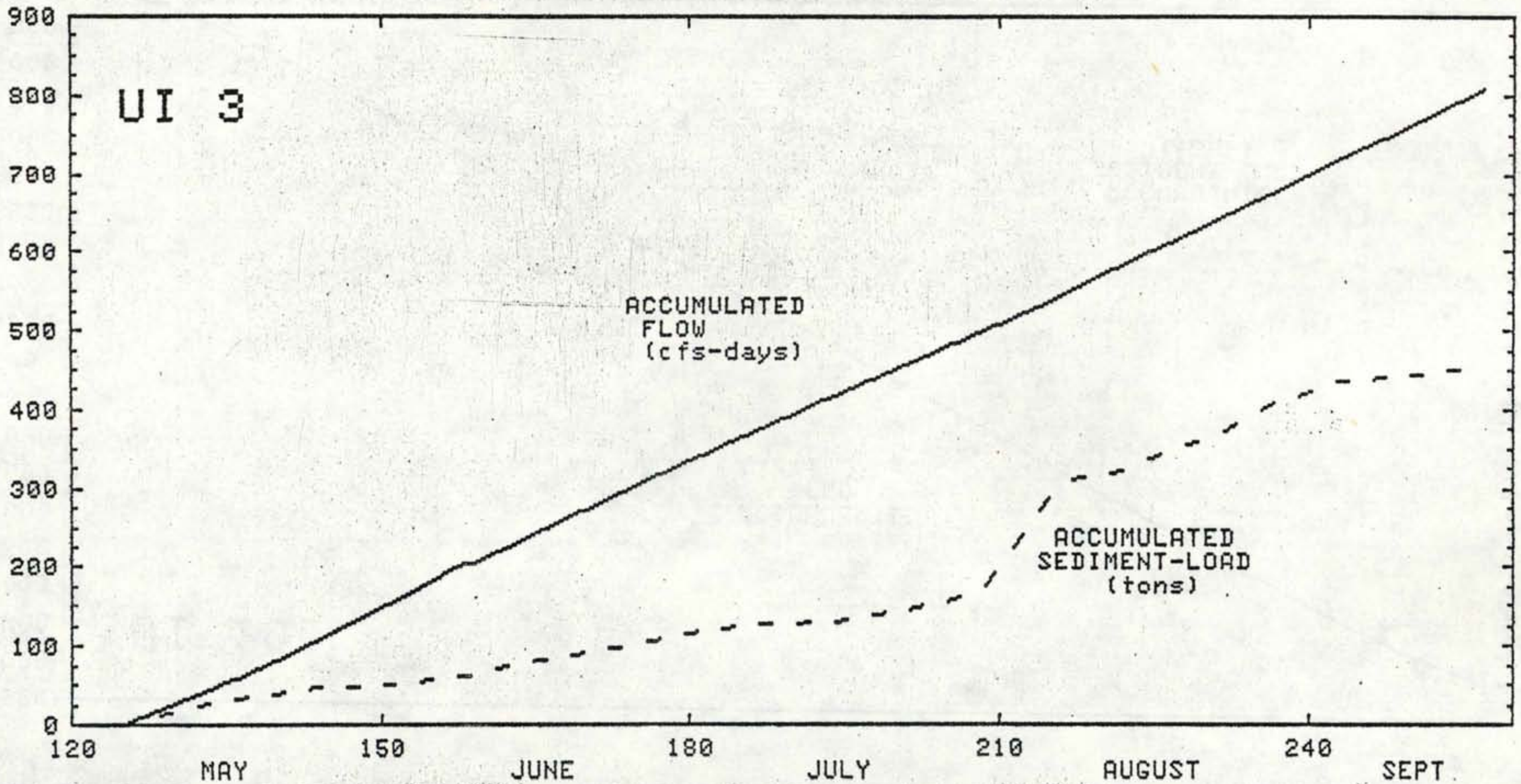

Figure 10. Accumulated Sediment Load and Flow for Station UI 3.

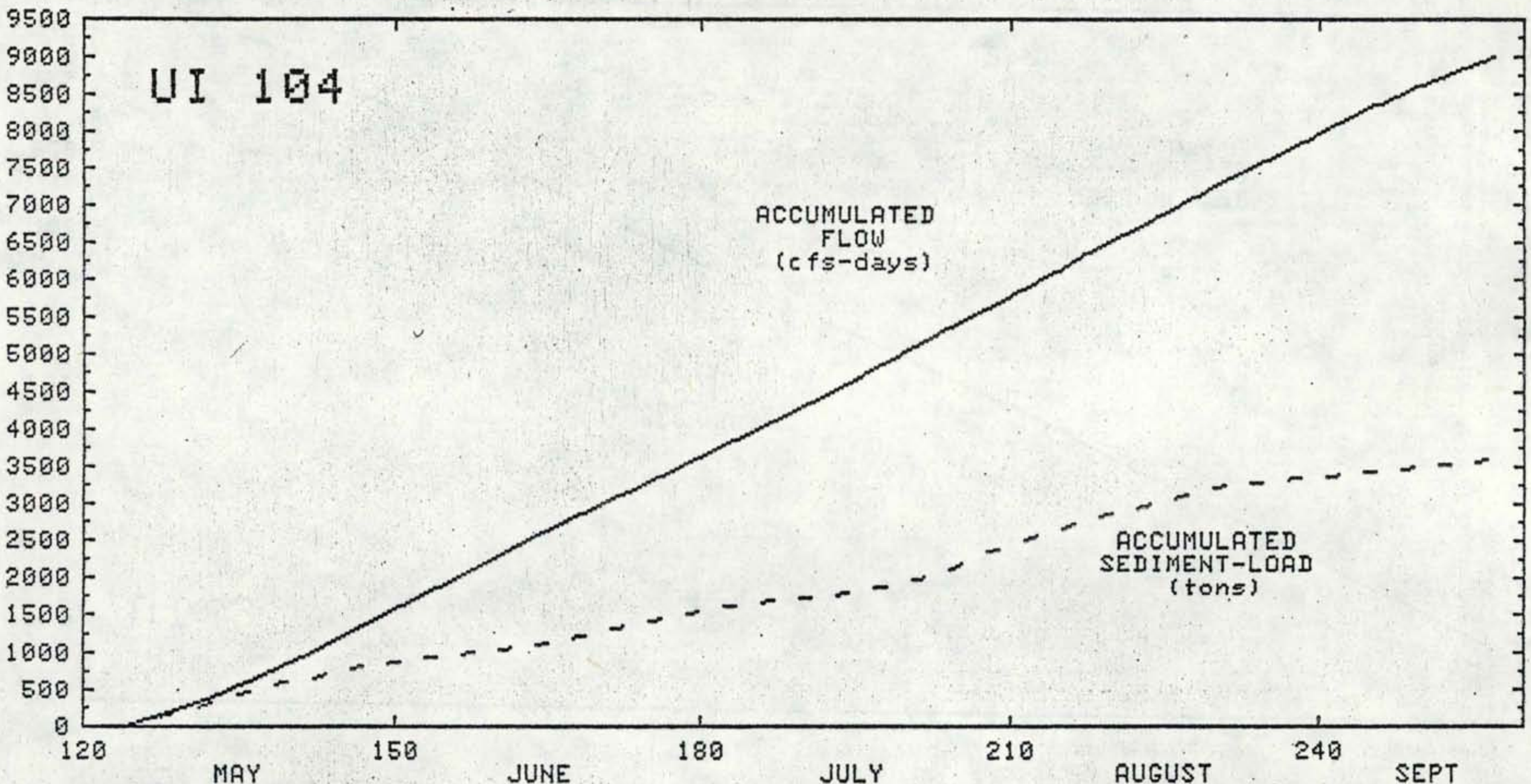

Figure 11. Accumulated Sediment Load and Flow for Station UI 104.

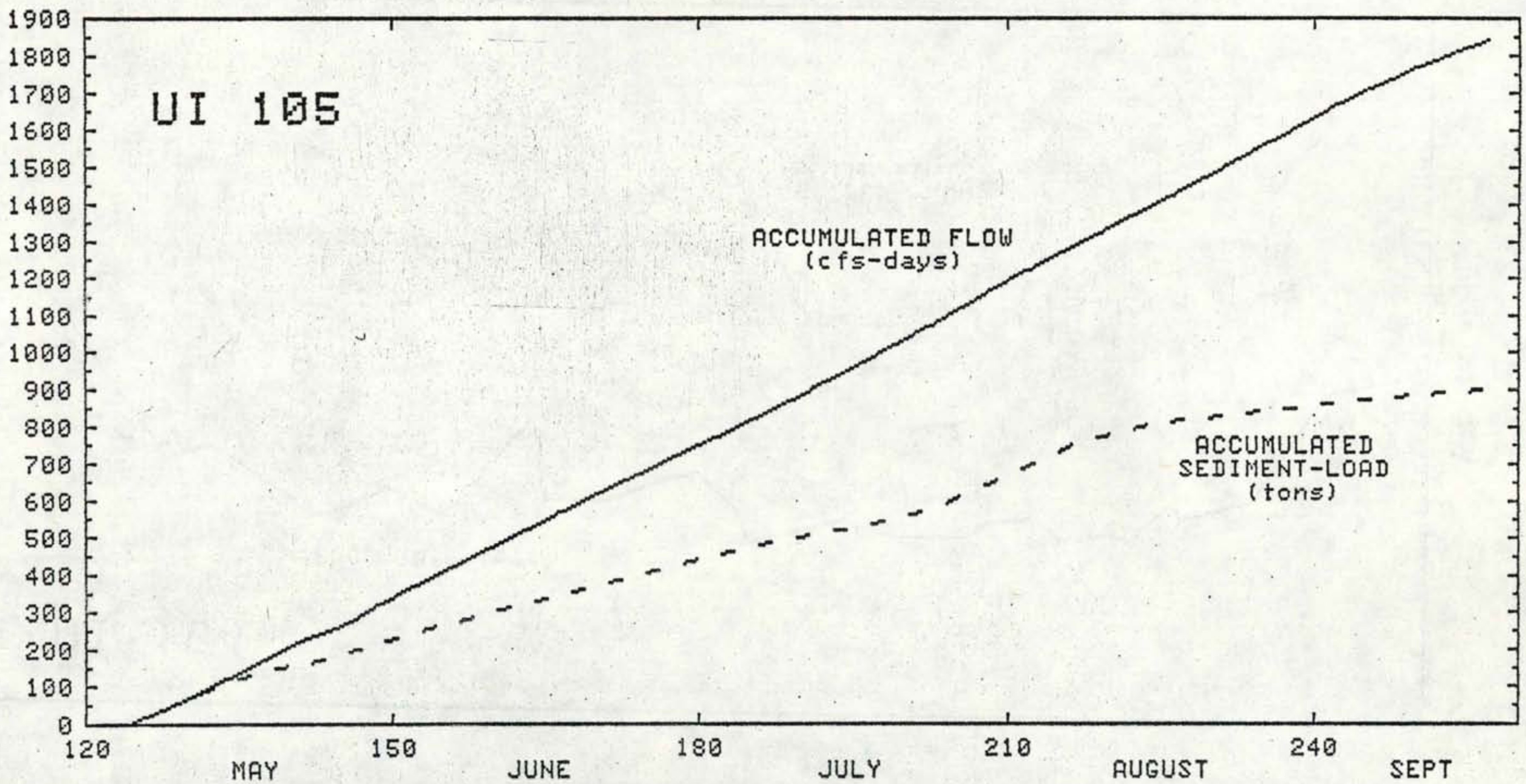

Figure 12. Accumulated Sediment Load and Flow for Station UI 105.

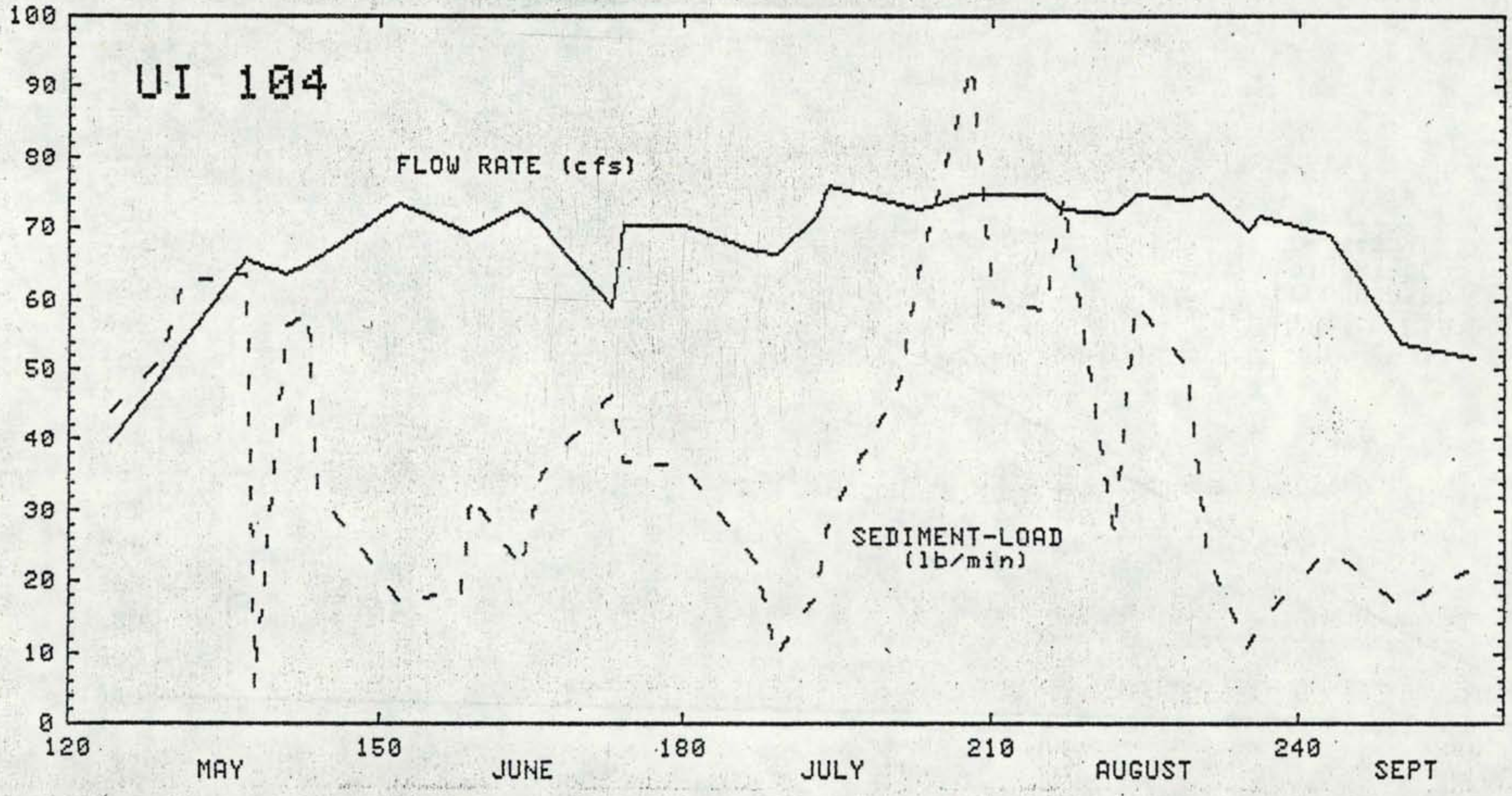

Figure 13. Hydrograph and Sediment Load for Station UI 104.

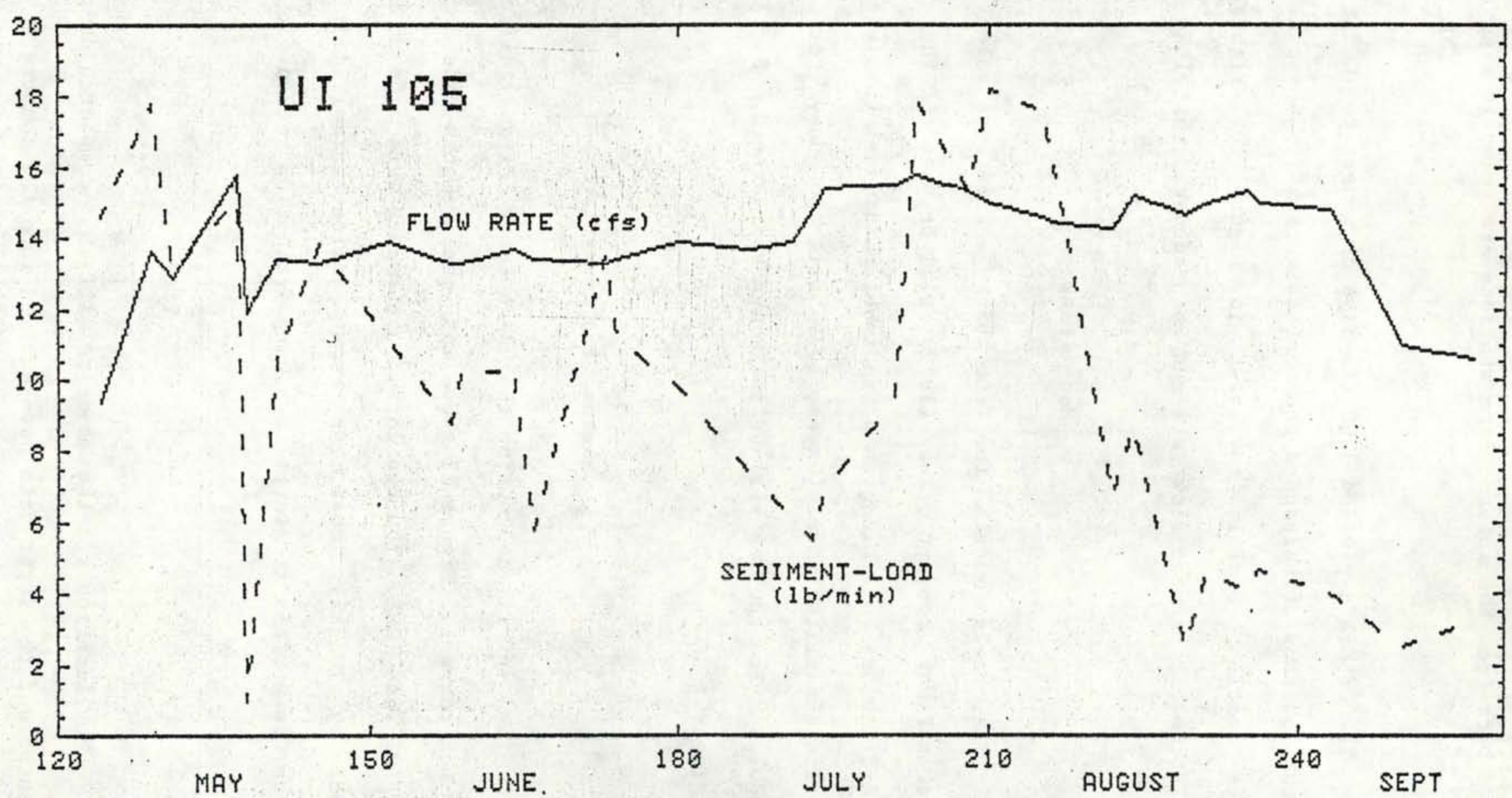

Figure 14. Hydrograph and Sediment Load for Station UI 105.

Data from the intermediate stations are shown in figures 15 through 18.

The LF drain yielded 3300 cfs-days of water to Cedar Draw along with 3750 tons of suspended sediment (Figure 19). Seasonal variation at this station, UI-101, is shown in figure 20. Figure 21 shows no relationship between flow rate and suspended sediment load.

Model Package

The basic models for the package have been selected. The Unit Stream Power concept, Yang (1972), will be used for the erosion model. Modifications of Lindgren's sediment pond model (Lindgren, 1978) and Barfield's filter model (Hayes, 1979) will be used for the treatment models. The routing will be performed using the U. S. Army Corp of Engineer's HEC-6 model.

Assumption Analysis

The initial assumption that Rock Creek has insignificant bed load is not correct. Figure 22 shows mass measurements made on Rock Creek by IWERRI and DOE. The bed load measurements were made on September 11, 1982 by IWERRI. These measurements indicate significant bed load in Rock Creek after it starts receiving irrigation return flow.

NEXT YEAR

Modification of the models will be completed during the winter months and the input data base entered into the computer. It is hoped

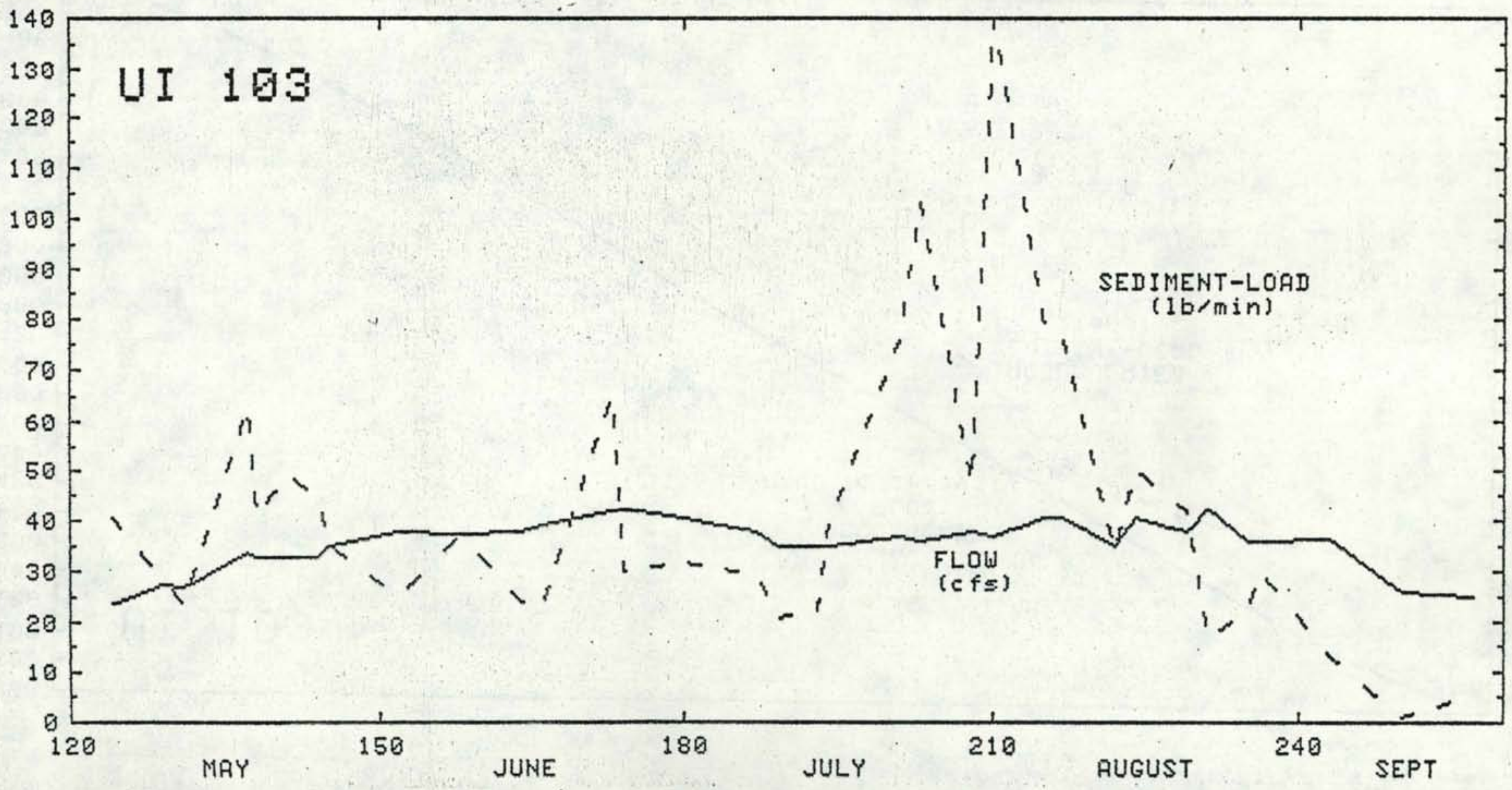

Figure 15. Hydrograph and Sediment Load for Station UI 103.

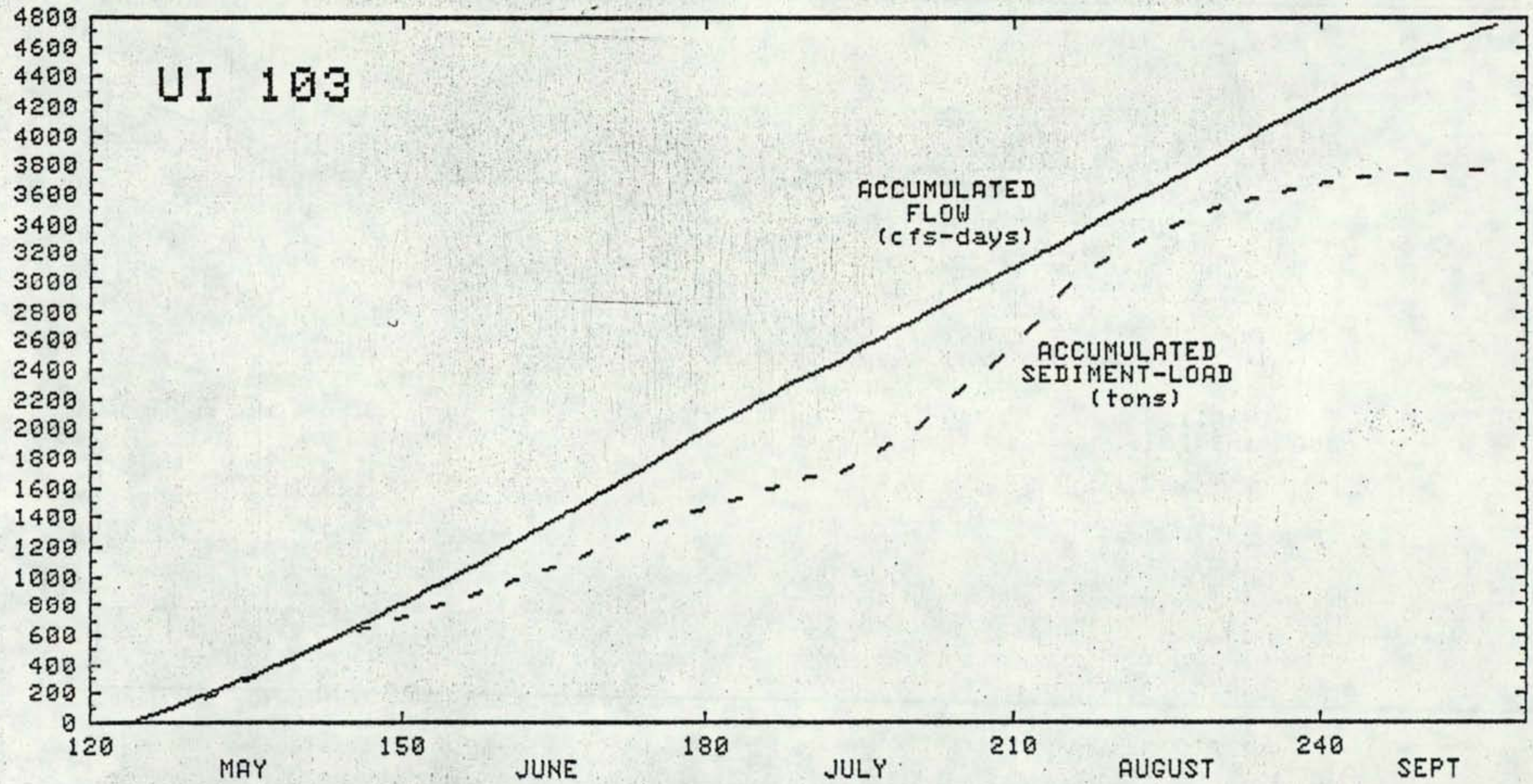

Figure 16. Accumulated Sediment Load and Flow for Station UI 103.

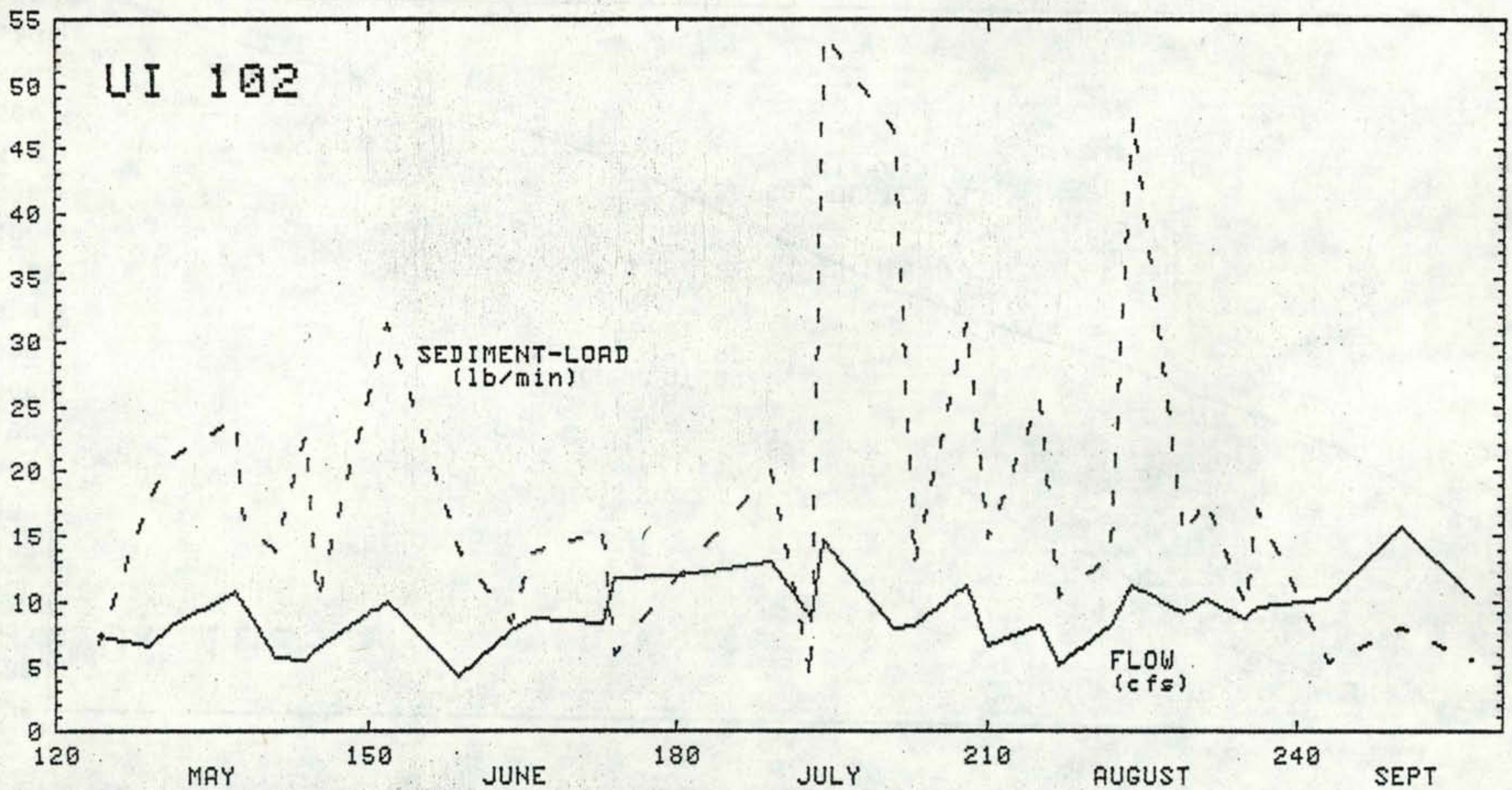

Figure 17. Hydrograph and Sediment Load for Station UI 102

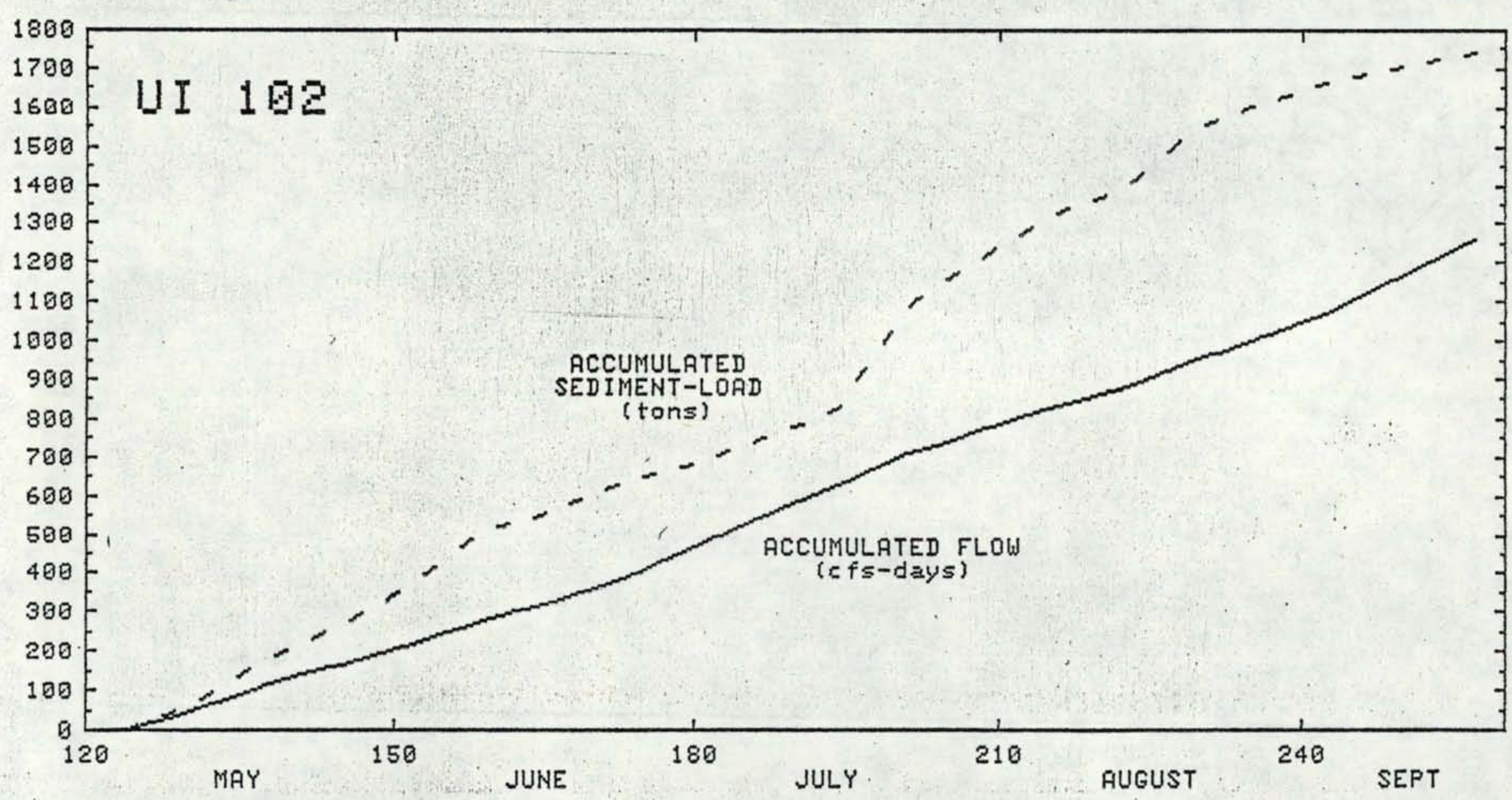

Figure 18. Accumulated Sediment Load and Flow for Station UI 102.

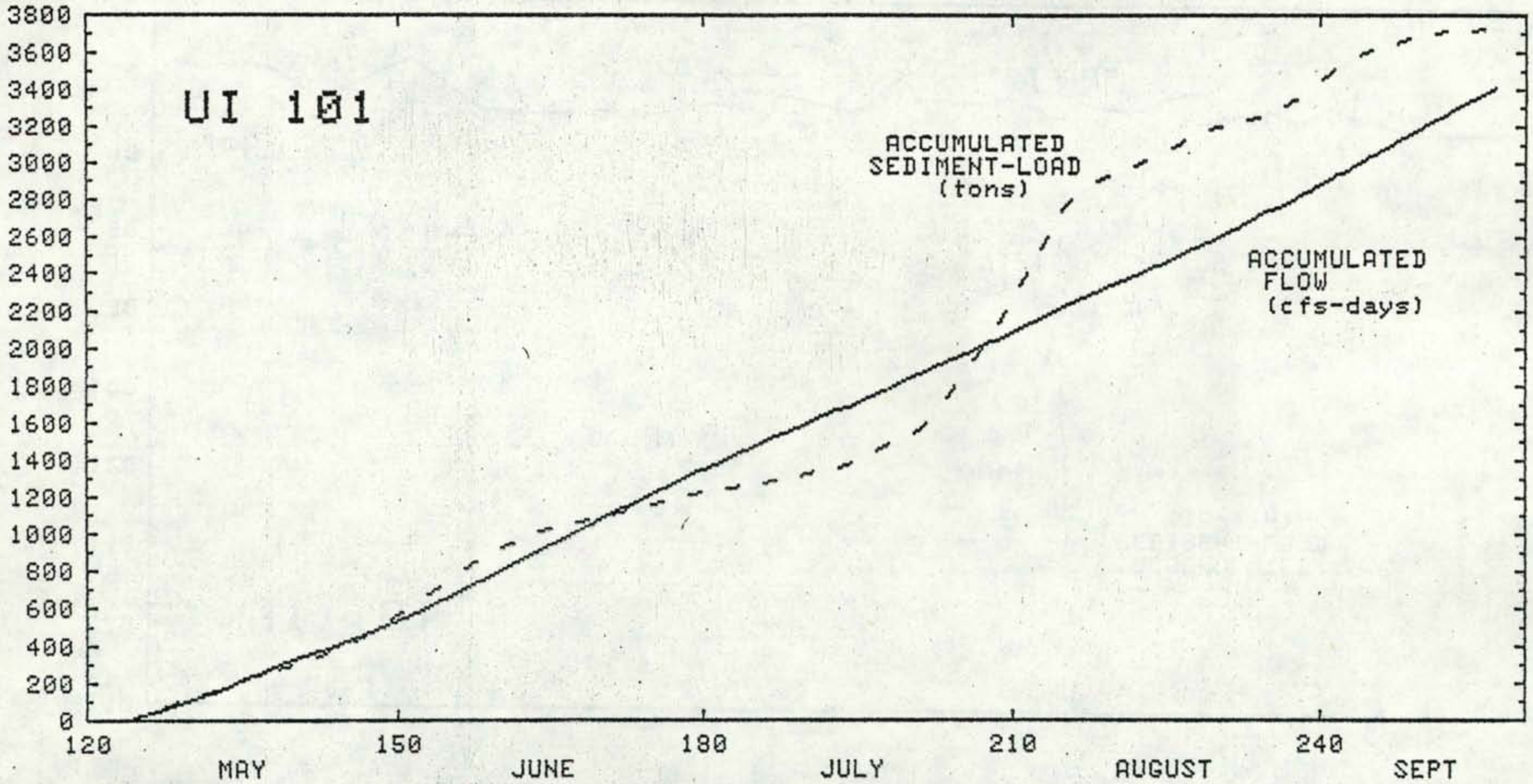

Figure 19. Accumulated Sediment Load and Flow for Station UI 101.

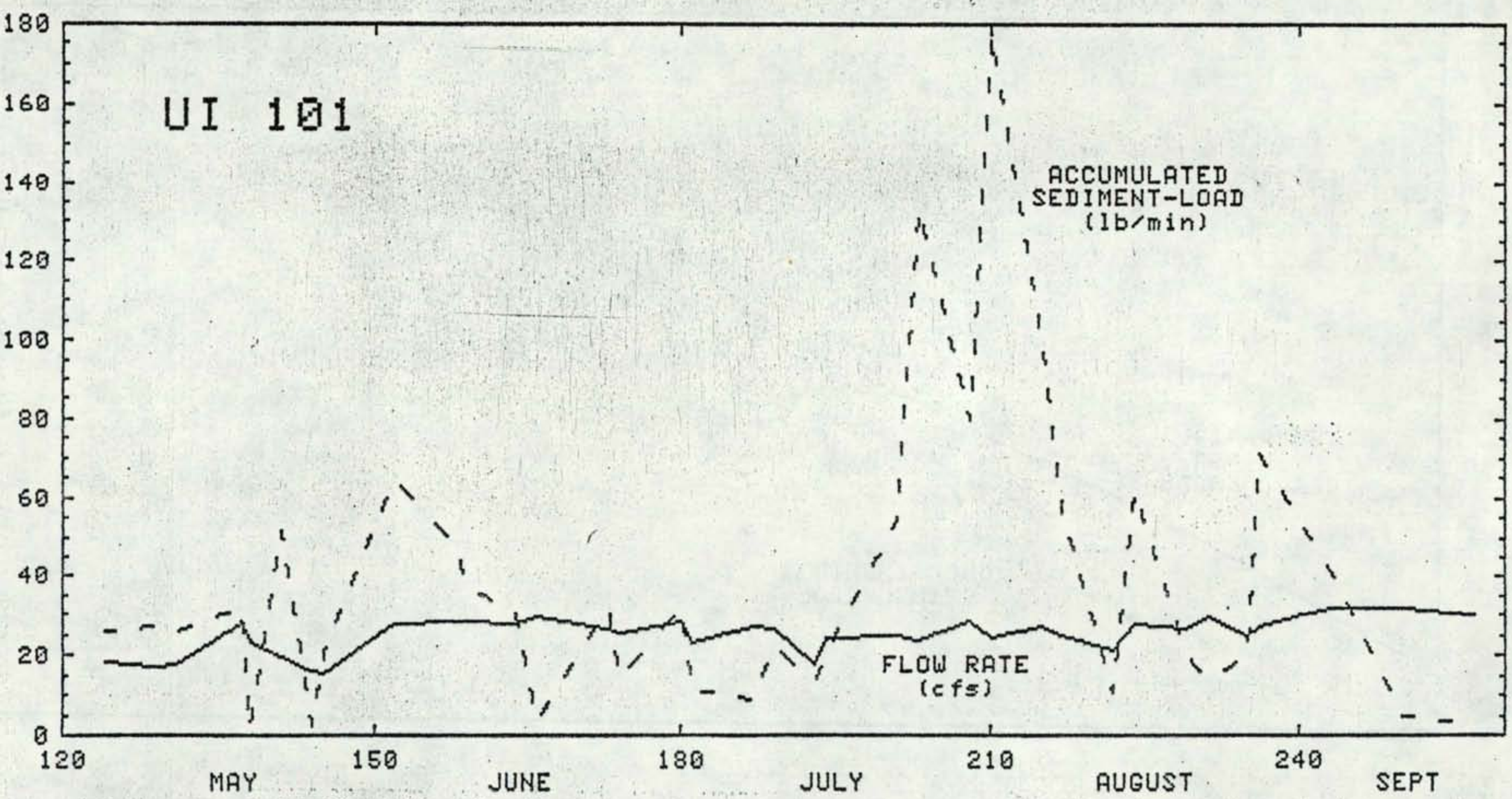

Figure 20. Hydrograph and Sediment Load for Station UI 101.

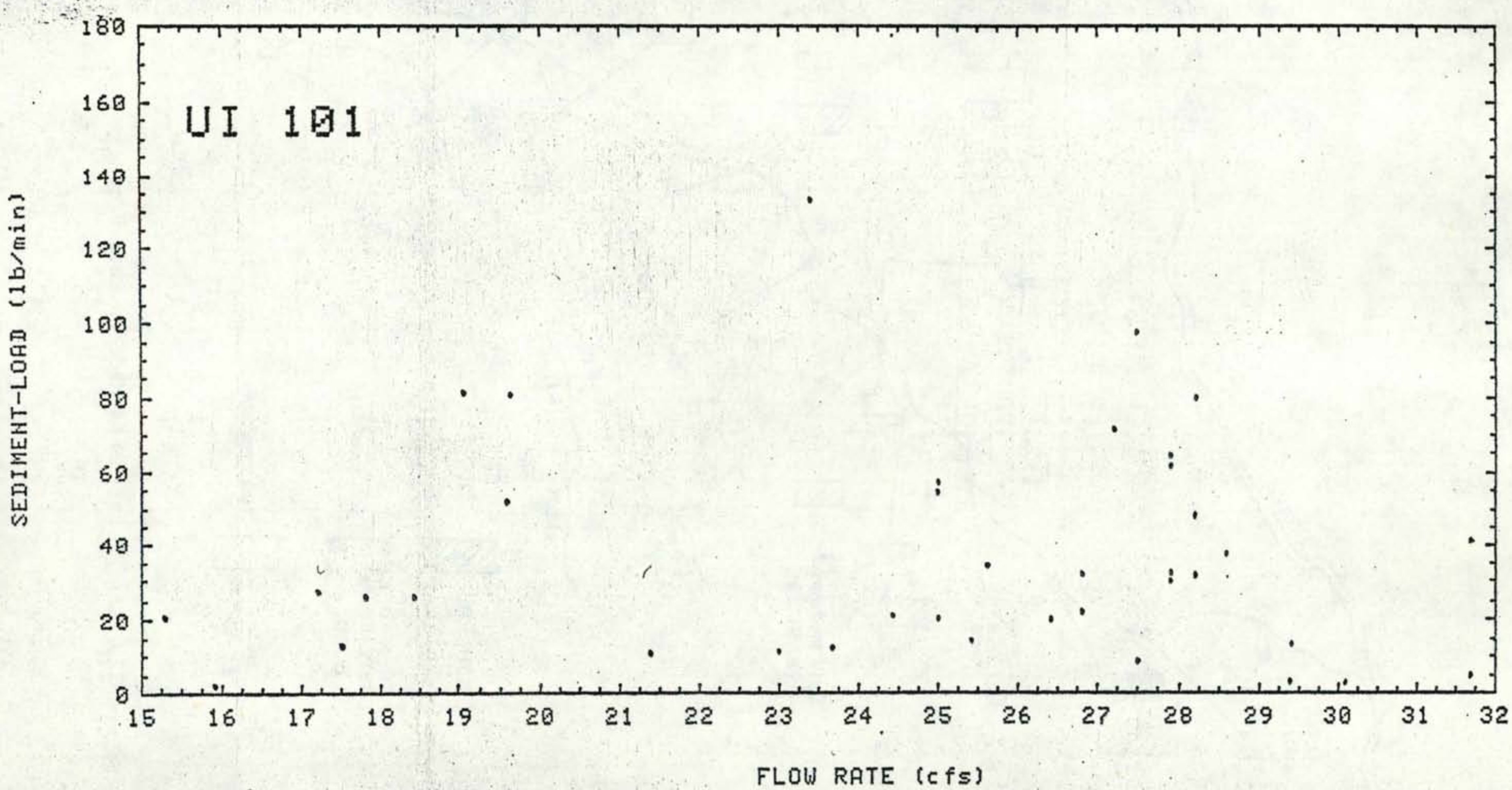

Figure 21. Suspened Sediment Load versus Flowrate for Station 101.

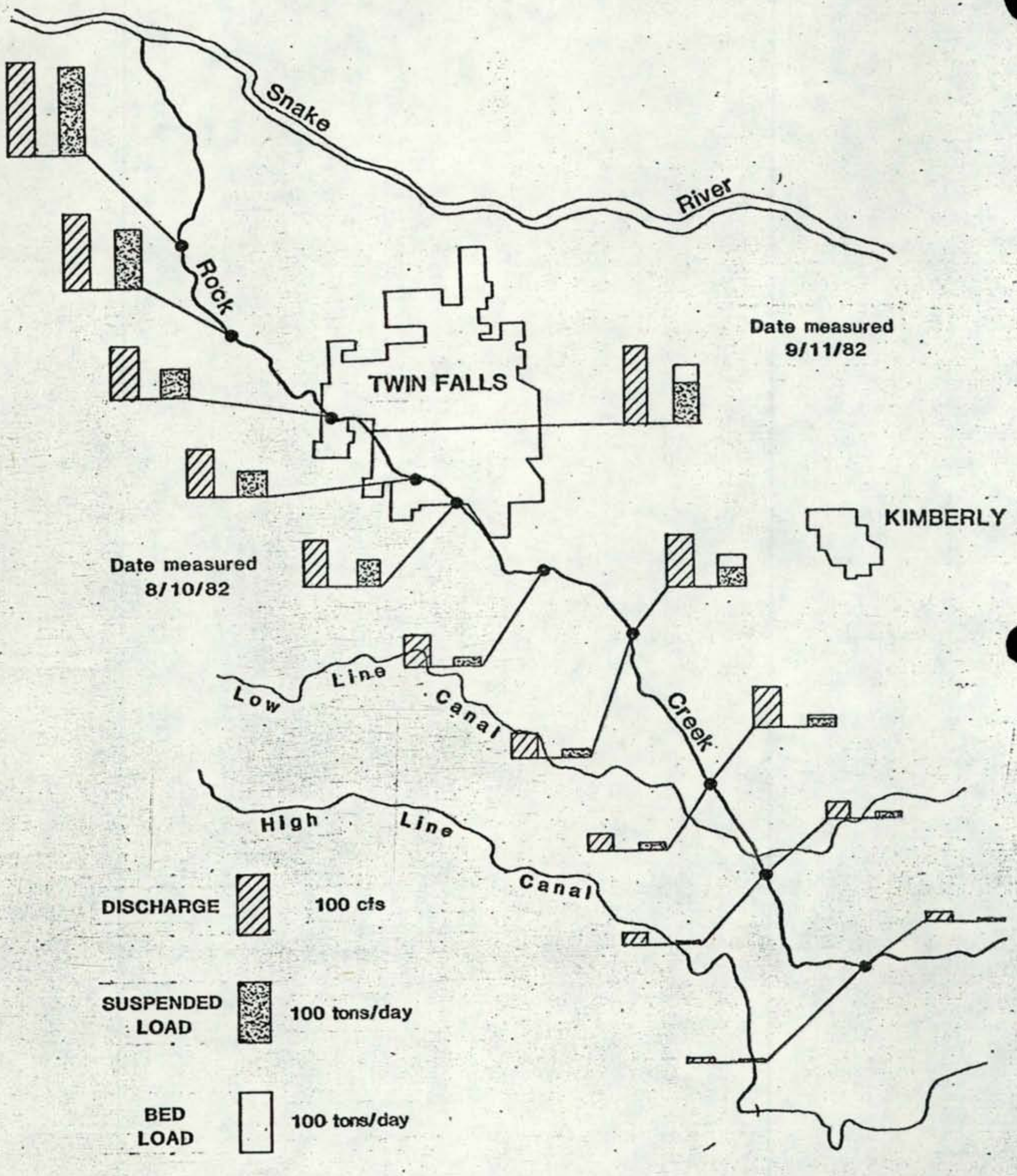

Figure 22. Mass Measurements Made on Rock Creek

to have the calibration of the model package in progress by February, 1983. Problems arising from the calibration will be evaluated and additional data requirements will be determined.

Data collection procedures will be revised to reflect this year's experiences and problems encountered during model calibration. Henceforth bed load samples will be collected from selected stations on a regular basis.

The verification of the model package will be performed after a successful calibration. If problems arise during the verification of the package the models will be examined for needed corrections and re-calibrated. The verified model package will then be used for forecasting the total Rock Creek watershed using different BMP implementation schemes.

EROSION MODEL

Selection and Justification

The key model in the package is the erosion and field irrigation model. The other models rely on the erosion model for the dynamic input of sediment load and flow.

Type of Erosion Model

The erosion model is built around a sediment transport equation. A furrow can be treated as a scaled down alluvial stream. Thus, the potential model is one which is adapted from routines which predicts sediment movement in alluvial streams with a minimum of input data. Yang´s transport theory is the concept chosen for the erosion model.

Yang´s transport concept is known as the unit Stream Power Transport equation, which simply compares the available energy in a flowing stream to a critical energy level for sediment movement. This is different than most sediment transport equations which compare tractive bed forces against a critical value. The basic form of the equation is:

$$\log (C) = A + B \log (VS - CVS)$$

where:

C is the total sediment concentration

VS is the stream power defined as average water velocity times energy slope.

CVS is the critical stream power

A and B are coefficients describing particle sizes and depth of flow.

Physical Basis

The stream power concept is based on energy availability. The only source of energy in a stream is the energy of the water-sediment mixture above a datum. and it´s velocity head. The stream power (VS) has been defined by Yang (1972) as the time rate of energy expenditure per unit weight of water. Under steady-state conditions the stream power is expressed as the product of velocity and slope of the water surface.

Part of the stream power is used for transportation of the sediment and part is used through dissipation of frictional heat. The stream power available must first be used to satisfy friction losses then to transport the sediment load. If the energy available for sediment movement is insufficient, deposition will result, and, if in excess, erosion will occur. Thus, a critical stream power is established.

Data Requirements

The velocity in the furrow is dependent on the geometry, flow rate, slope, and the roughness of the furrow. The model requires the following infomation: furrow flow, rate, furrow geometry, furrow slope, furrow roughness, and soil particle size distribution.

Accuracy of Erosion Model

The stream power concept accuracy reported by Yang was excellent for alluvial streams. The correlation coefficient associated with this concept when tested with flume data and actual streams ranged from .90 to .97 (Yang, 1972).

Predicted versus Measured

The stream power equation adequately describes the "steady-state" portion of runoff leaving a furrow. Longley (1978) reported on his application of the concept to fields in the LQ Drain watershed. Figure 23 shows his results on a typical field and the model output. The measured field data showed a sediment concentration of approximately 3500 mg/l in the later part of the irrigation. The model also predicted

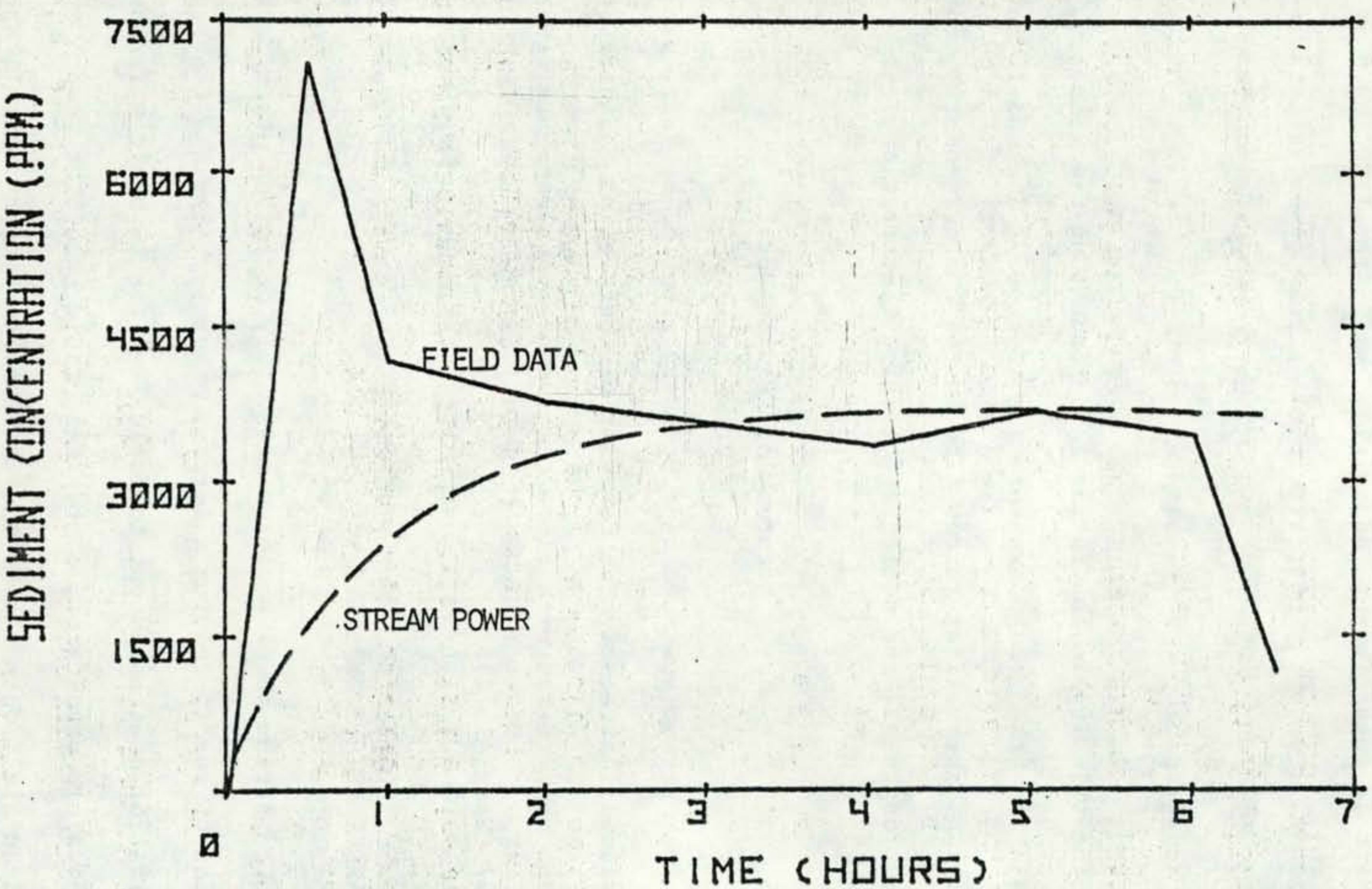

FIGURE 2.3. Typical Sediment Concentration vs Time for a 6-hr Irrigation on Portneuf Silt Loam Soil. (Longley, 1978)

approximately 3500 mg/l. Currently, the model is being evaluated using a bean tillage study data set which shows that the total sediment concentration varies greatly as shown in figure 24 and 25. The total sediment concentration is shown by the solid line, the maximum and minimum concentrations are shown by the dotted lines and one standard deviation from the mean is plotted with the dashed line. The sample size from the bean tillage study was 27 plots consisting of two furrows each.

The stream power model does not accurately predict the sediment concentration at and near the beginnng of the runoff event. The problem was described by Longley (1978) and is currently being evaluated. This appears to be the major problem with utilization of the stream power function.

Sensitivity of Variables

The model appears to be most sensitive to the furrow slope followed by the roughness flow rate, and channel geometry roughness. Table 1 shows the predicted sediment concentration variation when the input parameters are varied by 20%. The critical input variables, slope and Manning's n, have the most effect causing a variaition in sediment concentration of 39 and 22 percent respectively. The other parameters caused a variation in concentration of less than 7 percent.

Future Plans

The segments of the model related to the start of runoff will be modified. It is hoped that a factor describing soil erosivity,

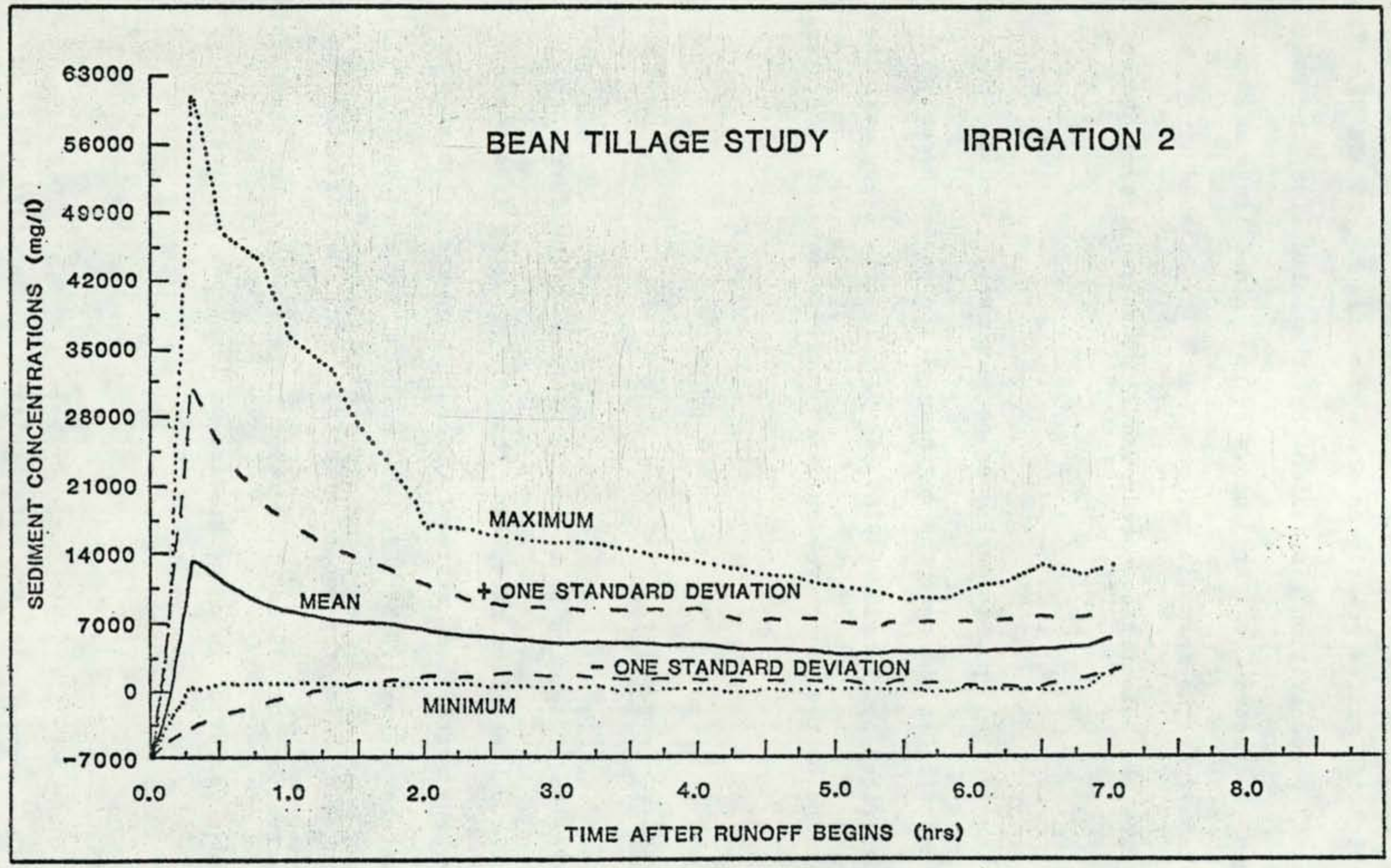

Figure 24. Erosion Model test data set from the bean tillage study irrigation 2.

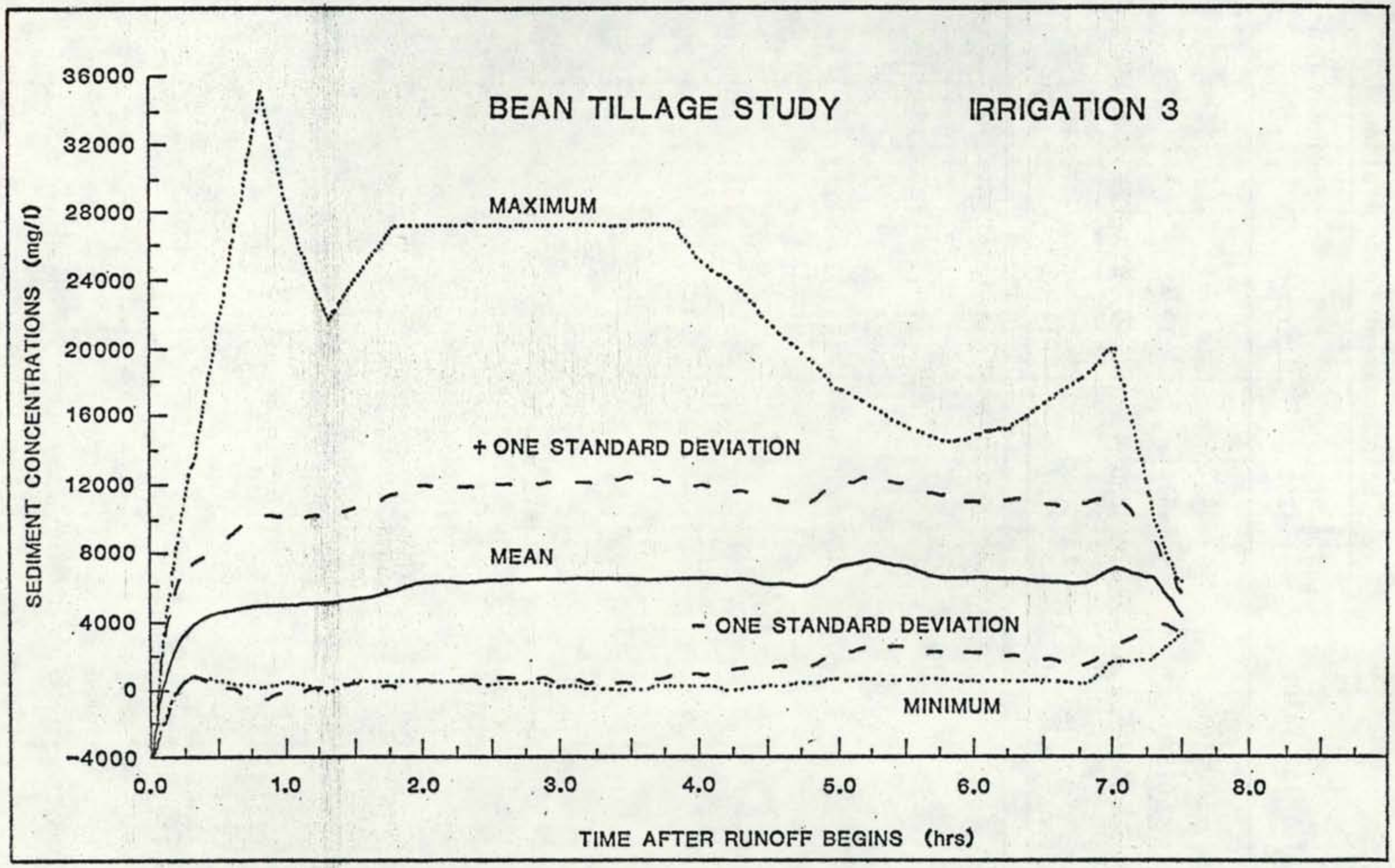

Figure 25. Erosion Model test data set from the bean tillage study irrigation 3.

TABLE 1. Erosion model sensitivity.

Variable	Base Value	Sediment Conc +20%	% Error	Sediment Conc -20%	% Error
		Base Sediment Concentration 3239 mg/ℓ			
Flowrate	.005 cfs	3462	6.9%	3162	-2.4%
Slope	.015	4514	39.4%	2299	-29. %
Mean Particle Size	.008	3236	-0.1%	3249	+0.1%
Manning's n	.020	2767	-14.6%	3962	+22.3%

irrigation number, and/or tillage will improve the model results. The model then will be coupled to the furrows irrigation water movement model.

TREATMENT MODELS

General

The runoff treatment portions of the model package will be operated separately. When a cost share BMP treatment is installed it is required to meet a certain sediment removal efficiency. The treatment models will be utilized to evaluate and predict reasonably expected removal efficiencies. Once the efficiency of a practice is established; that efficiency will be used to modify the loading predicted by the erosion model.

Filter Strips

Status

The model for filter strips is not yet operational at Kimberly. The selected model was developed at the University of Kentucky by Barfield and Associates (Hayes, 1979) for treatment of runoff from surface mines. Because of differences between suspended solids and flow regimes, the model is undergoing calibration for irrigated agricultural strips.

Future Plans

It is expected to have the calibration completed next spring. Then the model will be tested for sensitivity of the input variables and receive modifications on data input and output. Several different data input and output level options will be developed to create a user friendly model.

Sediment Basins

Status

The sediment basin subroutine is operational but has not yet been modified. Using T. R. Camp's idealized settling basin concept the subroutine was developed under the direction of Brockway and Watts by several graduate students (Lindgren, 1980).

Future Plans

The subroutine's input and output formats will be modified to be compatable with the rest of the treatment models. Again several different levels of input and output will be developed for different user requirements.

Water Management Practices

After discussion with RCWP personnel, it was decided by IWERRI to forego the development of these routines. The major problem was the lack of criteria for defining the implementation of a IWM practice.

Changes in irrigation systems, ie., changing slopes and run lengths, will be modelled.

Other Treatment Practices

Status

These models have not been developed; however, most detention type or a filter treatment can be evaluated by using versions of existing models.

Future Plans

The sediment basin model will be revised to handle the detention practices such as buried drains, mini basins, I-slots, and T-slots. Other practices which are similar to filter systems will be handled by a modification of the filter model.

ROUTING MODEL

Introduction

The sediment routing model will enable the evaluation of changes in water and sediment flow regimes in surface return flow streams resulting from the implementation of various sediment control practices or water management programs on irrigated farmland within a watershed. The primary objective of the routing model is to enable the prediction of water quality in receiving streams as a result of various BMP implementation schemes. A secondary objective of the routing model is to be able to simulate and predict changes that may occur in the receiving stream channels themselves, due to changes in sediment loads and hydraulic loads that result from implementation of BMPs.

Model Selection

To meet the desired objectives, a model must be developed to evaluate the effectiveness of BMP implementation. There are several possible approaches to development, one is to make some simplifying assumptions about the system being modeled. For this case, a simplifying assumption might be that all of the generated sediment is routed as suspended load with no possibility for deposition or scour along the way. It might also be assumed that the receiving stream is straight and constant in cross section, or that the channel has a completely rigid boundary with no sediment generated from the channel banks or bed. Assumptions as gross as these make a routing model unnecessary since all sediment generated would pass through the system.

Another possible means of meeting the desired objectives of the routing model is to adopt and modify existing sediment routing procedures. There have been several sediment routing routines developed previously, although most have been developed for a specific purpose or location, and would be difficult to modify so they would satisfy the objectives of this project. However, a model developed by the Army Corps of Engineers, HEC-6 (_____, 1977), is versatile enough that it could be used with little modification as a routing routine for this project.

HEC-6

HEC-6 is a simulation program designed to analyze scour and deposition by modeling the interaction between the water-sediment mixture, sediment material forming the stream's boundary, and the hydraulics of flow. It is not designed as a sediment yield program; it simulates the ability of the stream to transport sediment. Nature maintains a delicate balance between the water-sediment mixture flowing in a natural stream, the size and gradation of sediment material forming the stream's boundary, and the hydraulics of flow. When man changes the sediment and water inputs into a stream that balance is upset. This computer program can be used to measure the impact of changing one or more of the above parameters.

HEC-6 is a large and somewhat cumbersome model. Even in studies involving a fixed bed, open channel hydraulics problems require large amounts of data. Extending solution techniques to include a movable boundary is an even greater task, because not only do data requirements increase, but the body of theory available to describe the physical process is not complete. The level of sophistication of HEC-6 is necessary so that important distinguishing features of a stream will be recognized and treated. This allows the model to be easily utilized for a variety of streams.

An important advantage of HEC-6 over other models is its flexibility. It is important to use a model that can be directly applied to a study rather than one that requires modification before use.

Detailed sediment studies require large amounts of data, whereas more general cases involve studies with limited amounts of data. is available. Lack of required data diminishes the flexibility of a program. It is important to use a model that can be directly applied to a study rather than one requires the study to be simplified and approximated in order to fit the requirements of a computer program. HEC-6 overcomes this limitation by internally generating much of the required data, subject to being overridden if such data are available. This permits the program to be used for detailed studies while at the same time not requiring a high level of detailed data before the program can be applied. Of course, the results are no more dependable than the data used to obtain them.

HEC-6 does have some limitations. For example, it cannot simulate stream meandering and channel bends, often a source of significant sediment loads due to bank erosion as well as a location for sediment deposition. Lateral distribution of sediment across a stream also cannot be simulated. The procedure of moving the entire movable bed vertically up and down when scour or deposition occurs might also be considered a limitation. Probably the most serious limitation of HEC-6 is the inability to re-entrain silts and clays once deposition has occurred. Most of these limitations would be taken care of by a new version of HEC-6 currently being developed. This latest version of HEC-6 is expected to be available in the very near future, and can hopefully be incorporated into the model for this project.

Other Possibilities for Modeling

Several models other than HEC-6 were considered for routing. One model that showed promise and had an advantage over HEC-6 in that it has stream widening capabilities was the FLUVIAL model (Chang, 1982). However, the high cost of running this model was felt to be prohibitive. Sediment routing procedures in the CREAMS (Knisel, 1980) and SEDLAB (Borah, 1981) models were also considered, but it appeared that these routines did not consider all significant variables and therefore, did not meet the requirements for this project. A final possibility for routing is to develop an entirely new routing model specifically for this project; however, this was felt to be unnecessary since HEC-6 seems to meet necessary criteria for a good routing model.

Model Calibration

In order to ensure that the routing model will give satisfactory results, calibration must be performed. The general approach to calibration of the model consists of collecting actual input data, running the model to obtain a theoretical output, and comparing this output to what was actually measured or observed in the field. The model must then be modified and adjusted, and the above procedure repeated until the model predictions satisfactorily match what actually occurred.

To determine whether the model has been properly calibrated, criteria must be established to provide a basis for comparison of model output to actual occurrences. For this study, total sediment load has been selected as the primary criterion. Along with matching the total sediment loads the sources of the sediments and the predicted channel changes will be used to determine the accuracy of the model simulation.

Calibration of the model may prove to be difficult for several reasons. One reason is that changes in a stream usually occur very slowly, often over a period of many years. Since detailed data have not been collected for many years, and since all of the stream changes may not occur within the life of this project, past and future sediment loads and channel changes may have to be estimated.

Another problem in calibrating the model is the difficulty in measuring certain parameters. As is the case in nearly all sedimentation studies, measurements of sediment loads and channel changes are very crude and often inaccurate. The accuracy of the model can be no better than the accuracy of the data used for calibration. By the same token, the accuracy of the routing model can be no better than the accuracy of the input data.

Difficulties in calibration also arise due to the amount of input and output that are required. For example, describing 15 miles of Rock Creek geometrically requires a very large amount of data. These data are necessary for predicting changes in channel geometry. An equally large body of new data is necessary to verify the calibration constants used in the model. For a detailed study this degree of verification is probably not practical. For this reason only those output parameters that can be conveniently measured and evaluated will be used for calibration.

Data Collection

To provide a means of calibrating the routing model, data have been collected on Rock Creek during the 1982 rrigation season. General characteristics and detailed data have been obtained so that both the hydraulics and the sedimentation of Rock Creek could be simulated.

General Characteristics of Rock Creek

Rock Creek within the study area can be divided into three reaches in which the flow and sediment regimes are distinctly different. Because of these differences, treatment by the model will probably not be the same in each reach.

The upper reach, extending from the southeast boundary of the study area to near the Low Line Canal Siphon, can be characterized as gently sloping with a strong tendency towards meandering. Discharges are low with very little suspended sediment. The canyon is shallow, bordered mostly by pasture land. Sediment is readily available in bank materials which are well graded from cobbles to fine sands. The stream bed is well armored with coarse gravel. Meandering has caused significant bank erosion and deposition in many places.

The middle reach extends from near the Low Line Canal Siphon, downstream to Pole Line Road. Slopes are fairly steep with varying sections of smooth and rough channel. Discharges are much greater than in the upper reach, due mainly to irrigation return flows. Suspended sediment concentrations are high enough to give the water an opaque tan color. The canyon is fairly deep and narrow in this reach and is bordered by agricultural, industrial, and residential development. In the canyon, Rock Creek is bordered by natural cover and pasture land composed of fine silts. Sediment is readily available in a few areas where severe bank erosion is occurring. Portions of the reach have gravelly, unarmored movable beds, while in other sections the streambed is bedrock.

Below Pole Line Road, Rock Creek becomes very steep and rough. The stream is generally wider, shallower, and faster flowing than in the middle reach. Discharges and suspended sediment concentrations are higher, again due to irrigation return flows. The canyon becomes quite deep and narrow in this reach, and access is very limited. The stream bed and stream banks are mostly rock and talus slopes. Detailed geometric data have not been collected in this reach, since nearly all of the sediment reaching this point will pass through with very little chance for deposition, and since very little material is available for scour.

Data Requirements

Data required for the routing model can be categorized as one of three types; geometric data, sediment data, and hydrologic data. Geometric data include cross sections, reach lenghts, and n-values, existing at the beginning of the study. Some data has been obtained from CH2M Hill Engineering as part of a flood insurance study (____, 1981) for approximately 10 miles of Rock Creek. Additional geometric data must still be collected for about 6 miles of the upper part of Rock Creek.

Sediment data consist of inflowing sediment load information, gradation of material in the stream bed, and information about fluid and sediment properties. Some of the data have been collected throughout the summer, and the rest of the data are to be generated by other portions of the modeling package. Data collected so far however, have shown that further study of Rock Creek sediment loads may be warranted.

Hydrologic data required include water discharges, temperatures, and flow durations. Some of the data have been collected and are available, while other data must still be obtained. A comphrensive summary of the data collected to date appears in Table 2. Routing data that must still be collected appears in Table 3.

Areas For Further Investigation

When the study plan and the data aquisition plans for the project were developed it was assumed the bed load in Rock Creek was negligible. Measurements taken this fall indicate a significant portion of the total sediment load in Rock Creek is bed load. In most cases, the bed load quantity is somewhat less than the suspended load in terms of both weight and volume. Most of the bed load is probably not due to irrigation return flows, since the particle sizes are too large. The bed load presents a difficulty in that it may not be possible to define changes that occur in the stream channel as a result of reduced sediment loads from farmland if the majority of the changes are due to bed load.

The existence of several small drains spilling over the canyon rim and into Rock Creek is another discovery that could be of major importance in this study. These small drains, though running

TABLE 2. Rock Creek sediment routing data collected to date.

GEOMETRIC DATA	
Cross sections	Meandering and straight reaches
Reach lengths	Bank erosion areas
Manning's n-values	Movable bed locations
Major tributary locations	Channel bottom profile
Major sediment deposit locations	Water surface Profiles
SEDIMENT DATA	
Suspended loads	Depth of deposits
Bed material gradations	Layering effects of deposits
Channel armoring effects	Preliminary bed loads
HYDROLOGIC DATA	
Flow hydrograph at mouth	Flow hydrographs at tributaries

Table 3.

Rock Creek Sediment Routing Data Still to be Collected and Calculated

GEOMETRIC DATA

- Cross Section
- Reach Lengths
- Manning's n-values

SEDIMENT DATA

- Sediment loads at low Q, very dirty tributaries
- Bed loads
- Gradations of bed and suspended loads
- Sediment specific gravity
- Age of sediment deposits

HYDROLOGIC DATA

- Water temperatures

intermittantly and draining only a few fields, deliver a significant quantity of suspended sediment to Rock Creek. Some of these have been sampled and have shown sediment concentrations typically 10 times as high as in major drains. The difference in water quality upstream and downstream of these drains is readily apparent. To date it is uncertain how many of these types of drains exist, but locating and monitoring them could be difficult, These drains could play a major role in sedimentation of Rock Creek, and further study seems to be necessary.

OPERATION OVERVIEW

Sub-model Interaction

The model package will consist of several subroutines in addition to the major sub-models. The first subroutine will be an input program for preparing the actual input data base for the physical characteristics of the watershed. Another subroutine will develop the BMP data base.

Once the physical and BMP data bases have been established the irrigation, erosion and routing models will be utilized and the output examined to establish actual treatment efficiencies for the critical BMPs. This would be particularly true if a BMP's storage was exceeded.

Data Requirements

The required data fall into the following catagories: field, crop, irrigation, BMP, and drain characteristics.

The field data consist of the location and elevation of the field, average slope in the direction of irrigation, length of run, area, slope at last fifty feet of the field, and if the field runoff directly enters a drain or is re-applied to another field. The crop data consist of crop rotation, furrow spacing per crop, average number of irrigations per crop, average input stream size per furrow for the crop and field. The data requirements for the BMPs are efficiencies and sediment storage volumes. Drain data requirements are typical cross sections, slopes, channel roughness, and bed materials between the cross sections.

Time Step

The model package will operate on a two-week timestep. This time step will insure that most fields are irrigated during the timestep.

Model Output

Maximum Output

The model output will be multi-level. The complete output mode will furnish for each field described erosion levels per irrigation and seasonal totals. Every described BMP will have values of sediment removed. If monitoring stations have been specified, total flow and sediment and average flow and sediment for each timestep will be printed.

Minimum Output

The minimum output will consist of annual total of sediment eroded from the fields in the watershed, removed by each BMP classification, and passing monitoring stations. Annual water volume will also be given for each station.

Special Output

Fields with unacceptable erosion rates will be flagged. Should a BMP storage volume be exceeded; the BMP will be flagged. The drain reaches where erosion or deposition occurs will be flagged.

BIBLIOGRAPHY

____, 1981. Flood Insurance Study, Twin Falls County, Idaho for the Federal Emergency Management Agency, Federal Insurance Adminstration. CH2M HILL, Boise, Idaho. Project number B12866, April 1981.

____, 1977. HEC-6 Scour and Deposition in Rivers and Reservoirs, Users Manual. Hydrologic Engineering Center, U.S. Department of Army, Corps of Engineers, March 1977.

Brockway, C. E., D. L. Carter, C. W. Robison, 1981. LQ Drain Irrigation Return Flow Final Report. University of Idaho Department of Agricultural Engineering.

Chang, H. H., 1982. "A Mathematical Model for Erodible Channels", Journal of the Hydraulics Division, Proceeding of the ASCE. Vol. 108:HY5, May 1982, pp 678-689.

Hayes, J. C., 1979. Evaluation of Design Procedures for Vegetal Filtration of Sediment from Flowing Water. A Ph.D. Dissertation. University of Kentucky Department of Agricultural Engineering.

Knisel, W. G., Jr., et. al., 1980. CREAMS: A Field Scale Model for Chemicals, Runoff, and Erosion from Agricultural Management Systems. U.S. Department of Agriculture, Conservation Research Report 26.

Lindgren, M., 1978. Mathematical Model for Design of Settling Ponds. Master's Thesis, University of Idaho Department of Civil Engineering.

Longley, T. S., 1978. Erosion Control/Sediment Modeling - A Progress Report, ASAE Paper number 78-2028, Presented at the ASAE National Summer Meeting in Logan, Utah.

Yang, C. T., 1972. "Unit Stream Power and Sediment Transport", Journal of the Hydraulics Division, Proceedings of the ASCE, Vol. 98:HY10, October 1972, pp 1805-1826.