Research Technical Completion Report
Project A-047-IDA

SIMULATION OF SOIL EROSION IN THE PALOUSE PRAIRIE OF THE PACIFIC NORTHWEST

by
Kyung Hak Yoo

IDAHO WATER RESOURCES RESEARCH INSTITUTE
UNIVERSITY OF IDAHO
MOSCOW, IDAHO

JUNE 1978

TABLE OF CONTENTS

Symbol	Definition	Unit
OVL	Overland flow length	m
PCAS	Percentage of a zone cascading to lower zone or channel	%
PIUP	Pick-up rate of soil particles from detachment storage by overland flow	tons/hectare/hour
QI	Interrill flow part of total overland flow	mm/hour
QL1	Lateral flow from A horizon simulated by watershed model	mm/hour
QOI	Overland flow simulated by watershed model	mm/hour
QR	Rill flow	mm/hour
RDS	Rill detachment storage	tons/hectare
RF	Flow rate from a watershed	m^3/second
RFC	Critical flow rate from a watershed at which scour erosion starts	m^3/second
RILD	Average rill depth	m
RQI	Interrill flow concentrated in rills	mm/hour
SCR	Channel and gully scour erosion	tons/hour
SOLD	Sediment loaded to overland flow	tons/hectare/hour
SEEP	Subsurface flow from A horizon seeped to rills	mm/hour
SEDMT	Total soil loss from a watershed	tons/hour
SLP	Slope steepness of upland	%
SNCV	Percentage of snow covered area to total area	%
SOIL	Soil and soil moisture change factor	
SURCV	Surface cover factor (snow covered area and impervious area)	
TAU	Tractive force of overland flow	kg/m^2
TAUC	Modified critical tractive force considering soil and soil moisture change factor	
TEROS	Total soil loss from a zone	tons/hour
TIME	Time incremen during which a simulation is executed	hour

Symbol	Definition	Unit
TOTMST	Cumulative moisture input (rainfall and snowmelt) during an erosion season	mm
TOTRF	Total observed if available or simulated stream flow during an erosion season	mm
TRF	Transpor capacity of overland flow estimated by Yalin's method	tons/hectare/hour
WIND	Watershed face factor	
ZEROS	Soil loss cascaded to lower zone	tons/hour

ABSTRACT

A soil erosion simulation study was done to help understand the severe soil loss from agricultural lands in the Palouse Prairie of the Pacific Northwest. A soil erosion model was coupled with the Idaho version of the USDAHL watershed model which supplied primary information such as rainfall, snowfall, snowmelt, overland flow, stream flow, soil moisture and crop growth index to the erosion model.

The main factors used by the erosion model are: overland flow, rainfall, snowmelt, snow covered area, organic material covered area, soil moisture, rill development on upland areas and stream flow for channel scouring. These are used to calculate soil particle detachment and transport capacity of raindrop and overland flow. There are several coefficients which are used to estimate the conditions for or against soil erosion. This first generation Palouse erosion model was fitted to measured sediment discharge by using trial-and-error techniques.

The model was tested on two different size watersheds (3.3 hectare and 59.4 hectare) near Moscow, Idaho. The results showed poor simulation on a daily basis. The monthly and yearly simulations were good compared with the observed except for the period of high stream flow simulated at the start of the water year. The eroded particles from each hydrologic zone cascades to a lower zone and finally to the channel. This cascading system shows the amount and location in terms of zones, where the erosion and deposition occur. Rill depth and distribution for any erosion period are the most important part of the model since rill erosion is calculated as a function of them. From field measurements rill erosion has proven to be one of the most serious erosion sources in the Palouse.

Channel scouring erosion is not as significant as upland erosion. High stream flow does not necessarily cause high soil loss and vice versa. Many of the problems, particularly with upland erosion, can be traced to inadequacies in the hydrologic model.

This is the first study of its type in the Palouse area. There must be further calibration and modification of both the hydrologic and erosion model in order to improve the simulation of erosion in this area.

CHAPTER III

LITERATURE REVIEW

There are many references which discuss detachment and movement of soil particles by flowing water. However, not all of them are generally applicable, especially, to agricultural lands which may have different properties from river beds upon which most studies of sedimentation have been done. Also, agricultural practices, soils and variations in climate will have a profound influence on the erosion process of agricultural soils. Erosion-sedimentation on agricultural fields is one of the most complicated natural systems. Many factors must be included: hydrology, climatology, soil characteristics, crops and plants, tillage practices and land treatments. Some of them are controllable and some are not. If the controllable factors are appropriately practiced, it would be possible to reduce soil and water loss from agricultural lands.

A. Equations and Simulation Models

Since upland soil erosion was recognized as a major pollution source and a problem of losing important soil nutrients attached to agricultural topsoils, many studies have been done to predict the amount of soil loss from crop land. Table 1 shows a brief summary of some of the more important equations developed from these studies. These regression type equations are restricted to the conditions of the experiments. According to the equations slope length and steepness are the main erosion predicting factors.

One of the most commonly used empirical type equations is the Universal Soil Loss Equation (USLE), (Wischmeier and Smith, 1965). The equation is expressed as

$$A = R\ K\ LS\ C\ P$$

	EROSION EQUATIONS	
Zingg (1940)	$E \propto L^{0.66} S^{1.37}$	(1)
Musgrave (1947)	$E \propto L^{0.37} S^{1.35} C$	(2)
	$E \propto L^{0.35} S^{1.35} I_{30}^{1.75}$	(3)
Wischmeier and Smith (1965)	$E \propto L^{0.5} (0.0076 S^{2.0} + 0.0053 S + 0.0076) C$	(4)
Meyer and Monke (1965)	$E \propto L^{0.9} S^{3.5}$	(5)
Meyer (1965)	$E \propto (L - LC)^{1.0 \text{ to } 1.5}$	(6)
	$E \propto (S - SC)^{1.5}$	(7)
Meyer and Kramer (1968)	$E \propto L^{0.5} (S - SC)^{1.4}$	(8)
Young and Mutchler (1969)	$E \propto L^{1.24} S^{0.74}$	(9)
Kilinc (1972)	$E \propto L^{1.04} S^{1.66}$	(10)

Where

E ; soil erosion loss,
L ; slope length,
LC ; critical slope length,
S ; slope steepness,
SC ; critical slope steepness,
I_{30} ; 30 minutes intensity of rainfall,
C ; cropping factor

Table 1. Upland soil erosion prediction equations.

where:

A ; average annual soil loss in tons per acre,
R ; rainfall factor,
K ; soil erodibility factor,
LS; length and steepness factor of slope,
C ; cropping management factor,
P ; conservation practice factor.

This equation does not seem to be usable in the Pacific Northwest because of the differences in hydrology and field conditions of the Palouse from the eastern states where the equation was developed. This model has been revised for more dependable simulation (Foster and others, 1973 and Williams, and Berndt, 1977). The rainfall and slope factors were the main parameters subject to the revision.

Onstad and Foster (1975) described an erosion-deposition model based on a modified form of the Universal Soil Loss Equation incorporating hydrologic variables. Runoff volumes and peak rates were adopted from the predicted values obtained from the USDAHL watershed model. Their concepts and procedures were used in the Agricultural Chemical Transport Model (ACTMO) as a submodel to predict erosion and deposition (Frere and others, 1975).

The USLE has been modified to fit Pacific Northwest conditions (McCool and others, 1976). The rainfall factor in the equation was changed to a "rainfall and runoff" factor so that the snowmelt effect on erosion was included. Because the slopes are longer and steeper in the Palouse area than the Midwest, the slope length and steepness factors also were modified. The two modified factors are expressed as:

$$R_{\star} = 0.0245\ P(2Y,6H)^{2.17} + 0.059\ P(D\text{-}M)$$

where:

P(2Y, 6H); 2 year return interval, 6 hour duration precipitation in mm
P(D-M); December through March precipitation in mm

$$LS = (L/22.13)^{0.3} (S/9)^{1.3} \text{ for } S \geq 9 \text{ percent}$$
$$LS = (L/22.13)^{0.3} (0.43 + 0.35 + 0.0435^{2})/6.613$$
$$\text{for } S > 9 \text{ percent}$$

where:

LS; slope length and steepness factor

L ; slope length in m

S ; slope steepness in percent

Simulation techniques in hydrology are now well established with many different models in existence. The first generation of a comprehensive erosion simulation model superimposed on a watershed model was developed by Negev (1967). He used the Stanford Watershed Model IV by Crawford and Linsley (1966) to obtain the flow component for the erosion sedimentation model. David and Beer (1975) developed a sheet erosion model using the Kentucky Watershed Model, a Fortran version of the Stanford Watershed Model. The sediment sources in these models are interill, rills and gullies, and channel. The rills and gullies were considered a single erosion source area.

B. Erosion Processes

It is necessary to understand the process of water-caused erosion and sedimentation in order to develop methods for reducing soil loss from upland areas. Rainfall and runoff are the two main causes of soil detachment and transportation. Therefore, erosion control practices should be oriented to reducing runoff or its flowing power and to increasing surface protection and resistance to raindrop impact and runoff.

The soil erosion process on upland areas was described as the following four processes (Meyer and Wischmeier, 1969):

1) detachment by rainfall, proportional to I^2,
2) transport by rainfall, proportional to I,
3) detachment by runoff, proportional to V^2,
4) transport by runoff, proportional to V^5,

where:

I; rainfall intensity,
V; flowing velocity

Figure 1 shows the flow diagram of the erosion process.

Upland erosion starts when raindrops strike the soil surface. The kinetic energy produced by the raindrop impact detaches soil particles from the surface soil mass. The detached particles are splashed in all directions from the impact point, with net movement downslope. However, soil particles transported by the raindrop impact normally account for only a small part of the total soil erosion. It is especially true in the Pacific Northwest where the rainfall intensity is comparatively low. Klages (1965) observed that slightly more than 60 percent of the storm events per 24 hour period for 70 crop years (1893-1963) were less than 5mm per hour at Moscow, Idaho.

After the rainfall and snowmelt rate exceeds all the surface detention factors, and the infiltration and evapotranspiration rates, the excess water flows overland on the surface. The prerill type of runoff is termed interrill flow. Rowlison and Martin (1971) considered the detachment by interrill flow to be negligible because of the small tractive force of shallow depth compared with the shear strength of cohesive soils. However, because of surface conditions such as tillage marks, natural microtopography, or previous erosion, the interrill flow tends to concentrate and to form small channel-like flows. This is called rill flow. The rill flow has a deeper depth and greater detaching and transporting power than the interrill flow. The rills are the main source of sediment from upland areas in the Palouse region of the Pacific Northwest.

The initial detachment of surface soil particles generated by flowing water consists of the three components: 1) shear stress (tractive force), 2) velocity and 3) lift force. Figure 2 shows the force diagram on soil particles by surface runoff. Among them tractive force will be chosen as

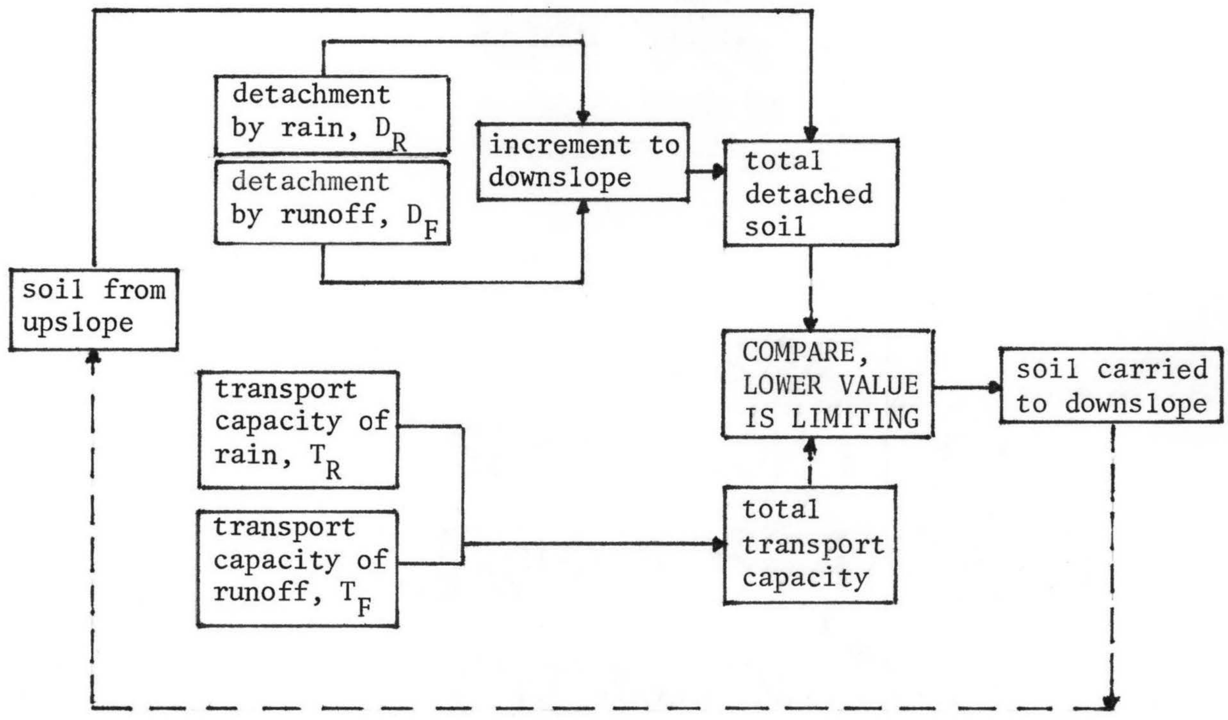
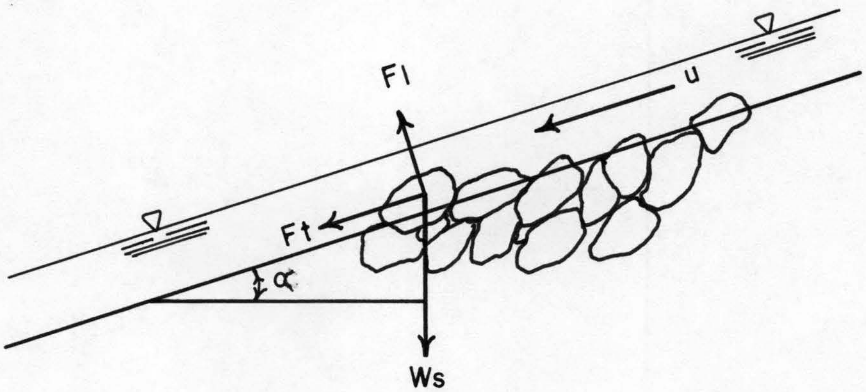


Figure 1. Schematic diagram of the erosion process (Meyer and Wischmeier, 1969).

Fig 2



F_l ; lift force,
F_t ; tractive force,
W_s ; submerged weight of soil particle,
u ; flow velocity,
α ; angle of bed slope

Figure 2. Force diagram on soil particles by runoff water.

the estimator of soil movement since it has been the most widely studied of the three factors to predict sedimentation. The tractive force is obtained as:

$$T = \gamma R S \qquad (12)$$

where:

T ; tractive force in kg/m^2
γ ; unit weight of water in kg/m^3
R ; hydraulic radius of water in m
S ; surface slope steepness

The tractive force of runoff does not move soil particles until it reaches a critical value that, if increased, will put the soil particle or aggregate into motion. The problem of determining critical conditions for the initial movement of soil particles has been studied for a long time. However, most of the equations used are empirically derived using coarse materials for natural channel flows. Shields (after Vanoni and others, 1966) developed the following relationship to estimate the critical tractive force:

← insu
com

$$\frac{\tau_c}{(\gamma_s - \gamma_f)\ d} \propto \left(\frac{d u_*}{\nu}\right)$$

where:

τ_c ; critical tractive force, kg/m^2
γ_s ; unit weight of soil particles, kg/m^3
γ_f ; unit weight of water, kg/m^3
d ; mean diameter of soil particles in m
u_* ; shear velocity, $u_* = \sqrt{g R S}$,
ν ; kinematic viscosity of water in m^2/sec.

This relationship is not directly applicable to agricultural soils which are composed of fine cohesive particles. Sundborg (after Vanoni, 1975) suggested that the cohesive force of a soil particle resisting movement is proportional to the shearing strength of the soil. Dunn (1959) used shearing strength and plasticity index of soil to estimate the critical tractive force. Smerdon and Beasley (1961) used clay content of a soil to estimate the critical tractive force. The soil samples they used ranged from a silty loam to a clay in irrigation canals. Their relationship is:

$$\tau_c = o.0503 * 10^{0.0183PC} \qquad (14)$$

where:

τ_c = critical tractive force kg/m^2

PC ; clay content of a soil in percent

As the clay percentage increases, the increased cohesiveness of the extra clay particles will increase the critical tractive force.

When tractive force acting on a soil particle or on an aggregate of particles of a cohesive soil exceeds the critical tractive force, the soil particles begin to move. This explains duBoys' sediment equation (Graf, 1971):

$$q_s = \chi\tau(\tau \;\; \tau_c) \qquad (15)$$

O'Brien and others (1934) generalized the equation as:

$$q_s = \chi' \; (\tau-\tau_c)^m \qquad (16)$$

where:

q_s ; volume amount of bed load per unit width and time,

χ and χ' ; parameters,

m ; an exponent

The parameters will be specific for each site and time.

The detached soil particles are transported downslope in an amount less than or equal to the transport capacity of runoff. Foster and Meyer (1975) recommended Yalin's bed load equation (Yalin, 1963) to estimate the transport capacity of runoff. The equation assumes that flow is turbulent with a laminar sublayer having a thickness not exceeding the size of the bed roughness. It is also assumed that all bed grains have the same shape and size and motion is by saltation. The existence of critical tractive force is accepted. More details of the equation are given by Yalin (1963) and Foster and Meyer (1975).

The stability of channels against scour is dependent on the properties of the soils from which the channel is formed, rather than only the hydraulics of the flow in the channel. Critical discharge, below which no channel scouring occurs, can be used to estimate the channel scouring erosion.

$$C_s = K\ (Q - Q_c)n$$

where:

C_s ; channel scouring erosion

K and n ; coefficients depending on stream and watershed characteristics

Q ; mean discharge at watershed outlet

Q_c ; critical discharge

Channel scouring is usually small when compared with total soil loss from upland areas of small to medium size agricultural watersheds where channels are temporary and not distinctive. For moderate size watersheds channel erosion might be significant but not dominant. It is, however, necessary to obtain good channel scour equations in order to evaluate the overall simulation.

A more detailed literature review of erosion is given by Yoo (1978).

CHAPTER IV
MODELING OF SOIL EROSION (EROS)

Erosion prediction methods have been developed for better understanding and control of the tremendous amount of soil loss from agricultural lands. The upland erosion process includes too many factors to be evaluated individually. Some of them are significantly interrelated and others are independent. The conditions of the Pacific Northwest are especially emphasized here for this model while general conditions are considered.

There are three erosive factors; 1) raindrop, 2) overland flow and 3) gully and channel flow. The first two factors act on upland interrill and rill areas and the third on gullies and channels. These will be considered separately. The flow chart outline of the model is shown in Figure 3. The detailed flow charts are shown in Appendix I.

A. Raindrop Impact Erosion

Soil erosion begins when any movement of moisture on a watershed takes place. Therefore, the falling of precipitation on the ground surface would be the initiation of possible erosion. For the purposes of this discussion, the kinetic energy of snow flakes will be ignored. The precipitation drop produces kinetic energy which is described by Ellison (1945) as:

$$KE \propto M V_t^2 \qquad (18)$$

where:

KE ; kinetic energy

M ; mass of drops

V_t ; terminal velocity of raindrop

Capital
← E

Terminal velocity and raindrop size can be related to rainfall intensity (Laws, 1941; Laws and Parsons, 1943, Chow and Harbaugh, 1965). The equation can be expressed as:

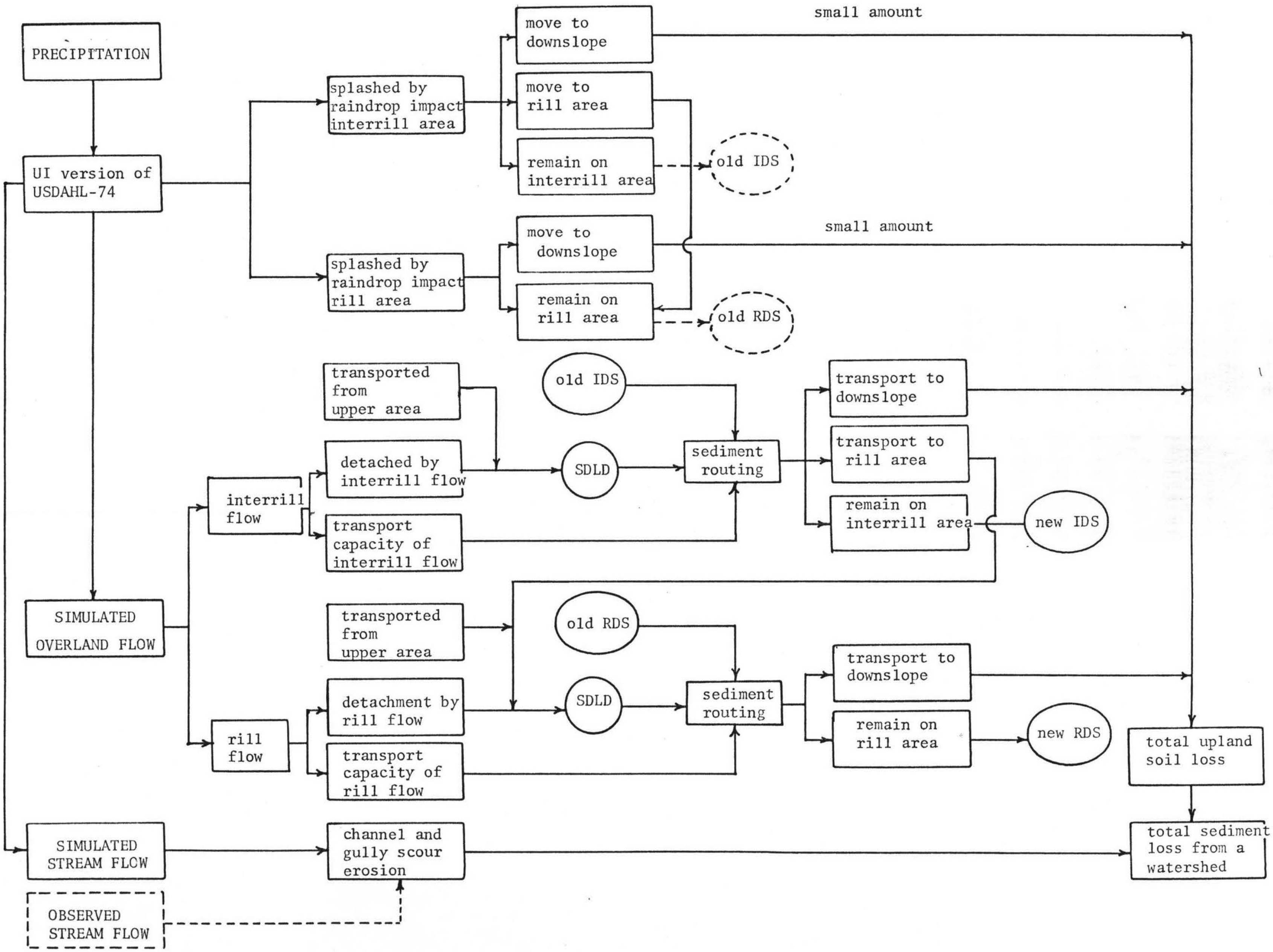


Figure 3. Schematic flow chart of the Soil Erosion Simulation Model (EROS).

$$KE = K' \; I^{n} \tag{19}$$

where:

n ; overall exponent

K' ; a constant

I ; rainfall intensity

Because of soil surface conditions, all of this energy is not effective in detaching soil particles. The windward face of a hill and the flatter surfaces receive higher kinetic energy than the leeward and the steeper sides. The most significant erosion resisting factors are soil type, runoff depth and surface cover (organic material or snow). These factors were evaluated based on physical or experimental knowledge and finally combined together to simulate soil detachment by raindrop impact. More details of this part of the model is given by Yoo (1978). The detachment by raindrop is simulated by:

$$DHR = C1 * I^{EXP1} * \exp(-SOIL) * \cos(SLP/WIND) * DEP * (1 - SURCV) * CMCV \tag{20}$$

where:

DHR ; detachment rate of soil particles

I ; rainfall intensity in mm/hour

exp ; base of natural logarithm

cos ; trigonometrical function

SOIL ; soil and soil moisture change factor

WIND ; watershed face factor, WIND = 0.5 + WWS

WWS ; ratio of windward slope area to total area

SLP ; slope steepness of upland in percent

DEP ; overland flow depth factor, DEP $\propto$ (I/D)

D ; depth of overland flow in mm

SURCV ; surface cover factor (snow covered area and impervious area)

SURCV = SNCV + (1-SNCV) * IMPCV

SNCV ; ratio of snow covered area to total area
IMPCV ; ratio of impervious area to total area
CMCV ; erosion resistance factor of organic materials on soil surface, one for no resistance and zero for perfect resisting condition
C1 ; a constant
EXP1 ; an exponent related to rainfall characteristics

This equation is used as the basis for evaluating soil detachment by raindrop impact on upland area.

B. Overland Flow Erosion

When the rainfall or snowmelt rate exceeds the surface detention storage and infiltration and evapotranspiration rates, water will start to flow over the land surface and eventually to the streams. The kinetic energy generated by the flowing water detaches, picks up and transports soil particles. This process of soil erosion is the largest and the most significant source of erosion in the Pacific Northwest agricultural fields. Because mild rainfall intensities, small drop sizes, and runoff from snowmelt or rain on snow are dominant conditions during the erosion season (October through March) in this area, detachment and transport by runoff is more significant and erosion by raindrop splash is less important than in other areas (McCool and others, 1976).

The overland flow influences surface soil movement in two ways; one is detachment of soil particles and the other is transport of soil particles. They will be discussed separately.

1. Detachment

When water flows on soil surfaces, it generates a tractive force as shown by equation 12. It has been mentioned before that soil particles have a certain amount of resistant force below which no detachment takes place.

The tractive force at which soil detachment is initiated is called the critical tractive force. There are several studies on critical tractive force. However, it is difficult to choose any of them for upland erosion studies. Smerdon and Beasley (1961) found a high correlation between clay content of soil and critical tractive force. They obtained the relationship using cohesive soils on irrigation canals (equation 14).

Soil structure and surface conditions are also important in resistance to the detaching force of runoff water. The soil structure depends on soil moisture content, organic material within the soil and plant roots. Plant, plant residues and mulches on the surface reduce the flowing power of overland flow and its erosive force. Assuming that duBoys' bed load equation (Graf, 1971) is valid, the detachment by runoff is estimated as:

$$DHF = C2 * (TAU - TAUC)^{EXP2} * (1-IMPCV) * CMCV / OVL \qquad (21)$$

where:

DHF ; detachment rate of soil particles by overland flow in tons/hectare/hour

TAU ; tractive force of overland flow in kg/m^2

TAUC ; modified critical tractive force considering soil and soil moisture condition, $TAUC = \tau_c * (1 - \exp(-SOIL))$

τ_c ; critical tractive force from equation 14

IMPCV ; ratio of impervious area to total area

C2 ; a constant

EXP2 ; an exponent

OVL ; overland flow length in m

In this equation, it was assumed that no detachment takes place on impervious areas, and snow cover on ground does not affect the detachment capacity of runoff.

2. Transport

The detached soil particles are picked up and transported downslope by the flowing water. The transport capacity of overland flow depends on flowing power, soil characteristics, surface conditions, water temperature and sediment concentration. The first three factors are the most significant. There is no definite method of evaluating the transport capacity. It is known that the transport capacity of flowing water is proportional to the fifth power of the water velocity (Ellison, 1947).

Many studies have been done to estimate sediment movement in natural channels but none of them agree with each other. These studies do not seem to be applicable to overland flow transport because non-cohesive coarse materials were usually tested in deep wide channels. The Yalin's bed load equation (Yalin, 1963) will be used to estimate the transport capacity by runoff water in shallow flow. This method was derived analytically for the discharge of solids in steady, uniform flow in which movement of material is confined to the vicinity of the bed. Foster and Meyer (1975) recommended this equation because of 1) theoretical soundness for shallow flow, 2) good fit to observed data, 3) simplicity and no information is available for overland flow transport capacity associated with upland erosion.

When rain falls on overland flow, the turbulence of the flow will be increased. This turbulence increases the transport capacity of the runoff. The actual transport capacity of the overland flow would be dependent upon rainfall intensity and surface roughness of plant on soil surface. The relationship is expressed as:

$$\mathrm{ATRF} = \mathrm{TRF}\ (1 + \mathrm{C3} * \mathrm{I}) * \mathrm{CMCV} \qquad (23)$$

where:

ATRF = actual transport capacity of overland flow in tons/hectare/hour
TRF = transport capacity of overland flow estimated by Yalin's method in tons/hectare/hour
CMCV = erosion resistance factor of organic materials on surface
C3 = a constant depending on rainfall intensity

However, because of the low rainfall intensity, rain on snow cover or snowmelt as a moisture source in the Pacific Northwest C3 can be assumed equal to zero. The net result would be:

$$ATRF = TRF * CMCV$$

3. Upland Erosion Routing

Upland erosion occurs on both rill and interrill areas. When surface runoff starts the interrill flow tends to concentrate and form rills. There are only a few studies to describe rill forming phenomenon (Horton, 1945; Kilinc, 1972; Young and Wiersma, 1973). They found that runoff and rainfall are the most significant rill causing factors.

The size and number of rills increase as overland flow occurs until any surface tillage practice levels them. In the Pacific Northwest cultivation takes place just before a long winter rainy season. This is the main erosion season in the area. It is assumed that rill development is a function of rainfall, runoff and surface organic material condition during the season.

$$AAR = MAAR * \left(\frac{TOTMST}{OMPRE}\right) * \left(\frac{RF}{TOTRF}\right) * CMCV \tag{24}$$

$$RILD = MRILD * \left(\frac{TOTMST}{OMPRE}\right) * \left(\frac{RF}{TOTRF}\right) * CMCV \tag{25}$$

where:

AAR = percentage of rill area to total area
MAAR = maximum AAR at the end of an erosion season without organic materials in soil

TOTMST = cumulative moisture input (rainfall and snowmelt) during an erosion season in mm
OMPRE = total observed precipitation during an erosion season in mm
RF = cumulative stream flow during an erosion season in mm
TOTRF = total observed, if available, or simulated stream flow during an erosion season in mm
RILD = average rill depth in mm
MRLD = maximum average rill depth at the end of an erosion season with no organic materials effect in mm

If a field within a zone is cultivated, AAR and RILD will be reduced by the ratio of the area of cultivated field to the total area of the zone. The two factors, MAAR and MRILD can be approximately estimated from field observation or actual measurement (McCool and other, 1976).

The more rills that exist on a field, the more interrill flow will concentrate to the rills. At a certain ratio of rill distribution and afterwards all the overland flow concentrates and passes through rills. The amount of interrill flow moved to rills depends on rill size and distribution and physical condition of the surface. Interrill flow is estimated as:

$$QI = QOI * (1 - AAR) \qquad (26)$$

$$RQI = C4 * AAR * QI \qquad (27)$$

where:

QI ; interrill flow part of total overland flow in mm/hour,
QOI ; overland flow simulated by watershed model in mm/hour,
RQI ; interrill flow concentrated in rills in mm/hour,
C4 ; a constant related to surface and rill characteristics

The interrill flow after RQI is:

$$AQI = QI - RQI \qquad (28)$$

The interrill erosion is calculated with QI rather than AQI since QI actually causes erosion on interrill area. There is another moisture input to rill. It is subsurface water seeping to rills when the rill is deep enough. There is no study of minimum rill depth above which subsurface flow appears. However, it is observed that water flows through rills even though no rainfall or interrill flow exists. Rill flow is obtained as the sum of interrill flow concentration, rill part of overland flow and subsurface flow appeared to rills.

$$\mathrm{SEEP} = \mathrm{C5} * \mathrm{AAR} * (\mathrm{QL1} * \mathrm{RILD}/\mathrm{TOPD}) \tag{29}$$

$$\mathrm{QR} = \mathrm{QOI} * \mathrm{AAR} + \mathrm{RQI} + \mathrm{SEEP} \tag{30}$$

where:

SEEP ; subsurface flow from a horizon seeped to rill in mm/hour,
QL1 ; lateral flow from A horizon simulated by watershed model in mm/hour,
← insert comm
RILD ; average rill depth in mm,
TOPD ; top soil (A horizon) depth in mm,
QR ; rill flow in mm/hour,
C5 ; a constant same as in equation 27,

It is assumed that the splashed soil particles remain on rill or interrill areas until transported downslope by overland flow. However, the soil particles detached by runoff are added to the amount of sediment loaded to runoff, SDLD.

The detachment storage for interrill and rill (IDS and RDS, respectively) are defined in the model as the amount of soil particles detached by runoff, rainfall and loosened soils by tillage practices or environmental changes such as freezing, thawing, drying and wetting. The amount of detached soil particles in detachment storage changes as a function of time and soil conditions. They are estimated as:

$$DS_i = DS_{i-1} * \exp(-C6 * SOIL * TIME_{i-1}) + DHR * TIME_i + CDS \qquad (31)$$

where:

DS ; soil particles in rill or interrill detachment storage in tons/hectare

TIME ; time increment during which a simulation is executed in hour

CDS ; increment to interrill and rill detachment storages in tons/hectare. This is a function of temperature, soil moisture change, tillage practices and surface organic material content

i ; time increment

C6 ; a constant related to soil characteristics

The number of soil particles in detachment storage will change as the environment changes.

When eroded soil particles are carried downslope to lower lands by overland flow, several factors must be considered in order to evaluate the particles' movement to a defined channel. Overland flow detaches soil particles and at the same time removes others from detachment storage and transports them downslope.

If the transport capacity is less than the delivered sediment, the flowing water is not able to increase the particle concentration in the water, which means that no detached soil particles are picked up from the soil surface. The amount of soil particles exceeding the transport capacity will drop to the surface and be added to IDS or RDS. This procedure is expressed as:

If $ATRF \leq SDLD$

← Inse
If ATRF ≤

← If ATRF

$$\mathrm{PIUP} = 0.0$$

$$\mathrm{DPS} = \mathrm{C7} * (\mathrm{SDLD} - \mathrm{ATRF}) \tag{32}$$

Therefore, soil particles lost downslope is: (33)

$$\mathrm{EROS} = \mathrm{SDLD} - \mathrm{DPS} \tag{34}$$

where:

SDLD ; sediment loaded to overland flow in tons/hectare/hour,
PIUP ; pick-up rate of soil particles from detachment storage by overland flow in tons/hectare/hour,
C7 ; a constant related to sediment settling velocity and water quality

where:

C8 ; a constant related to sediment settling velocity and water quality
DPS ; deposition rate of soil particles in tons/hectare/hour
EROS ; erosion rate delivered to downslope and eventually to next zone and channel in tons/hectare/hour

If the transport capacity exceeds the sediment load, the flowing water picks up the difference of transport capacity and sediment load. It is assumed that no deposition occurs in this case.

If ATRF > SDLD

$$\mathrm{DPS} = 0.0 \tag{35}$$

$$\mathrm{PIUP} = \mathrm{C8} * (\mathrm{ATRF} - \mathrm{SDLD}) \tag{36}$$

If PIUP * TIME > IDS or RDS, PIUP = IDS/TIME or RDS/TIME, respectively

Actual soil loss is:

$$\mathrm{EROS} = \mathrm{PIUP} + \mathrm{SDLD} \tag{37}$$

After the soil particles in detachment storages of rill and interrill are transported downslope the amount in the storages will be changed as:

$$IDS_{i+1} = IDS_i + (DPS - PIUP)_{ir} * TIME \qquad (38)$$

and

$$RDS_{i+1} = RDS_i + (DPS - PIUP)_r * TIME \qquad (39)$$

IDS = interrill detachment storage in tons/hectare
RDS = rill detachment storage in tons/hectare
TIME ; time increment in hour
ir ; interrill area,
r ; rill area,
subscripts i ; time increment,

These will be the new deposition storages for the next time period. The total soil loss from a zone is:

$$TEROS = (EROS_r * AAR + EROS_{ir} * (1 - AAR)) * AREA \qquad (40)$$

This will be cascaded to lower zones or to the channel.

$$ZEROS = TEROS * PCAS \qquad (41)$$

$$CEROS = TEROS * (1 - PCAS) \qquad (42)$$

where:

TEROS ; total soil loss from a zone in tons/hour over a zone,
ZEROS ; soil loss cascaded to lower zone in tons/hour over a zone,
CEROS ; soil loss cascaded to channel from a zone in tons/hour over a zone,
PCAS ; percentage of a zone cascading to lower zone or channel
AREA ; area of a zone in hectare

The sum of CEROS from each zone and alluvium will be the total soil loss from upland to channel. The soil particles routed to the channel are assumed to be transported to outlet of a watershed as the total upland soil loss.

C. Channel and Gully Erosion

Scour in streams and gullies could be significant in the case of large floods. The source areas are gullies and channels, which are scoured on the bottom and side walls by flowing water and bank slumping. These contributions to total erosion are not easy to estimate, but it is usually not comparable in quantity with total erosion from upland areas of a small to medium size agricultural watershed, however, this could be significant for a large watershed. Bank and head cuts by flow in gullies are serious erosion sources and cause damage to land management practices. These erosion events are neither regular nor predictable in time and space.

There is no dependable prediction method for channel and gully erosion. The well known channel sedimentation formulas show errors involved of magnitudes of 100 percent or more (David, 1972). For practical purposes, the hydraulic properties of channel flow will be used to predict sediment yield from the channel.

$$\mathrm{SCR} = \mathrm{C9} * (\mathrm{RF} - \mathrm{RFC})^{\mathrm{EXP3}} \tag{43}$$

where:

SCR ; channel and gully scour erosion in tons/hour,
RF ; flow rate from a watershed in cms,
RFC ; critical RF at which scour erosion starts in cms,
EXP3 and C9; coefficients related to channel and watershed characteristics such as channel and gully densities and watershed shape

The total sediment loss from a watershed is the sum of upland soil loss and channel and gully scouring erosion.

$$\mathrm{SEDMT} = \mathrm{DELTSL} + \mathrm{SCR} \tag{44}$$

where:

SEDMT ; total soil loss from a watershed in tons/hour,
DELTSL ; total soil loss from upland to channel and gully in tons/hour

The flow chart of the model is shown in Appendices. Since this report does not include full details of the model, anyone who is more interested in the model should refer to Yoo (1978).

CHAPTER V

APPLICATION OF THE SOIL EROSION SIMULATION MODEL (EROS)

A. Description of Study Area and Watersheds

The study area is located (Figure 4) in eastern Washington and northwest Idaho. The area is the eastern part of the Palouse prairie of the Pacific Northwest dryland grain region and has a relatively high rainfall (more than 500 mm). Yields range from 4 to 8 tons of wheat per hectare. However, a critical soil erosion problem exists. Typical conditions of the area are very favorable to erosion. They are: 1) long duration rainfall although of relatively low intensity on wet or supersaturated soil surface, 2) rapid snow melting of large snow drifts located on steep northward slope caused by warm wind and rainfall, 3) snowmelt with or without rain on thawing soil with little vegetation protection for the soil surface above a frozen subsurface, 4) steep and long slopes, and 5) heavy cultivations with summer fallow.

The soils of the area have marked variations associated with the prevailing climatic factors, especially precipitation (Horner and others, 1944). The major soil of the area is the Palouse silt loam and others associated with the Palouse, Thatuna, Garfield, Staley, Athena, Latah, Caldwell, Koster, Snow and Chambers soil types. They are related primarily to the topography (Pawson, 1961). Thatuna is found most on north and northeast slopes, next three are on hill tops and the last five are on the alluvium and drainage areas. The Palouse silt loam is found on the broad intermediate slopes. The Palouse and Thatuna silt loams are the most commonly found soil series in the area.

A considerable part of the cultivated land in the area has slopes ranging from 10 to 40 percent. Some of the land has more than 50 percent slope. However, it is not uncommon in the area to farm slopes of 40 percent or more.

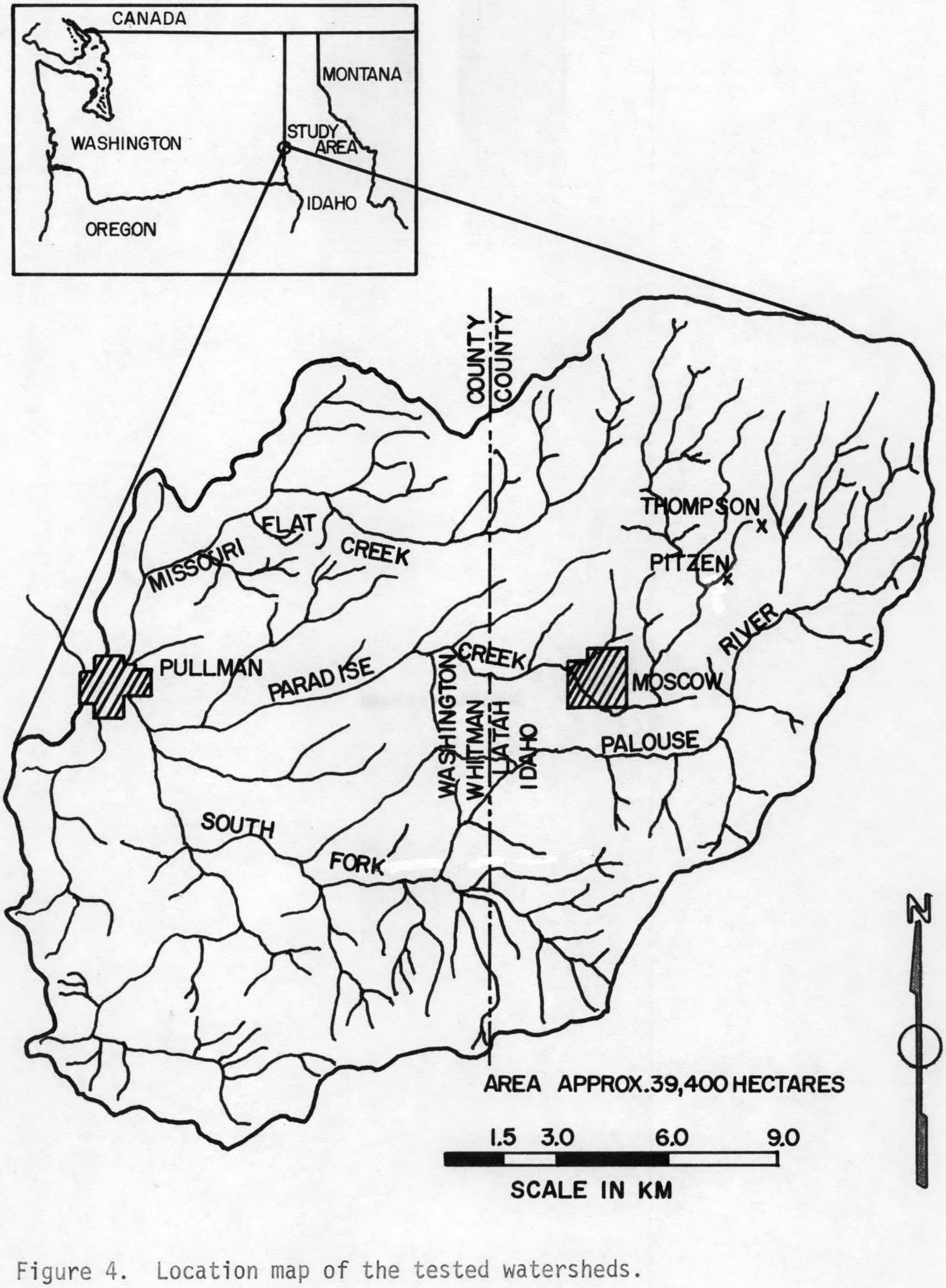


Figure 4. Location map of the tested watersheds.

The climate of the area is quite different from any other part of the nation because of its location (between the Cascade and the Rocky Mountains) and a predominant maritime climate originating over the Pacific Ocean. The entire area has humid winters and dry summers (Table 2). The average annual precipitation from 1893 to 1963 crop years at Moscow, Idaho was 560 mm (Klages, 1965). Approximately 60 percent of the precipitation occurs during the 5-month period of November to March. Rainfall intensities of most winter storms are low, less than 5mm per hour in 24 hours for the 70 study years. Higher intensity storms are common in late spring and summer.

← insert comma after lo

Grain crops and peas are the most widely grown crops in the Palouse. Because of extremely light rainfall during the summer season, yields of hay and pasture crops are relatively low. Therefore, the principal crops grown are winter wheat, winter and spring barley and dry peas, with some land in green manure, hay crops or in clean cultivation. Winter wheat is the basic cash crop for the area.

The watersheds selected for this study are located on the eastern edge of the South Fork Palouse River basin above Pullman, Washington (Figure 4). Two different size watersheds were selected to test the erosion model. They are Pitzen and Thompson Watersheds. These watersheds are devoted almost entirely to cultivated crops. Tables 3 and 4 give physical and hydrological data for these watersheds.

1. Pitzen Watershed

This watershed was intensively studied as a part of the South Palouse River Demonstration project during late 1930's to early 1940's. Figures 5 and 6 show a topographic map and watershed zones for the watershed and erosion models from which most of the necessary data for the erosion model were obtained. Table 5 shows the available recorded data from the watershed. Three consecutive water years (1938, 1939 and 1940) were chosen for the testing years. They had significantly different patterns in hydrology and weather.

months	monthly average precipitation		accumulated monthly average precipitation		monthly average temperature
	mm	percent	mm	percent	°C
Oct.	45.2	8.12	45.2	8.12	9.3
Nov.	72.6	13.05	117.8	21.17	3.2
Dec.	71.4	12.82	189.2	33.99	-0.4
Jan.	70.9	12.73	260.1	46.72	-2.2
Feb.	55.4	9.95	315.5	56.67	0.2
Mar.	53.8	9.67	369.3	66.34	3.3
Apr.	40.9	7.34	410.2	73.68	8.1
May	46.2	8.30	456.4	81.98	11.8
Jun.	38.6	6.93	495.0	88.91	15.3
Jul.	14.2	2.55	509.2	91.46	19.6
Aug.	16.0	2.88	525.2	94.34	18.9
Sep.	31.5	5.66	556.7	100.00	14.5
total	556.7				

Table 2. Seventy years (1893-1963) average monthly precipitation and temperature at Moscow, Idaho (Klages, 1965).

	Pitzen	Thompson
size (hectare)	59.4	3.3
width/length	0.51	0.51
mean sea level (m)	808 - 853	850 - 875
overland slopes (%)	0.0 - 30.0	15.5 (average)
average channel slope (%)	2.5	no defined channel
average channel width (m)	0.3	no defined channel
dominant soil series	Thatuna silt loam (86%) Palouse silt loam (14%)	Thatuna silt loam
soil depth (m)	1.0 - 1.5	1.0 - 1.5
infiltration rate (mm/hr)	0.64[1] - 2.54[2]	not available

[1] seventeen percent slope of undisturbed Thatuna silt loam on winter puddled surface.

[2] Thatuna silt loam having mulched surface with straw

Table 3. Physical and hydrological characteristics of the tested watersheds.

SOIL TYPE	TOPOGRAPH	LAYER	TP[1]	15	0.3	S	G	AWC
Thatuna silt loam I	moderately sloping (9%) upland	A	55.1	16.7	33.4	38.4	21.7	16.7
		B	45.1	22.2	37.6	22.9	7.5	15.4
Thatuna silt loam II	moderately sloping(15%) upland	A	52.5	15.8	35.1	36.6	17.4	19.2
		B	44.8	21.3	39.9	23.5	4.9	18.6
Thatuna silt loam III	Thompson watershed	A[2]	55.1	19.2	43.3	35.9	11.8	24.1
		B	44.8	21.3	39.9	23.5	4.9	18.6
Palouse silt loam	strongly sloping, long slopes	A	53.8	13.4	29.2	40.4	24.6	15.7
		B	45.6	18.7	35.8	27.2	10.0	17.2
Garfield silt loam	rounded ridge hilly upland	A	45.9	19.3	35.7	26.6	10.2	16.4
		B	44.0	22.7	37.2	21.3	6.7	14.6

[1] TP ; total porosity in percent volume computed by assuming specific gravities equal to 2.65 for all soils in moist condition

S ; total storage capacity in percent volume

G ; moisture freely drained by gravity in percent volume

AWC; moisture drained by vegetation in percent volume

15 and 0.3 ; respective atmospheres of tension

[2] soil moisture data obtained by Neff (1966) at the Thompson watershed

Table 4. Hydrologic characteristics of soils for the test watersheds

DATA	BASE TIME	PERIOD
evaporation	daily (growing season)	10/1/37 - 12/31/41
max. and min. temperature	daily	10/1/37 - 12/31/41
humidity	daily	10/1/37 - 12/31/41
precipitation	daily break-point time	10/1/37 - 12/31/41
stream flow	daily break-point time	10/1/37 - 12/31/41
soil loss	daily	2/1/38 - 12/31/41
infiltration rate		
soil moisture for spring, fall and winter		1937 - 1941
surface cover and tillage map	Oct. - Mar.	1937 - 1941
cropping plan		1937 - 1941
contour map		
soil map		
erosion map		1939 - 1940

Table 5. Available data for the Pitzen Watershed.

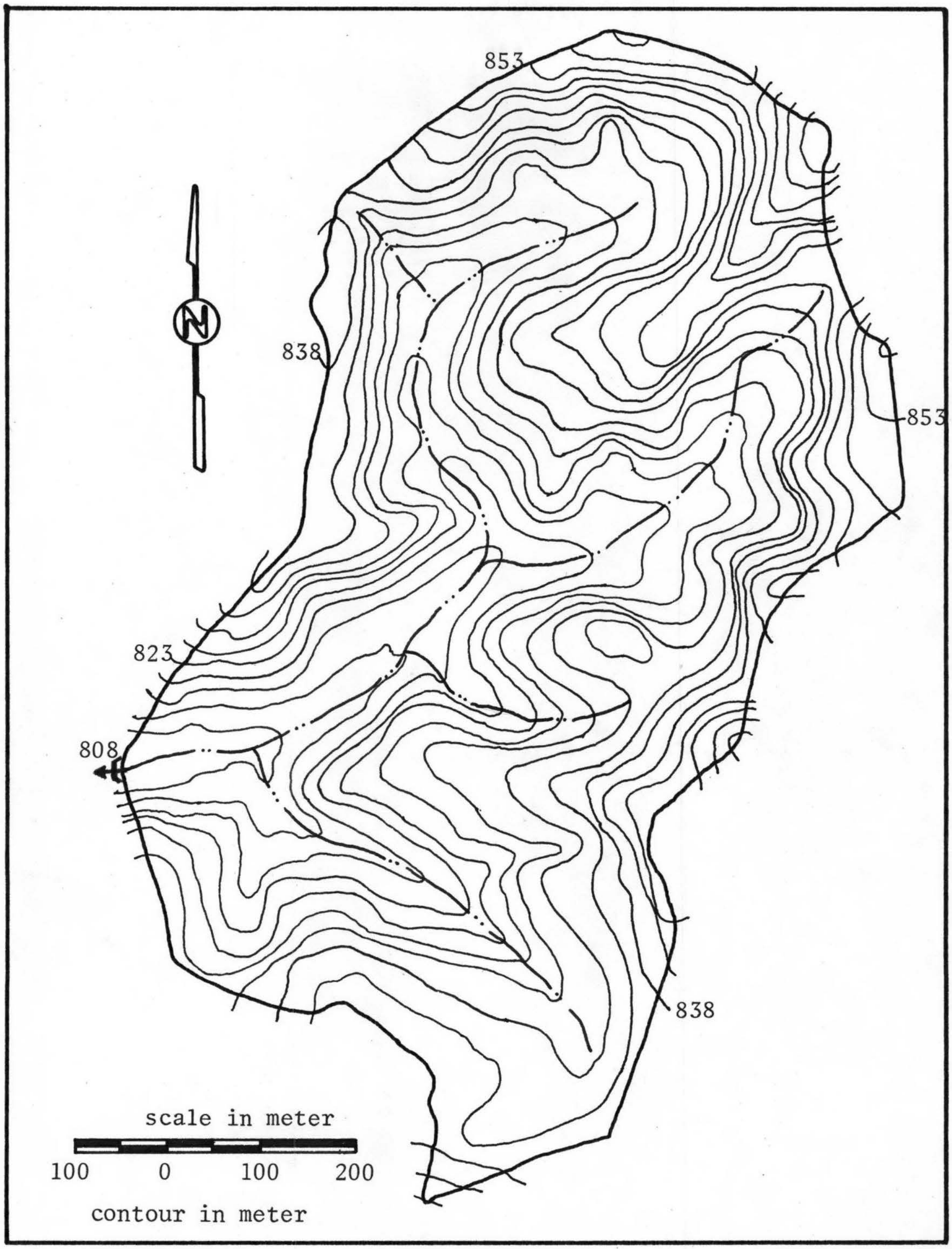


Figure 5. Map of the Pitzen watershed.

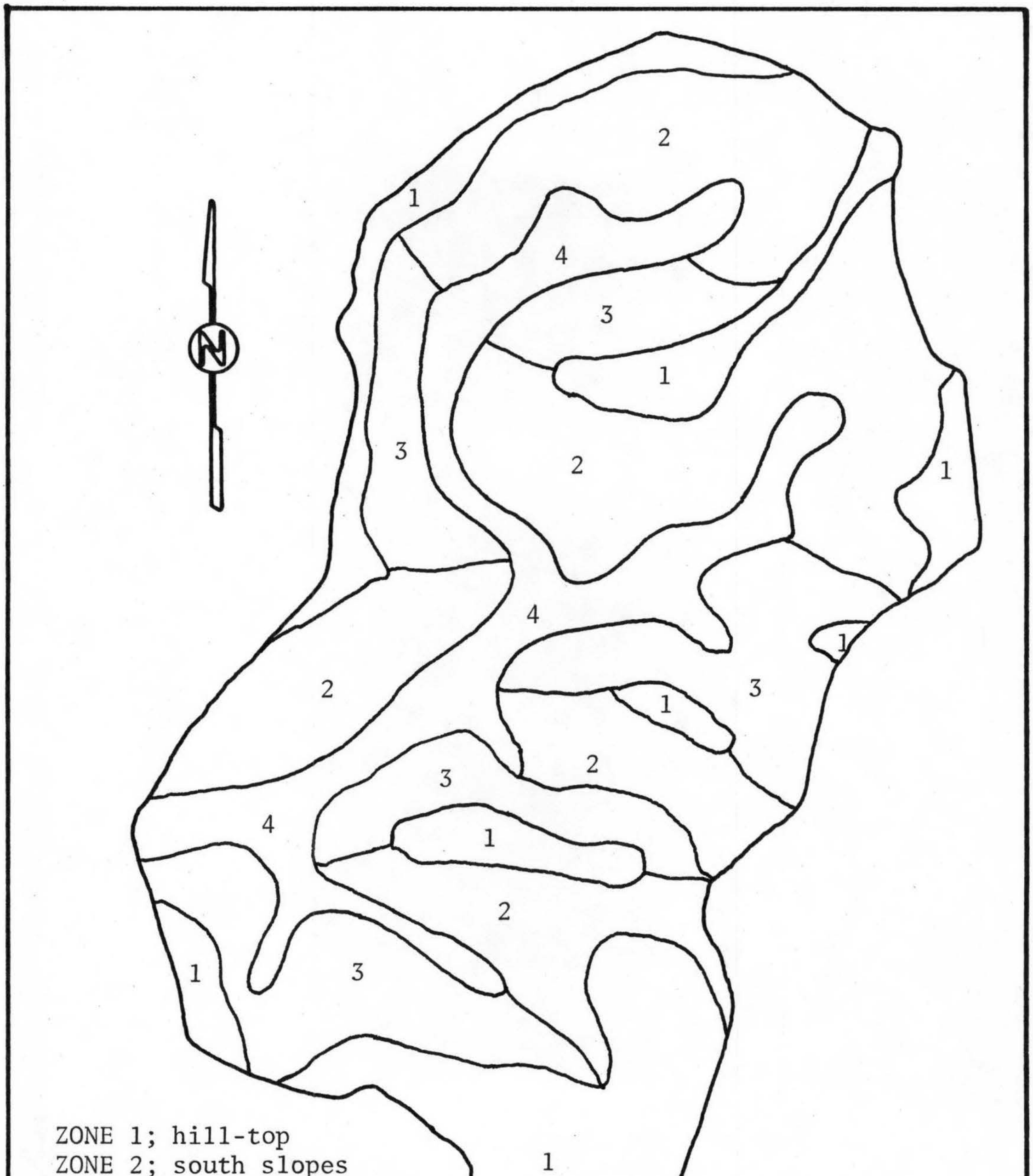


Figure 6. Watershed zones of the Pitzen watershed.

The water year 1938 was relatively normal in terms of precipitation (500 mm) and runoff (130 mm). There are no recorded soil loss data before February of 1938. Water year 1939, was dry (398 mm) and cold. However, high stream flow (33.5% of total precipitation or 133 mm) was recorded. Most of the precipitation was snow and remained on the ground until the snowmelt season. A total of 115 mm of the runoff took place in March. The snow was melted in less than 10 warm days around mid March after a long cold spell. This year was a good year for testing of snowmelt and soil erosion caused by snowmelt. The 1940 water year was warm and wet (629 mm). Rainfall was the dominant form of precipitation. A very small portion of the precipitation (11% or 69 mm) appeared as runoff from the watershed. Although the 1939 water year had twice as much stream flow as 1940, the 1939 soil loss was only one-third of that of 1940. This could explain that channel scour erosion does not seem to be significant comparing with total soil loss from this watershed; there should be high overland flow in 1940 and low in 1939 erosion season.

← insert parenthes

However, the different patterns of surface conditions during the erosion seasons could be another important factor. The crop and field conditions are shown in Figures 7, 8 and 9 for the three test years.

2. Thompson Watershed

This watershed is located approximately 1.6 km northeast of the Pitzen Watershed (Figure 4). Data was collected from this watershed in the late 1960's and early 1970's. The watershed was divided into three zones as shown in Figure 10. However, there is only one water year (1972) with good recorded soil loss data. A more detailed description of the watershed is available in Davis and Molnau (1973). Table 6 shows the available recorded data for the watershed. This water year had very high precipitation (639 mm) and runoff (46% of total precipitation or 291 mm). Spring barley was harvested and plowed in fall 1971 and same crop was seeded in spring 1972. The high runoff was mostly caused by snowmelt on a warm day preceded by and coupled with rainfall.

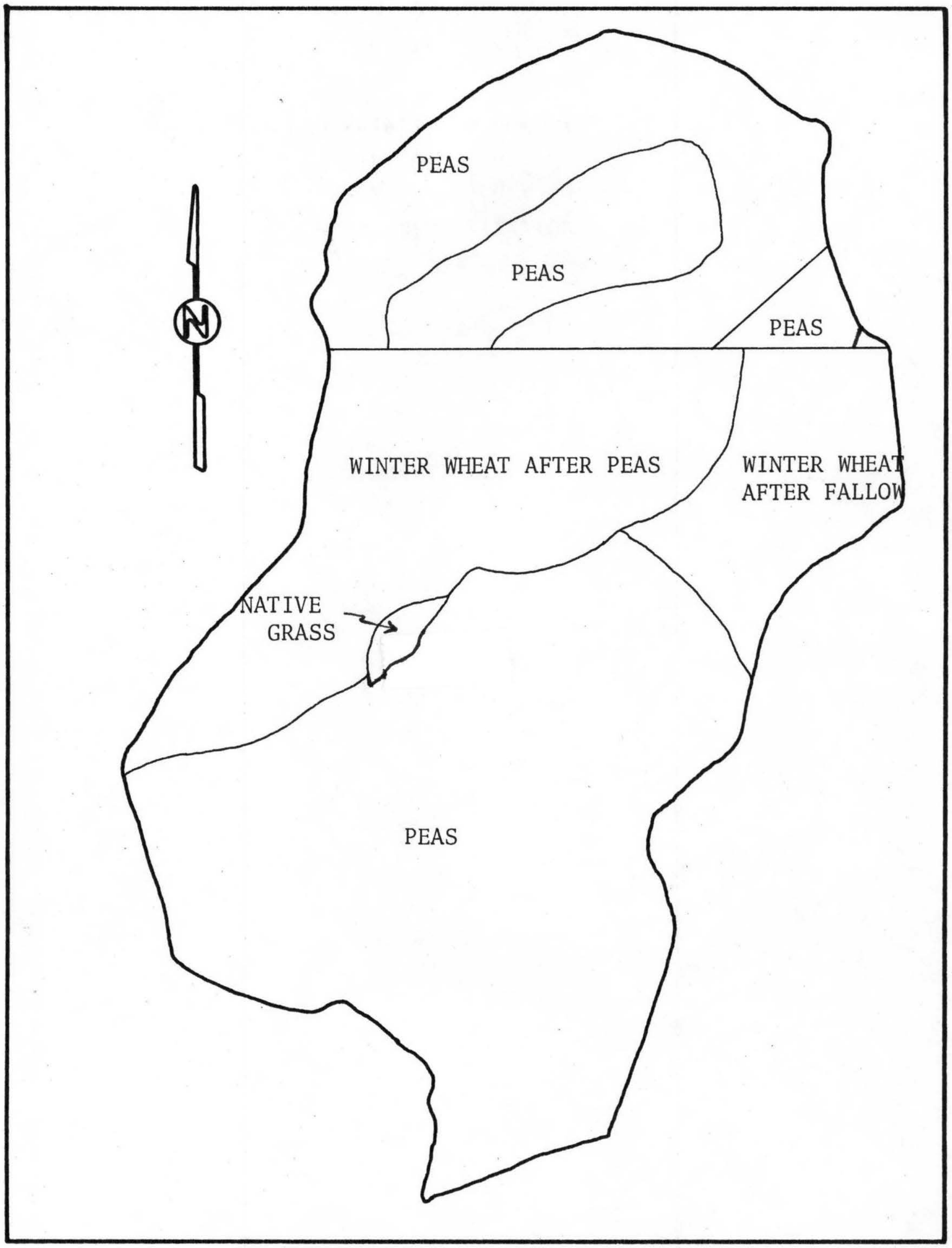


Figure 7. Land-use classes of the Pitzen watershed in 1938.

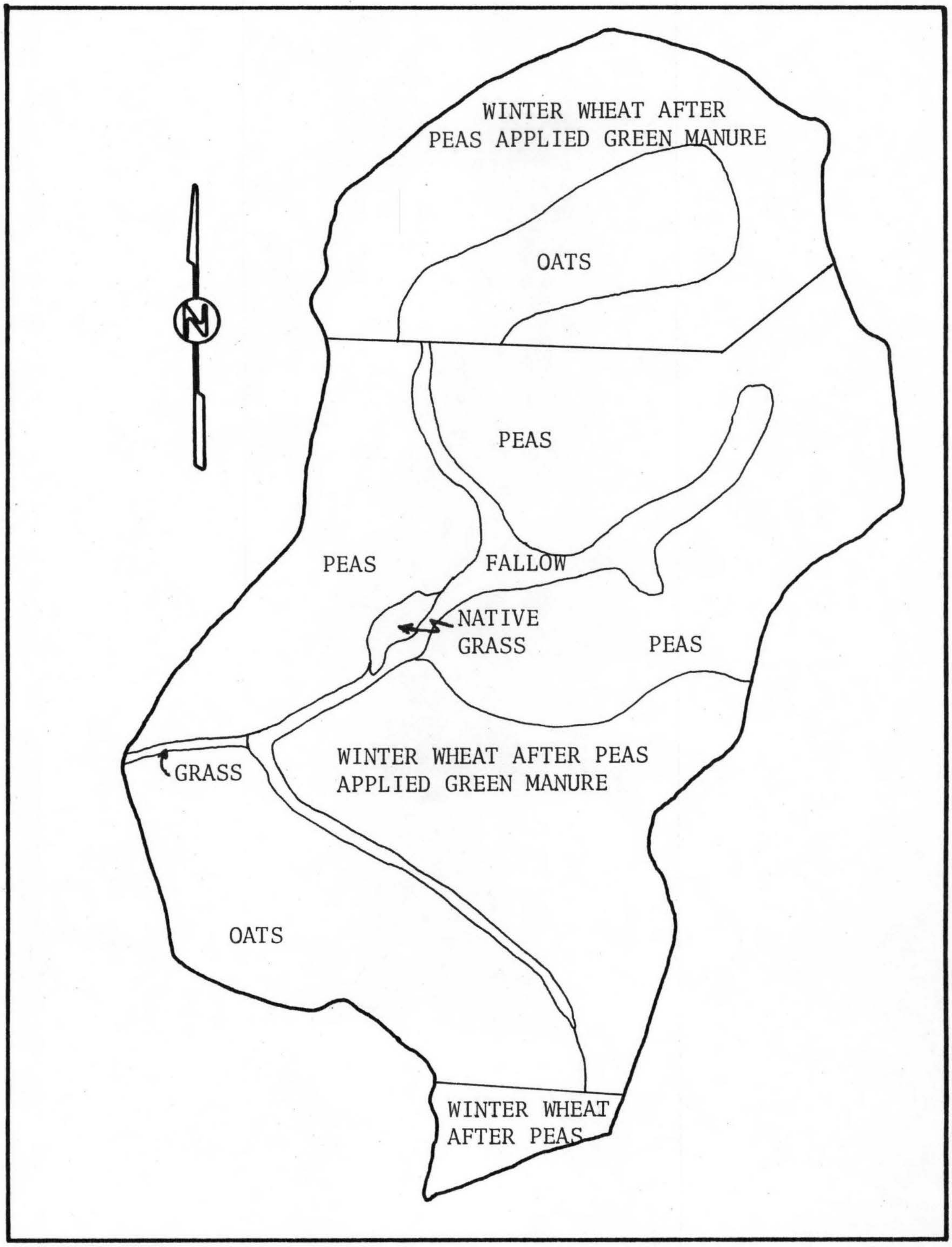


Figure 8. Land-use classes of the Pitzen watershed in 1939.

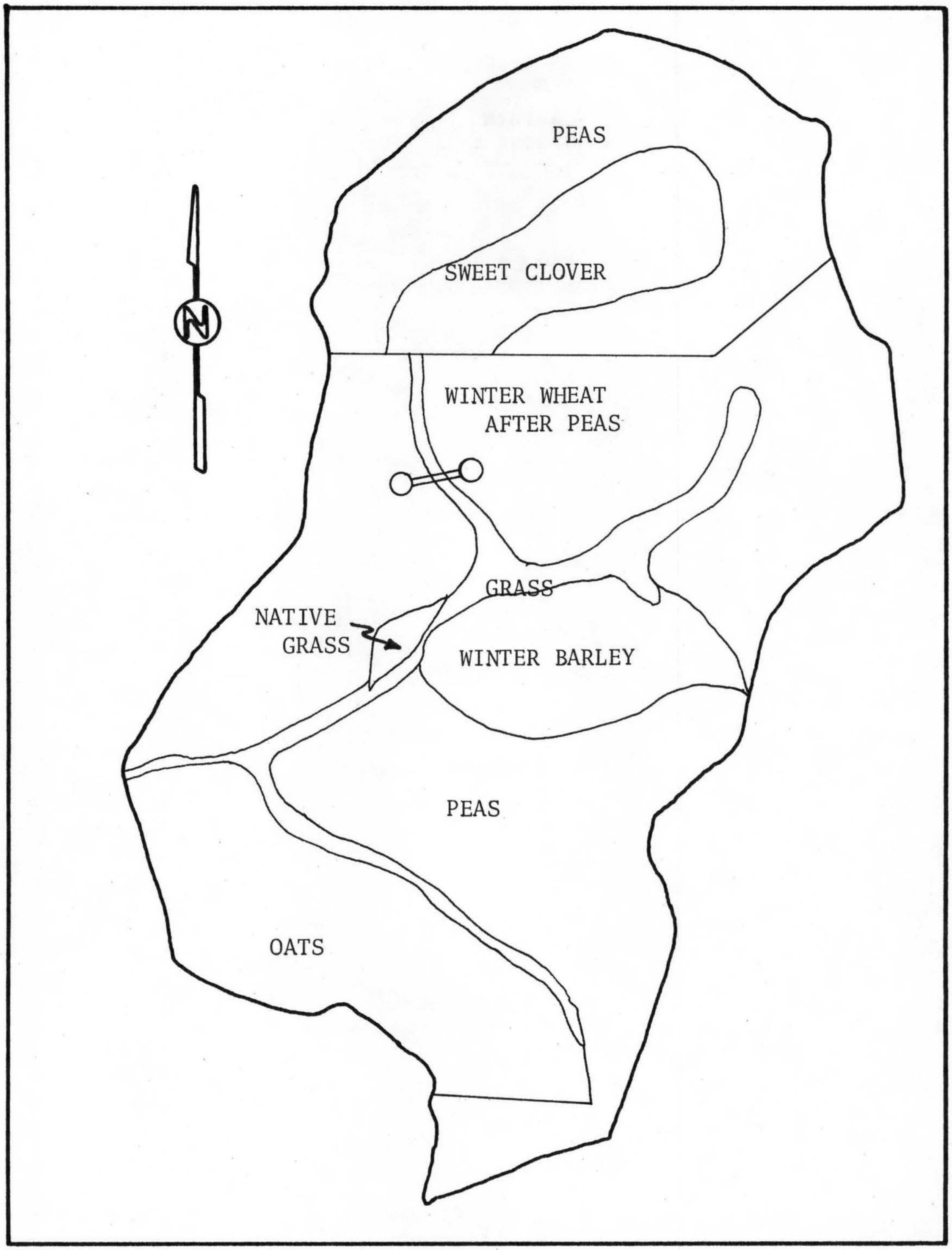


Figure 9. Land-use classes of the Pitzen watershed in 1940.

B. Operation of the Model

The erosion model was designed to be operated as a subroutine of the University of Idaho version of the USDAHL watershed model. The watershed model is described in more detail by Yoo and Molnau (1976) and King (1976). The base data requirement obtained from the watershed model for the erosion model are:

1) precipitation (observed) at break-point time. This must be so detailed that any high intensity (even a minute duration) is shown, which is the main source of overland flow;
2) daily maximum and minimum air temperature (observed);
3) overland flow (simulated) at break-point time:
4) channel flow (simulated or observed) at simulated channel routing time interval or observed daily value;
5) cropping practices (observed);
6) tillage practices (observed);
7) growth index curve of plants (simulated);
8) subsurface flow (simulated) at break-point time;
9) snow and snowmelt (simulated) at break-point time;
10) soil moisture (simulated) in A horizon

The upland erosion will be simulated using these values.

There are several unknown coefficients and exponents within the erosion model. These values must be approximated and optimized later using trial-and-error methods. Some of them can be first estimated from other studies or be assumed from watershed or soil characteristics. After a value is applied, the simulated output is compared with observed stream flow and soil loss. This continues until the user is satisfied. They are shown in Tables 7 and 8 with their approximate range and variables and equations related to them.

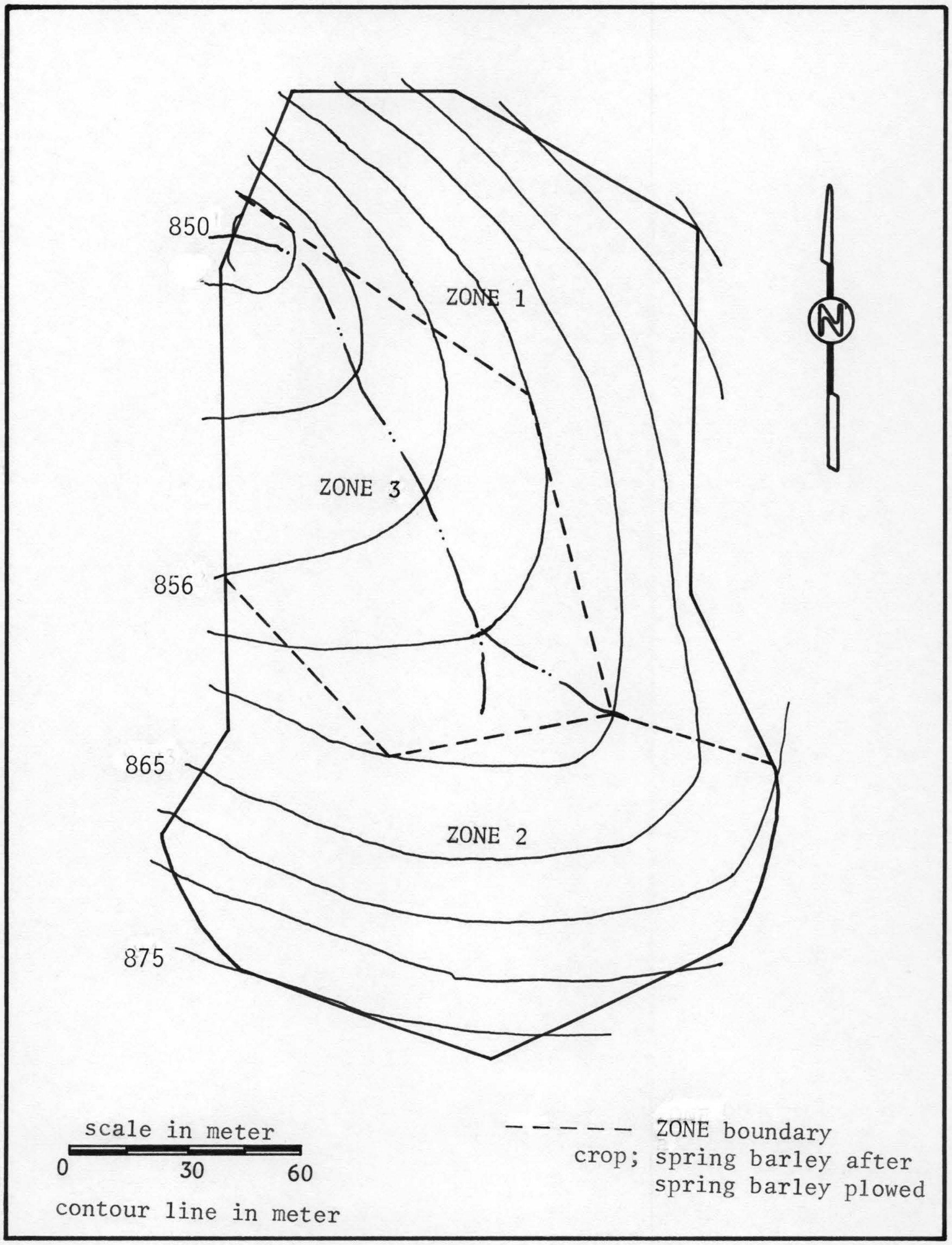


Figure 10. Map of the Thompson watershed.

DATA	BASE TIME	PERIOD
evaporation	daily (growing season)	1969 - 1973
max. and min. temperature	daily break-point time	1969 - 1973
solar radiation	daily (growing season)	1969 - 1971
net soil heat flux	daily (growing season)	1970 - 1971
wind movement	daily (growing season)	1970 - 1972
precipitation	daily break-point time	1969 - 1973
stream flow	daily	1969 - 1973
snow covered area	daily	1971 - 1973
soil temperature	daily	1972 - 1973
water temperature	daily	1971 - 1972
soil moisture	daily	1971 - 1972
soil loss	daily	1972
contour map		
hydrologic capacity of soil		

Table 6. Available data for the Thompson Watershed.

COEFFICIENTS	EXPLANATION	APPROXIMATE RANGE	VARIABLES OBTAINED	EQUATIONS APPLIED
C(1)	Surface water depth effect to rainfall impact erosion, negligible where low rainfall intensity is dominant.	1.0	DEP	20
C(2)	Rill effect to surface and subsurface water concentration to rill.	10.0*	RQI SEEP	27,29
C(3)	Snow covered area related to snow drifting index, a ratio of maximum snow free area to total area after a snow storm.	0.8*	SNCV	20
C(4)	Rainfall detachment related to rainfall intensity, it will be approximately estimated comparing rainfall and soil loss for a first erosion event after a storm.	0.1*	DHR	20
C(5)	Overland flow detachment related to tractive force, it will be approximately estimated comparing observed stream flow and soil loss when overland flow is assumed to be dominant.	100.0*	DHF	21
C(6)	Rainfall effect to runoff transport capacity, negligible where low rainfall intensity is dominant.	0.0	ATRF	23
C(7)	Soil particle detachment storage change by soil moisture change	1.0	CDS	31
C(8)	Delivered sediment settling rate factor when SDLD exceeds ATRF.	1.0	DPS	32
C(9)	Sediment pick-up rate factor when ATRF exceeds SDLD.	1.0	PIUP	36
C(10)	Channel scouring erosion related to channel flow, it will be approximately estimated comparing observed stream flow and soil loss when overland flow is assumed to be negligible.	10.0*	SCR	43
C(11)	Soil particle detachment storage decreasing rate factor as time passes.	0.0025**	DS	31

* optimized value for the Pitzen watershed.
** optimized by David (1972).

Table 7. Coefficients to be applied to variables in various equations in the erosion model.

EXPONENTS	EXPLANATION	APPROXIMATE RANGE	VARIABLES OBTAINED	EQUATIONS APPLIED
EXP(1)	Soil moisture effect of resisting to erosion when soil is dry, i.e., SM1 PL*	≧ 1.0	SOIL	20,31
EXP(2)	Soil moisture effect of resisting to erosion when soil is wet, i.e., LL SM1 PL*	≧ 1.0	SOIL	20,31
EXP(3)	Surface water effect to rainfall impact to erosion, negligible where low rainfall intensity is dominant.	≃ 1.0	DEP	20
EXP(4)	Crop growing factors related to time and growing index simulated by the USDAHL watershed model. (Rickman's drymatter simulation curve (1975))	≧ 1.0	CMCV	20,21, 23,24,25
EXP(5)	Snow covered area related to snow drifting	≃ 1.0	SNCV	20,21
EXP(6)	Snow covered area depleted by snow melting	≧ 1.0	SNCV	20
EXP(7)	Rainfall detachment related to rainfall intensity	≃ 2.0 David and Beer, 1975)	DHR	20
EXP(8)	Overland flow detachment related to tractive force	1.5 - 1.8 (Graf, 1971)	DHF	21
EXP(9)	Channel scouring erosion related to channel flow	0.8 - 1.24 (Gilbert, 1914) 1.33 (David, 1972)	SCR	43

SM1 ; soil moisture content in percent volume obtained from USDAHL watershed model
PL ; plastic limit of a soil in percent
LL ; liquid limit of a soil in percent
* ; It is assumed that soil is dry when SM1 ≦ PL and wet when SM1 ≧ PL

Table 8. Exponents to be applied to obtain variables in the erosion model

The input data for the erosion model are given for zones, crops, upland and channel factors. Most of these values can be obtained from physical and cropping characteristics of a watershed.

Zone Factors

WWS (%) ; windward face factor, percent of windward area to total area
PL (%) ; plastic limit of a soil
LL (%) ; liquid limit of a soil
CLAY (%) ; clay content of a soil
IMPCV (%) ; percent of impervious area to total area
MAAR (%) ; maximum rill area in percent to total area at the end of an erosion season
MRILD (mm) ; maximum rill depth at the end of an erosion season
DRIFT (mm/hour) ; snow drifting factor
MCDS (tons/hectare/hour) ; maximum increment of detachment storage when soil is wet

Crop Factors

CRMCV (%) ; percent of maximum crop covered area to total area
CRMHT (m) ; maximum crop height
XCOV (weeks) ; the week when CRMCV is measured after planting
MULCH (tons/hectare) ; plant residue left on a crop field
RESU ; plant residue conditions; plowed, standing stubble or no-till
CROP ; planting season of a crop; winter, spring, perennial or permanent
SBD ; number of weeks between seeding and spring break of dormancy for winter crops, zero for spring crops

Upland Factors

N0, N1, N2, N3, N4, and N5 ; values describing upland surface conditions used to obtain Manning's surface roughness coefficient, n (Cowan, 1956)

N = (N0 + N1 + N2 + N3 + N4) N5

N ; final roughness coefficient,

N0 ; basic n value for a straight, uniform, smooth channel in the natural material involved

N1 ; effect of surface irregularity

N2 ; variations in shape and size of cross section

N3 ; obstructions

N4 ; vegetation

N5 ; meandering of channel

Values of these can be obtained from Appendix V.

AX ; erosion resistance index of upland soil at plastic limit

AX1 ; erosion resistance index of upland soil at wilting point

DEGHR ; index degree-hour to define complete melt of frozen soil

DXTHW ; critical temperature at which the surface of the frozen soil starts melting

OMPRE (mm) ; total precipitation during erosion season (October through March in the Pacific Northwest)

OSPRE (mm) ; total precipitation at the beginning of simulation after erosion season starts

ACCRUN (mm) ; total channel flow during erosion season

OSRUN (mm) ; total channel flow at the beginning of simulation after erosion season starts

Channel Factors

WDTH (m) ; average width of channel
VP (m/s) ; permissible velocity of channel flow below which no scouring occurs
CSL (%) ; channel bottom slope steepness
CMANN ; Manning's roughness coefficient of channel
CORFCT ; correcting factor for channel scouring erosion when observed daily stream flow is used instead of simulated routing time interval

The following values are also necessary to initialize surface conditions at the beginning of a simulation:

SNCV (%) ; percent of snow covered area to total area,
RDS (tons/hectare) ; amount of detached soil particles remaining in rills,
IDS (tons/hectare) ; amount of detached soil particles remaining on interrill areas
AARI (%) ; initial rill distribution,
RILDI (mm) ; initial average rill depth.

These values can be obtained by field observation. If observed daily sediment loss data are available, they can be used to compare and evaluate the simulated results.

Appendix II shows format of the input parameters to the erosion model. They are read completely separately from the USDAHL watershed model input file.

C. Results and Discussion

The 1939 water year of the Pitzen watershed was used for the parameter optimization. This was done by trial and error using the total sediment yield as the parameter for comparison. Once this was done, the other water years were tested using the same parameters. For the Thompson watershed a second set of parameters was derived. However, only a few values were needed to be changed from those of the Pitzen watershed. The parameters of the erosion simulation model used for the two watersheds are shown in Appendices III and IV.

For the runoff simulation, initial values were obtained from the value of the last day of the previous water year's output. Table 9 shows the initial soil moisture used for the test water years. The values were obtained at the end of previous water year simulation except the 1938, Pitzen watershed. The lowest simulated soil moisture in 1939 water year was chosen for 1938 test. Many parameters could be set to zero since the water year in the Palouse starts after a long dry season. It seemed that the runoff events of the beginning months (October, November, and December) were very sensitive to the initial soil moisture. The higher than observed stream flows (Tables 10 and 11)show that the initial soil moisture used might be inadequate. It could be true since the runoff was simulated as subsurface flow which usually occurs when soil moisture is saturated or at near saturation. It seems that more moisture should be extracted from subsurface moisture so that more water could be held in the soil after a dry season. Past records show that soil moisture reaches below wilting point (8.3% at 150 mm, 15% at 300 mm, and 20% at 600 mm below soil surface on the 20th of August, 1970) at the end of summer season on the Thompson watershed (Davis, 1971). The simulated soil moisture hardly reaches this point. This condition is well shown in Tables 17, 19, 20 and 21 as the simulated stream flow is higher than the observed in the beginning season of each year, most of which were simulated as subsurface flow. As shown in Tables 10 and 11 the monthly simulated stream flows do not deviate much from the recorded flows except for the early season. The least accuracy of

WATERSHED	LAYER 1							LAYER 2					
THOMPSON	ZONE	SMWP	SMI			SMAWC	DEPTH	SMWP	SMI			SMAWC	DEPTH
			1972						1972				
	1	38.4	85.2	·	·	86.6	200	255.6	394.8	·	·	478.8	1200
	2	48.0	93.3	·	·	108.3	250	255.6	400.8	·	·	478.8	1200
	3	57.6	107.1	·	·	129.9	300	319.5	513.0	·	·	598.5	1500
PITZEN *			1938	1939	1940				1938	1939	1940		
	1	33.4	35.4	40.4	36.4	66.8	200	333.0	423.0	427.5	427.5	564.0	1500
	2	31.6	39.6	44.2	39.2	70.2	200	255.6	345.6	345.6	346.8	478.8	1200
	3	39.5	47.0	53.0	48.5	87.8	250	255.6	351.6	352.8	356.4	478.8	1200
	4	50.1	56.1	58.5	55.5	100.2	300	333.0	468.0	465.0	475.5	564.0	1500

* It is assumed that Zones 1 and 4 have Thatuna silt loam I (9% slope) and Thatuna silt loam II (15% slope) on Zones 2 and 3 (Table 4).

SMWP = Soil moisture at wilting point or 15 bar tension atmosphere in mm.

SMI = Soil moisture obtained at the end of previous water year.

SMAWC = Soil moisture at available water capacity or 0.3 bar tension atmosphere in mm

DEPTH = Soil layer depth in mm.

Table 9. Soil moisture, initial soil moisture and soil depth used for the test watersheds.

			RAIN +	STREAM FLOW		SOIL LOSS			TOTAL SOIL LOSS	
YEAR	MON	PRECIP	MELT[a]	SIMUL	OBSER	UPLAND	CHAN1[b]	CHAN2[b]	SIMUL[c]	OBSER
1971	10	31.00	27.43	0.02	0.0	0.0	0.0	0.0	0.0	0.0
	11	69.08	72.64	0.87	0.0	0.0	0.01	0.0	0.01	0.0
	12	109.47	46.87	19.92	0.0	0.36	0.09	0.0	0.45	0.0
1972	1	81.49	72.56	57.02	90.00	9.57	0.56	0.97	10.13	10.55
	2	89.53	156.12	120.64	109.60	8.23	1.08	0.92	9.31	17.64
	3	104.90	109.85	94.18	91.72	48.23	0.73	0.77	48.96	13.18
	4	25.13	25.14	2.93	0.38	0.28	0.01	0.0	0.29	0.0
	5	60.45	69.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6	10.92	10.92	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7	21.08	21.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8	15.24	15.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9	17.78	17.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		639.09	639.09	295.58	291.70	66.67	2.48	2.66	69.15	41.37

a ; simulated moisture input

b ; CHAN1 - channel scouring erosion using simulated channel flow
CHAN2 - channel scouring erosion using observed channel flow

c ; UPLAND + CHAN1

Table 10. Monthly summary of simulated and observed output for the Thompson Watershed - moisture in millimeter and soil loss in metric tons.

YEAR	MON	PRECIP	RAIN + MELT[a]	STREAM FLOW		SOIL LOSS			TOTAL SOIL LOSS	
				SIMUL	OBSER	UPLAND	CHAN1[b]	CHAN2[b]	SIMUL[c]	OBSER
1937	10	33.53	33.53	0.0	0.0	0.0	0.0	0.0	0.0	-
	11	90.17	90.17	1.11	0.0	0.0	0.41	0.0	0.41	-
	12	104.94	100.89	58.86	4.11	85.32	27.50	0.88	112.82	-
1938	1	44.19	44.77	36.60	30.73	30.75	12.05	7.28	42.80	-
	2	44.46	36.71	20.44	41.63	0.33	4.36	9.52	4.69	0.08
	3	49.28	60.40	38.89	42.52	29.47	11.18	9.80	40.65	29.51
	4	38.61	38.71	19.64	11.40	169.06	5.99	1.87	175.05	33.91
	5	38.82	38.82	1.18	0.28	0.30	0.07	0.01	0.37	7.91
	6	30.48	30.48	0.0	0.0	0.0	0.0	0.0	0.0	0.00
	7	2.79	2.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8	4.57	4.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9	19.05	19.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		500.89	500.89	176.72	130.39	315.23	61.56	29.36	376.79	71.41[d]
1938	10	45.47	45.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	60.20	60.10	0.51	0.0	0.00	0.21	0.0	0.21	0.0
	12	29.21	28.08	0.20	0.18	0.00	0.08	0.01	0.08	0.05
1939	1	38.36	38.98	13.78	0.25	0.00	3.03	0.00	3.03	0.08
	2	89.93	31.49	15.31	14.05	0.00	3.17	2.63	3.17	2.49
	3	53.84	112.87	90.71	114.95	111.72	45.71	48.91	157.43	260.44
	4	9.40	9.40	3.17	4.14	0.03	0.37	0.46	0.40	0.24
	5	22.35	22.35	0.07	0.0	0.0	0.0	0.0	0.00	0.0
	6	20.07	20.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7	19.56	19.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9	9.91	9.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		398.26	398.26	123.61	133.57	111.75	52.57	52.01	164.32	263.30
1939	10	30.23	30.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	7.11	8.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	112.76	112.44	6.23	0.20	63.93	3.54	0.03	67.47	0.0
1940	1	43.93	37.70	28.58	1.65	0.33	9.27	0.15	9.60	1.59
	2	120.83	125.95	89.47	19.86	166.80	44.45	12.84	211.25	383.71
	3	78.76	78.74	52.83	38.38	150.40	20.07	10.38	170.47	260.40
	4	56.41	56.41	23.68	8.56	15.48	6.53	1.63	22.01	92.88
	5	21.33	21.33	9.79	0.61	5.12	2.27	0.07	7.39	3.70
	6	12.70	12.70	0.19	0.0	0.0	0.00	0.0	0.0	0.0
	7	43.94	43.94	0.10	0.0	0.09	0.06	0.0	0.15	0.0
	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9	101.85	101.85	1.19	0.0	0.23	0.58	0.0	0.81	0.0
TOTAL		629.43	629.43	212.05	69.26	402.38	86.77	25.10	489.15	742.28

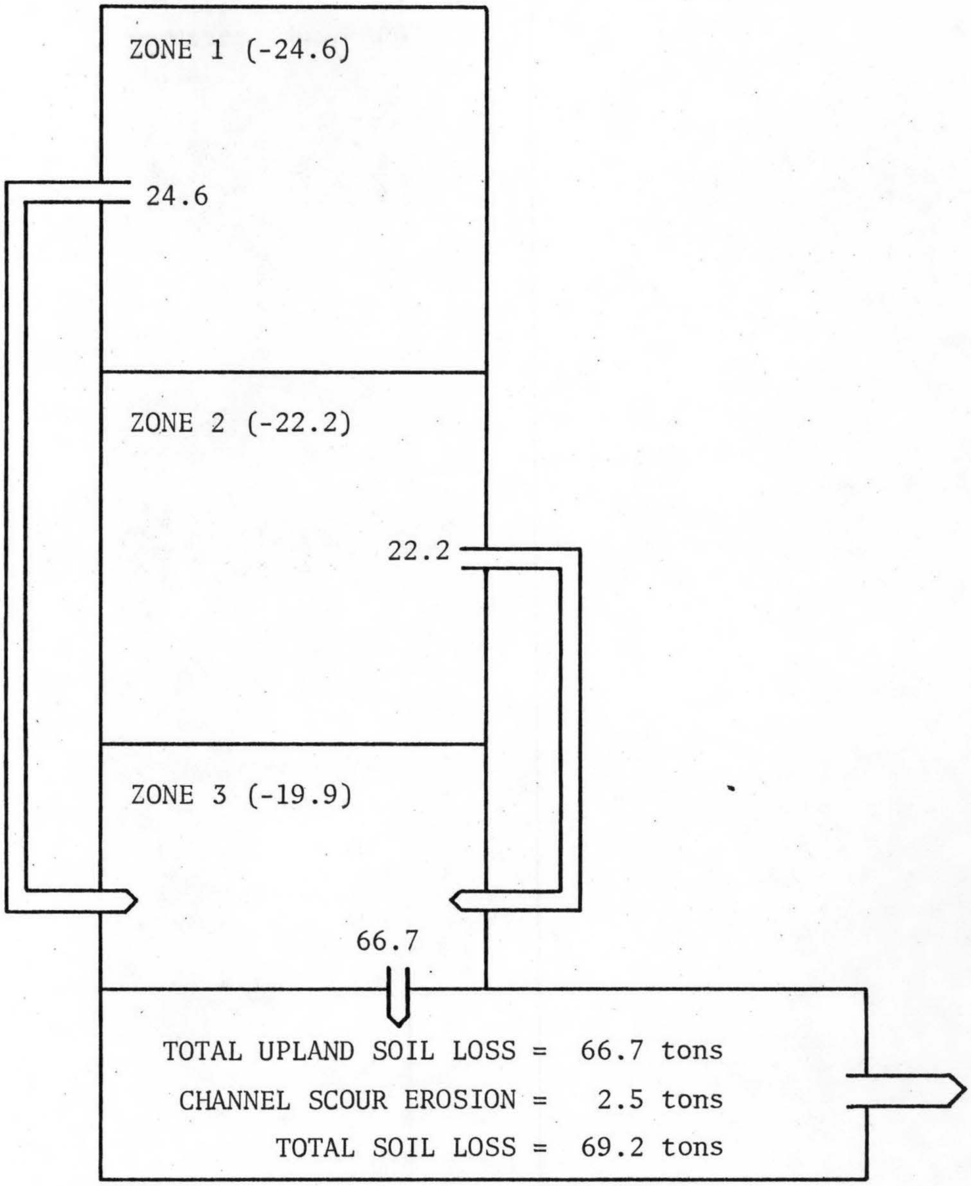
a, b and c ; see Table 10 , d ; no record before February.

Table 11. Monthly summary of simulated and observed output for the Pitzen Watershed - moisture in millimeter and soil loss in metric tons.

the simulations is 1940 of the Pitzen watershed (212 mm and 69 mm of annual simulated and observed stream flows, respectively). These are mostly because of the high initial soil moisture obtained from the previous year's simulated and low deep percolation water loss. For more information on this problem, see Yoo and Molnau, 1976.

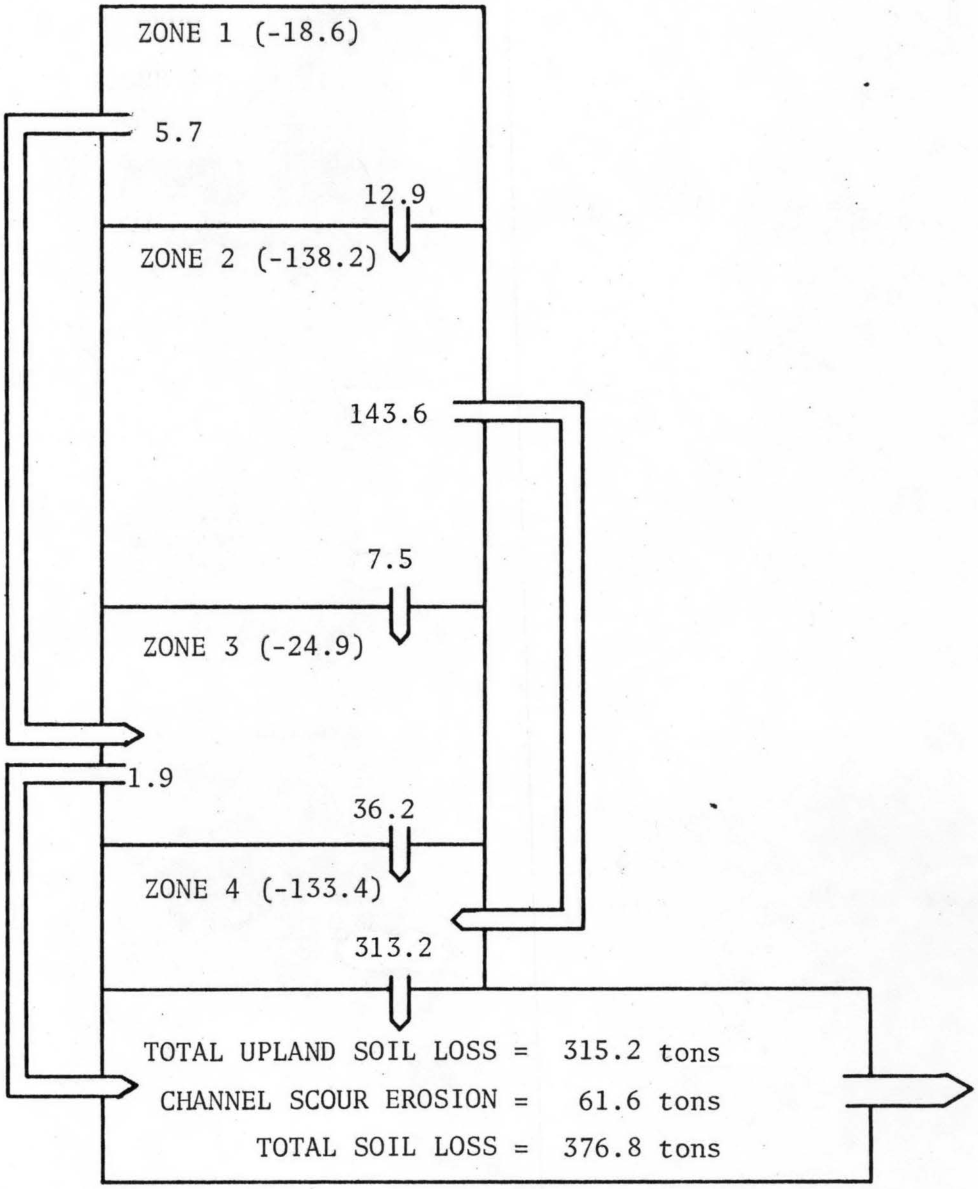
The Tables 10 and 11 also give the monthly and yearly simulated and observed soil loss. The simulated results show the three different sources of erosion in the model. They are: 1) soil loss from upland areas (UPLAND), 2) channel scour erosion using simulated stream flow (CHAN1), and 3) channel scour erosion using observed stream flow (CHAN2). The last two values are usually comparable to each other when the stream flow simulation is accurate. However, upland soil loss and total soil loss does not follow this pattern because upland soil loss is caused by overland flow and high stream flow does not necessarily mean that an overland flow event occurred. As will be discussed later, the watershed model does not estimate good values for overland flow. In the Palouse, overland flow usually takes place when any of the following events or some combination of them exist: 1) high intensity rainfall or snowmelt, 2) saturated A or B horizon and 3) partially thawed ground surface above frozen subsurface. There are several other deficiencies of the watershed model as a tool for erosion simulation such as inaccuracies in determination of infiltration rate, defining of rain-snow event, snowmelt, frozen ground and subsurface flow routing. These are directly or indirectly related to overland flow. These conditions will also be discussed in a later part of this chapter with daily events of the model output. It should be noted that the timing of the high soil loss event matches with the recorded even though the amount does not.

It is important to identify the source area of soil loss. The watershed model cascades overland flow on or around upland zones. This routine was also used to cascade the upland soil loss through zones downward. The flow paths of the cascades for flow and soil are shown in Figures 11 to 14. Tables 12 to 15 also show upland soil loss cascaded through the rill and interill area. Since rill erosion simulation depends on the estimated rill size and distribution this estimation should be obtained as



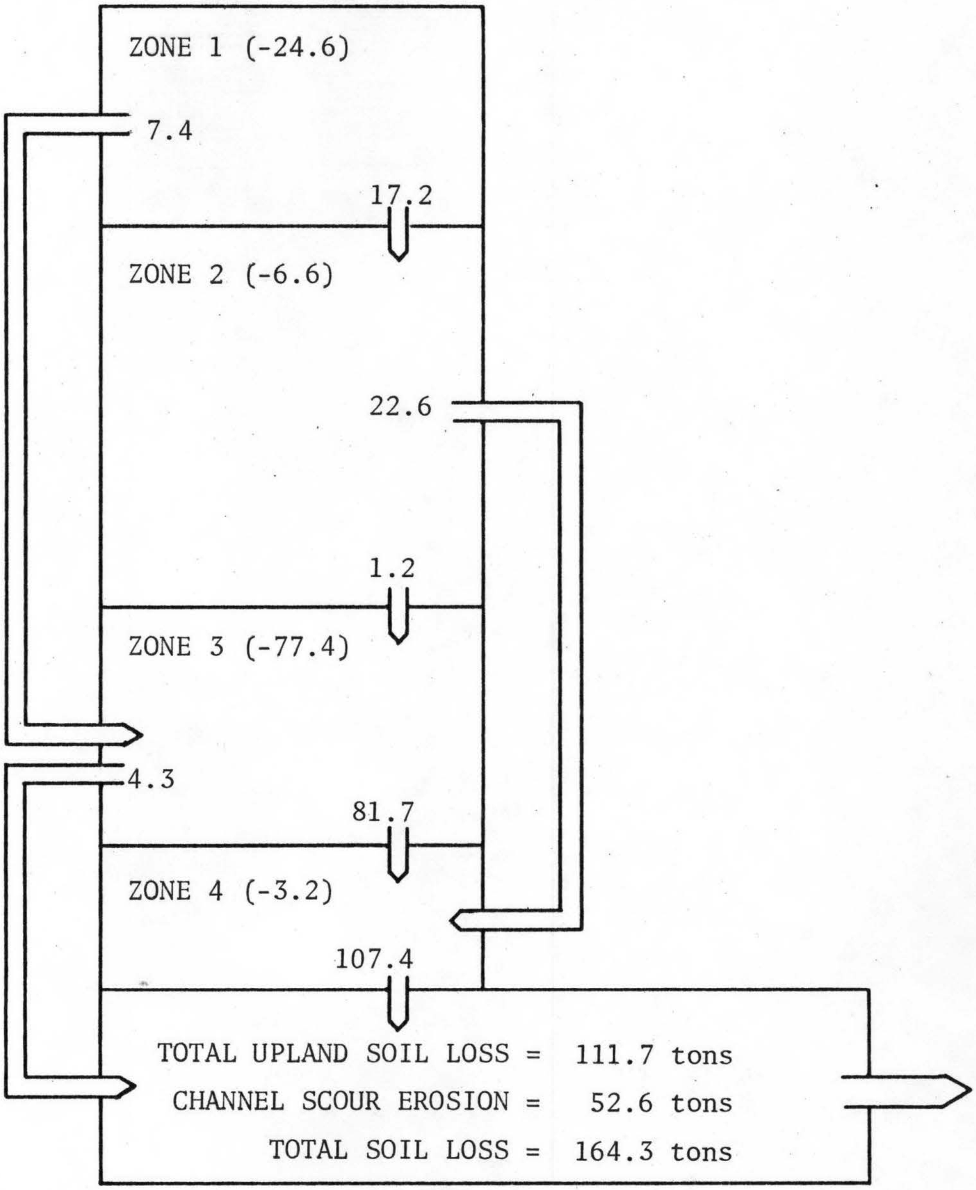
* in parenthesis; negative indicates erosion and positive deposition

Figure 11. Simulated soil loss cascaded on three successive soil zones and channel of the Thompson watershed in water year 1972 (soil loss in metric tons).



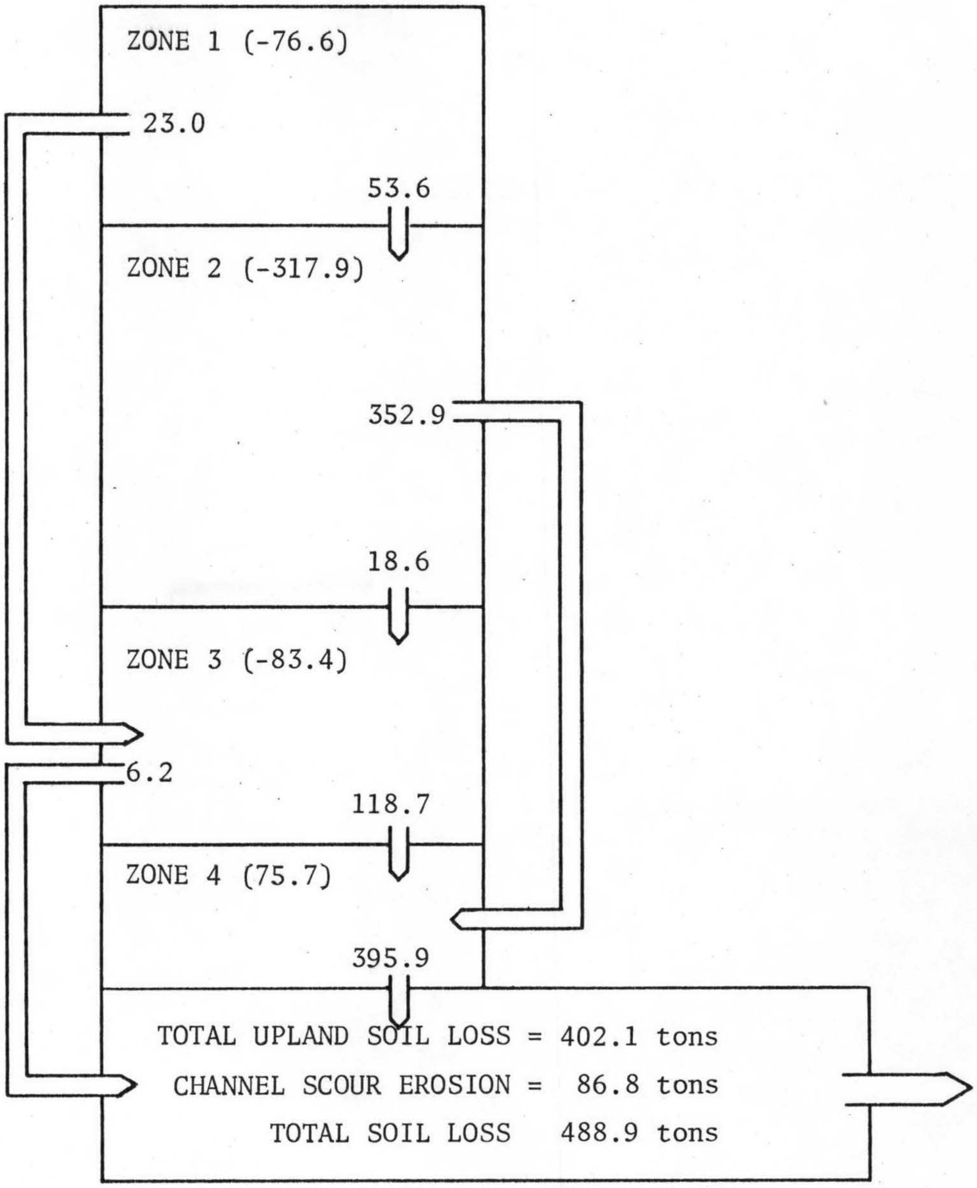
* in parenthesis; negative indicates erosion and positive deposition

Figure 12. Simulated soil loss cascaded on four successive soil zones and channel of the Pitzen watershed in water year 1938 (soil loss in metric tons).



* in parenthesis; negative indicates erosion and positive deposition

Figure 13. Simulated soil loss cascaded on four successive soil zones and channel of the Pitzen watershed in water year 1939 (soil loss in metric tons)



* in parenthesis; negative indicates erosion and positive deposition

Figure 14. Simulated soil loss cascaded on four successive soil zones and channel of the Pitzen watershed in water year 1940 (soil loss in metric tons)

	ZONE I					ZONE II				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE	QO	REROS	IEROS	ZEROS	BALANCE
1971 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	1.5	0.0	2.2	0.0	-2.2	0.0	0.0	0.0	0.0	0.0
1972 1	9.7	0.0	1.3	0.0	-1.4	4.9	0.1	3.1	0.0	-3.2
2	12.7	0.6	2.8	0.0	-3.4	7.5	0.4	1.3	0.0	-1.7
3	11.0	8.9	8.5	0.0	-17.4	4.0	12.8	4.2	0.0	-17.0
4	0.0	0.2	0.0	0.0	-0.2	0.0	0.3	0.0	0.0	-0.3
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	34.9	9.8	14.8	0.0	-24.6	16.4	13.6	8.6	0.0	-22.2

	ZONE III				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE
1971 10	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0
12	0.7	0.0	0.3	2.2	1.9
1972 1	43.0	0.3	9.3	4.6	-5.0
2	47.2	1.4	6.8	5.2	-3.0
3	30.1	24.2	24.1	34.4	-13.9
4	0.0	0.3	0.0	0.4	0.1
5	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0
TOTAL	121.0	26.2	40.5	46.8	-19.9

QO ; overland flow in mm
REROS ; soil loss from rills in tons
IEROS ; soil loss from interrill in tons
ZEROS ; soil loss transported from upper zone in tons
BALANCE ; soil loss balance on a zone in tons - negative shows erosion and positive for deposition

Table 12 -- Monthly summary of soil loss and overland flow from zones of the Thompson watershed in water year 1972.

	ZONE I					ZONE II				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE	QO	REROS	IEROS	ZEROS	BALANCE
1937 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
12	1.6	0.3	5.9	0.0	-6.2	13.1	3.7	57.1	4.3	-56.5
1938 1	2.6	0.8	4.0	0.0	-4.8	4.7	2.9	14.0	3.3	-13.6
2	0.0	0.0	0.0	0.0	-0.0	0.0	0.1	0.0	0.0	-0.1
3	0.1	0.8	0.8	0.0	-1.6	1.4	13.1	12.9	1.1	-24.9
4	1.2	3.2	2.4	0.0	-5.6	4.8	25.1	18.8	3.9	-40.0
5	0.0	0.4	0.0	0.0	-0.4	0.0	2.8	0.0	0.3	-2.5
6	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	-0.6
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	5.5	5.5	13.1	0.0	-18.6	24.0	48.3	102.8	12.9	-138.2

	ZONE III					ZONE IV				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE	QO	REROS	IEROS	ZEROS	BALANCE
1937 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0
12	0.3	1.9	11.7	4.9	-8.7	67.1	5.3	79.3	70.7	-13.9
1938 1	1.0	2.9	5.7	2.3	-6.3	15.9	4.9	25.5	24.2	-6.2
2	0.0	0.2	0.0	0.0	-0.2	0.0	0.3	0.0	0.3	-0.0
3	0.0	8.3	0.0	1.8	-6.5	2.8	17.0	12.0	32.6	3.6
4	0.0	7.4	0.0	3.9	-3.5	13.6	80.1	88.6	48.8	-119.9
5	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.0	2.7	2.4
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1.3	20.7	17.4	13.2	-24.9	99.4	107.9	205.4	179.9	-133.4

symbols ; see Table 10

Table 13 ; Monthly summary of soil loss and overland flow from zones of the Pitzen watershed in water year 1938.

	ZONE I					ZONE II				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE	QO	REROS	IEROS	ZEROS	BALANCE
193810	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	-0.0
2	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	-0.0
3	8.7	8.8	15.8	0.0	-24.6	1.9	7.2	16.6	17.2	-6.6
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	8.7	8.8	15.8	0.0	-24.6	1.9	7.2	16.6	17.2	-6.6

	ZONE III					ZONE IV				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE	QO	REROS	IEROS	ZEROS	BALANCE
193810	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.0
3	8.9	50.3	35.7	8.6	-77.4	43.1	40.9	66.5	104.2	-3.2
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	8.9	50.3	35.7	8.6	-77.4	43.1	40.9	66.5	104.2	-3.2

symbols ; see Table 10

Table 14 ; Monthly summary of soil loss and overland flow from zones of the Pitzen watershed in water year 1939.

	ZONE I					ZONE II				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE	QO	REROS	IEROS	ZEROS	BALANCE
1939 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	2.7	0.2	8.3	0.0	-8.5	7.2	1.1	47.1	5.9	-42.3
1940 1	0.0	0.0	0.5	0.0	-0.5	0.2	0.3	4.6	0.4	-4.5
2	11.8	2.9	12.9	0.0	-15.8	23.7	16.9	78.2	11.1	-84.0
3	3.4	13.3	19.2	0.0	-32.5	11.2	55.4	86.7	22.7	-119.4
4	0.1	0.5	3.4	0.0	-3.9	0.5	7.0	19.0	2.7	-23.3
5	0.2	1.5	13.9	0.0	-15.4	1.3	12.0	42.3	10.8	-43.5
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	-0.0	0.0	0.9	0.0	0.0	-0.9
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	18.2	18.4	58.2	0.0	-76.6	44.1	93.6	277.9	53.6	-317.9

	ZONE III					ZONE IV				
MONTH	QO	REROS	IEROS	ZEROS	BALANCE	QO	REROS	IEROS	ZEROS	BALANCE
1939 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	5.0	5.0	15.1	2.0	62.0	45.9	-18.1
1940 1	0.0	0.2	0.0	0.4	0.2	0.2	0.2	0.1	4.8	4.5
2	7.6	12.0	31.5	9.5	-34.0	88.9	34.7	129.9	131.7	-32.9
3	0.7	47.0	27.0	16.8	-57.2	22.7	52.4	94.3	205.3	58.6
4	0.0	5.5	0.0	2.5	-3.0	0.0	15.2	0.0	29.9	14.7
5	0.0	1.7	0.0	7.3	5.6	0.0	5.0	0.0	53.2	48.2
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.8	0.7
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
TOTAL	8.3	66.4	58.5	41.5	-83.4	126.9	109.6	286.3	471.6	75.7

for symbols, see Table 10

Table 15 -- Monthly summary of soil loss and overland flow from zones of the Pitzen watershed in water year 1940.

precisely as possible. This is an area which has to receive further study if better computations of soil erosion are to be made. The preceeding results may give some information where (zones) the erosion and deposition occur. This would be a good planning tool of evaluating and controlling soil erosion from upland area.

Because upland erosion occurs when and where overland flow exists, a monthly summary can not explain the accuracy of the simulation. An example computer output of the simulation for short time periods (channel routing time and overland flow routing time) is shown in Appendix IV. However, there is no recorded data with which simulated results are compared. In most cases sediment loss data from a watershed are collected on a daily basis. Tables 17, 19, 20 and 21 have the daily results of the watershed and erosion models. The simulated total soil loss from a watershed with estimated channel erosion using simulated stream flow (SIMUL1) or observed stream flow (SIMUL2) are shown in the tables. They also show snowmelt and rain-snow form simulations. For convenience, discussion of the daily simulation output will be done for each water year for each watershed.

1. Thompson Watershed (Table 17)

As discussed before the high initial soil moisture (Table 9) obtained from the last day of the previous year caused stream flow and soil loss in the early months of the water year (Table 10) when no events were observed. The following days were selected to be discussed in detail since they have high stream flow and soil loss. Table 16 shows the simulation of overland flow, upland erosion and their cascading to lower zones of the selected days. Table 17 shows the daily summary for the periods discussed.

a) Days 112-114 (January 20 - January 22)

There would be high moisture input from snowmelt on day 113, which caused the high observed stream flow on the day and the next days. The low soil loss and high stream flow as recorded during this period explains that most of the water came from subsurface flow. Snowmelt simulation of the model shows that there was an average of 60 mm snow water equivalent

YEAR.	DAY	ZONE	QO 1/	FROM RILLS	FROM INTE-RILL	FROM 2/ UPPER ZONE	3/ BALANCE	TOTAL FROM UPLAND	CHAN-NEL	TOTAL SOIL LOSS
1972	Jan 20	I	7.82	0.03	1.09	0.0	-1.12			
		II	4.58	0.07	1.58	0.0	-1.65			
		III	33.43	0.23	7.89	2.77	-5.35	8.12	0.24	8.36
	Jan 21	I	0.0	0.00	0.0	0.0	-0.00			
		II	0.0	0.00	0.0	0.0	-0.00			
		III	7.20	0.01	0.26	0.00	-0.27	0.27	0.15	0.42
	Jan 22	I	0.0	0.0	0.0	0.0	0.0			
		II	0.0	0.0	0.0	0.0	0.0			
		III	0.0	0.00	0.0	0.0	-0.00	0.00	0.08	0.08
	Feb 18	I	0.17	0.01	0.0	0.0	-0.01			
		II	0.0	0.01	0.0	0.0	-0.01			
		III	1.86	0.05	0.20	0.02	-0.23	0.25	0.07	0.32
	Feb 19	I	0.0	0.00	0.0	0.0	-0.00			
		II	0.0	0.00	0.0	0.0	-0.00			
		III	0.67	0.03	0.13	0.00	-0.16	0.16	0.10	0.26
	Feb 27	I	9.31	0.58	2.35	0.0	-2.93			
		II	6.34	0.38	0.90	0.0	-1.29			
		III	36.35	1.23	5.31	4.21	-2.33	6.54	0.25	6.79
	Mar 5	I	1.46	0.11	0.31	0.0	-0.42			
		II	0.51	0.14	0.23	0.0	-0.37			
		III	6.17	0.40	1.33	0.79	-0.94	1.73	0.09	1.82
	Mar 13	I	5.15	6.84	6.31	0.0	-13.15			
		II	2.95	9.43	2.91	0.0	-12.34			
		III	16.36	18.18	17.42	25.49	-10.11	35.60	0.16	35.76

1/ Amount of overland flow in a day in mm.

2/ Thompson Watershed was divided such that all eroded soil particles from Zone I and Zone II cascade to alluvium (Zone III).

3/ Negative value shows erosion and positive for deposition.

Table 16 ; Simulated output of overland flow and soil loss on watershed zones for selected days for the Thompson Water shed in water year 1972 (soil loss in tons).

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1972

	PRECIPITATION(MM)			TEMPERATURE(!C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
56	0.25	0.0	0.25	5.0	-0.6	2.2	0.254	0.0	0.254	0.0	0.0	0.0	0.0	0.0
57	17.78	0.0	17.78	2.2	0.0	1.1	17.780	0.0	17.780	0.225	0.0	0.001	0.0	0.0
58	0.0	0.0	0.0	7.8	0.0	3.9	0.0	0.0	0.0	0.169	0.0	0.001	0.0	0.0
59	14.22	0.0	14.22	2.2	0.6	1.4	14.224	0.0	14.224	0.165	0.0	0.001	0.0	0.0
60	7.37	0.0	7.37	3.9	1.1	2.5	7.366	0.0	7.366	0.061	0.0	0.000	0.0	0.0
61	0.0	0.0	0.0	3.3	-1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	2.2	-2.2	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	1.7	-0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	0.0	1.27	1.27	2.2	-6.1	-1.9	0.0	0.640	0.640	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.0	-2.8	-1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	4.32	6.35	10.67	5.6	-1.7	1.9	4.318	0.630	4.948	0.060	0.0	0.000	0.0	0.0
67	0.0	29.21	29.21	0.0	-14.4	-7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	0.0	0.0	0.0	-5.0	-17.8	-11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	0.0	13.97	13.97	-0.6	-10.0	-5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	1.1	-3.3	-1.1	0.0	0.024	0.024	0.0	0.0	0.0	0.0	0.0
71	0.0	1.27	1.27	0.0	-5.6	-2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72	0.0	0.0	0.0	-3.9	-11.7	-7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	0.0	0.0	0.0	-0.6	-5.6	-3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	0.0	5.84	5.84	-1.7	-5.6	-3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	11.43	11.43	0.6	-3.9	-1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	0.0	1.27	1.27	-1.7	-14.4	-8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	8.89	1.27	10.16	1.7	-10.6	-4.4	8.890	0.600	9.490	0.235	0.0	0.002	0.0	0.0
78	9.65	0.0	9.65	3.9	0.6	2.2	9.652	2.945	12.597	3.198	0.0	0.022	0.0	0.0
79	0.0	0.0	0.0	2.8	-1.7	0.6	0.0	1.142	1.142	2.796	0.0	0.016	0.0	0.0
80	0.0	0.0	0.0	0.6	-3.3	-1.4	0.0	0.0	0.0	1.130	0.0	0.004	0.0	0.0
81	2.54	3.30	5.84	0.6	-1.7	-0.6	2.540	0.0	2.540	0.628	0.0	0.002	0.0	0.0
82	0.0	0.51	0.51	2.8	-1.7	0.6	0.0	1.442	1.442	0.695	0.0	0.002	0.0	0.0
83	2.54	0.0	2.54	5.6	-0.6	2.5	2.540	4.670	7.210	1.689	0.0	0.370	0.0	0.361
84	0.0	0.0	0.0	2.8	-1.1	0.8	0.0	1.751	1.751	2.267	0.0	0.011	0.0	0.0
85	0.0	0.0	0.0	5.6	0.6	3.1	0.0	4.288	4.288	1.928	0.0	0.009	0.0	0.0
86	0.0	0.0	0.0	1.1	-3.9	-1.4	0.0	0.024	0.024	1.900	0.0	0.009	0.0	0.0
87	0.0	0.0	0.0	0.0	-11.7	-5.8	0.0	0.0	0.0	1.189	0.0	0.004	0.0	0.0
88	0.0	0.0	0.0	-4.4	-14.4	-9.4	0.0	0.0	0.0	0.741	0.0	0.002	0.0	0.0
89	0.0	4.57	4.57	-6.1	-12.2	-9.2	0.0	0.0	0.0	0.511	0.0	0.001	0.0	0.0
90	0.0	1.27	1.27	-4.4	-8.9	-6.7	0.0	0.0	0.0	0.388	0.0	0.001	0.0	0.0
91	0.0	0.0	0.0	-2.8	-8.3	-5.6	0.0	0.0	0.0	0.268	0.0	0.000	0.0	0.0
92	0.0	0.0	0.0	1.1	-3.9	-1.4	0.0	0.024	0.024	0.173	0.0	0.000	0.0	0.0
93	0.0	0.0	0.0	2.8	-5.6	-1.4	0.0	0.750	0.750	0.128	0.0	0.000	0.0	0.0
94	0.0	0.0	0.0	0.6	-13.3	-6.4	0.0	0.0	0.0	0.093	0.0	0.000	0.0	0.0
95	0.0	0.0	0.0	-7.2	-12.8	-10.0	0.0	0.0	0.0	0.035	0.0	0.0	0.0	0.0
96	0.0	3.81	3.81	-5.6	-10.0	-7.8	0.0	0.0	0.0	0.001	0.0	0.0	0.0	0.0
97	0.0	2.03	2.03	-1.1	-6.1	-3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.0	0.0	0.0	4.4	-2.2	1.1	0.0	2.734	2.734	0.268	0.0	0.001	0.0	0.0
99	1.27	1.27	2.54	2.2	-3.3	-0.6	1.270	0.566	1.836	0.625	0.0	0.002	0.0	0.0
100	0.0	2.54	2.54	2.2	-5.0	-1.4	0.0	0.501	0.501	0.396	0.0	0.001	0.0	0.0
101	0.0	0.0	0.0	2.2	-3.3	-0.6	0.0	0.595	0.595	0.244	0.0	0.000	0.0	0.0
102	0.0	0.0	0.0	-1.7	-5.0	-3.3	0.0	0.0	0.0	0.188	0.0	0.000	0.0	0.0
103	0.0	0.0	0.0	2.8	-3.3	-0.3	0.0	0.871	0.871	0.151	0.0	0.000	0.0	0.0
104	0.0	0.0	0.0	-1.7	-8.9	-5.3	0.0	0.0	0.0	0.116	0.0	0.000	0.0	0.000
105	0.0	10.16	10.16	-3.9	-12.2	-8.1	0.0	0.0	0.0	0.053	0.127	0.000	0.0	0.000
106	0.0	0.0	0.0	-2.2	-11.1	-6.7	0.0	0.0	0.0	0.007	0.127	0.0	0.0	0.000
107	0.0	0.0	0.0	2.2	-2.8	-0.3	0.0	0.800	0.800	0.020	0.127	0.000	0.0	0.000
108	0.0	0.0	0.0	2.8	-1.1	-0.8	0.0	1.195	1.195	0.082	0.127	0.000	0.0	0.000
109	0.0	0.0	0.0	2.2	-2.8	-0.3	0.0	0.671	0.671	0.096	0.127	0.000	0.0	0.000
110	4.83	3.05	7.87	2.2	-3.3	-0.6	4.826	1.332	6.158	1.259	0.178	0.145	0.0	0.138

CAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1972

	PRECIPITATION(MM)			TEMPERATURE('C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
111	9.42	0.0	9.42	3.9	1.7	2.8	9.418	4.947	14.365	4.812	4.216	1.066	0.185	1.055
112	24.07	0.0	24.07	5.0	2.2	3.6	24.072	7.635	31.707	16.111	37.338	8.359	8.653	8.626
113	5.84	0.0	5.84	3.9	1.7	2.8	5.842	3.772	9.614	13.643	28.448	0.420	1.624	0.615
114	0.0	3.81	3.81	3.3	-1.1	1.1	0.0	1.511	1.511	8.824	7.671	0.080	0.062	0.054
115	0.0	2.54	2.54	-0.6	-5.0	-2.8	0.0	0.0	0.0	4.498	4.445	0.031	0.022	0.025
116	0.0	0.0	0.0	-1.7	-5.6	-3.6	0.0	0.0	0.0	1.993	2.515	0.010	0.0	0.011
117	0.0	0.0	0.0	-1.1	-10.6	-5.8	0.0	0.0	0.0	1.218	1.676	0.005	0.0	0.006
118	0.0	3.81	3.81	-10.6	-15.6	-13.1	0.0	0.0	0.0	0.783	0.914	0.002	0.0	0.002
119	0.0	3.05	3.05	-8.9	-15.6	-12.2	0.0	0.0	0.0	0.522	0.610	0.001	0.0	0.001
120	0.0	0.0	0.0	-9.4	-21.1	-15.3	0.0	0.0	0.0	0.404	0.406	0.001	0.0	0.001
121	0.0	0.0	0.0	-5.6	-17.2	-11.4	0.0	0.0	0.0	0.284	0.330	0.000	0.0	0.000
122	0.0	0.0	0.0	-3.3	-10.6	-6.9	0.0	0.0	0.0	0.186	0.305	0.000	0.0	0.000
123	0.0	0.0	0.0	-5.6	-15.0	-10.3	0.0	0.0	0.0	0.108	0.173	0.000	0.0	0.000
124	0.0	0.0	0.0	-10.0	-22.8	-16.4	0.0	0.0	0.0	0.047	0.127	0.0	0.0	0.000
125	0.0	0.0	0.0	-8.3	-18.3	-13.3	0.0	0.0	0.0	0.005	0.102	0.0	0.0	0.000
126	0.0	0.0	0.0	-3.9	-11.1	-7.5	0.0	0.0	0.0	0.0	0.076	0.0	0.0	0.0
127	0.0	2.79	2.79	-1.7	-3.9	-2.8	0.0	0.0	0.0	0.0	0.051	0.0	0.0	0.0
128	0.0	4.57	4.57	0.0	-6.1	-3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
129	3.30	1.02	4.32	1.1	-1.1	-0.0	3.302	0.085	3.387	0.430	0.0	0.001	0.0	0.0
130	0.0	0.0	0.0	5.0	0.6	2.8	0.0	4.052	4.052	0.895	0.0	0.003	0.0	0.0
131	0.0	0.0	0.0	3.3	-1.7	0.8	0.0	1.535	1.535	1.092	0.0	0.004	0.0	0.0
132	0.0	0.0	0.0	3.3	-4.4	-0.6	0.0	1.609	1.609	0.729	0.0	0.002	0.0	0.0
133	0.0	0.0	0.0	3.3	-2.8	0.3	0.0	1.861	1.861	0.641	0.0	0.002	0.0	0.0
134	3.81	0.0	3.81	1.7	-1.1	0.3	3.810	0.719	4.529	1.230	0.0	0.005	0.0	0.000
135	5.08	1.27	6.35	3.9	1.1	2.5	5.080	3.401	8.481	2.513	0.330	0.015	0.0	0.001
136	8.25	1.90	10.16	2.8	-2.2	0.3	8.255	1.278	9.533	5.555	7.188	0.888	0.0	0.838
137	6.35	0.0	6.35	0.6	-3.9	-1.7	6.350	0.0	6.350	4.871	3.277	0.035	0.0	0.016
138	5.08	0.0	5.08	4.4	0.0	2.2	5.080	3.110	8.190	7.065	9.474	0.497	0.491	0.512
139	3.56	2.29	5.84	6.7	-1.7	2.5	3.556	5.395	8.951	6.834	29.286	0.055	11.164	0.357
140	5.72	7.62	13.34	1.7	-1.1	0.3	5.720	0.932	6.652	6.687	3.480	0.054	0.054	0.018
141	2.54	0.0	2.54	9.4	1.7	5.6	2.540	12.668	15.208	8.144	14.402	0.323	1.084	0.331
142	0.0	0.0	0.0	10.0	3.9	6.9	0.0	13.955	13.955	10.514	4.978	0.261	0.009	0.138
143	0.0	0.0	0.0	4.4	-1.7	1.4	0.0	3.136	3.136	10.210	2.972	0.098	0.0	0.014
144	0.0	0.0	0.0	5.6	-1.1	2.2	0.0	4.489	4.489	6.471	1.956	0.051	0.0	0.008
145	0.0	0.0	0.0	5.6	-1.1	2.2	0.0	4.489	4.489	4.848	2.769	0.034	0.0	0.013
146	0.0	0.0	0.0	3.3	-1.1	1.1	0.0	2.055	2.055	3.854	1.981	0.025	0.0	0.008
147	0.0	0.0	0.0	3.9	-0.6	1.7	0.0	2.770	2.770	2.716	1.753	0.015	0.0	0.007
148	0.0	0.0	0.0	4.4	-0.6	1.9	0.0	3.289	3.289	2.386	0.914	0.012	0.0	0.007
149	4.06	0.0	4.06	1.7	-1.1	0.3	4.064	0.802	4.866	2.638	0.635	0.018	0.0	0.005
150	20.32	0.0	20.32	10.6	1.1	5.8	20.320	9.409	29.729	15.658	15.469	6.790	4.136	6.686
151	0.0	0.0	0.0	12.8	5.0	8.9	0.0	5.780	5.780	8.449	5.715	0.075	0.567	0.036
152	0.0	0.0	0.0	5.6	-1.7	1.9	0.0	1.225	1.225	6.286	2.667	0.049	0.131	0.012
153	5.33	2.54	7.87	0.6	-2.8	-1.1	5.334	0.0	5.334	4.285	0.660	0.029	0.0	0.002
154	5.84	14.48	20.32	0.6	-0.6	-0.0	5.842	0.0	5.842	5.172	3.073	1.209	0.0	1.186
155	0.0	0.0	0.0	1.7	-6.1	-2.2	0.0	0.236	0.236	3.774	2.946	0.024	0.0	0.014
156	4.06	0.0	4.06	5.0	-4.4	0.3	4.064	4.405	8.469	2.577	1.753	0.021	0.0	0.014
157	10.41	0.0	10.41	7.8	0.6	4.2	10.414	7.072	17.486	9.603	11.430	1.820	0.884	1.825
158	0.0	2.29	2.29	7.2	-3.3	1.9	0.0	5.566	5.566	8.180	32.309	0.074	3.977	0.412
159	0.0	0.0	0.0	4.4	-3.3	0.6	0.0	1.182	1.182	5.652	2.235	0.043	0.0	0.009
160	0.0	0.0	0.0	10.6	1.7	6.1	0.0	4.570	4.570	3.214	1.270	0.019	0.0	0.004
161	0.0	0.0	0.0	15.6	7.2	11.4	0.0	1.227	1.227	3.021	0.711	0.017	0.0	0.002
162	0.0	0.0	0.0	12.8	4.4	8.6	0.0	0.0	0.0	2.134	0.610	0.011	0.0	0.001
163	4.57	0.0	4.57	11.1	2.8	6.9	4.572	0.0	4.572	2.185	1.143	0.119	0.0	0.112
164	9.65	0.0	9.65	7.8	5.0	6.4	9.652	0.0	9.652	3.373	2.769	0.258	0.017	0.249
165	25.15	0.0	25.15	13.9	4.4	9.2	25.146	0.0	25.146	13.390	14.529	35.756	8.298	35.734

```
CAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1972
        PRECIPITATION(MM)       TEMPERATURE('C)AVAILABLE MCISTURE(MM)      RUNOFF(MM)                SOIL LOSS(TONS)
DAY   RAIN   SNOW   TOTAL    MAX    MIN    AVG    RAIN     SNOW     TOTAL    SIMUL    OBSER    SIMUL1    OBSER    SIMUL2
166    0.0    0.0    0.0    10.0    1.1    5.6    0.0      0.0      0.0      7.045    4.140    0.059     0.0      0.023
167    0.0    0.0    0.0    13.9    1.7    7.8    0.0      0.0      0.0      2.319    1.854    0.012     0.0      0.007
168    0.0    0.0    0.0    17.8    7.8   12.8    0.0      0.0      0.0      0.899    1.143    0.003     0.0      0.003
169    0.0    0.0    0.0    18.3    5.0   11.7    0.0      0.0      0.0      1.425    0.584    0.006     0.0      0.001
170   13.97   0.0   13.97    9.4    4.4    6.9   13.970    0.0     13.970    6.505    3.581    9.310     0.0      9.267
171    0.0    0.0    0.0     7.2    2.8    5.0    0.0      0.0      0.0      3.734    1.295    0.024     0.0      0.004
172    0.0    0.0    0.0    11.1    0.6    5.8    0.0      0.0      0.0      1.479    0.787    0.006     0.0      0.002
173    0.0    0.0    0.0    13.3    6.1    9.7    0.0      0.0      0.0      0.824    0.508    0.003     0.0      0.001
174    3.05   0.0    3.05   16.7    4.4   10.6    3.048    0.0      3.048    0.807    0.559    0.063     0.0      0.061
175    0.0    0.0    0.0     6.1   -0.6    2.8    0.0      0.0      0.0      0.532    0.330    0.001     0.0      0.000
176    3.56   0.0    3.56    8.3   -1.7    3.3    3.556    0.0      3.556    0.707    0.610    0.067     0.0      0.066
177    0.0    0.0    0.0     0.6   -4.4   -1.9    0.0      0.0      0.0      0.510    0.432    0.001     0.0      0.001
178    0.0    0.0    0.0     1.7   -3.3   -0.8    0.0      0.0      0.0      0.384    0.229    0.001     0.0      0.000
179    0.0    0.0    0.0     2.8   -3.3   -0.3    0.0      0.0      0.0      0.225    0.127    0.000     0.0      0.000
180    0.0    0.0    0.0     6.1   -1.1    2.5    0.0      0.0      0.0      0.194    0.076    0.000     0.0      0.0
181    0.0    0.0    0.0     7.8   -2.2    2.8    0.0      0.0      0.0      0.121    0.025    0.000     0.0      0.0
182    0.0    0.0    0.0    12.2   -0.6    5.8    0.0      0.0      0.0      0.062    0.0      0.0       0.0      0.0
183    0.0    0.0    0.0    16.1    0.6    8.3    0.0      0.0      0.0      0.000    0.0      0.0       0.0      0.0
184    3.30   0.0    3.30   12.2    5.6    8.9    3.302    0.0      3.302    0.161    0.0      0.018     0.0      0.018
185    0.0    0.0    0.0     6.7   -3.9    1.4    0.0      0.0      0.0      0.012    0.0      0.0       0.0      0.0
186    0.0    0.0    0.0    11.1   -3.3    3.9    0.0      0.0      0.0      0.000    0.0      0.0       0.0      0.0
187    0.0    0.0    0.0    10.6    5.6    8.1    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
188    5.33   0.0    5.33   12.8    6.1    9.4    5.334    0.0      5.334    0.143    0.051    0.106     0.0      0.105
189    2.79   0.0    2.79   10.0    0.0    5.0    2.794    0.0      2.794    0.375    0.076    0.078     0.0      0.077
190    0.0    0.0    0.0     6.7    0.0    3.3    0.0      0.0      0.0      0.224    0.051    0.000     0.0      0.0
191    0.0    0.0    0.0     6.7   -1.1    2.8    0.0      0.0      0.0      0.092    0.0      0.000     0.0      0.0
192    0.0    0.0    0.0     6.1   -3.3    1.4    0.0      0.0      0.0      0.026    0.0      0.0       0.0      0.0
193    0.0    0.0    0.0     9.4   -0.6    4.4    0.0      0.0      0.0      0.000    0.0      0.0       0.0      0.0
194    3.81   0.0    3.81    5.0    0.6    2.8    3.810    0.0      3.810    0.173    0.0      0.024     0.0      0.023
195    1.52   2.29   3.81    5.0   -1.1    1.9    1.524    2.286    3.810    0.871    0.102    0.056     0.0      0.053
196    0.0    0.0    0.0     4.4   -2.8    0.8    0.0      0.0      0.0      0.657    0.0      0.002     0.0      0.0
197    0.0    0.0    0.0     8.3    0.6    4.4    0.0      0.0      0.0      0.258    0.0      0.000     0.0      0.0
198    0.0    0.0    0.0     8.3    3.3    5.8    0.0      0.0      0.0      0.147    0.0      0.000     0.0      0.0
199    0.0    0.25   0.25    4.4   -2.2    1.1    0.0      0.0      0.0      0.078    0.102    0.000     0.0      0.000
200    0.0    2.54   2.54    3.9   -2.8    0.6    0.0      2.072    2.072    0.023    0.0      0.0       0.0      0.0
201    0.0    0.0    0.0     6.7   -3.9    1.4    0.0      0.722    0.722    0.0      0.0      0.0       0.0      0.0
202    0.0    0.0    0.0    10.6   -2.8    3.9    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
203    3.05   0.0    3.05   11.7    0.6    6.1    3.048    0.0      3.048    0.0      0.0      0.0       0.0      0.0
204    0.0    0.25   0.25    7.8   -1.7    3.1    0.0      0.254    0.254    0.0      0.0      0.0       0.0      0.0
205    0.0    0.0    0.0     7.8   -3.9    1.9    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
206    0.0    0.0    0.0    18.9    2.8   10.8    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
207    0.0    0.0    0.0    14.4    3.3    8.9    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
208    0.0    0.0    0.0     8.9    0.0    4.4    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
209    0.0    0.0    0.0    13.9   -1.7    6.1    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
210    0.0    0.0    0.0    21.7    5.6   13.6    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
211    0.0    0.0    0.0    12.2   -0.6    5.8    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
212    0.0    0.0    0.0     6.7   -4.4    1.1    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
213    0.0    0.0    0.0     9.4   -5.0    2.2    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
214    0.0    0.0    0.0    15.0   -2.8    6.1    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
215    0.0    0.0    0.0    17.2    5.6   11.4    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
216    0.0    0.0    0.0    20.6    2.8   11.7    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
217    0.0    0.0    0.0    21.1    3.9   12.5    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
218    0.0    0.0    0.0    20.0    4.4   12.2    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
219    0.0    0.0    0.0    19.4    8.9   14.2    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
220    0.0    0.0    0.0    13.3    7.2   10.3    0.0      0.0      0.0      0.0      0.0      0.0       0.0      0.0
```

(SWE) remaining on the ground at the end of day 114. Therefore, there could be more moisture input from snowmelt.

b) Days 138-148 (February 15 - February 25)

This simulation is not good because of the less than expected runoff from snowmelt and possible frozen ground event (Table 17). It might be improved if actual temperature distributions of the days were used instead of the estimated values computed as sine function of maximum and minimum temperatures and their normal occurring times of a day (0400 h for minimum temperature and 1500 h for maximum temperature were used for this study). Figure 15 shows that the estimated temperatures are usually low during critical times, decreasing snowmelt. The simulated temperature at a break-point time in a day is used to determine snow-rain form and snowmelt event. The simulation of the days 142-148 could be much improved if no or little snow remained on the ground, i.e., faster snowmelt before this period.

c) Day 150 - 158 (February 27 - March 6)

Simulation of stream flow and soil loss during this period is moderately accurate. Later in the period (days 157, 158) both observed runoff and erosion are higher than simulated. This is probably due to the temperature (Figure 16) again as anything else. More runoff from the rain of days 156 and 157 would give better erosion simulation. The cumulative degree-day method used in the snowmelt simulation gives less snowmelt during a warm period followed by a cold period than a continuous warm period. This is well explained with the results on the 6th of March (Figure 16). However, two more conditions could be added to this situation. One is that the simulated rainfall should be snowfall as indicated in the recorded temperatures:

1) the precipitation started at 1900 h on March 1st and ended at 0700 h on the next day. The actual temperature distribution was below freezing between 1800 h on March 1st and 0500 h on March 2nd, 2) the precipitation occurred between 0700 h on March 4th and 0600 h on March 5th. As shown in the Figure 16 the recorded temperature during the period was partly below ← ucF

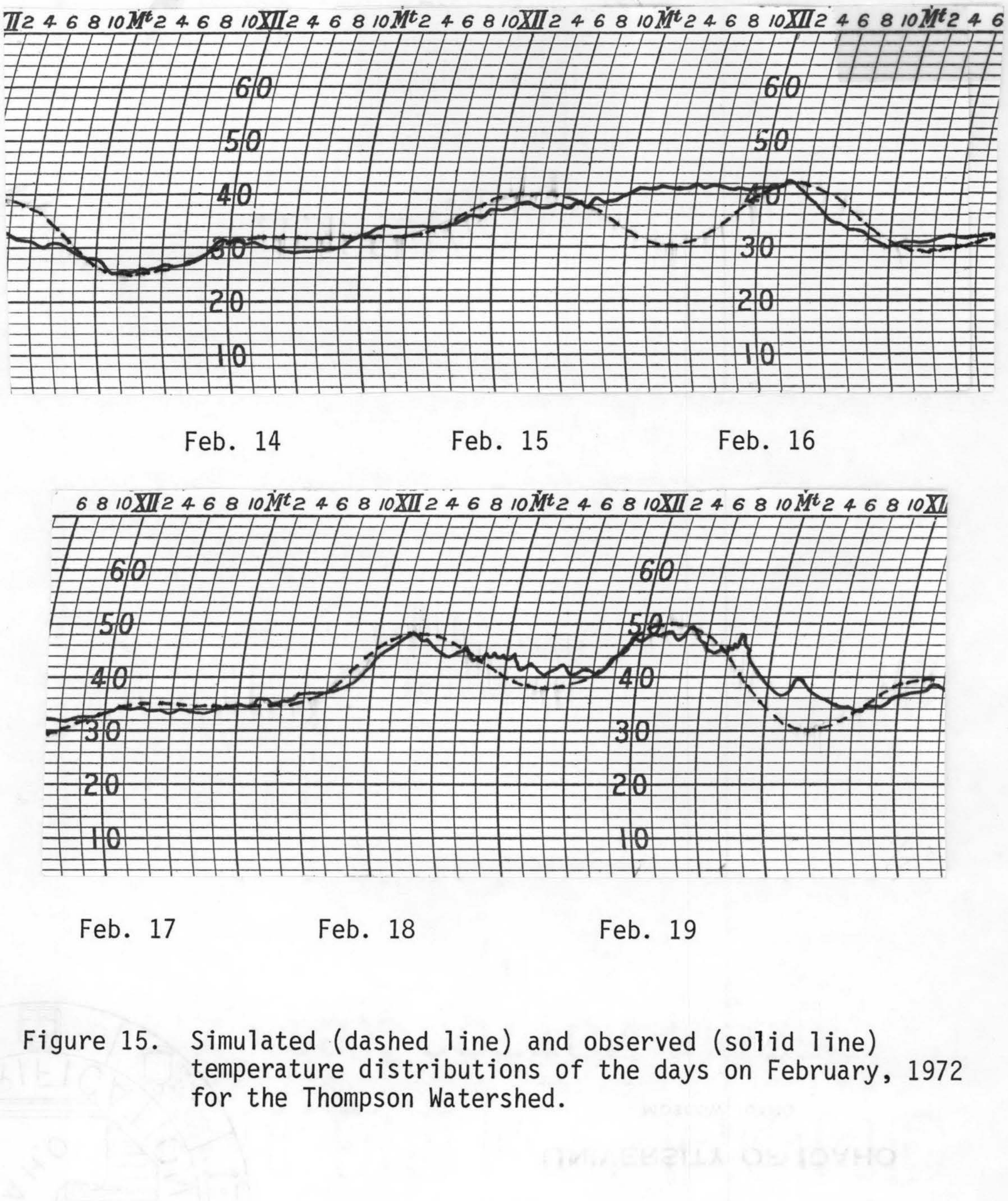
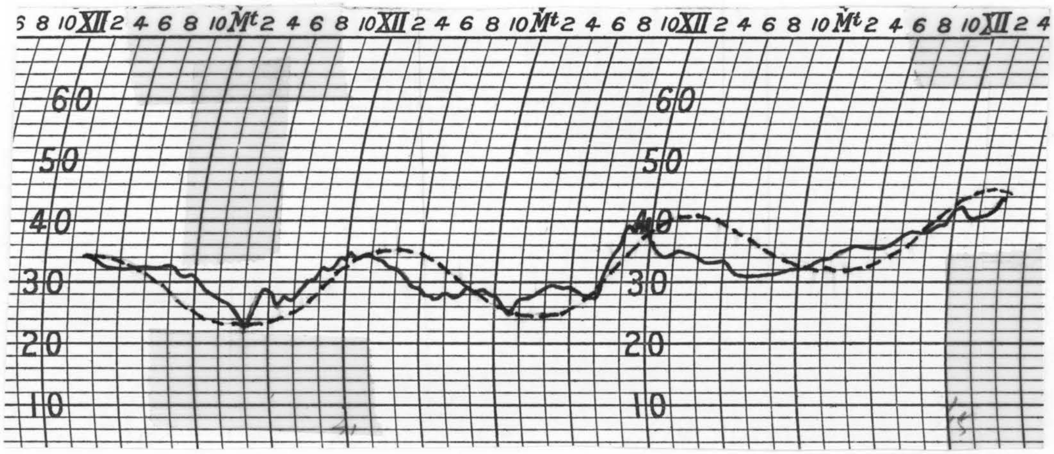
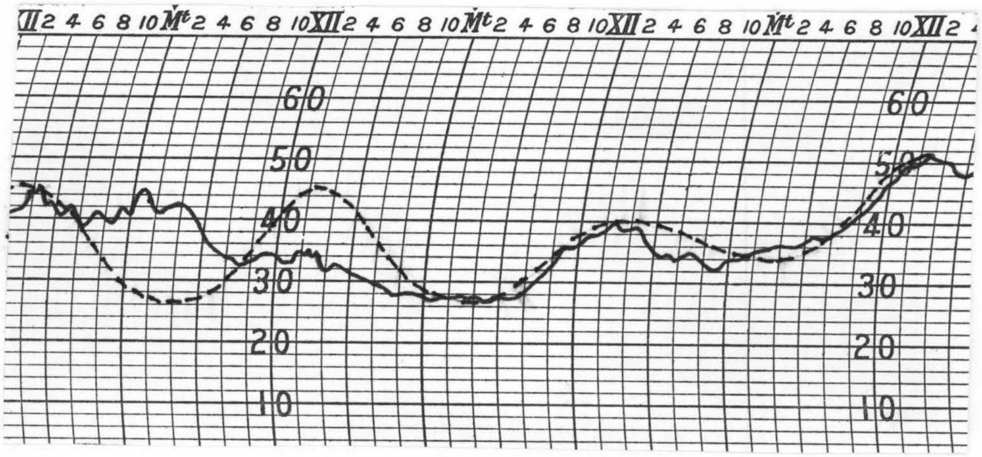


Figure 15. Simulated (dashed line) and observed (solid line) temperature distributions of the days on February, 1972 for the Thompson Watershed.



Mar. 3 Mar. 4 Mar. 5



Mar. 6 Mar. 7 Mar. 8

Figure 16. Simulated (dashed line) and observed (solid line) temperature distributions of the days on March, 1972 for the Thompson Watershed.

freezing temperature. But the precipitation was simulated only as rainfall. Another is that the possible high soil moisture and well below freezing temperatures at night during the period could result in a frozen ground surface. The differences of simulated and observed temperature distribution could explain some other bad erosion simulations. Another problem is that temperature is measured in a shelter while the ground surface and upper air temperatures are unknown.

d) Day 165 (March 13)

The stream flow simulation was relatively accurate, but the estimated soil loss was too high. There were only 0.16 tons of simulated channel erosion. Therefore, most of the soil loss was simulated as rill and interrill erosion by overland flow. As compared with the result of day 150, it suggests that either rill or interrill erosion simulation was incorrect.

2. Pitzen Watershed

This watershed has a large amount of recorded data. Three water years (1938, 1939, and 1940) were chosen to test the model. These years had three different types of weather and hydrology. Because there was not a complete set of recorded soil loss data in water year 1938, 1939 was used to calibrate and optimize the parameters. The 1939 water year was dry but there was good evidence of snowmelt events and their effect on runoff and soil erosion. There were no recorded temperature distribution data for this watershed. Table 18 shows the overland flow, upland soil erosion and deposition and cascading for each zone of the test years.

1) Water Year 1938 (Table 19)

It was not possible to reduce the high simulated stream flow in the early months (between days 70 to 100 in Table 19), even with the lowest soil moisture of each zone (the lowest soil moistures of each zone obtained in 1939 were used as the initial data for this year). As shown in other tests the initial soil moistures obtained from previous year's result do not seem to be correct, in all cases they are higher than expected. There are no recorded soil loss data available before February, 1938, during which high precipitation and low observed but high simulated stream flow are shown.

YEAR	DAY	ZONE	QO1/	FROM RILLS	FROM INTE-RILL	FROM 2/ UPPER ZONE	3/ BALANCE	TOTAL FROM UPLAND	CHAN-NEL	TOTAL SOIL LOSS
1938	Mar 2	I	0.06	0.23	0.79	0.0	-1.02			
		II	0.37	1.68	4.95	0.71	-5.92			
		III	0.0	0.49	0.0	0.64	0.15			
		IV	1.49	2.65	7.25	6.77	-3.13	9.92	1.07	11.00
	Mar 18	I	0.01	0.18	0.0	0.0	-0.18			
		II	1.07	8.87	7.79	0.12	-16.54			
		III	0.0	1.73	0.0	0.89	-0.84			
		IV	1.30	6.25	4.74	17.48	6.48	11.08	0.70	11.78
	Mar 19	I	0.0	0.0	0.0	0.0	0.0			
		II	0.0	0.0	0.0	0.0	0.0			
		III	0.0	0.0	0.0	0.0	0.0			
		IV	0.0	0.0	0.0	0.0	0.0	0.0	0.87	0.87
	Mar 23	I	0.0	0.15	0.0	0.0	0.15			
		II	0.0	0.37	0.0	0.10	-0.27			
		III	0.0	2.09	0.0	0.06	-2.03			
		IV	0.0	1.15	0.0	2.33	1.18	1.27	0.50	1.76
	Apr 4	I	1.20	2.96	2.41	0.0	-5.37			
		II	4.61	17.80	15.65	3.76	-29.69			
		III	0.0	2.70	0.0	3.28	0.58			
		IV	13.57	70.55	88.58	34.34	-124.79	159.27	2.26	161.52
1939	Mar 18	I	0.0	0.0	0.0	0.0	0.0			
		II	0.0	0.0	0.0	0.0	0.0			
		III	0.0	0.0	0.0	0.0	0.0			
		IV	0.0	0.0	0.0	0.0	0.0	0.0	1.41	1.41
	Mar 19	I	8.70	8.76	15.83	0.0	-24.59			
		II	1.94	7.10	16.56	17.22	-6.44			
		III	0.0	0.0	0.0	8.56	8.56			
		IV	1.28	3.88	9.64	22.47	8.95	13.53	3.59	17.12

1/ Amount of overland flow in a day in mm.

2/ Pitzen Watershed was divided such that, seventy percent of eroded soil particles from Zone I cascades to Zone II and rest to Zone III, five percent from Zone II to Zone III and ninety-five percent to alluvium and ninety-five percent from Zone III to alluvium and rest to channel.

3/ Negative value shows erosion and positive for deposition.

Table 18.;Simulated output of overland flow and soil loss on watershed zones for selected days for the Pitzen Watershed in water years 1938, 1939 and 1940 - Soil loss in tons

YEAR	DAY	ZONE	QO	FROM RILLS	FROM INTE-RILL	FROM UPPER ZONE	BALANCE	TOTAL FROM UPLAND	CHAN-NEL	TOTAL SOIL LOSS
	Mar 20	I	0.0	0.0	0.0	0.0	0.0			
		II	0.0	0.0	0.0	0.0	0.0			
		III	0.0	0.0	0.0	0.0	0.0			
		IV	24.71	9.59	14.98	0.0	-24.57	24.57	9.55	34.12
	Mar 21	I	0.0	0.0	0.0	0.0	0.0			
		II	0.0	0.0	0.0	0.0	0.0			
		III	8.35	41.02	30.91	0.0	-71.93			
		IV	12.03	20.44	37.01	68.33	10.87	61.05	9.31	70.36
	Mar 22	I	0.0	0.0	0.0	0.0	0.0			
		II	0.0	0.0	0.0	0.0	0.0			
		III	0.51	8.06	4.75	0.0	-12.81			
		IV	5.10	4.69	4.89	12.17	2.59	10.22	8.64	18.86
	Mar 23	I	0.0	0.0	0.0	0.0	0.0			
		II	0.0	0.0	0.0	0.0	0.0			
		III	0.0	0.0	0.0	0.0	0.0			
		IV	0.0	1.25	0.1	0.0	-1.25	1.25	4.31	5.56
1940	Feb 6	I	11.32	2.28	10.70	0.0	-12.98			
		II	21.74	11.36	59.57	9.09	-61.84			
		III	7.56	8.88	31.55	7.44	-32.99			
		IV	88.60	27.41	127.29	105.79	-48.92	156.72	17.34	174.06
	Feb 25	I	0.36	0.48	1.75	0.0	-2.23			
		II	1.09	2.86	9.97	1.56	-11.27			
		III	0.0	0.61	0.0	1.31	0.70			
		IV	0.27	2.13	2.58	12.77	8.06	4.74	2.04	6.81
	Feb 26	I	0.0	0.01	0.0	0.0	-0.01			
		II	0.0	0.07	0.0	0.01	-0.07			
		III	0.0	0.35	0.0	0.01	-0.35			
		IV	0.0	0.45	0.0	0.41	-0.04	0.47	2.63	3.10
	Feb 27	I	0.0	0.01	0.0	0.0	-0.01			
		II	0.22	0.86	2.69	0.01	-3.54			
		III	0.0	0.38	0.0	0.18	-0.20			
		IV	0.0	0.73	0.0	3.74	3.01	0.74	2.42	3.17
	Feb 28	I	0.09	0.14	0.41	0.0	-0.55			
		II	0.20	0.99	3.03	0.38	-3.64			
		III	0.0	0.38	0.0	0.36	-0.01			
		IV	0.0	0.91	0.0	4.18	3.27	0.93	2.61	3.54

Table 18. (continue)

YEAR	DAY	ZONE	QO	FROM RILLS	FROM INTERRILL	FROM UPPER ZONE	BALANCE	TOTAL FROM UPLAND	CHANNEL	TOTAL SOIL LOSS
1940	Mar 2	I	0.46	0.57	1.91	0.0	-2.49			
		II	3.14	3.50	10.22	1.74	-11.97			
		III	0.0	0.24	0.0	1.43	1.19			
		IV	6.41	13.28	38.85	13.26	-38.87			
								52.14	3.70	55.84
	Mar 7	I	1.79	0.78	2.12	0.0	-2.90			
		II	6.01	6.17	17.07	2.03	-21.20			
		III	0.0	2.81	5.05	2.03	-5.82			
		IV	15.50	19.39	48.75	29.53	-38.61			
								68.53	3.49	72.02
	Mar 25	I	0.58	10.43	11.91	0.0	-22.34			
		II	0.73	34.65	37.08	15.64	-56.09			
		III	0.68	38.53	18.17	10.29	-46.41			
		IV	0.82	10.16	6.67	122.01	105.19			
								19.66	1.06	20.72
	Mar 26	I	0.0	0.26	0.0	0.0	-0.26			
		II	0.0	0.76	0.0	0.18	-0.57			
		III	0.0	0.95	0.0	0.12	-0.84			
		IV	0.0	1.79	0.0	1.62	-0.17			
								1.84	0.95	2.79
	Mar 31	I	0.57	0.38	2.42	0.0	-2.80			
		II	1.18	5.91	18.68	1.96	-22.63			
		III	0.00	3.46	3.73	2.07	-5.13			
		IV	0.00	2.70	0.02	30.20	27.49			
								3.08	0.66	3.74
	Apr 1	I	0.0	0.00	0.0	0.0	-0.00			
		II	0.10	0.05	0.0	0.0	-0.05			
		III	0.0	0.72	0.00	0.0	-0.72			
		IV	0.0	3.17	0.0	0.74	-2.43			
								3.20	1.81	5.02
	Apr 8	I	0.0	0.01	0.0	0.0	-0.01			
		II	0.0	0.08	0.0	0.01	-0.07			
		III	0.0	0.38	0.0	0.01	-0.37			
		IV	0.0	0.04	0.0	0.43	0.39			
								0.06	0.18	0.24
	Apr 9	I	0.08	0.41	3.43	0.0	-3.84			
		II	0.41	5.62	19.00	2.69	-21.94			
		III	0.0	2.06	0.0	2.38	0.33			
		IV	0.0	6.48	0.0	25.35	18.86			
								6.59	0.94	7.53

Table 18. (continue)

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1938

	PRECIPITATION(MM)			TEMPERATURE('C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
56	6.10	2.54	8.64	9.4	1.7	5.6	6.096	2.955	9.051	0.027	0.0	0.004	0.0	0.000
57	0.0	0.0	0.0	5.0	-1.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	13.97	0.0	13.97	8.3	-0.6	3.9	13.970	0.0	13.970	0.188	0.0	0.075	0.0	0.000
59	0.0	0.0	0.0	8.9	2.8	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	4.4	-2.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	0.0	0.0	0.0	5.0	-1.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	7.2	-0.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	-3.9	-1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	2.2	-2.2	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	5.6	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	0.0	0.0	0.0	6.7	-1.1	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	0.0	0.0	0.0	0.6	-2.2	-0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	0.0	0.0	0.0	-1.1	-3.9	-2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	0.0	0.0	0.0	-3.9	-7.8	-5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	1.27	1.27	0.6	-5.0	-2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	11.43	4.32	15.75	6.7	-1.7	2.5	11.430	4.902	16.332	1.749	0.089	31.626	0.0	30.766
72	9.65	0.0	9.65	7.2	4.4	5.8	9.652	0.686	10.338	3.449	0.074	1.307	0.0	0.004
73	0.0	1.02	1.02	4.4	0.6	2.5	0.0	0.960	0.960	2.439	0.002	0.791	0.0	0.0
74	0.0	0.0	0.0	6.1	0.6	3.3	0.0	0.056	0.056	1.199	0.0	0.286	0.0	0.000
75	0.76	0.0	0.76	4.4	1.7	3.1	0.762	0.0	0.762	0.911	0.0	0.194	0.0	0.0
76	0.0	0.25	0.25	5.6	2.8	4.2	0.0	0.084	0.084	0.598	0.0	0.107	0.0	0.0
77	2.79	8.13	10.92	3.9	1.1	2.5	2.794	3.431	6.225	0.827	0.132	0.182	0.0	0.010
78	4.06	1.27	5.33	8.3	0.6	4.4	4.064	4.930	8.994	3.044	0.109	5.508	0.0	4.312
79	0.0	0.0	0.0	5.6	-1.7	1.9	0.0	0.682	0.682	3.170	0.0	1.136	0.0	0.0
80	0.0	0.0	0.0	5.6	-2.2	1.7	0.0	0.524	0.524	1.619	0.0	0.442	0.0	0.0
81	0.0	0.0	0.0	6.1	-1.1	2.5	0.0	0.0	0.0	0.980	0.0	0.215	0.0	0.0
82	0.0	0.0	0.0	-1.1	-2.8	-1.9	0.0	0.0	0.0	0.596	0.0	0.106	0.0	0.0
83	0.0	0.25	0.25	-2.2	-3.9	-3.1	0.0	0.0	0.0	0.319	0.0	0.043	0.0	0.0
84	0.0	0.0	0.0	-2.8	-6.7	-4.7	0.0	0.0	0.0	0.154	0.0	0.014	0.0	0.0
85	0.0	1.27	1.27	0.0	-6.1	-3.1	0.0	0.0	0.0	0.086	0.0	0.006	0.0	0.0
86	0.0	1.02	1.02	0.6	-4.4	-1.9	0.0	0.0	0.0	0.069	0.0	0.004	0.0	0.0
87	7.27	11.31	18.58	3.3	-4.4	-0.6	7.268	1.339	8.607	2.182	0.0	32.835	0.0	31.557
88	0.0	31.24	31.24	4.4	-2.8	0.8	0.0	3.315	3.315	2.075	0.0	0.629	0.0	0.0
89	1.02	0.0	1.02	7.8	3.3	5.6	1.016	21.143	22.159	5.045	0.0	18.864	0.0	16.429
90	2.29	0.0	2.29	7.2	3.9	5.6	2.286	13.480	15.766	12.643	0.152	10.179	0.0	1.986
91	1.27	3.05	4.32	3.9	2.2	3.1	1.270	3.634	4.904	9.367	2.118	5.329	0.0	0.720
92	0.0	0.0	0.0	4.4	-1.7	1.4	0.0	1.178	1.178	6.365	1.445	3.015	0.0	0.310
93	0.0	0.0	0.0	3.3	-2.2	0.6	0.0	0.539	0.539	3.737	0.671	1.429	0.0	0.104
94	0.0	0.0	0.0	4.4	-4.4	-0.0	0.0	0.709	0.709	2.076	0.406	0.626	0.0	0.051
95	0.0	0.0	0.0	1.7	-5.6	-1.9	0.0	0.052	0.052	1.202	0.198	0.288	0.0	0.018
96	0.0	0.0	0.0	-2.2	-5.6	-3.9	0.0	0.0	0.0	0.798	0.117	0.161	0.0	0.008
97	0.0	0.0	0.0	-1.7	-4.4	-3.1	0.0	0.0	0.0	0.478	0.071	0.077	0.0	0.003
98	0.0	0.0	0.0	-2.2	-5.0	-3.6	0.0	0.0	0.0	0.259	0.051	0.032	0.0	0.002
99	0.0	0.0	0.0	-1.7	-3.9	-2.8	0.0	0.0	0.0	0.155	0.041	0.014	0.0	0.001
100	0.0	0.0	0.0	-1.1	-3.3	-2.2	0.0	0.0	0.0	0.135	0.030	0.012	0.0	0.001
101	0.0	0.0	0.0	-0.6	-3.9	-2.2	0.0	0.0	0.0	0.127	0.033	0.011	0.0	0.001
102	0.0	0.0	0.0	6.7	-1.1	2.8	0.0	0.103	0.103	0.123	1.222	0.010	0.0	0.244
103	0.0	0.0	0.0	0.0	-2.8	-1.4	0.0	0.0	0.0	0.117	0.140	0.009	0.0	0.010
104	0.0	4.32	4.32	3.3	-1.1	1.1	0.0	0.888	0.888	0.114	0.356	0.009	0.0	0.042
105	0.76	0.76	1.52	4.4	0.0	2.2	0.762	2.388	3.150	0.273	0.510	0.042	0.0	0.070
106	6.86	3.81	10.67	7.2	0.6	3.9	6.858	3.899	10.757	4.149	3.360	32.911	0.0	31.146
107	1.78	0.0	1.78	7.2	3.3	5.3	1.778	0.200	1.978	2.710	2.916	0.937	0.0	0.856
108	1.52	1.27	2.79	3.9	-1.1	1.4	1.524	0.228	1.752	1.646	2.225	0.607	0.0	0.686
109	2.29	1.02	3.30	5.0	-0.6	2.2	2.286	1.277	3.563	1.514	1.689	0.420	0.0	0.400
110	4.05	2.03	6.10	4.4	-1.7	1.4	4.064	1.927	5.991	2.406	2.446	0.995	0.0	0.819

Table 19. Daily summary of watershed model and soil erosion simulation model of the Pitzen Watershed during erosion season of the water year 1938.

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1938

	PRECIPITATION(MM)			TEMPERATURE('C			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
111	0.0	0.0	0.0	3.9	-2.2	0.8	0.0	0.185	0.135	2.429	1.742	0.777	0.0	0.403
112	0.0	0.51	0.51	3.3	-3.9	-0.3	0.0	0.203	0.203	1.340	1.445	0.337	0.0	0.310
113	1.27	3.56	4.83	7.2	0.6	3.9	1.270	3.476	4.746	1.353	2.492	0.387	0.0	0.705
114	4.06	0.0	4.06	5.6	3.3	4.4	4.064	1.081	5.145	2.849	3.312	1.235	0.0	1.254
115	0.0	0.0	0.0	3.3	-2.8	0.3	0.0	0.255	0.255	1.978	1.610	0.587	0.0	0.361
116	0.0	0.0	0.0	3.9	-4.4	-0.3	0.0	0.240	0.240	1.095	0.927	0.252	0.0	0.165
117	0.0	0.0	0.0	3.9	-2.8	0.6	0.0	0.222	0.222	0.772	0.526	0.153	0.0	0.073
118	0.0	0.0	0.0	5.0	-2.2	1.4	0.0	0.405	0.405	0.530	0.472	0.089	0.0	0.063
119	0.0	0.0	0.0	6.7	-0.6	3.1	0.0	1.059	1.059	0.388	0.643	0.057	0.0	0.096
120	0.51	2.79	3.30	7.2	0.5	3.9	0.508	1.521	2.029	0.501	0.584	0.091	0.0	0.092
121	0.0	0.76	0.76	0.6	-10.6	-5.0	0.0	0.0	0.0	0.652	0.317	0.121	0.0	0.035
122	0.0	0.25	0.25	-5.0	-16.1	-10.6	0.0	0.0	0.0	0.462	0.033	0.073	0.010	0.001
123	0.0	0.0	0.0	3.3	-7.8	-2.2	0.0	0.799	0.799	0.336	0.152	0.046	0.070	0.012
124	3.30	0.51	3.81	4.4	-5.6	-0.6	3.302	2.173	5.475	0.731	1.163	0.299	1.030	0.352
125	1.78	0.0	1.78	5.0	1.1	3.1	1.778	0.361	2.139	1.722	1.460	0.640	1.270	0.454
126	0.0	2.03	2.03	5.0	-1.1	1.9	0.0	1.496	1.496	1.171	1.255	0.287	1.090	0.254
127	0.0	0.51	0.51	3.9	-1.1	1.4	0.0	0.306	0.306	1.038	0.800	0.239	0.700	0.140
128	0.0	0.0	0.0	3.3	-3.3	-0.0	0.0	0.273	0.273	0.779	0.653	0.155	0.630	0.100
129	0.0	15.75	15.75	1.1	-1.1	-0.0	0.0	0.018	0.018	0.546	0.571	0.094	0.850	0.083
130	0.0	3.30	3.30	2.8	-1.7	0.6	0.0	0.717	0.717	0.381	1.079	0.055	0.840	0.205
131	0.25	1.27	1.52	3.3	-2.8	0.3	0.254	0.982	1.236	0.339	0.838	0.047	0.510	0.143
132	0.0	0.0	0.0	2.8	-6.1	-1.7	0.0	0.912	0.912	0.329	0.871	0.045	0.600	0.151
133	0.0	0.0	0.0	7.8	0.6	4.2	0.0	5.106	5.106	0.458	1.699	0.076	1.150	0.369
134	0.0	3.56	3.56	5.0	0.6	2.8	0.0	2.797	2.797	1.131	2.791	0.304	4.850	0.824
135	0.0	8.64	8.64	1.7	-2.2	-0.3	0.0	0.134	0.134	1.375	1.313	0.352	1.410	0.275
136	0.0	0.0	0.0	2.8	-3.9	-0.6	0.0	0.736	0.736	1.078	2.494	0.246	1.830	0.669
137	0.0	0.0	0.0	5.6	-1.7	1.9	0.0	2.580	2.580	0.927	2.217	0.198	1.590	0.567
138	0.0	0.0	0.0	0.6	-2.2	-0.8	0.0	0.0	0.0	0.952	1.788	0.206	1.120	0.419
139	0.0	0.0	0.0	0.0	-8.3	-4.2	0.0	0.0	0.0	0.725	1.064	0.140	0.380	0.201
140	0.0	0.0	0.0	1.1	-8.9	-3.9	0.0	0.003	0.003	0.500	0.884	0.082	0.280	0.154
141	0.0	0.76	0.76	0.6	-5.0	-2.2	0.0	0.0	0.0	0.344	0.749	0.048	0.200	0.122
142	0.0	2.29	2.29	1.7	-2.8	-0.6	0.0	0.160	0.160	0.242	0.790	0.029	0.280	0.131
143	0.0	0.0	0.0	2.8	-6.1	-1.7	0.0	0.912	0.912	0.183	0.782	0.019	0.200	0.130
144	0.0	0.51	0.51	1.7	0.5	1.1	0.0	0.377	0.377	0.187	1.349	0.019	0.700	0.281
145	0.0	0.0	0.0	6.1	0.6	3.3	0.0	3.689	3.689	0.279	2.200	0.038	1.700	0.550
146	0.0	0.0	0.0	3.9	0.0	1.9	0.0	1.853	1.853	0.707	2.225	0.135	1.380	0.570
147	0.0	0.0	0.0	5.0	0.0	2.5	0.0	2.354	2.354	0.808	2.233	0.163	1.170	0.572
148	0.0	0.0	0.0	8.9	-1.7	3.6	0.0	1.805	1.805	0.969	2.245	0.211	0.780	0.577
149	0.0	0.0	0.0	6.1	-2.8	1.7	0.0	0.330	0.330	1.049	2.040	0.236	1.270	0.504
150	0.0	0.0	0.0	7.2	-0.6	3.3	0.0	0.427	0.427	0.880	2.007	0.184	0.920	0.492
151	0.0	0.0	0.0	11.1	-1.7	4.7	0.0	0.872	0.872	0.724	2.057	0.139	0.780	0.510
152	1.78	0.0	1.78	7.2	4.4	5.8	1.778	0.779	2.557	0.866	2.355	0.275	1.240	0.709
153	4.57	0.0	4.57	8.3	1.1	4.7	4.572	2.772	7.344	2.198	2.398	11.004	3.020	10.563
154	0.0	0.0	0.0	8.9	1.7	5.3	0.0	1.990	1.990	2.380	1.709	0.757	0.840	0.393
155	0.0	0.0	0.0	7.8	1.1	4.4	0.0	2.688	2.688	1.646	1.153	0.449	0.320	0.225
156	4.06	2.03	6.10	5.0	0.6	2.8	4.064	3.213	7.277	2.852	2.027	1.555	1.590	1.055
157	0.0	0.0	0.0	7.8	1.1	4.4	0.0	1.814	1.814	3.129	1.097	1.109	0.180	0.210
158	0.0	0.0	0.0	10.6	0.0	5.3	0.0	0.0	0.0	1.946	0.853	0.574	0.150	0.147
159	0.0	0.0	0.0	12.2	1.1	6.7	0.0	0.0	0.0	1.070	0.688	0.244	0.190	0.108
160	0.76	0.0	0.76	9.4	0.0	4.7	0.762	0.0	0.762	0.791	0.696	0.211	0.130	0.152
161	0.0	0.0	0.0	11.1	0.0	5.6	0.0	0.0	0.0	0.542	0.561	0.093	0.050	0.081
162	0.0	0.0	0.0	12.8	3.9	8.3	0.0	0.0	0.0	0.352	0.505	0.050	0.060	0.069
163	2.29	0.0	2.29	13.9	9.4	11.7	2.286	0.0	2.286	0.502	0.686	0.779	0.150	0.802
164	0.51	0.0	0.51	9.4	4.4	6.9	0.508	0.0	0.508	0.368	0.508	0.053	0.100	0.070
165	1.78	3.05	4.83	6.1	1.7	3.9	1.778	0.088	1.866	0.301	0.582	0.220	0.210	0.264

Table 19. (Continued)

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1938

	PRECIPITATION(MM)			TEMPERATURE(°C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
166	3.05	0.76	3.81	6.1	0.0	3.1	3.048	2.727	5.775	0.770	1.135	3.028	0.830	3.057
167	0.25	3.30	3.56	3.3	0.0	1.7	0.254	1.491	1.745	1.373	1.463	0.962	2.350	0.926
168	0.0	1.52	1.52	1.1	-2.8	-0.8	0.0	0.014	0.014	1.112	0.899	0.257	0.840	0.158
169	5.84	5.08	10.92	4.4	-1.7	1.4	5.842	2.496	8.338	2.085	1.798	11.778	1.150	11.505
170	0.0	0.0	0.0	4.4	0.0	2.2	0.0	3.253	3.258	2.644	3.719	0.874	5.290	1.173
171	0.0	0.0	0.0	3.3	-3.3	-0.0	0.0	0.302	0.302	2.106	2.423	0.636	1.810	0.642
172	0.0	0.0	0.0	3.3	-5.0	-0.8	0.0	0.094	0.094	1.241	1.598	0.301	1.430	0.357
173	3.81	0.0	3.81	3.9	-3.9	-0.0	3.810	0.228	4.038	1.050	1.252	2.207	0.800	2.210
174	1.78	0.0	1.78	9.4	-0.6	4.4	1.778	1.075	2.853	1.731	3.597	1.753	7.230	2.375
175	0.0	1.52	1.52	4.4	1.7	3.1	0.0	1.699	1.699	1.583	2.095	0.636	1.720	0.733
176	0.0	0.0	0.0	8.9	1.1	5.0	0.0	1.767	1.767	1.067	1.537	0.242	0.470	0.338
177	0.0	0.0	0.0	10.6	0.6	5.6	0.0	0.0	0.0	1.021	1.293	0.228	0.450	0.255
178	0.25	0.0	0.25	12.8	2.2	7.5	0.254	0.0	0.254	0.753	1.069	0.148	0.180	0.202
179	0.0	1.27	1.27	2.8	-1.7	0.6	0.0	0.699	0.699	0.550	0.960	0.094	0.280	0.174
180	0.0	0.0	0.0	3.3	-4.4	-0.6	0.0	0.253	0.253	0.412	0.734	0.062	0.410	0.118
181	0.0	0.0	0.0	4.4	-3.3	0.6	0.0	0.121	0.121	0.325	0.604	0.044	0.320	0.090
182	0.0	0.0	0.0	6.1	-1.1	2.5	0.0	0.095	0.095	0.248	0.523	0.029	0.120	0.073
183	0.0	0.0	0.0	10.0	-1.7	4.2	0.0	0.102	0.102	0.175	0.444	0.018	0.150	0.058
184	0.0	0.0	0.0	12.8	0.0	6.4	0.0	0.0	0.0	0.158	0.363	0.015	0.150	0.043
185	3.81	0.0	3.81	10.0	1.1	5.6	3.810	0.0	3.810	0.441	0.592	2.224	0.530	2.180
186	11.43	2.54	13.97	5.6	1.1	3.3	11.430	2.432	13.862	4.179	2.433	161.524	3.570	159.909
187	0.25	0.0	0.25	7.2	1.7	4.4	0.254	0.108	0.362	2.945	0.808	1.146	0.110	0.247
188	0.0	0.0	0.0	10.0	0.6	5.3	0.0	0.0	0.0	1.253	0.513	0.306	0.050	0.071
189	0.0	0.0	0.0	13.9	1.1	7.5	0.0	0.0	0.0	0.802	0.389	0.162	0.040	0.047
190	0.0	0.0	0.0	14.4	3.9	9.2	0.0	0.0	0.0	0.490	0.343	0.080	0.030	0.040
191	0.25	0.0	0.25	8.9	3.3	6.1	0.254	0.0	0.254	0.306	0.363	0.040	0.050	0.043
192	0.0	0.0	0.0	12.2	0.6	6.4	0.0	0.0	0.0	0.184	0.274	0.019	0.020	0.028
193	0.0	0.0	0.0	13.3	2.8	8.1	0.0	0.0	0.0	0.158	0.211	0.015	0.010	0.019
194	2.03	0.0	2.03	7.2	4.4	5.8	2.032	0.0	2.032	0.177	0.348	0.282	0.040	0.304
195	0.0	0.0	0.0	11.1	0.0	5.6	0.0	0.0	0.0	0.151	0.236	0.014	0.020	0.023
196	0.0	0.0	0.0	11.7	2.2	6.9	0.0	0.0	0.0	0.135	0.185	0.012	0.010	0.016
197	0.51	0.0	0.51	12.8	2.2	7.5	0.508	0.0	0.508	0.136	0.160	0.012	0.010	0.013
198	7.37	0.0	7.37	12.8	6.7	9.7	7.366	0.0	7.366	0.439	0.648	1.653	0.260	1.679
199	8.13	0.0	8.13	13.9	9.4	11.7	8.128	0.0	8.128	1.734	1.272	5.067	1.720	4.813
200	2.29	0.0	2.29	10.0	6.7	8.3	2.286	0.0	2.286	1.986	0.798	1.788	1.070	1.333
201	0.0	0.0	0.0	10.6	0.0	5.3	0.0	0.0	0.0	1.243	0.256	0.299	0.020	0.026
202	0.0	0.0	0.0	13.3	0.6	6.9	0.0	0.0	0.0	0.831	0.165	0.170	0.020	0.013
203	0.0	0.0	0.0	15.6	3.3	9.4	0.0	0.0	0.0	0.490	0.124	0.080	0.010	0.009
204	0.0	0.0	0.0	14.4	5.0	9.7	0.0	0.0	0.0	0.272	0.109	0.034	0.010	0.007
205	0.0	0.0	0.0	16.1	2.8	9.4	0.0	0.0	0.0	0.165	0.086	0.016	0.010	0.005
206	0.0	0.0	0.0	16.7	6.1	11.4	0.0	0.0	0.0	0.154	0.066	0.014	0.0	0.003
207	0.0	0.0	0.0	13.9	5.6	9.7	0.0	0.0	0.0	0.146	0.063	0.013	0.0	0.003
208	0.0	0.0	0.0	12.8	4.4	8.6	0.0	0.0	0.0	0.139	0.046	0.012	0.0	0.001
209	0.0	0.0	0.0	17.8	3.9	10.8	0.0	0.0	0.0	0.132	0.041	0.011	0.0	0.001
210	0.0	0.0	0.0	23.9	7.2	15.6	0.0	0.0	0.0	0.125	0.033	0.010	0.0	0.001
211	0.0	0.0	0.0	23.3	7.2	15.3	0.0	0.0	0.0	0.119	0.025	0.010	0.0	0.000
212	0.0	0.0	0.0	22.8	6.7	14.7	0.0	0.0	0.0	0.111	0.015	0.009	0.0	0.000
213	0.0	0.0	0.0	12.8	7.2	10.0	0.0	0.0	0.0	0.105	0.015	0.008	0.0	0.000
214	0.0	0.0	0.0	10.6	0.0	5.3	0.0	0.0	0.0	0.098	0.008	0.007	0.0	0.0
215	0.0	1.02	1.02	8.3	0.0	4.2	0.0	0.169	0.169	0.094	0.013	0.007	0.0	0.0
216	0.0	0.0	0.0	9.4	1.1	5.3	0.0	0.847	0.847	0.089	0.015	0.006	0.0	0.000
217	0.0	0.0	0.0	11.1	0.0	5.6	0.0	0.0	0.0	0.083	0.015	0.005	0.0	0.000
218	0.25	0.0	0.25	14.4	0.0	7.2	0.254	0.0	0.254	0.078	0.015	0.005	0.0	0.000
219	1.02	0.0	1.02	15.6	1.7	8.6	1.016	0.0	1.016	0.073	0.015	0.004	0.0	0.000
220	0.76	0.0	0.76	15.6	4.4	10.0	0.762	0.0	0.762	0.068	0.015	0.004	0.0	0.000

Table 19. (Continued)

This water year had relatively normal precipitation (501 mm) but probably had a low soil loss. Stream flow and soil loss lower than the observed value during February (days 123-151 might be the result of bad estimation of snowmelt and frozen ground event (Table 19). During this entire period, the problem of observed and simulated runoff and erosion are well matched.

a) Days 153 (March 2) and 169 (March 18)

These two days have good stream flow simulation but the soil losses were estimated four to ten times as much as the recorded. It is hard to explain the reason, however, it seems that the erosion model overestimates upland soil loss when overland flow occurs.

b) Days 170 -174 (March 19 - March 23)

This period has moderately accurate simulation except days 170 and 174, which have lower simulated stream flow and soil loss than the observed. Table 18 shows that there were no overland flow estimated. Overland flow seems to be necessary to cause that amount of soil loss of this period (5 - 7 tons per day). It is, however, possible to look into some other erosion sources such as landslide or channel bank collapsing which cannot be simulated in the model.

c) Day 186 (April 4)

The simulated soil loss is more than fifty times as much as the observed. However, the difference of their stream flows is not so high. The high estimated overland flow on Zone IV (13.6 mm) might be the reason for this bad simulation. But comparing the results of days 153 and 169 the erosion model overestimates the soil loss for this water year. It should be remembered that the erosion model parameters were optimized using 1939 data.

2) Water Year 1939 (Table 20)

This year was dry (398 mm) and cold. Most of the precipitation was snow, which remained on the ground until the snowmelt season started (end of March in the year). The snow-water-equivalent on the ground at the beginning of the melt season averaged 80 mm (higher on north slope [120 mm]

```
DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1939
          PRECIPITATION(MM)        TEMPERATURE('C) AVAILABLE MOISTURE(MM)        RUNOFF(MM)             SOIL LOSS(TONS)
 DAY   RAIN   SNOW  TOTAL    MAX    MIN    AVG   RAIN    SNOW   TOTAL  SIMUL   OBSER  SIMUL1   OBSER  SIMUL2
  56    0.0    0.0    0.0    2.8   -6.7   -1.9    0.0   0.457   0.457    0.0     0.0     0.0     0.0     0.0
  57    0.0    0.0    0.0    3.3   -4.4   -0.6    0.0   0.174   0.174    0.0     0.0     0.0     0.0     0.0
  58    0.0    0.0    0.0    5.0   -2.8    1.1    0.0   0.248   0.248    0.0     0.0     0.0     0.0     0.0
  59    0.0    0.0    0.0    7.2   -0.6    3.3    0.0   0.210   0.210    0.0     0.0     0.0     0.0     0.0
  60    0.0    0.0    0.0    8.3    2.2    5.3    0.0   0.205   0.205    0.0     0.0     0.0     0.0     0.0
  61   2.03    0.0   2.03    5.6    1.7    3.6  2.032   0.159   2.191  0.004     0.0   0.000     0.0   0.000
  62   1.02    0.0   1.02    7.2    2.2    4.7  1.016   0.100   1.116  0.004     0.0   0.000     0.0     0.0
  63   7.62   1.02   8.64    3.9    0.6    2.2  7.620   0.982   8.602  0.193     0.0   0.083     0.0   0.000
  64    0.0    0.0    0.0    3.3    0.6    1.9    0.0   0.034   0.034    0.0     0.0     0.0     0.0     0.0
  65    0.0   1.27   1.27    3.9    0.0    1.9    0.0   1.120   1.120    0.0     0.0     0.0     0.0     0.0
  66    0.0   4.32   4.32    7.8    1.7    4.7    0.0   4.148   4.148    0.0     0.0     0.0     0.0     0.0
  67    0.0    0.0    0.0    6.7    1.1    3.9    0.0   0.320   0.320    0.0     0.0     0.0     0.0     0.0
  68    0.0    0.0    0.0   12.8    3.3    8.1    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  69    0.0    0.0    0.0   13.9    6.1   10.0    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  70    0.0    0.0    0.0    6.1    3.3    4.7    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  71    0.0    0.0    0.0    3.3   -2.2    0.6    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  72    0.0    0.0    0.0   -1.1   -7.8   -4.4    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  73    0.0    0.0    0.0   -0.6   -7.8   -4.2    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  74    0.0    0.0    0.0    1.1   -6.7   -2.8    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  75    0.0    0.0    0.0    3.3   -5.0   -0.8    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  76    0.0    0.0    0.0    5.6   -3.3    1.1    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  77    0.0    0.0    0.0   -0.6   -6.7   -3.6    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  78    0.0    0.0    0.0    3.9   -6.1   -1.1    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  79    0.0    0.0    0.0   -5.0   -6.7   -5.8    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  80    0.0    0.0    0.0    0.6   -6.1   -2.8    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  81    0.0   0.76   0.76   -0.6   -6.7   -3.6    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  82    0.0   3.30   3.30    0.0   -5.6   -2.8    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  83    0.0   1.52   1.52   -1.7   -7.2   -4.4    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  84   0.25   1.02   1.27    5.6   -1.7    1.9  0.254   2.876   3.130    0.0     0.0     0.0     0.0     0.0
  85    0.0    0.0    0.0    5.6    0.5    3.1    0.0   1.815   1.815    0.0     0.0     0.0     0.0     0.0
  86    0.0    0.0    0.0    1.1   -1.1   -0.0    0.0   0.001   0.001    0.0     0.0     0.0     0.0     0.0
  87    0.0   4.06   4.06    0.0  -11.7   -5.8    0.0   0.0     0.0      0.0     0.0     0.0     0.0     0.0
  88    0.0   0.51   0.51    4.4   -7.2   -1.4    0.0   1.970   1.970    0.0     0.0     0.0     0.0     0.0
  89    0.0   0.25   0.25    3.9    0.6    2.2    0.0   1.335   1.335  0.000     0.0     0.0     0.0     0.0
  90    0.0   2.29   2.29    6.1    1.1    3.6    0.0   1.971   1.971    0.0   0.063     0.0   0.012   0.003
  91    0.0    0.0    0.0    6.7    1.7    4.2    0.0   1.000   1.000    0.0   0.066     0.0   0.017   0.003
  92    0.0    0.0    0.0    7.2    3.3    5.3    0.0   1.517   1.517    0.0   0.048     0.0   0.016   0.002
  93    0.0    0.0    0.0   12.8    3.3    8.1    0.0   1.230   1.230    0.0   0.018     0.0   0.004   0.000
  94   2.54    0.0   2.54   10.0    3.3    6.7  2.540   0.0     2.540  0.074   0.008   0.026   0.001   0.000
  95    0.0   1.27   1.27    4.4    2.2    3.3    0.0   1.143   1.143  0.067   0.010   0.006   0.003     0.0
  96    0.0    0.0    0.0    3.3   -1.1    1.1    0.0   0.025   0.025  0.006     0.0     0.0     0.0     0.0
  97    0.0   8.64   8.64    1.7    0.6    1.1    0.0   0.311   0.311  0.046   0.002   0.002   0.002     0.0
  98    0.0    0.0    0.0    2.8   -0.6    1.1    0.0   0.983   0.983  0.016   0.002   0.000     0.0     0.0
  99    0.0    0.0    0.0    2.2   -0.6    0.8    0.0   0.619   0.619  0.029     0.0   0.001     0.0     0.0
 100    0.0   4.83   4.83    1.1    0.0    0.6    0.0   0.024   0.024  0.017     0.0   0.000     0.0     0.0
 101    0.0   0.76   0.76    1.1    0.0    0.6    0.0   0.085   0.085  0.014     0.0   0.000     0.0     0.0
 102    0.0    0.0    0.0    3.3    1.1    2.2    0.0   2.235   2.235  0.037   0.005   0.002   0.001     0.0
 103    0.0    0.0    0.0    5.6    1.1    3.3    0.0   6.085   6.085  0.564   0.025   0.116   0.019   0.000
 104    0.0    0.0    0.0    3.3   -1.1    1.1    0.0   0.543   0.543  1.404     0.0   0.358     0.0     0.0
 105   3.30   0.51   3.81    5.0   -1.1    1.9  3.302   1.317   4.619  1.328   0.005   0.353   0.007   0.001
 106    0.0    0.0    0.0    5.6   -1.1    2.2    0.0   1.047   1.047  1.310     0.0   0.326     0.0     0.0
 107    0.0   0.25   0.25    0.6   -0.6   -0.0    0.0   0.0     0.0    0.870     0.0   0.182     0.0     0.0
 108    0.0   0.25   0.25    0.6   -1.1   -0.3    0.0   0.0     0.0    0.484   0.008   0.079     0.0     0.0
 109   5.84   1.78   7.62    4.4   -1.1    1.7  5.842   2.060   7.902  1.130   0.008   0.323     0.0   0.002
 110   1.02    0.0   1.02    4.4    0.6    2.5  1.016   0.743   1.759  1.649   0.028   0.451   0.004   0.001
```

Table 20. Daily summary of watershed model and soil erosion simulation model of the Pitzen Watershed during erosion season of the water year 1939.

```
DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1939
        PRECIPITATION(MM)          TEMPERATURE('C)AVAILABLE MOISTURE(MM)        RUNOFF(MM)                 SOIL LOSS(TONS)
 DAY    RAIN   SNOW    TOTAL     MAX    MIN    AVG   RAIN      SNOW      TOTAL    SIMUL     OBSER     SIMUL1     OBSER     SIMUL2
 111    0.0    0.0     0.0       7.2    2.2    4.7   0.0       1.066     1.066    1.104     0.043     0.254      0.014     0.001
 112    0.0    0.0     0.0       5.0   -1.1    1.9   0.0       0.0       0.0      0.886     0.043     0.186      0.009     0.001
 113    0.0    0.0     0.0       3.3   -3.9   -0.3   0.0       0.0       0.0      0.549     0.013     0.094      0.001     0.0
 114    0.0    0.0     0.0       3.3   -3.9   -0.3   0.0       0.0       0.0      0.290     0.0       0.038      0.0       0.0
 115    0.0    0.0     0.0       5.6   -2.2    1.7   0.0       0.0       0.0      0.143     0.0       0.013      0.0       0.0
 116    1.78   0.0     1.78      5.0   -1.1    1.9   1.778     0.0       1.778    0.182     0.005     0.025      0.004     0.001
 117    0.0    0.0     0.0       3.3   -3.9   -0.3   0.0       0.0       0.0      0.214     0.010     0.025      0.004     0.0
 118    0.0    0.0     0.0       3.3   -1.7    0.8   0.0       0.0       0.0      0.109     0.0       0.008      0.0       0.0
 119    1.27   1.27    2.54      4.4    0.6    2.5   1.270     0.126     1.396    0.145     0.005     0.015      0.0       0.0
 120    0.25   1.78    2.03      3.9   -1.1    1.4   0.254     1.788     2.042    0.175     0.008     0.018      0.0       0.000
 121    0.25   0.76    1.02      5.6   -1.1    2.2   0.254     1.181     1.435    0.378     0.008     0.057      0.001     0.0
 122    0.0    0.0     0.0       3.3   -3.3   -0.0   0.0       0.113     0.113    0.366     0.005     0.053      0.001     0.0
 123    0.0    0.0     0.0      -0.6   -3.9   -2.2   0.0       0.0       0.0      0.195     0.0       0.021      0.0       0.0
 124    0.0    0.51    0.51     -0.6   -5.0   -2.8   0.0       0.0       0.0      0.127     0.013     0.011      0.002     0.0
 125    0.0    0.0     0.0      -2.8   -6.7   -4.7   0.0       0.0       0.0      0.110     0.0       0.008      0.0       0.0
 126    0.0    0.0     0.0       1.1   -6.1   -2.5   0.0       0.006     0.006    0.105     0.0       0.008      0.0       0.0
 127    0.0   10.16   10.16      0.6   -3.3   -1.4   0.0       0.0       0.0      0.099     0.0       0.007      0.0       0.0
 128    0.25   2.29    2.54      2.8   -6.7   -1.9   0.254     0.665     0.919    0.102     0.0       0.007      0.0       0.0
 129    0.0    6.35    6.35     -0.6   -2.2   -1.4   0.0       0.0       0.0      0.099     0.0       0.007      0.0       0.0
 130    0.0    2.54    2.54      1.7   -3.9   -1.1   0.0       0.131     0.131    0.090     0.0       0.006      0.0       0.0
 131    0.0    1.27    1.27     -3.9  -15.0   -9.4   0.0       0.0       0.0      0.085     0.0       0.006      0.0       0.0
 132    0.0    0.0     0.0      -8.9  -21.1  -15.0   0.0       0.0       0.0      0.079     0.0       0.005      0.0       0.0
 133    0.0    0.0     0.0      -7.8  -12.2  -10.0   0.0       0.0       0.0      0.074     0.0       0.004      0.0       0.0
 134    0.0   11.43   11.43      1.7  -14.4   -6.4   0.0       0.578     0.578    0.070     0.0       0.004      0.0       0.0
 135    1.52  11.68   13.21      4.4    2.2    3.3   1.524     3.120     4.644    0.483     0.383     0.087      0.030     0.049
 136    0.0    0.0     0.0       2.8   -0.6    1.1   0.0       1.000     1.000    0.677     0.437     0.127      0.035     0.056
 137    5.08  26.42   31.50      2.8    0.0    1.4   5.080     1.132     6.212    1.020     0.310     0.252      0.025     0.035
 138    0.0    4.83    4.83      2.2   -0.6    0.8   0.0       0.440     0.440    1.595     2.075     0.434      0.365     0.517
 139    0.0    0.0     0.0       3.9   -7.2   -1.7   0.0       1.276     1.276    1.088     2.014     0.249      0.437     0.495
 140    0.0    0.0     0.0       5.0   -1.7    1.7   0.0       2.767     2.767    0.930     1.374     0.199      0.286     0.238
 141    0.0    0.0     0.0       6.7    1.1    3.9   0.0       3.750     3.750    1.037     1.201     0.233      0.334     0.239
 142    0.0    0.0     0.0       2.8   -4.4   -0.8   0.0       0.615     0.615    1.361     1.077     0.342      0.214     0.204
 143    0.0    0.0     0.0       2.8   -5.0   -1.1   0.0       0.570     0.570    1.099     0.808     0.253      0.109     0.136
 144    0.0    0.0     0.0       3.3   -6.7   -1.7   0.0       0.839     0.839    0.839     0.645     0.172      0.063     0.098
 145    0.0    0.0     0.0       4.4   -4.4   -0.0   0.0       1.411     1.411    0.623     0.577     0.113      0.064     0.084
 146    0.0    0.0     0.0       5.0   -6.1   -0.6   0.0       2.073     2.073    0.558     0.475     0.096      0.030     0.063
 147    0.0    0.0     0.0       6.1   -1.1    2.5   0.0       3.099     3.099    0.673     0.518     0.126      0.067     0.072
 148    0.0    1.78    1.78      1.1   -1.7   -0.3   0.0       0.017     0.017    0.873     0.561     0.182      0.194     0.081
 149    0.0    0.0     0.0       3.3   -1.7    0.8   0.0       1.002     1.002    0.639     0.571     0.117      0.127     0.083
 150    0.0    3.81    3.81      1.7   -3.9   -1.1   0.0       0.124     0.124    0.491     0.531     0.080      0.065     0.074
 151    0.0    0.0     0.0       1.1   -4.4   -1.7   0.0       0.015     0.015    0.315     0.465     0.042      0.038     0.061
 152    0.0    0.25    0.25      2.2   -5.0   -1.4   0.0       0.383     0.383    0.223     0.442     0.025      0.041     0.057
 153    0.25   0.25    0.51      4.4   -5.0   -0.3   0.254     1.821     2.075    0.234     0.485     0.028      0.053     0.055
 154    0.0    3.30    3.30      0.6   -1.7   -0.6   0.0       0.0       0.0      0.329     0.571     0.045      0.050     0.083
 155    0.0    0.0     0.0      -1.7   -5.0   -3.3   0.0       0.0       0.0      0.242     0.465     0.028      0.033     0.051
 156    0.0    0.0     0.0       2.8   -7.2   -2.2   0.0       0.617     0.617    0.178     0.406     0.018      0.026     0.051
 157    1.78   5.59    7.37      3.3   -2.2    0.6   1.778     0.970     2.748    0.387     0.406     0.070      0.028     0.053
 158    0.0    0.0     0.0       5.0   -5.0   -0.0   0.0       1.820     1.820    0.527     0.406     0.089      0.021     0.051
 159    0.0    0.0     0.0       5.6   -4.4    0.6   0.0       2.293     2.293    0.595     0.389     0.106      0.015     0.047
 160    0.0    0.25    0.25      2.8   -2.8    0.0   0.0       0.735     0.735    0.729     0.373     0.141      0.018     0.045
 161    0.25   0.0     0.25      6.1   -1.7    2.2   0.254     3.821     4.075    0.755     0.495     0.159      0.055     0.074
 162    6.35  20.32   26.67      3.3    1.7    2.5   6.350     2.267     8.617    1.966     2.271     0.823      0.630     0.795
 163    2.54   9.14   11.68      6.7    0.0    3.3   2.540     3.639     6.179    3.948     3.843     1.882      2.040     1.565
 164    1.27   0.76    2.03      3.3   -1.7    0.8   1.270     1.068     2.338    3.745     2.987     1.614      1.802     1.050
 165    0.0    0.0     0.0       5.6   -2.8    1.4   0.0       2.642     2.642    2.704     2.418     0.901      0.942     0.640
```

Table 20. (Continued)

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1939

	PRECIPITATION(MM)			TEMPERATURE('C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
166	0.25	0.76	1.02	3.3	-1.1	1.1	0.254	1.393	1.647	2.243	1.953	0.755	0.513	0.535
167	0.0	0.0	0.0	6.7	0.6	3.6	0.0	4.635	4.635	1.783	2.713	0.501	1.470	0.753
168	0.51	0.0	0.51	7.8	2.2	5.0	0.508	6.235	6.743	2.662	6.190	1.186	8.200	2.697
169	0.0	0.0	0.0	13.3	2.2	7.8	0.0	11.166	11.166	3.710	9.985	1.414	29.940	4.692
170	0.0	0.0	0.0	17.2	1.7	9.4	0.0	15.238	15.238	7.151	12.672	17.116	54.650	20.080
171	0.0	0.0	0.0	19.4	5.0	12.2	0.0	14.066	14.066	14.368	14.521	34.122	55.020	32.504
172	0.0	0.0	0.0	19.4	5.6	12.5	0.0	17.811	17.811	14.271	14.031	70.365	44.680	68.610
173	0.0	0.0	0.0	20.0	6.1	13.1	0.0	7.046	7.046	13.559	12.426	18.860	35.450	16.597
174	0.0	0.0	0.0	20.0	6.7	13.3	0.0	0.0	0.0	8.039	8.801	5.556	17.280	5.180
175	0.0	0.0	0.0	20.0	6.1	13.1	0.0	0.0	0.0	2.716	5.481	0.922	4.840	2.023
176	0.0	0.0	0.0	15.0	6.1	10.6	0.0	0.0	0.0	1.191	3.378	0.285	1.491	1.025
177	0.0	0.0	0.0	8.9	2.2	5.6	0.0	0.0	0.0	0.827	2.004	0.169	0.430	0.492
178	0.0	0.0	0.0	12.2	-1.1	5.6	0.0	0.0	0.0	0.586	1.410	0.103	0.416	0.299
179	0.0	0.0	0.0	12.8	-1.1	5.8	0.0	0.0	0.0	0.433	1.082	0.067	0.207	0.206
180	0.0	0.0	0.0	13.3	-0.6	6.4	0.0	0.0	0.0	0.320	0.780	0.043	0.060	0.129
181	0.0	0.0	0.0	15.6	3.9	9.7	0.0	0.0	0.0	0.198	0.640	0.021	0.021	0.097
182	0.0	0.0	0.0	16.1	6.1	11.1	0.0	0.0	0.0	0.158	0.538	0.015	0.020	0.076
183	0.0	0.0	0.0	16.1	7.2	11.7	0.0	0.0	0.0	0.155	0.411	0.014	0.021	0.052
184	0.0	0.0	0.0	17.2	3.3	10.3	0.0	0.0	0.0	0.123	0.363	0.010	0.011	0.043
185	0.0	0.0	0.0	11.7	7.2	9.4	0.0	0.0	0.0	0.145	0.300	0.013	0.009	0.032
186	0.0	0.0	0.0	9.4	-1.1	4.2	0.0	0.0	0.0	0.180	0.211	0.023	0.007	0.022
187	0.0	0.0	0.0	10.0	-1.1	4.4	0.0	0.0	0.0	0.140	0.165	0.012	0.006	0.013
188	0.0	0.0	0.0	12.8	-1.7	5.6	0.0	0.0	0.0	0.131	0.178	0.011	0.010	0.015
189	0.0	0.0	0.0	16.1	2.2	9.2	0.0	0.0	0.0	0.124	0.157	0.010	0.005	0.012
190	0.51	0.0	0.51	13.9	5.6	9.7	0.508	0.0	0.508	0.119	0.114	0.010	0.003	0.007
191	0.0	0.0	0.0	9.4	3.9	6.7	0.0	0.0	0.0	0.113	0.112	0.009	0.003	0.007
192	0.0	0.0	0.0	13.9	-0.6	5.7	0.0	0.0	0.0	0.106	0.114	0.008	0.003	0.007
193	0.0	0.0	0.0	14.4	2.2	8.3	0.0	0.0	0.0	0.100	0.086	0.007	0.002	0.005
194	8.13	0.0	8.13	3.9	-0.6	1.7	8.128	0.0	8.128	0.506	0.919	0.179	0.140	0.195
195	0.0	0.0	0.0	8.9	0.6	4.7	0.0	0.0	0.0	0.189	0.422	0.021	0.012	0.053
196	0.0	0.0	0.0	13.3	-1.1	6.1	0.0	0.0	0.0	0.109	0.183	0.008	0.002	0.016
197	0.0	0.0	0.0	12.8	2.2	7.5	0.0	0.0	0.0	0.098	0.094	0.007	0.001	0.005
198	0.0	0.0	0.0	16.1	-0.6	7.8	0.0	0.0	0.0	0.093	0.051	0.006	0.0	0.002
199	0.0	0.0	0.0	21.1	3.9	12.5	0.0	0.0	0.0	0.087	0.036	0.006	0.0	0.001
200	0.0	0.0	0.0	22.8	7.2	15.0	0.0	0.0	0.0	0.082	0.033	0.005	0.0	0.001
201	0.0	0.0	0.0	16.7	2.2	9.4	0.0	0.0	0.0	0.077	0.033	0.005	0.0	0.001
202	0.0	0.0	0.0	22.8	4.4	13.6	0.0	0.0	0.0	0.071	0.033	0.004	0.0	0.001
203	0.0	0.0	0.0	23.9	8.3	16.1	0.0	0.0	0.0	0.066	0.015	0.004	0.0	0.000
204	0.0	0.0	0.0	17.2	8.3	12.8	0.0	0.0	0.0	0.061	0.015	0.003	0.0	0.000
205	0.76	0.0	0.76	17.8	3.3	10.6	0.762	0.0	0.762	0.058	0.015	0.003	0.0	0.000
206	0.0	0.0	0.0	10.0	3.3	6.7	0.0	0.0	0.0	0.053	0.015	0.002	0.0	0.000
207	0.0	0.0	0.0	12.2	3.9	8.1	0.0	0.0	0.0	0.049	0.043	0.002	0.001	0.001
208	0.0	0.0	0.0	21.1	2.8	11.9	0.0	0.0	0.0	0.045	0.018	0.002	0.0	0.000
209	0.0	0.0	0.0	26.7	7.2	16.9	0.0	0.0	0.0	0.041	0.008	0.001	0.0	0.0
210	0.0	0.0	0.0	31.1	12.8	21.9	0.0	0.0	0.0	0.038	0.0	0.001	0.0	0.0
211	0.0	0.0	0.0	12.8	8.9	10.8	0.0	0.0	0.0	0.034	0.0	0.001	0.0	0.0
212	0.0	0.0	0.0	20.0	4.4	12.2	0.0	0.0	0.0	0.030	0.0	0.001	0.0	0.0
213	0.0	0.0	0.0	23.9	4.4	14.2	0.0	0.0	0.0	0.027	0.0	0.001	0.0	0.0
214	0.0	0.0	0.0	23.9	12.8	18.3	0.0	0.0	0.0	0.024	0.0	0.000	0.0	0.0
215	0.0	0.0	0.0	18.9	8.9	13.9	0.0	0.0	0.0	0.020	0.0	0.000	0.0	0.0
216	0.0	0.0	0.0	20.0	4.4	12.2	0.0	0.0	0.0	0.017	0.0	0.000	0.0	0.0
217	0.0	0.0	0.0	15.0	0.0	7.5	0.0	0.0	0.0	0.014	0.0	0.000	0.0	0.0
218	0.0	0.0	0.0	17.2	0.0	8.6	0.0	0.0	0.0	0.011	0.0	0.0	0.0	0.0
219	0.0	0.0	0.0	16.1	5.0	10.6	0.0	0.0	0.0	0.009	0.0	0.0	0.0	0.0
220	0.0	0.0	0.0	22.8	5.6	14.2	0.0	0.0	0.0	0.006	0.0	0.0	0.0	0.0

Table 20. (Continued)

and lower on south slopes [55 mm] as simulated). This snow was melted in less than a week under very high soil moisture conditions. Since this water year was used to optimize the parameters of the watershed and erosion models for the Pitzen watershed the output was more accurate than other years. The daily summary of runoff and erosion for this year is shown in Figure 18.

The entire runoff and erosion period covered only 44 days, March 16 to April 28 (days 167 - 210). Early in the period (days 167 - 170), the lower than recorded soil loss matches the lower than recorded stream flow. Possible frozen ground events in the previous days or less snowmelt simulation might be the reason of this. It is noted that Zones I and II, which are hill-top and southward slope areas, respectively, are the main overland flow and erosion sources in this period.

After this initial runoff, observed and simulated stream flows match each other quite well. Most of the erosion in this period came from Zones III (north slope) and IV (lower zone) where the snow remained longer and melted after longer continuous warm days than for the upper zones. However, the high overland flow (24.71 mm on Zone IV in day 171) did not cause as much erosion as compared to the results of 1940. The reason would be that snowmelt generates a relatively low rate of overland flow. The high stream flow with comparatively low soil loss during most years indicates that most snowmelt water flows through the subsurface to the channel, therefore no significant erosion occurs if snowmelt acts alone.

3) Water Year 1940 (Table 21)

← Table 21

This was a much higher than normal precipitation year (630 mm). This water year also had high simulated stream flow in the early months. It was even worse in terms of monthly and yearly total (Table 11). The deep percolation loss should be higher than the value optimized (0.02 mm/hour) in 1939 water year in order to reduce the total annual water yield of the year. Even with high precipitation (630 mm), the total stream flow was very low but a significant amount of soil was lost from the watershed. This would show that most of precipitation was lost to deep percolation, evapotran-

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1940

	PRECIPITATION(MM)			TEMPERATURE('C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
56	0.0	0.0	0.0	17.8	7.2	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	11.7	4.4	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	0.0	0.0	0.0	9.4	4.4	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	5.6	-2.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.25	0.25	7.2	1.1	4.2	0.0	0.254	0.254	0.0	0.0	0.0	0.0	0.0
61	0.0	0.0	0.0	11.1	5.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	1.02	0.0	1.02	8.9	1.7	5.3	1.016	0.0	1.016	0.0	0.0	0.0	0.0	0.0
63	1.02	0.0	1.02	13.9	6.1	10.0	1.016	0.0	1.016	0.0	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	11.1	3.9	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	10.0	4.4	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	0.0	0.0	0.0	12.8	6.7	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	0.0	0.0	0.0	12.8	1.7	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	1.27	0.0	1.27	9.4	4.4	6.9	1.270	0.0	1.270	0.0	0.0	0.0	0.0	0.0
69	8.38	0.0	8.38	9.4	7.2	8.3	8.382	0.0	8.382	0.0	0.0	0.0	0.0	0.0
70	9.14	0.0	9.14	7.8	4.4	6.1	9.144	0.0	9.144	0.017	0.0	0.002	0.0	0.0
71	9.14	0.0	9.14	12.2	6.7	9.4	9.144	0.0	9.144	0.158	0.0	0.045	0.0	0.0
72	0.0	0.0	0.0	7.2	3.3	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	0.0	0.0	0.0	3.3	-1.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	0.76	0.0	0.76	3.9	1.1	2.5	0.762	0.0	0.762	0.0	0.0	0.0	0.0	0.0
75	8.13	0.51	8.64	5.0	1.7	3.3	8.128	0.508	8.636	0.128	0.0	0.042	0.0	0.000
76	18.54	0.0	18.54	8.9	5.0	6.9	18.542	0.0	18.542	0.049	0.0	0.009	0.0	0.000
77	12.95	0.0	12.95	10.0	3.3	6.7	12.954	0.0	12.954	0.268	0.0	0.091	0.0	0.000
78	8.13	0.0	8.13	5.6	3.3	4.4	8.128	0.0	8.128	0.166	0.010	0.063	0.0	0.001
79	2.54	0.25	2.79	4.4	-0.6	1.9	2.540	0.092	2.632	0.054	0.0	0.018	0.0	0.001
80	1.52	2.03	3.56	7.2	1.7	4.4	1.524	2.194	3.718	0.041	0.0	0.012	0.0	0.000
81	0.0	0.0	0.0	7.2	1.7	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82	0.0	0.0	0.0	3.3	0.6	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	0.0	0.0	0.0	0.6	-1.1	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
84	0.0	0.0	0.0	0.0	-3.3	-1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	-2.2	-3.9	-3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
86	0.0	0.0	0.0	-3.3	-6.1	-4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87	0.0	2.03	2.03	-3.9	-6.1	-5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88	0.0	0.0	0.0	-1.7	-9.4	-5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	0.0	2.54	2.54	0.0	-6.1	-3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90	0.0	5.33	5.33	2.8	-0.6	1.1	0.0	1.086	1.086	0.0	0.0	0.0	0.0	0.0
91	0.0	2.79	2.79	1.7	0.6	1.1	0.0	0.341	0.341	0.0	0.0	0.0	0.0	0.0
92	9.91	4.83	14.73	3.3	0.6	1.9	9.906	1.973	11.879	0.757	0.196	0.328	0.0	0.025
93	4.83	0.0	4.83	7.8	0.6	4.2	4.826	9.983	14.809	4.596	0.129	65.858	0.0	63.925
94	4.83	1.02	5.84	8.9	3.3	6.1	4.826	3.478	8.304	4.667	0.094	2.307	0.090	0.158
95	0.0	2.79	2.79	7.2	0.6	3.9	0.0	4.274	4.274	4.715	0.160	2.032	0.040	0.069
96	2.79	2.03	4.83	5.6	1.1	3.3	2.794	2.156	4.950	4.390	0.129	1.939	0.040	0.130
97	0.0	0.0	0.0	5.0	-1.1	1.9	0.0	0.0	0.0	2.366	0.015	0.768	0.0	0.000
98	0.0	0.0	0.0	3.3	-1.7	0.8	0.0	0.0	0.0	0.642	0.008	0.117	0.0	0.0
99	0.0	0.0	0.0	1.1	-2.8	-0.8	0.0	0.0	0.0	0.879	0.0	0.184	0.0	0.0
100	0.0	0.0	0.0	1.7	-2.2	-0.3	0.0	0.0	0.0	0.581	0.0	0.102	0.0	0.0
101	0.0	6.60	6.60	-1.1	-3.3	-2.2	0.0	0.0	0.0	0.867	0.0	0.182	0.0	0.0
102	0.0	1.52	1.52	0.0	-3.3	-1.7	0.0	0.0	0.0	0.470	0.0	0.076	0.0	0.0
103	0.0	1.52	1.52	-1.7	-7.8	-4.7	0.0	0.0	0.0	0.222	0.0	0.025	0.0	0.0
104	0.0	2.29	2.29	-4.4	-7.2	-5.8	0.0	0.0	0.0	0.103	0.0	0.008	0.0	0.0
105	0.0	0.0	0.0	1.1	-7.8	-3.3	0.0	0.007	0.007	0.059	0.0	0.003	0.0	0.0
106	0.0	0.0	0.0	2.8	-2.8	0.0	0.0	0.677	0.677	0.060	0.0	0.003	0.0	0.0
107	0.0	0.0	0.0	2.2	-3.3	-0.6	0.0	0.715	0.715	0.058	0.0	0.003	0.0	0.0
108	0.0	0.0	0.0	3.9	1.1	2.5	0.0	2.481	2.481	0.093	0.0	0.007	0.0	0.0
109	0.0	0.0	0.0	4.4	1.7	3.1	0.0	2.262	2.262	0.333	0.0	0.057	0.0	0.0
110	0.0	0.0	0.0	1.7	-10.0	-4.2	0.0	0.118	0.118	0.498	0.0	0.082	0.0	0.0

Table 21. Daily summary of watershed model and soil erosion simulation model of the Pitzen Watershed during erosion season of the water year 1940.

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1940

	PRECIPITATION(MM)			TEMPERATURE(°C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)		SOIL LOSS(TONS)		
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
111	0.0	0.0	0.0	-4.4	-11.7	-8.1	0.0	0.0	0.0	0.339	0.0	0.047	0.0	0.0
112	0.0	0.0	0.0	-1.7	-8.3	-5.0	0.0	0.0	0.0	0.174	0.0	0.013	0.0	0.0
113	0.0	0.0	0.0	-4.4	-10.0	-7.2	0.0	0.0	0.0	0.100	0.0	0.007	0.0	0.0
114	0.0	0.0	0.0	1.7	-6.1	-2.2	0.0	0.141	0.141	0.081	0.0	0.005	0.0	0.0
115	0.0	0.0	0.0	-0.6	-5.0	-2.8	0.0	0.0	0.0	0.077	0.0	0.005	0.0	0.0
116	0.0	0.0	0.0	-5.0	-10.6	-7.8	0.0	0.0	0.0	0.073	0.0	0.004	0.0	0.0
117	0.0	1.78	1.78	-3.9	-9.4	-6.7	0.0	0.0	0.0	0.068	0.0	0.004	0.0	0.0
118	0.0	7.87	7.87	1.7	-6.7	-2.5	0.0	0.479	0.479	0.064	0.0	0.003	0.0	0.0
119	1.27	2.79	4.06	4.4	1.7	3.1	1.270	3.424	4.694	0.385	0.076	0.067	0.010	0.006
120	0.0	0.0	0.0	8.9	2.8	5.8	0.0	6.223	6.223	1.077	0.447	0.252	0.320	0.058
121	0.0	0.0	0.0	9.4	2.2	5.8	0.0	0.983	0.983	1.873	0.353	0.536	0.500	0.041
122	0.0	0.0	0.0	8.3	1.1	4.7	0.0	0.574	0.574	1.464	0.183	0.379	0.430	0.016
123	0.0	0.0	0.0	9.4	0.6	5.0	0.0	0.535	0.535	1.055	0.051	0.239	0.140	0.002
124	0.0	0.0	0.0	6.7	-5.6	0.6	0.0	0.287	0.287	0.731	0.0	0.142	0.020	0.0
125	0.0	1.27	1.27	0.0	-3.3	-1.7	0.0	0.0	0.0	0.428	0.0	0.066	0.0	0.0
126	0.25	3.81	4.06	5.6	-1.7	1.9	0.254	2.275	2.529	0.282	0.241	0.042	0.800	0.028
127	0.0	3.56	3.56	8.9	-0.6	4.2	0.0	3.851	3.851	0.558	0.411	0.101	0.940	0.052
128	8.13	1.52	9.65	4.4	-0.6	1.9	8.128	1.354	9.482	1.464	0.676	0.651	1.460	0.349
129	29.72	0.0	29.72	7.2	2.8	5.0	29.718	1.769	31.486	20.251	6.312	174.062	128.000	159.459
130	0.0	0.0	0.0	6.1	1.7	3.9	0.0	0.468	0.468	8.230	1.168	4.379	3.230	0.253
131	3.81	0.0	3.81	6.1	-1.1	2.5	3.810	0.191	4.001	4.494	1.077	2.271	2.020	0.326
132	6.66	0.0	6.66	6.7	2.8	4.7	6.664	0.987	7.651	4.770	1.867	2.757	18.630	1.165
133	1.27	0.0	1.27	5.0	2.8	3.9	1.270	1.209	2.479	3.848	1.049	1.746	0.920	0.461
134	0.0	0.0	0.0	5.6	-1.1	2.2	0.0	0.0	0.0	2.094	0.356	0.642	0.110	0.042
135	0.0	0.0	0.0	5.6	-1.7	1.9	0.0	0.0	0.0	0.581	0.472	0.102	2.640	0.063
136	0.0	4.57	4.57	1.7	-0.6	0.6	0.0	0.340	0.340	1.549	0.437	0.689	0.220	0.296
137	0.0	0.25	0.25	3.9	0.0	1.9	0.0	2.573	2.573	0.821	0.904	0.167	2.800	0.159
138	0.0	0.0	0.0	3.3	-1.7	0.8	0.0	1.066	1.066	0.792	0.495	0.159	0.540	0.067
139	1.52	0.0	1.52	3.3	-2.2	0.6	1.524	0.417	1.941	0.765	0.419	0.152	2.270	0.053
140	5.59	2.54	8.13	3.9	0.5	2.2	5.588	2.148	7.736	1.571	1.481	1.053	2.850	0.890
141	0.51	4.06	4.57	3.3	-0.6	1.4	0.508	1.845	2.353	2.640	2.631	0.956	7.190	0.805
142	0.0	0.0	0.0	6.1	-0.6	2.8	0.0	2.728	2.728	2.129	1.186	0.644	5.370	0.234
143	0.0	0.0	0.0	6.7	-2.2	2.2	0.0	1.338	1.338	1.900	0.780	0.550	2.570	0.129
144	0.0	0.0	0.0	6.1	-2.2	1.9	0.0	1.115	1.115	1.261	0.592	0.308	2.580	0.037
145	0.0	2.29	2.29	1.1	-2.8	-0.8	0.0	0.015	0.015	1.041	0.485	0.234	1.420	0.065
146	0.0	0.76	0.76	5.6	-2.2	1.7	0.0	2.771	2.771	0.835	0.726	0.171	2.260	0.117
147	3.56	0.0	3.56	6.7	0.0	3.3	3.556	1.734	5.290	1.063	1.189	0.646	4.570	0.627
148	12.19	0.0	12.19	8.9	2.8	5.8	12.192	0.0	12.192	4.725	4.298	6.773	60.600	6.175
149	6.80	0.0	6.80	8.3	3.3	5.8	6.800	0.0	6.800	5.774	3.919	3.092	33.700	1.729
150	6.10	0.0	6.10	7.8	2.8	5.3	6.096	0.0	6.096	5.424	4.087	3.173	43.500	2.089
151	9.14	0.0	9.14	10.6	4.4	7.5	9.144	0.0	9.144	5.728	5.067	3.538	51.100	2.738
152	0.51	0.0	0.51	9.4	3.9	6.7	0.508	0.0	0.508	4.585	2.423	2.125	1.420	0.860
153	5.33	0.51	5.84	9.4	1.1	5.3	5.334	0.508	5.842	2.890	2.756	1.166	10.000	0.944
154	9.91	0.0	9.91	7.8	3.3	5.6	9.906	0.0	9.906	7.203	5.771	55.843	51.800	54.317
155	0.0	0.0	0.0	10.6	-0.6	5.0	0.0	0.0	0.0	3.803	1.834	1.466	3.700	0.434
156	1.27	0.0	1.27	7.2	2.2	4.7	1.270	0.0	1.270	1.977	1.537	0.704	2.510	0.458
157	0.0	1.02	1.02	6.7	0.0	3.3	0.0	1.016	1.016	1.246	1.427	0.302	1.160	0.304
158	0.0	0.0	0.0	7.8	0.0	3.9	0.0	0.0	0.0	0.944	0.899	0.204	0.610	0.158
159	19.56	2.03	21.59	7.2	2.2	4.7	19.558	2.032	21.590	5.714	6.990	72.029	56.500	71.380
160	0.0	0.0	0.0	6.1	0.6	3.3	0.0	0.0	0.0	5.839	2.103	2.916	11.200	0.741
161	0.0	0.0	0.0	8.9	-1.7	3.6	0.0	0.0	0.0	1.701	1.542	0.468	0.810	0.339
162	0.0	0.0	0.0	6.1	-2.8	1.7	0.0	0.0	0.0	0.766	1.112	0.151	0.540	0.214
163	0.51	0.51	1.02	3.9	-3.3	0.3	0.508	0.464	0.972	2.568	1.067	2.754	1.600	2.019
164	0.0	0.0	0.0	5.0	-1.7	1.7	0.0	0.044	0.044	1.183	0.843	0.284	1.400	0.144
165	0.0	0.0	0.0	9.4	-1.1	4.2	0.0	0.0	0.0	0.822	0.648	0.168	0.190	0.099

Table 21. (Continued)

DAILY SUMMARY OF RUNOFF AND EROSION FOR YEAR 1940

	PRECIPITATION(MM)			TEMPERATURE('C)			AVAILABLE MOISTURE(MM)			RUNOFF(MM)			SOIL LOSS(TONS)	
DAY	RAIN	SNOW	TOTAL	MAX	MIN	AVG	RAIN	SNOW	TOTAL	SIMUL	OBSER	SIMUL1	OBSER	SIMUL2
166	0.0	0.0	0.0	14.4	1.7	8.1	0.0	0.0	0.0	0.614	0.523	0.110	0.060	0.073
167	0.0	0.0	0.0	16.7	5.0	10.8	0.0	0.0	0.0	0.431	0.411	0.079	0.060	0.052
168	3.56	0.0	3.56	7.2	6.7	6.9	3.556	0.0	3.556	0.771	0.879	1.359	1.500	1.357
169	0.0	0.0	0.0	11.7	-0.6	5.6	0.0	0.0	0.0	0.505	0.340	0.083	0.050	0.039
170	0.0	0.0	0.0	12.8	0.0	6.4	0.0	0.0	0.0	0.267	0.272	0.033	0.020	0.028
171	0.0	0.0	0.0	15.0	0.6	7.8	0.0	0.0	0.0	0.200	0.221	0.021	0.020	0.021
172	0.0	0.0	0.0	16.1	2.2	9.2	0.0	0.0	0.0	0.187	0.175	0.019	0.010	0.015
173	0.0	0.0	0.0	17.8	2.2	10.0	0.0	0.0	0.0	0.182	0.155	0.019	0.0	0.012
174	0.0	0.0	0.0	17.2	3.3	10.3	0.0	0.0	0.0	0.174	0.112	0.017	0.0	0.007
175	0.0	0.0	0.0	17.8	3.3	10.6	0.0	0.0	0.0	0.165	0.099	0.016	0.0	0.006
176	0.0	0.0	0.0	15.0	7.8	11.4	0.0	0.0	0.0	0.162	0.107	0.015	0.0	0.007
177	13.72	0.0	13.72	14.4	6.1	10.3	13.716	0.0	13.716	2.824	1.882	20.720	40.000	20.107
178	4.57	0.0	4.57	12.2	5.6	8.9	4.572	0.0	4.572	2.773	1.504	2.795	56.700	2.169
179	0.0	0.0	0.0	11.1	4.4	7.8	0.0	0.0	0.0	2.116	0.363	0.647	3.830	0.043
180	0.51	0.0	0.51	12.2	3.3	7.8	0.503	0.0	0.508	1.271	0.180	1.602	0.010	1.254
181	2.03	0.0	2.03	11.1	5.0	8.1	2.032	0.0	2.032	0.956	0.297	0.588	0.010	0.413
182	0.0	0.0	0.0	11.7	5.6	8.6	0.0	0.0	0.0	0.771	0.185	0.153	0.010	0.016
183	13.72	0.0	13.72	10.0	5.0	7.5	13.716	0.0	13.716	1.854	2.141	3.737	16.100	3.616
184	2.79	0.0	2.79	10.0	4.4	7.2	2.794	0.0	2.794	4.384	1.303	5.013	4.800	3.474
185	0.0	0.0	0.0	10.6	1.1	5.8	0.0	0.0	0.0	2.096	0.297	0.639	1.120	0.032
186	0.0	0.0	0.0	12.8	0.0	6.4	0.0	0.0	0.0	1.046	0.188	0.236	0.010	0.016
187	0.51	0.0	0.51	15.0	2.8	8.9	0.508	0.0	0.508	0.700	0.129	0.133	0.010	0.009
188	5.08	0.0	5.08	10.0	5.0	7.5	5.080	0.0	5.080	1.064	1.024	1.224	0.010	1.147
189	0.0	0.0	0.0	15.0	2.8	8.9	0.0	0.0	0.0	0.537	0.147	0.091	0.610	0.011
190	2.29	0.0	2.29	10.0	5.6	7.8	2.286	0.0	2.286	0.478	0.221	0.219	1.530	0.161
191	2.03	0.0	2.03	13.3	6.7	10.0	2.032	0.0	2.032	0.792	0.704	0.240	20.700	0.173
192	9.68	0.0	9.68	8.9	4.4	6.7	9.680	0.0	9.680	2.532	2.921	7.524	55.100	7.422
193	0.0	0.0	0.0	12.8	1.7	7.2	0.0	0.0	0.0	1.395	0.239	0.363	1.120	0.023
194	0.0	0.0	0.0	15.0	1.7	8.3	0.0	0.0	0.0	0.499	0.099	0.092	0.0	0.006
195	0.0	0.0	0.0	21.1	6.7	13.9	0.0	0.0	0.0	0.438	0.041	0.063	0.0	0.001
196	0.0	0.0	0.0	20.0	8.9	14.4	0.0	0.0	0.0	0.441	0.038	0.068	0.0	0.001
197	0.0	0.0	0.0	13.9	5.0	9.4	0.0	0.0	0.0	0.337	0.025	0.046	0.0	0.000
198	0.0	0.0	0.0	12.2	4.4	8.3	0.0	0.0	0.0	0.239	0.018	0.028	0.0	0.000
199	0.0	0.0	0.0	13.9	0.0	6.9	0.0	0.0	0.0	0.178	0.008	0.018	0.0	0.0
200	0.0	0.0	0.0	18.3	6.1	12.2	0.0	0.0	0.0	0.156	0.008	0.015	0.0	0.0
201	0.0	0.0	0.0	16.1	7.8	11.9	0.0	0.0	0.0	0.123	0.008	0.010	0.0	0.0
202	0.51	0.0	0.51	16.7	5.0	10.8	0.508	0.0	0.503	0.161	0.0	0.258	0.0	0.242
203	0.0	0.0	0.0	13.3	5.6	9.4	0.0	0.0	0.0	0.143	0.0	0.013	0.0	0.0
204	0.0	0.0	0.0	15.6	1.1	8.3	0.0	0.0	0.0	0.135	0.0	0.012	0.0	0.0
205	0.0	0.0	0.0	18.9	4.4	11.7	0.0	0.0	0.0	0.127	0.0	0.011	0.0	0.0
206	13.21	0.0	13.21	7.8	4.4	6.1	13.208	0.0	13.208	0.741	0.150	0.765	0.030	0.603
207	4.05	0.0	4.06	13.9	3.9	8.9	4.064	0.0	4.064	1.225	0.221	0.749	0.030	0.457
208	5.08	0.0	5.08	12.8	4.4	8.6	5.080	0.0	5.080	0.685	0.323	1.280	4.800	1.110
209	0.0	0.0	0.0	13.9	6.1	10.0	0.0	0.0	0.0	0.852	0.071	0.192	0.010	0.003
210	0.0	0.0	0.0	12.8	5.0	8.9	0.0	0.0	0.0	0.427	0.013	0.065	3.000	0.0
211	3.81	0.0	3.81	11.1	5.0	8.1	3.810	0.0	3.810	0.654	0.079	0.509	0.0	0.389
212	0.0	0.0	0.0	11.1	1.7	6.4	0.0	0.0	0.0	0.350	0.005	0.049	0.0	0.0
213	7.37	0.0	7.37	9.4	0.6	5.0	7.366	0.0	7.366	0.844	0.284	2.087	0.0	1.827
214	0.0	0.0	0.0	22.2	5.6	13.9	0.0	0.0	0.0	1.478	0.041	0.391	0.900	0.001
215	4.06	0.0	4.06	22.8	11.1	16.9	4.064	0.0	4.064	0.894	0.038	1.196	0.0	0.981
216	0.0	0.0	0.0	15.0	3.3	9.2	0.0	0.0	0.0	0.875	0.015	0.187	0.0	0.000
217	7.11	0.0	7.11	13.3	7.8	10.6	7.112	0.0	7.112	1.811	0.503	4.880	2.000	4.205
218	0.0	0.0	0.0	11.7	3.3	7.5	0.0	0.0	0.0	1.522	0.015	0.407	0.800	0.000
219	0.0	0.0	0.0	15.0	2.8	8.9	0.0	0.0	0.0	0.520	0.002	0.087	0.0	0.0
220	0.0	0.0	0.0	17.8	5.6	11.7	0.0	0.0	0.0	0.371	0.0	0.053	0.0	0.0

Table 21. (Continued)

spiration or soil moisture. High intensity rainfall and snowmelt on wet or frozen soil condition could cause overland flow and the high soil loss. The following days were selected for further discussion.

a) Days 148 - 151 (February 25 - February 28)

The stream flow simulation was good for this period but lower soil loss was computed by the model than was actually observed. This might be caused by little or no overland flow simulated on Zone IV, since all the overland flow and upland soil loss cascade to the alluvium. None of the days show simulated overland flow on this zone except a low amount (0.27 mm) in February 25. This shows that most of the stream flow was simulated as subsurface flow.

b) Day 154 (March 2)

The stream flow was simulated a little higher than the observed but the simulated soil loss is very close to the recorded. The calculated overland flow is 6.41 mm on zone IV (Table 18).

c) Day 159 (March 7)

The actual water yield is higher than the simulated stream flow. The lower observed soil loss than the estimated would show that the erosion model estimated soil loss inaccurately because of the high overland flow on Zone IV (Table 18). But the erosion simulation of this day is relatively accurate.

d) Days 177 and 178 (March 25 and March 26)

The actual streamflow for three days is lower than the simulated, but the observed soil loss is much higher than simulated. A high intensity of rainfall (84 mm/hour) in a two-minute duration was observed during day 177. This might cause the high actual soil loss in the day. If the record is correct there might be some other sources of the soil erosion such as channel bank collapsing or gully head cut which cannot be estimated by the model.

e) Days 191 and 192 (April 7 and April 8)

The simulated soil loss for these days is significantly lower than the observed, however, the stream flow simulation is good. No overland flow was obtained from the watershed model (Table 18). The seeped water from upper shallow soil layer to rills was the only erosive water of the upland erosion. This condition is also seen in the days 148 - 151 and 184. The overland flow seems to be the main cause of the soil loss in this period. However, the simulated stream flow was only from subsurface flow which is not counted in the erosion model except small amounts of seepage to rills. If the later is increased, the results can be improved.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

The following conclusions were drawn from the results of the testing of the watershed erosion model.

1) It is difficult to calibrate the erosion model unless the watershed model reliably simulates overland flow. This is mainly related to overland and subsurface flow routing and cascading, moisture excess on surface, snowmelt, snow-rain determination and frozen ground events.

2) Temperature distribution during the day is important to the snowmelt effect on runoff and erosion during a period when frontal movement is the more dominant temperature controlling factor than direct solar energy. If the timing of maximum and minimum temperatures were known and used for estimating the break-point time temperature it would improve the snowmelt portion of the simulation and, consequently, runoff and erosion simulations.

3) When snowmelt is the only moisture source it does not cause significant upland erosion since the snowmelt rate will barely exceed the infiltration rate. Under this condition the overland flow rate is generally low and stream flow appears mainly as subsurface flow. However, the combined effect of rainfall and snowmelt causes high overland flow and erosion. The effect of snowmelt in raising soil moisture is also important since it will decrease the infiltration of subsequent rainfall.

4) The erosion model seems to overestimate upland soil loss when overland flow occurs in small amounts.

5) The record shows that high soil loss does not always accompany high stream flow and vice versa. This is explained by the fact that channel scour is not a significant source of soil erosion as compared with upland erosion from the small test watersheds.

6) A wet year may have a greater deep percolation rate than a dry year.

7) No or little soil is discharged to the stream if no overland flow occurs on the last zone or alluvium area since only a small or no portion of overland flow and soil loss from an upper zone directly cascades to the stream.

8) The soil moisture simulation during the dry season is not accurate (supposedly higher than actual value). This causes high stream flow to be simulated early in the water year when simulated soil moisture at the end of the previous water year is used as the initial value. Records in the Palouse show soil moisture content reaches to below the wilting point on dry hot summer days.

9) The cost of the combined model was high so that any comprehensive optimization of the parameters was prevented ($20-30). Because of this high cost, it is not possible to have the usual sensitivity analysis by which each parameter is increased and decreased.

10) The erosion simulation shows where, in terms of zones, soil is eroded and deposited. This is useful for erosion control studies and practices.

The erosion model did not always compute an accurate simulation. There are several reasons explaining this. Among others, the complexity of natural phenomenon that cause and prevent erosion must be the most signifcant. It should not be expected to be able to estimate exactly the same values as measured since recorded data also includes some error, as well as errors in the runoff model. ← insert comma

This study is the first of this kind in the Palouse area. Even though the result is not as good as expected, it is a first generation model and will be improved upon as time and manpower become available. It is felt that the combined watershed-erosion model is usable as the basis for further research both in hydrologic and erosional processes.

B. Recommendations

The following items are recommended for future studies of the runoff and erosion model if any further improvement of the simulation is desired:

1) Snowmelt and snow drift effects on runoff and erosion.
2) Effect of surface and subsurface frozen soil on runoff and erosion.
3) Surface infiltration rate and subsurface flow routing.
4) Overland flow routing and cascading.
5) Effect of daily temperature distribution on snowmelt and erosion.
6) Estimation of rill size and distribution on each zone.
7) Land use change and cultivation effects on erosion and runoff.
8) Simulation of soil moisture depletion during summer season.
9) Manual of selecting parameter values, which would be based on:
    a) watershed size and shape, ← insert comma
    b) soil type,
    c) climate and hydrology of a study area and study year, and
    d) crop and cultivation practices.

APPENDIX I

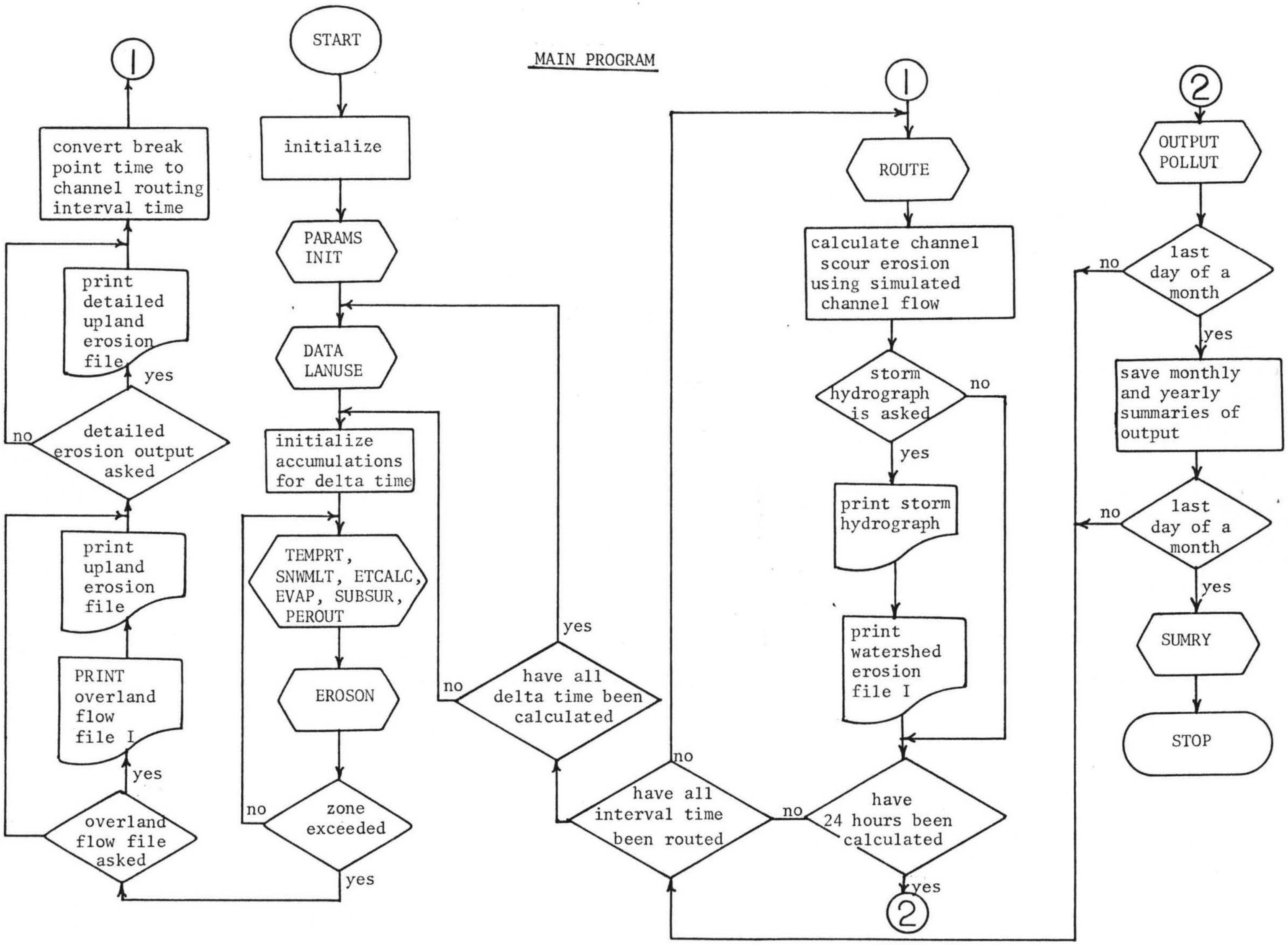
The procedure For Estimating the Surface Roughness Coefficient n
(Cowan, 1956)

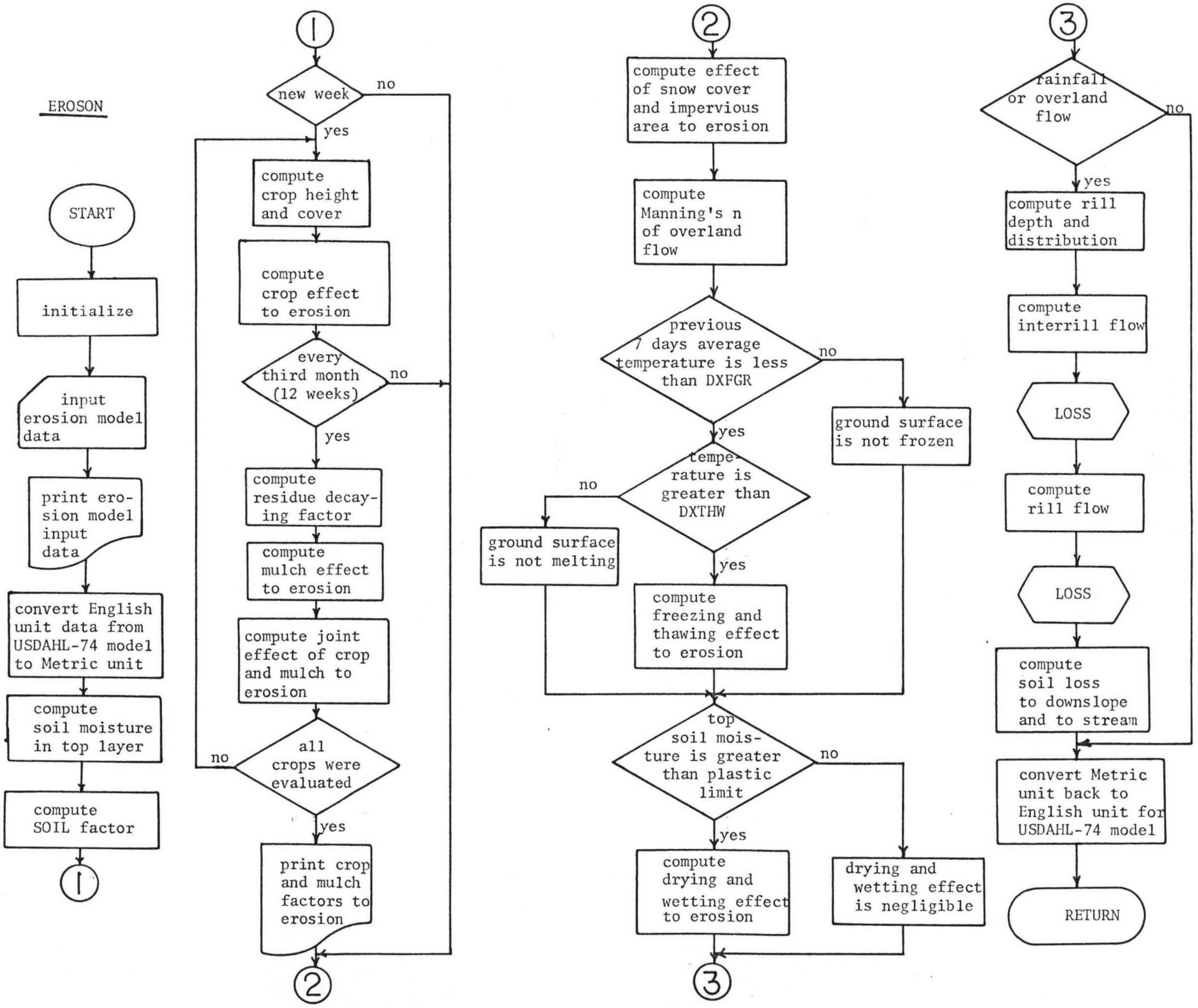
← uc P

character of channel	earth	n_0	0.02
	cut into rock		0.025
	fine gravel		0.024
	coarse gravel		0.028
degree of irregularity	smooth	n_1	0.000
	minor		0.005
	moderate		0.010
	severe		0.020
character of variation of size and shape of cross sections	gradually	n_2	0.000
	alternating occasionally		0.005
	alternating frequently		0.010-0.015
relative effect of obstructions	negligible	n_3	0.000
	minor		0.010-0.015
	appreciable		0.020-0.030
	severe		0.040-0.060
vegetation and flow conditions	low	n_4	0.005-0.010
	medium		0.010-0.025
	high		0.025-0.050
	very high		0.050-0.100
ratio of meander length to straight length	1.0 to 1.2	n_5	1.000
	1.2 to 1.5		1.150
	1.5 and greater		1.300

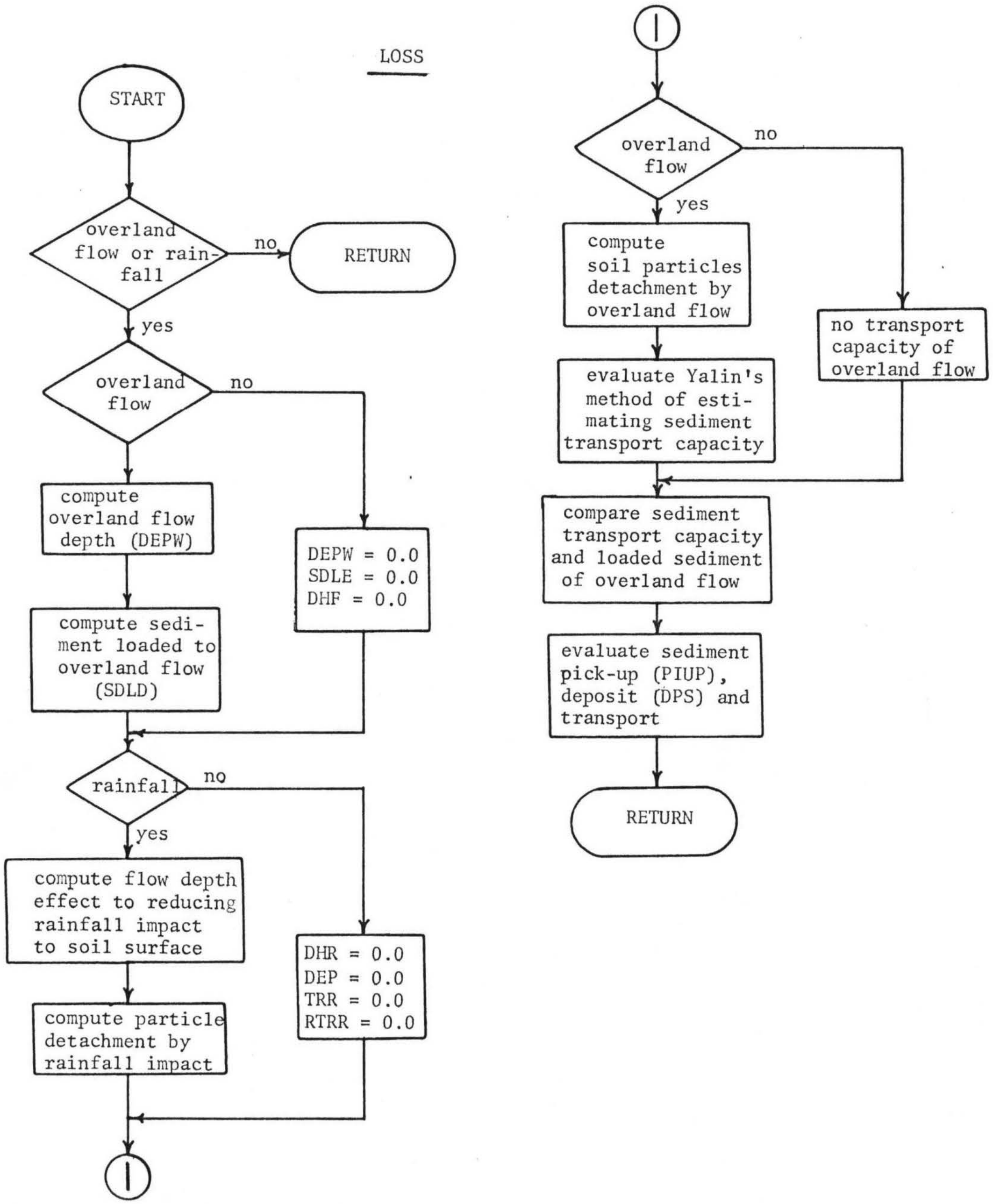
APPENDIX II

Flow Charts of the Watershed Model (USDAHL) and The Erosion Simulation Model (EROS)

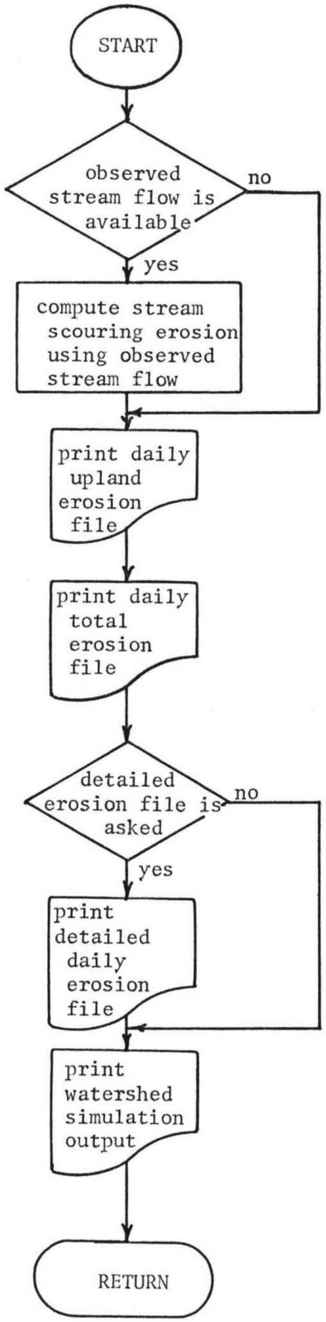

MAIN PROGRAM


EROSON
START
initialize
input erosion model data
print erosion model input data
convert English unit data from USDAHL-74 model to Metric unit
compute soil moisture in top layer
compute SOIL factor
①
①
new week
no
yes
compute crop height and cover
compute crop effect to erosion
every third month (12 weeks)
no
yes
compute residue decaying factor
compute mulch effect to erosion
compute joint effect of crop and mulch to erosion
all crops were evaluated
no
yes
print crop and mulch factors to erosion
②
②
compute effect of snow cover and impervious area to erosion
compute Manning's n of overland flow
previous 7 days average temperature is less than DXFGR
no
yes
ground surface is not frozen
temperature is greater than DXTHW
no
yes
ground surface is not melting
compute freezing and thawing effect to erosion
top soil moisture is greater than plastic limit
no
yes
compute drying and wetting effect to erosion
drying and wetting effect is negligible
③
③
rainfall or overland flow
no
yes
compute rill depth and distribution
compute interrill flow
LOSS
compute rill flow
LOSS
compute soil loss to downslope and to stream
convert Metric unit back to English unit for USDAHL-74 model
RETURN

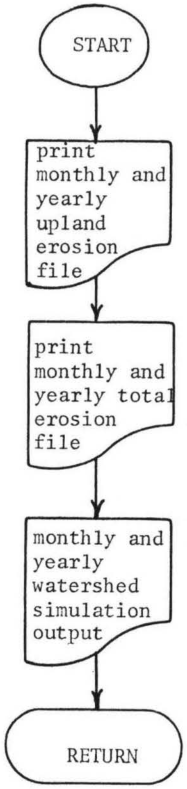
LOSS



OUTPUT



SUMRY



APPENDIX III

Input Data Format For the Soil Erosion Simulation Model (SESMO)

max. # of cards	INPUT PARAMETERS TO THE SOIL EROSION SIMULATION MODEL (SESMO)									
	0 1	0 9	1 7	2 5	3 3	4 1	4 9	5 7	6 5	7 3
1	DAILY OUTPUT BETWEEN THE FOLLOWING DAYS (2(312,2X)									
	MMDDYR	MMDDYR								
1	EXPONENTS (10F8.0)									
	1	2	3	4	5	6	7	8	9	10
2	CONSTANTS (10F8.0)									
	1	2	3	4	5	6	7	8	9	10
	11									
4	ZONE FACTORS (10F8.0)									
	ZONE	WWS	PL	LL	CLAY	MAAR	MRILD	DRIFT	MCDS	IMPCV
4	INITIAL VALUES (10F8.0)									
	ZONE	SNCV	RDS1	IDS1	AARI	RILDI				
1	UPLAND SURFACE ROUGHNESS COEFFICIENTS FOR MANNING'S N (10F8.0)									
	NO	N1	N2	N3	N4	N5				
1	UPLAND PARAMETERS (10F8.0)									
	AX	AX1	DEGHR	DXTHW	OMPRE	OSPRE	ACCRUN	OSRUN		
8	CROP FACTORS (9F8.0) or (9(2A4))									
	CROP1	CROP2	CROP3	CROP4	CROP5	CROP6	CROP7	CROP8	CROP9	
										CRPS
										CRMCV
										CRMHT
										XCOV
										MULCH
										RESU
										CROP
										SBD
1	CHANNEL FACTORS									
	WDTH	VP	CSL	CMANN	CORFCT					

APPENDIX IV

Input Data Of The Erosion Model For The Thompson Watershed In Water Year 1972

```
INPUT COEFFICIENTS FOR THE SOIL EROSION SIMULATION MODEL (SESMO)
DAILY EROSION OUTPUT FOR THE DAYS BETWEEN THE FOLLOWING DAYS WILL BE PRINTED

        MO DAY(JULIAN)YEAR          MO DAY(JULIAN)YEAR
  FROM  10   1      1  1940   TO   9  30    366  1940

EXPONENTS FOR THE EROSION MODEL

       EXPT 1      EXPT 2      EXPT 3      EXPT 4      EXPT 5
         1.50        2.00        2.00        2.00        2.00

       EXPT 6      EXPT 7      EXPT 8      EXPT 9      EXPT 10
         1.50        2.00        0.50        1.40        0.0

CONSTANTS FOR THE EROSION MODEL

       CONST1      CONST2      CONST3      CONST4      CONST5
        1.000      10.000       0.800       0.100     100.000

       CONST6      CONST7      CONST8      CONST9      CONST10     CONST11
        0.0         1.000       1.000       1.000      10.000       0.00025

ZONE FACTORS
  ZONE         WWS(%)     PL(%)        LL(%)      CLAY(%)     MAAR(%) MRILD(MM) DRIFT(MM/HR) MCDS(T/HEC/HR) IMPCV(%)
   1            50.0       30.0         40.0         20.0      10.0      50.00       0.0            0.0            0.0
   2            70.0       30.0         40.0         20.0      10.0      50.00       0.0            0.0            0.0
   3            30.0       30.0         40.0         20.0      15.0     200.00       0.0            0.0            0.0
   4            50.0       30.0         40.0         15.0      10.0     500.00       0.0            0.0            0.0

PRINT INITIAL VALUES
 ZONE    SNOW COVER    DETACHMENT STORAGE (T/HEC)          INITIAL RILLS
             (%)                 RILL    INTERRILL       DIST'N(%)  DEPTH(M)
   1        0.0                  0.0       0.0             0.0       0.0
   2        0.0                  0.0       0.0             0.0       0.0
   3        0.0                  0.0       0.0             0.0       0.0
   4        0.0                  0.0       0.0             0.0       0.0

MANNING'S ROUGHNESS COEFFICIENTS

   N0          N1          N2          N3          N4          N5
 0.020       0.020       0.010       0.030       0.020       1.200

OTHER COEFFICIENTS FOR THE EROSION SIMULATION
X =   2.00  XI =   5.00  DEGHR = 120.00 DEGREE-HOUR  DXTHW =   1.00 'C

PRECIPITATION BETWEEN OCTOBER THROUGH END OF EROSION SEASON =    380.00 MM
TOTAL PRECIPITAION ON STARTING DAY AFTER  OCTOBER 1ST =       0.0  MM
ACCUMULATED STREAM FLOW BETWEEN OCTOBER THROUGH THE END OF EROSION SEASON =     60.00 MM
TOTAL STREAM FLOW ON STARTING DAY AFTER OCTOBER 1ST =      0.0  MM
CROP FACTORS

CROP NAMES                    WW1        WB         PEAS       OATS       NGRASS     GRASS      SC

1 MAX. CROP COVER             80.00      80.00      80.00      70.00      90.00      90.00      90.00
   (CRMCV) IN PERCENT
2 MAX. CROP HEIGHT             0.80       0.80       0.50       0.80       0.30       0.30       0.20
   (CRMHT) IN METERS
3 THE WEEK WHEN CRMCV         41.0       41.0       45.0       45.0        0.0        0.0        0.0
    IS MEASURED IN WEEK
4 MULCHES APPLIED              5.00       5.00       7.00       5.00      10.00       1.00       5.00
   TONS/HECTARE
5 RESIDUE CONDITION           PLOW       PLOW       PLOW       PLOW       STAN       STAN       PLOW
   PLOWED, STANDING OR NOTILL ?
6 KIND OF CROP                WINT       WINT       SPRI       SPRI       PERM       PERE       PERE
   WINTER, SPRING, PERENNIS OR PERMANENT
7 SPRING BREAK OF             24.0       24.0        0.0        0.0        0.0        0.0        0.0
   DORMANCY IN WEEK

 PRINT CHANNEL COEFFICIENTS FOR EROSION MODEL

           WIDTH       VP            SLOPE  MANNING'S N
         IN METER     M/SEC           IN %
           1.00       0.30           2.50      0.03

CORRECTING FACTOR OF CONSTANT 10 FOR CHANNEL SCOURING EROSION
SIMULATION USING OBSERVED STREAM FLOW =  20.00
```

APPENDIX V

Input Data and Sample Print of Computer Output For The Pitzen Watershed in Water Year 1940

```
           UNIVERSITY OF IDAHO VERSION OF USDAHL MODEL OF WATERSHED HYDROLOGY

                                      REVISED BY KYUNG HAK YOO, 1977
                                      DEPARTMENT OF AGRICULTURAL ENGINEERING
                                      UNIVERSITY OF IDAHO, MOSCOW

   OPTIONS OF THE OPERATION

   OPTION 1 = 0--- PRINT POLLUTION STUDY INFORMATION
   OPTION 2 = 1--- CALCULATE STATISTICAL COMPARISON
   OPTION 3 = 1--- PLOT GRAPHICAL COMPARISON
   OPTION 4 = 1--- SIMULATE EROSION PREDICTION
   OPTION 5 = 1--- PRINT DETAILED EROSION SIMULATION OUTPUT

   UOI VERSION OF USDAHL74 WATERSHED HYDROLOGY MODEL AND EROSION MODEL
  PITZEN WATERSHED NEAR MOSCOW, IDAHO IN 1940 WATER YEAR

   INDEX TEMPERATURE TO CONTROL THE CRITICAL VALUES
      SNOW   FREEZING        MELT          ET      TIME OF MAX TEMP      TIME OF MIN TEMP
    2.50'C   -5.00'C       1.00'C     -1.00'C            15.00                  4.00

  STORM HYDROGRAPHS WILL BE PRINTED FOR THE FOLLOWING DATES:
       MO DAY (JULIAN) YR
        2   6     129   40        3   7    159   40        3   8    160   40        3  25      177   40
        3  31     183   40        9  17    353   40        9  18    354   40

  WATERSHED PARAMETERS
      HECTARES=     59.4      NUMBER OF  ZONES = 4.0     RTG COEFF: TOTAL= 5.0   ABOVE WEIR= 5.0     NUMBER OF CROPS= 7.0
      DEEP GROUND WATER RECHARGE=  0.0200MM/HR   DOES LAND USE CHANGE? YES           DOES YEARLY TILLAGE CHANGE? YES

   PRINT SNOWMELT COEFFICIENTS
      ZONE        DEGSLP     DEGSIN
        1       .0010000   .0500000
        2       .0100000   .0600000
        3       .0002000   .0050000
        4       .0005000   .0200000

  GENERAL ZONE PARAMETERS
      ZONE        W/S %         LENGTH(M)     SLOPE%      FC(MM/HR)      DPTH TOP(MM) AERATED DPTH(MM) WP1%    WP2%    INITIAL
                                                                                                                      SNOW(MM)
        1         22.4            80.0          8.00        1.000           200.0           1500.0      16.70   22.20    0.0
        2         39.0           150.0         15.00        0.800           200.0           1200.0      15.80   21.30    0.0
        3         23.8           100.0         20.00        2.000           250.0           1200.0      15.80   21.30    0.0
        4         14.8            40.0          5.00        1.500           300.0           1500.0      16.70   22.20    0.0

  SOIL PARAMETERS
      ZONE          % G1      % AWC1     % ASM1       % CRAK1              % G2      % AWC2        % ASM2      % CRAK2
        1           21.7       16.7        1.5          6.00                7.5       15.4           6.3          6.00
        2           17.4       19.2        3.8          6.00                4.9       18.6           7.6          6.00
        3           17.4       19.2        3.6          6.00                4.9       18.6           8.4          6.00
        4           21.7       16.7        1.8          6.00                7.5       15.4           9.5          6.00
```

```
ROUTING PARAMETERS
     CHANNEL ROUTING DELTA TIME =  0.500HR  CHANNEL COEFF.=   0.30HR  INITIAL STREAM FLO=   0.0  MM/HR

SUBSURFACE PARAMS
                 REGIME                 Q-MAX(MM/HR)     COEFFICIENT(HR)

                   1                     0.56000              1.59
                   2                     0.22900              6.59
                   3                     0.13700             47.68
                   4                     0.02540            700.00

COEFFICIENTS AND MAXIMUM Q'S PROPORTIONED TO ZONES ACCORDING TO TOPSOIL DEPTH
 REGIME            M Z1        Q Z1            M Z2       Q Z2               M Z3      Q Z3                M Z4       Q Z4
   1               1.05    28.571960           2.36    8.265138              0.37  37.509232               1.10  45.394987
   2              19.77     1.658991          30.67    1.222653              8.56   5.548704              14.57   4.118432
   3              47.68     0.139220          47.69    0.090856             47.68   0.151427              47.63   0.232033
   4             700.00     0.025812         700.00    0.016845            700.00   0.028075             700.00   0.043019
CASCADING PARAMETERS
    ZONE      % TO NEXT ZONE       REST GOES TO?
     1            70.0               ZONE THREE
     2             5.0               ALLUVIUM
     3            95.0               CHANNEL
   (100% OF ALLUVIUM (ZONE 4) FLO GOES TO CHANNEL)
   (%BASEFLO DIVERTED FROM ALLUVIUM=     0.0)
THE SOIL PARAMETERS IN MM
  ZONE LAYER     G(MM)    AWC(MM)      SA      CRACKING     C(MM/HR)   TOPD(MM)   SOILD(MM)
   1      1     29.880    30.060     57.240     10.800      1.6790     130.00    1000.00
          2     32.800   123.000    104.140     49.200      0.1592
          3      6.638     0.0        6.638      0.0        0.0458
          4     18.068     0.0       18.068      0.0        0.0200
   2      1     19.500    29.250     43.050      9.000      1.2427     150.00     900.00
          2     37.500   135.000    115.500     45.000      0.1109
          3      4.332     0.0        4.332      0.0        0.0368
          4     11.791     0.0       11.791      0.0        0.0200
   3      1     32.500    48.750     72.250     15.000      5.5687     250.00    1200.00
          2     47.500   171.000    138.700     57.000      0.1714
          3      7.220     0.0        7.220      0.0        0.0481
          4     19.652     0.0       19.652      0.0        0.0200
   4      1     49.800    50.100     94.500     18.000      4.1384     300.00    1500.00
          2     60.000   215.999    162.480     72.000      0.2520
          3     11.063     0.0       11.063      0.0        0.0630
          4     30.113     0.0       30.113      0.0        0.0200
LAND USE PARAMETERS

                     WW1         WB          PEAS         OATS        NGRASS        GRASS         SC
    A VALUES        0.20        0.20         0.20         0.20         0.90          0.50         0.50
    CROP VD         1.27MM      1.27MM       1.27MM       1.27MM       2.54MM        2.54MM       2.54MM
    ETEP            1.50        1.50         1.30         1.30         1.50          1.50         1.50
    ROOT DEPTH   1500.00MM   1500.00MM    1200.00MM    1200.00MM    2000.00MM     2000.00MM    2000.00MM
    UPPER TEMP     34.00'C     34.00'C      32.00'C      32.00'C      35.00'C       35.00'C      35.00'C
    LOWER TEMP      1.00'C      1.00'C       1.00'C       1.00'C       1.00'C        1.00'C       1.00'C
TILLACE WILL BE READ YEARLY.

 CROP          % GRAZING           TILLAGE PRACTICES

 WW1               0               CUL 10 540   PLA 101040   HAR  81540   PLO  9 140   CUL  91540

 WB                0               CUL 10 140   PLA 101040   HAR  81040

 PEAS              0               PLO 10 140   CUL  4 140   CUL  41540   CUL  5 140   CUL  51040   PLA  51540   HAR  91040

 OATS              0               PLO 10 140   CUL  4 140   CUL  41540   CUL  5 140   PLA  51540   HAR  91040

 NGRASS            0               NONE

 GRASS             0               CUL  51040   CUL  71040   CUL  91040

 SC                0               PLO  61540   CUL  71540   CUL  81540   CUL  91540
```

```
LAND USE FOR YEAR 1940 FOLLOWS.  IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.
ZONE  1  WW1      = 17.5%   WB       =  2.7%   PEAS     = 53.7%   OATS     = 25.9%   NGRASS  =  0.0%   GRASS    =  0.2%
         SC      =  0.0%
ZONE  2  WW1      = 22.6%   WB       = 13.3%   PEAS     = 27.0%   OATS     = 27.8%   NGRASS  =  0.0%   GRASS    =  1.2%
         SC      =  8.1%
ZONE  3  WW1      = 46.2%   WB       =  6.1%   PEAS     = 41.6%   OATS     =  0.0%   NGRASS  =  0.1%   GRASS    =  0.3%
         SC      =  5.7%
ZONE  4  WW1      = 20.9%   WB       =  5.4%   PEAS     =  7.9%   OATS     =  9.4%   NGRASS  =  4.0%   GRASS    = 31.6%
         SC      = 20.8%
PAN EVAPORATION FOR YEAR 1940 FOLLOWS (MM/DAY)
WEEK   1            2.896           2.464           2.032           1.600
WEEK   5            1.067           1.067           1.067           1.067
WEEK   9            1.067           0.406           0.406           0.406
WEEK  13            0.406           0.406           0.406           0.406
WEEK  17            0.406           0.686           0.686           0.686
WEEK  21            0.686           1.651           1.651           1.651
WEEK  25            1.651           1.651           3.734           2.286
WEEK  29            3.150           2.540           1.727           3.810
WEEK  33            3.251           6.020           3.886           4.343
WEEK  37            7.620           6.858           7.899           5.918
WEEK  41            6.960           5.359           4.826           4.674
WEEK  45            6.096           5.232           6.756           5.156
WEEK  49            4.166           3.226           2.134           2.692
```

```
GI CURVES
 WEEK TEMP('C)     WW1       WB        PEAS      OATS      NGRASS    GRASS     SC
    1     8.81     0.21      0.21      1.00      1.00      0.23      0.23      0.23
    2    12.14     0.10      0.10      0.75      0.75      0.33      0.33      0.33
    3    10.72     0.12      0.12      0.10      0.10      0.29      0.29      0.29
    4     6.63     0.14      0.14      0.10      0.10      0.17      0.17      0.17
    5     6.79     0.15      0.15      0.10      0.10      0.17      0.17      0.17
    6     5.99     0.15      0.15      0.10      0.10      0.15      0.15      0.15
    7     8.06     0.19      0.19      0.10      0.10      0.21      0.21      0.21
    8     8.53     0.22      0.22      0.10      0.10      0.22      0.22      0.22
    9     6.31     0.17      0.17      0.10      0.10      0.16      0.16      0.16
   10     7.58     0.20      0.20      0.10      0.10      0.19      0.19      0.19
   11     5.00     0.12      0.12      0.10      0.10      0.12      0.12      0.12
   12     2.18     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   13    -2.74     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   14     3.17     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   15    -2.70     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   16    -1.75     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   17    -3.73     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   18     3.17     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   19     3.73     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   20     1.47     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   21     1.79     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   22     5.99     0.15      0.15      0.10      0.10      0.15      0.15      0.15
   23     4.09     0.10      0.10      0.10      0.10      0.10      0.10      0.10
   24     4.80     0.12      0.12      0.10      0.10      0.11      0.11      0.11
   25     8.53     0.23      0.23      0.10      0.10      0.22      0.22      0.22
   26     8.97     0.24      0.24      0.10      0.10      0.23      0.23      0.23
   27     7.46     0.20      0.20      0.19      0.19      0.19      0.19      0.19
   28     9.76     0.27      0.27      0.28      0.28      0.26      0.26      0.26
   29     9.88     0.27      0.27      0.26      0.26      0.26      0.26      0.26
   30     8.93     0.24      0.24      0.26      0.26      0.23      0.23      0.23
   31    10.00     0.27      0.27      0.26      0.26      0.26      0.26      0.26
   32    13.65     0.38      0.38      0.37      0.41      0.37      0.33      0.37
   33    12.52     0.35      0.35      0.10      0.10      0.34      0.34      0.34
   34    17.14     0.49      0.49      0.15      0.15      0.47      0.47      0.47
   35    14.05     0.40      0.40      0.22      0.22      0.38      0.38      0.38
   36    12.94     0.36      0.36      0.28      0.28      0.35      0.35      0.35
   37    19.29     0.55      0.55      0.44      0.44      0.54      0.54      1.00
   38    18.93     0.54      0.54      0.52      0.52      0.53      0.53      0.75
   39    19.60     0.56      0.56      0.58      0.58      0.55      0.55      0.10
   40    20.95     0.60      0.60      0.64      0.64      0.59      0.59      0.10
   41    21.39     0.62      0.62      0.66      0.66      0.60      0.54      0.10
   42    20.99     0.61      0.61      0.64      0.64      0.59      0.59      0.53
   43    18.65     0.53      0.53      0.57      0.57      0.52      0.52      0.52
   44    16.79     0.48      0.48      0.51      0.51      0.46      0.46      0.46
   45    19.88     0.57      0.17      0.61      0.61      0.56      0.56      0.56
   46    18.57     0.16      0.26      0.57      0.57      0.52      0.52      0.47
   47    20.12     0.26      0.42      0.62      0.62      0.56      0.56      0.56
   48    18.73     0.40      0.51      0.57      0.57      0.52      0.52      0.52
   49    15.60     1.00      0.44      0.47      0.47      0.43      0.43      0.43
   50    20.56     0.75      0.59      0.19      0.19      0.58      0.52      0.58
   51    13.81     0.35      0.39      0.25      0.25      0.38      0.38      0.34
   52    15.68     0.44      0.44      0.36      0.36      0.43      0.43      0.43
```

```
INPUT COEFFICIENTS FOR THE SOIL EROSION SIMULATION MODEL (SESMO)

DAILY EROSION OUTPUT FOR THE DAYS BETWEEN THE FOLLOWING DAYS WILL BE PRINTED

        MO DAY(JULIAN)YEAR          MO DAY(JULIAN)YEAR
  FROM  10  1      1 1940   TO   9  30   366  1940


EXPONENTS FOR THE EROSION MODEL

      EXPT 1      EXPT 2      EXPT 3      EXPT 4      EXPT 5
        1.50        2.00        2.00        2.00        2.00

      EXPT 6      EXPT 7      EXPT 8      EXPT 9      EXPT 10
        1.50        2.00        0.50        1.40        0.0


CONSTANTS FOR THE EROSION MODEL

      CONST1      CONST2      CONST3      CONST4      CONST5
       1.000      10.000       0.800       0.100     100.000

      CONST6      CONST7      CONST8      CONST9      CONST10     CONST11
       0.0         1.000       1.000       1.000      10.000       0.00025

ZONE FACTORS
  ZONE        WWS(%)    PL(%)       LL(%)     CLAY(%)    MAAR(%) MRILD(MM) DRIFT(MM/HR) MCDS(T/HEC/HR) IMPCV(%)
    1         50.0      30.0        40.0       20.0      10.0     50.00      0.0           0.0             0.0
    2         70.0      30.0        40.0       20.0      10.0     50.00      0.0           0.0             0.0
    3         30.0      30.0        40.0       20.0      15.0    200.00      0.0           0.0             0.0
    4         50.0      30.0        40.0       15.0      10.0    500.00      0.0           0.0             0.0

PRINT INITIAL VALUES
 ZONE    SNOW COVER    DETACHMENT STORAGE (T/HEC)       INITIAL RILLS
            (%)               RILL     INTERRILL       DIST'N(%)  DEPTH(M)
   1        0.0               0.0        0.0             0.0        0.0
   2        0.0               0.0        0.0             0.0        0.0
   3        0.0               0.0        0.0             0.0        0.0
   4        0.0               0.0        0.0             0.0        0.0


MANNING'S ROUGHNESS COEFFICIENTS

    N0          N1          N2          N3          N4          N5
  0.020       0.020       0.010       0.030       0.020       1.200

OTHER COEFFICIENTS FOR THE EROSION SIMULATION
X =    2.00  XI =    5.00  DEGHR = 120.00 DEGREE-HOUR  DXTHW =    1.00 'C

PRECIPITATION BETWEEN OCTOBER THROUGH END OF EROSION SEASON =     380.00 MM
TOTAL PRECIPITAION ON STARTING DAY AFTER  OCTOBER 1ST =        0.0  MM
ACCUMULATED STREAM FLOW BETWEEN OCTOBER THROUGH THE END OF EROSION SEASON =      60.00 MM
TOTAL STREAM FLOW ON STARTING DAY AFTER OCTOBER 1ST =        0.0  MM
CROP FACTORS

CROP NAMES                  WW1         WB          PEAS        OATS        NGRASS      GRASS       SC

1 MAX. CROP COVER           80.00       80.00       80.00       70.00       90.00       90.00       90.00
   (CRMCV) IN PERCENT
2 MAX. CROP HEIGHT           0.80        0.80        0.50        0.80        0.30        0.30        0.20
   (CRMHT) IN METERS
3 THE WEEK WHEN CRMCV       41.0        41.0        45.0        45.0         0.0         0.0         0.0
   IS MEASURED IN WEEK
4 MULCHES APPLIED            5.00        5.00        7.00        5.00       10.00        1.00        5.00
   TONS/HECTARE
5 RESIDUE CONDITION         PLOW        PLOW        PLOW        PLOW        STAN        STAN        PLOW
   PLOWED, STANDING OR NOTILL ?
6 KIND OF CROP              WINT        WINT        SPRI        SPRI        PERM        PERE        PERE
   WINTER, SPRING, PERENNIS OR PERMANENT
7 SPRING BREAK OF           24.0        24.0         0.0         0.0         0.0         0.0         0.0
   DORMANCY IN WEEK


 PRINT CHANNEL COEFFICIENTS FOR EROSION MODEL

            WIDTH        VP             SLOPE   MANNING'S N
          IN METER      M/SEC            IN %
            1.00        0.30            2.50       0.03

CORRECTING FACTOR OF CONSTANT 10 FOR CHANNEL SCOURING EROSION
SIMULATION USING OBSERVED STREAM FLOW =  20.00
```

```
 PRINT CROP GROWTH SIMULATION FOR WATER YEAR 1940

CROP     WW1            WB              PEAS            OATS             NGRASS          GRASS            SC
WEEK COVER HEIGHT COVER HEIGHT COVER HEIGHT COVER HEIGHT COVER HEIGHT COVER HEIGHT COVER HEIGHT
       %      M      %      M      %      M      %      M      %      M      %      M      %      M
  1   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   20.67  0.069 20.67  0.069 20.67  0.046
  2   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   29.50  0.098 29.50  0.098 29.50  0.066
  3   0.02   0.000  0.02   0.000  0.0    0.0    0.0    0.0   25.71  0.086 25.71  0.086 25.71  0.057
  4   0.08   0.001  0.08   0.001  0.0    0.0    0.0    0.0   14.89  0.050 14.89  0.050 14.89  0.033
  5   0.19   0.002  0.19   0.002  0.0    0.0    0.0    0.0   15.32  0.051 15.32  0.051 15.32  0.034
  6   0.33   0.003  0.33   0.003  0.0    0.0    0.0    0.0   13.21  0.044 13.21  0.044 13.21  0.029
  7   0.52   0.005  0.52   0.005  0.0    0.0    0.0    0.0   18.68  0.062 18.68  0.062 18.68  0.042
  8   0.74   0.007  0.74   0.007  0.0    0.0    0.0    0.0   19.94  0.066 19.94  0.066 19.94  0.044
  9   1.01   0.010  1.01   0.010  0.0    0.0    0.0    0.0   14.05  0.047 14.05  0.047 14.05  0.031
 10   1.32   0.013  1.32   0.013  0.0    0.0    0.0    0.0   17.42  0.058 17.42  0.058 17.42  0.039
 11   1.67   0.017  1.67   0.017  0.0    0.0    0.0    0.0   10.59  0.035 10.59  0.035 10.59  0.024
 12   2.07   0.021  2.07   0.021  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 13   2.07   0.021  2.07   0.021  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 14   2.93   0.030  2.98   0.030  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 15   2.98   0.030  2.98   0.030  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 16   2.98   0.030  2.98   0.030  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 17   2.98   0.030  2.98   0.030  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 18   5.29   0.053  5.29   0.053  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 19   5.97   0.060  5.97   0.060  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 20   6.69   0.067  6.69   0.067  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 21   7.46   0.075  7.46   0.075  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 22   8.26   0.083  8.26   0.083  0.0    0.0    0.0    0.0   13.21  0.044 13.21  0.044 13.21  0.029
 23   9.11   0.091  9.11   0.091  0.0    0.0    0.0    0.0    9.00  0.030  9.00  0.030  9.00  0.020
 24   9.11   0.091  9.11   0.091  0.0    0.0    0.0    0.0   10.06  0.034 10.06  0.034 10.06  0.022
 25   9.11   0.091  9.11   0.091  0.0    0.0    0.0    0.0   19.94  0.066 19.94  0.066 19.94  0.044
 26   9.11   0.091  9.11   0.091  0.0    0.0    0.0    0.0   21.09  0.070 21.09  0.070 21.09  0.047
 27   9.43   0.094  9.43   0.094  0.0    0.0    0.0    0.0   17.10  0.057 17.10  0.057 17.10  0.038
 28  10.37   0.104 10.37   0.104  0.0    0.0    0.0    0.0   23.19  0.077 23.19  0.077 23.19  0.052
 29  11.95   0.119 11.95   0.119  0.0    0.0    0.0    0.0   23.51  0.078 23.51  0.078 23.51  0.052
 30  14.15   0.142 14.15   0.142  0.0    0.0    0.0    0.0   20.99  0.070 20.99  0.070 20.99  0.047
 31  16.99   0.170 16.99   0.170  0.0    0.0    0.0    0.0   23.82  0.079 23.82  0.079 23.82  0.053
 32  20.45   0.205 20.45   0.205  0.0    0.0    0.0    0.0   33.49  0.112  0.0   0.0   33.49  0.074
 33  24.55   0.245 24.55   0.245  0.0    0.0    0.0    0.0   30.76  0.103  2.50  0.008 30.76  0.068
 34  29.28   0.293 29.28   0.293  0.56   0.003  0.49   0.006 42.73  0.142 10.00  0.033 42.73  0.095
 35  34.63   0.346 34.63   0.346  2.22   0.014  1.94   0.022 34.54  0.115 22.50  0.075 34.54  0.077
 36  40.62   0.406 40.62   0.406  5.00   0.031  4.38   0.050 31.60  0.105 40.00  0.133 31.60  0.070
 37  47.23   0.472 47.23   0.472  8.89   0.056  7.78   0.089 48.40  0.161 62.50  0.208  0.0   0.0
 38  54.48   0.545 54.48   0.545 13.89   0.087 12.15   0.139 47.46  0.158 90.00  0.300  2.50  0.006
 39  62.36   0.624 62.36   0.624 20.00   0.125 17.50   0.200 49.24  0.164 90.00  0.300 10.00  0.022
 40  70.86   0.709 70.86   0.709 27.22   0.170 23.82   0.272 52.82  0.176 90.00  0.300 22.50  0.050
 41  80.00   0.800 80.00   0.800 35.56   0.222 31.11   0.356 53.97  0.180  0.0   0.0   40.00  0.089
 42  80.00   0.800 80.00   0.800 45.00   0.281 39.37   0.450 52.92  0.176  2.50  0.008  0.0   0.0
 43  80.00   0.800 80.00   0.800 55.56   0.347 48.61   0.556 46.72  0.156 10.00  0.033  2.50  0.006
 44  80.00   0.800 80.00   0.800 67.22   0.420 58.82   0.672 41.79  0.139 22.50  0.075 10.00  0.022
 45  80.00   0.800  0.0    0.0   80.00   0.500 70.00   0.800 49.99  0.167 40.00  0.133 22.50  0.050
 46   0.0    0.0    0.0    0.0   80.00   0.500 70.00   0.800 46.51  0.155 62.50  0.208  0.0   0.0
 47   0.0    0.0    0.0    0.0   80.00   0.500 70.00   0.800 50.61  0.169 90.00  0.300  2.50  0.006
 48   0.0    0.0    0.0    0.0   80.00   0.500 70.00   0.800 46.93  0.156 90.00  0.300 10.00  0.022
 49   0.0    0.0    0.0    0.0   80.00   0.500 70.00   0.800 38.63  0.129 90.00  0.300 22.50  0.050
 50   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   51.76  0.173  0.0   0.0   40.00  0.089
 51   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   33.91  0.113  2.50  0.008  0.0   0.0
 52   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   38.84  0.129 10.00  0.033  2.50  0.006
```

```
THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS AND SEDIMENT LOSSES FOR 1940:

         RAIN+                                RETURN FLOW                               SEDIMENT LOSS(TONS)
MONTH    MELT      ET      EVAP     RUNOFF   ONSITE  OFFSITE      GR       UPLAND    CHANNEL1  CHANNEL2  OBSERVED
   1     30.23    12.01    0.04     0.0       0.0     0.0        0.0        0.0       0.0       0.0       0.0
   2      8.13     4.84    0.01     0.0       0.0     0.0        0.0        0.0       0.0       0.0       0.0
   3    112.44     1.61    0.43     6.23      4.00    0.0        0.49      63.926     3.544     0.026     0.0
   4     37.70     1.01    0.07    28.58     28.58    0.0       13.08       0.332     9.271     0.149     1.590
   5    125.95     3.38    1.46    89.47     76.34    0.0       13.44     166.795    44.453    12.844   383.709
   6     78.74    10.02    1.82    52.83     49.55    0.0       14.88     150.399    20.067    10.383   260.396
   7     56.41    28.10    0.59    23.68     23.77    0.0       14.39      15.476     6.523     1.631    92.877
   8     21.33    48.97    0.29     9.79      9.86    0.0        8.24       5.116     2.272     0.071     3.700
   9     12.70    66.97    0.07     0.19      0.22    0.0        0.89       0.0       0.003     0.0       0.0
  10     43.94    34.42    0.07     0.10      0.13    0.0        0.0        0.090     0.056     0.0       0.0
  11      0.0     30.91    0.0      0.0       0.0     0.0        0.0        0.0       0.0       0.0       0.0
  12    101.85    34.59    0.45     1.19      1.30    0.0        0.0        0.023     0.576     0.0       0.0

TOTAL   629.43   276.81    5.39   212.05    193.75    0.0       65.42     402.157    36.770    25.104   742.273

MONTHLY YIELDS OF SEDIMENT LOSS FROM EACH ZONE FOR 1940 IN TONS

                  ZONE 1                              ZONE 2                              ZONE 3                              ZONE 4

MON  REROS   IEROS   ZEROS  BALANCE  REROS   IEROS   ZEROS  BALANCE  REROS   IEROS   ZEROS  BALANCE  REROS   IEROS   ZEROS  BALANCE
 1    0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 2    0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3    0.23    8.26    0.0    -8.5     1.15   47.11    5.94   -42.3    0.04    0.0     4.96    4.9     1.95   61.98   45.89   -15.0
 4    0.03    0.50    0.0    -0.5     0.28    4.56    0.38    -4.5    0.17    0.0     0.40    0.2     0.23    0.09    4.76    4.4
 5    2.95   12.87    0.0   -15.8    16.93   78.18   11.07   -84.0   11.99   31.55    9.50  -34.0    34.75  129.87  131.72   -32.9
 6   13.25   19.17    0.0   -32.4    55.40   86.72   22.69  -119.4   46.99   26.95   16.83  -57.1    52.41   94.29  205.25   58.6
 7    0.50    3.43    0.0    -3.9     7.04   19.00    2.75   -23.3    5.48    0.0     2.49   -3.0    15.20    0.0    29.94   14.7
 8    1.50   13.90    0.0   -15.4    11.96   42.27   10.78   -43.4    1.73    0.0     7.33    5.6     5.03    0.0    53.16   48.1
 9    0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
10    0.02    0.0     0.0    -0.0     0.86    0.0     0.01    -0.9    0.0     0.0     0.05    0.0     0.09    0.0     0.82    0.7
11    0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
12    0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.02    0.0     0.0    -0.0

TOT  18.48   58.14    0.0   -76.6    93.62  277.85   53.63  -317.8   66.41   58.50   41.56  -83.3   109.69  286.24  471.56   75.6

MONTHLY SUMMARY OF WATER YIELD
               ZONE 1                           ZONE 2                           ZONE 3                           ZONE 4

            RETURN FLOW                      RETURN FLOW                      RETURN FLOW                      RETURN FLOW

  MO     QO   ONSITE OFFSITE   GR        QO   ONSITE OFFSITE   GR        QO   ONSITE OFFSITE   GR        QO   ONSITE OFFSITE   GR
   1    0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0
   2    0.0     0.0    0.0    0.0       0.0     0.01   0.0    0.0       0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0
   3    2.75   19.85   0.0    0.66      7.18   13.28   0.0    0.66      0.0     3.28   0.0    0.0      15.10   27.02   0.0    0.60
   4    0.0    33.07   0.0   14.80      0.25   34.44   0.0   14.18      0.0    15.53   0.0    8.54      0.22  193.13   0.0   14.88
   5   11.76   74.87   0.0   13.44     23.68   68.60   0.0   13.44      7.56  101.21   0.0   13.44     83.88  515.84   0.0   13.44
   6    3.44   50.55   0.0   14.87     11.16   41.71   0.0   14.87      0.68   56.80   0.0   14.88     22.73  334.79   0.0   14.87
   7    0.08   25.72   0.0   14.39      0.52   21.08   0.0   14.39      0.0    24.95   0.0   14.39      0.0   160.60   0.0   14.39
   8    0.25    8.12   0.0    7.80      1.28    6.52   0.0    6.73      0.0     8.07   0.0    7.02      0.02   66.61   0.0   14.88
   9    0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0       0.0     1.46   0.0    6.02
  10    0.0     1.74   0.0    0.0       0.0     4.38   0.0    0.0       0.0     0.0    0.0    0.0       0.0     0.88   0.0    0.0
  11    0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0       0.0     0.0    0.0    0.0
  12    0.0     9.49   0.0    0.0       0.0     6.55   0.0    0.0       0.0     1.29   0.0    0.0       0.0     8.77   0.0    0.0

TOTAL  18.28  223.41   0.0   65.97     44.08  196.56   0.0   64.28      6.24  211.22   0.0   58.27    126.951309.11   0.0   79.09
THE FOLLOWING ARE SA VALUES AT THE TIME ABOVE SUMMARY WAS PRINTED IN MM
ZONE=    1    30.6605    65.0832     6.6380    18.0681
ZONE=    2    20.3488    74.4719     4.3320    11.7914
ZONE=    3    33.4239   108.5414     7.2200    19.6524
ZONE=    4    50.7512   115.6727    11.0633    30.1134

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED IN MM

   INITIAL STREAM FLO=   0.0      MM/HR
   ZONE              % ASM1         % ASM2
     1               16.266         11.063
     2               18.934         13.070
     3               19.130         11.575
     4               16.383         13.361
  RAIN   -  ET    - RUNOFF  - E    -  CN    - SOIL  -CHANNEL-DEPRESSION-OVERLAND-OFFSITE-SUBLIMATION- SNOW   =    0.014MM
629.402 276.809  212.052  5.392  65.418  69.377   0.0         0.0        0.0      0.0        0.0        0.0
```

```
DAILY SUMMARIES FOR YEAR 1940
                      RUNOFF                  ZONE 1                  ZONE 2                  ZONE 3                  ZONE 4
        DAY  RAIN   MM        CMS              MM                      MM                      MM                      MM
             (MM)             *100   QO     ET:E GR    SM1:2 QO     ET:E GR    SM1:2 QO     ET:E GR    SM1:2 QO     ET:E GR    SM1:2
        109  2.26   0.383      0.26  0.0    0.05 0.480 57.1  0.0    0.05 0.480 51.8  0.0    0.05 0.289 86.3  0.0    0.05 0.480 96.3
                                             0.00      287.0         0.00      286.2         0.00      361.0         0.00      456.7
        110  0.12   0.498      0.34  0.0    0.02 0.480 57.1  0.0    0.02 0.480 51.8  0.0    0.02 0.009 86.2  0.0    0.02 0.480 95.5
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      456.0
        111  0.0    0.339      0.23  0.0    0.0  0.480 57.1  0.0    0.0  0.480 51.7  0.0    0.0  0.000 86.2  0.0    0.0  0.480 95.2
                                             0.0       287.0         0.0       285.0         0.0       361.0         0.0       456.0
        112  0.0    0.174      0.12  0.0    0.0  0.480 57.1  0.0    0.0  0.480 51.7  0.0    0.0  0.000 86.2  0.0    0.0  0.480 95.1
                                             0.0       287.0         0.0       285.0         0.0       361.0         0.0       456.0
        113  0.0    0.100      0.07  0.0    0.0  0.480 57.1  0.0    0.0  0.480 51.7  0.0    0.0  0.000 86.2  0.0    0.0  0.480 95.1
                                             0.0       287.0         0.0       285.0         0.0       361.0         0.0       456.0
        114  0.14   0.081      0.06  0.0    0.02 0.480 57.1  0.0    0.02 0.480 51.8  0.0    0.02 0.000 86.2  0.0    0.02 0.480 95.1
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      456.0
        115  0.0    0.077      0.05  0.0    0.01 0.480 57.1  0.0    0.01 0.480 51.7  0.0    0.01 0.000 86.2  0.0    0.01 0.480 95.1
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      456.0
        116  0.0    0.073      0.05  0.0    0.0  0.540 57.1  0.0    0.0  0.540 51.7  0.0    0.0  0.000 86.2  0.0    0.0  0.540 95.1
                                             0.0       287.0         0.0       285.0         0.0       361.0         0.0       456.0
        117  0.0    0.068      0.05  0.0    0.0  0.420 57.1  0.0    0.0  0.018 51.7  0.0    0.0  0.001 86.2  0.0    0.0  0.420 95.1
                                             0.0       287.0         0.0       285.0         0.0       361.0         0.0       456.0
        118  0.48   0.064      0.04  0.0    0.03 0.402 57.2  0.0    0.03 0.181 51.9  0.0    0.03 0.002 86.3  0.0    0.03 0.480 95.2
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      456.0
        119  4.69   0.385      0.26  0.0    0.05 0.480 57.8  0.0    0.06 0.480 52.4  0.0    0.06 0.369 86.3  0.0    0.06 0.480 96.9
                                             0.01      287.8         0.01      287.3         0.01      361.0         0.01      457.6
        120  6.22   1.077      0.74  0.0    0.09 0.480 58.3  0.0    0.09 0.480 51.8  0.0    0.10 0.480 86.4  0.0    0.10 0.480 98.7
                                             0.00      290.5         0.00      290.2         0.00      361.0         0.00      461.9
        121  0.98   1.873      1.29  0.0    0.09 0.480 57.0  0.0    0.10 0.480 51.7  0.0    0.10 0.480 86.4  0.0    0.10 0.480 97.0
                                             0.00      287.0         0.00      285.6         0.00      361.0         0.00      462.5
        122  0.57   1.464      1.01  0.0    0.09 0.480 57.0  0.0    0.10 0.480 51.6  0.0    0.10 0.480 86.3  0.0    0.10 0.480 96.0
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      460.8
        123  0.54   1.055      0.73  0.0    0.08 0.480 56.9  0.0    0.09 0.480 51.5  0.0    0.09 0.480 86.3  0.0    0.09 0.480 95.4
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      457.7
FEB  1  124  0.29   0.731      0.50  0.0    0.05 0.480 56.8  0.0    0.06 0.480 51.4  0.0    0.06 0.480 86.3  0.0    0.06 0.480 95.2
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      456.0
        125  0.0    0.428      0.29  0.0    0.05 0.480 56.8  0.0    0.05 0.480 51.4  0.0    0.05 0.480 86.2  0.0    0.05 0.480 95.1
                                             0.00      287.0         0.00      285.0         0.00      361.0         0.00      456.0
        126  2.53   0.282      0.19  0.0    0.07 0.480 57.1  0.0    0.08 0.480 51.7  0.0    0.08 0.480 86.2  0.0    0.08 0.480 95.1
                                             0.00      287.8         0.00      286.2         0.00      361.0         0.00      457.3
        127  3.85   0.558      0.38  0.0    0.09 0.480 57.1  0.0    0.09 0.480 51.8  0.0    0.10 0.480 86.3  0.0    0.10 0.480 97.2
                                             0.02      288.5         0.02      287.3         0.02      361.0         0.02      458.7
        128  9.48   1.464      1.01  0.000  0.09 0.480 58.1  0.425  0.10 0.480 52.4  0.0    0.10 0.480 86.7  0.0    0.10 0.480 97.7
                                             0.05      290.7         0.05      289.4         0.05      365.3         0.05      468.7
        129  31.49  20.251    13.92  11.320 0.09 0.480 57.1  21.740 0.09 0.480 51.8  7.561  0.09 0.480 86.3  88.602 0.09 0.480 106.6
                                             0.38      296.3         0.38      295.7         0.38      365.7         0.38      495.2
        130  0.47   8.230      5.66  0.0    0.09 0.483 57.0  0.0    0.10 0.483 51.7  0.0    0.10 0.483 86.3  0.0    0.09 0.483 98.4
                                             0.03      288.9         0.03      289.1         0.03      361.0         0.03      479.8
        131  4.00   4.494      3.09  0.0    0.08 0.477 57.1  0.0    0.09 0.477 51.8  0.0    0.09 0.477 86.3  0.0    0.09 0.477 95.2
                                             0.00      288.8         0.00      288.3         0.00      362.9         0.00      473.9
        132  7.65   4.770      3.28  0.0    0.09 0.480 57.1  0.018  0.09 0.480 51.7  0.0    0.10 0.480 86.4  0.0    0.10 0.480 95.9
                                             0.07      288.4         0.07      289.4         0.07      363.2         0.07      475.7
        133  2.48   3.848      2.65  0.0    0.09 0.480 57.0  0.0    0.10 0.480 51.7  0.0    0.10 0.480 86.4  0.0    0.10 0.480 97.8
                                             0.00      287.0         0.00      286.4         0.00      362.3         0.00      469.0
        134  0.0    2.094      1.44  0.0    0.08 0.480 56.9  0.0    0.09 0.480 51.6  0.0    0.09 0.480 86.2  0.0    0.09 0.480 104.0
                                             0.00      287.0         0.00      285.1         0.00      361.2         0.00      460.9
        135  0.0    0.581      0.40  0.0    0.09 0.480 56.9  0.0    0.10 0.480 51.5  0.0    0.10 0.480 86.1  0.0    0.10 0.480 104.2
                                             0.00      287.0         0.00      285.0         0.00      361.1         0.00      461.4
```

```
 DETAILED DAILY SUMMARIES OF EROSION SIMULATION FOR WATER YEAR 1940
                            CHANNEL SCOUR    SURFACE COVER           RILL SYSTEM                  UPLAND SOIL EROSION IN TONS                                     DETACHMENT
DAY ZONE    RAIN  RUNOFF  CHAN1  CHAN2  ACRCV   MLCV  SURCV DIST'N  DEPTH    COL    FROM     FROM                FROM  SEDIMENT   TOTAL STORAGE TONS
              MM      MM   T/HR   T/HR                           %     MM     MM    RILL INTERRILL    TOTAL   UPPER   BALANCE    LOSS  RILL INTERRILL
121    1                                0.991  0.214    0.0   1.05    5.2    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.08
       2                                0.977  0.235    0.0   1.13    5.7    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.25
       3                                0.972  0.223  0.994   1.60   21.4    0.0     0.0      0.0     0.0     0.0      0.0           0.05  12.26
       4                                0.945  0.284  0.931   1.32   66.1    0.0     0.0      0.0     0.0     0.0      0.0           0.00   5.48
     W/S   0.983   1.873   0.54   0.04                                                                                         0.0
122    1                                0.991  0.214    0.0   1.08    5.4    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.08
       2                                0.977  0.235    0.0   1.17    5.8    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.24
       3                                0.972  0.223  0.991   1.65   22.1    0.0     0.0      0.0     0.0     0.0      0.0           0.05  12.14
       4                                0.946  0.284  0.894   1.37   68.3    0.0     0.0      0.0     0.0     0.0      0.0           0.00   5.42
     W/S   0.574   1.464   0.38   0.02                                                                                         0.0
123    1                                0.991  0.214    0.0   1.11    5.5    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.08
       2                                0.977  0.235    0.0   1.20    6.0    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.24
       3                                0.972  0.223  0.989   1.70   22.6    0.0     0.0      0.0     0.0     0.0      0.0           0.05  12.02
       4                                0.945  0.284  0.842   1.40   69.9    0.0     0.0      0.0     0.0     0.0      0.0           0.00   5.35
     W/S   0.535   1.055   0.24   0.00                                                                                         0.0
124    1                                0.991  0.214    0.0   1.12    5.6    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.08
       2                                0.977  0.235    0.0   1.22    6.1    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.24
       3                                0.972  0.223  0.988   1.72   23.0    0.0     0.0      0.0     0.0     0.0      0.0           0.05  11.90
       4                                0.946  0.284  0.809   1.42   71.1    0.0     0.0      0.0     0.0     0.0      0.0           0.00   5.29
     W/S   0.287   0.731   0.14    0.0                                                                                         0.0
125    1                                0.991  0.214  1.000   1.14    5.7    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.08
       2                                0.977  0.235  1.000   1.23    6.2    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.24
       3                                0.972  0.223  1.000   1.74   23.2    0.0     0.0      0.0     0.0     0.0      0.0           0.05  11.79
       4                                0.946  0.284  1.000   1.44   71.9    0.0     0.0      0.0     0.0     0.0      0.0           0.00   5.23
     W/S     0.0   0.428   0.07    0.0                                                                                         0.0
126    1                                0.991  0.214  1.000   1.15    5.8    0.0    0.00      0.0    0.00     0.0    -0.00            0.0   0.09
       2                                0.977  0.235  1.000   1.25    6.2    0.0    0.00      0.0    0.00    0.00    -0.00           0.00   0.26
       3                                0.972  0.223  1.000   1.76   23.5    0.0     0.0      0.0     0.0    0.00     0.00           0.05  11.70
       4                                0.946  0.234  1.000   1.46   72.8    0.0    0.00      0.0    0.00    0.00    -0.00           0.00   5.13
     W/S   2.529   0.282   0.04   0.02                                                                                        0.00
127    1                                0.990  0.214    0.0   1.17    5.8    0.0     0.0      0.0     0.0     0.0      0.0            0.0   0.08
       2                                0.975  0.235    0.0   1.26    6.3    0.0     0.0      0.0     0.0     0.0      0.0           0.00   0.26
       3                                0.969  0.223  0.998   1.78   23.8    0.0     0.0      0.0     0.0     0.0      0.0           0.05  11.59
       4                                0.944  0.284  0.965   1.47   73.7    0.0     0.0      0.0     0.0     0.0      0.0           0.00   5.07
     W/S   3.851   0.558   0.10   0.05                                                                                         0.0
128    1                                0.990  0.214    0.0   1.20    6.0   0.00    0.01     0.01    0.02     0.0    -0.02           0.00   0.58
       2                                0.975  0.235    0.0   1.30    6.5   0.42    0.64     2.92    3.56    0.02    -3.54            0.0    0.0
       3                                0.969  0.223  0.999   1.84   24.5    0.0    0.12      0.0    0.12    0.18     0.07           0.05  12.24
       4                                0.944  0.234  0.990   1.52   76.0    0.0    0.24      0.0    0.24    3.49     3.26           0.08  12.90
     W/S   9.462   1.464   0.41   0.11                                                                                        0.24
129    1                                0.990  0.214    0.0   1.32    6.6  11.32    2.28    10.70   12.98     0.0   -12.98            0.0    0.0
       2                                0.975  0.235    0.0   1.43    7.1  21.74   11.36    59.57   70.93    9.09   -61.84            0.0    0.0
       3                                0.969  0.223  0.994   2.02   26.9   7.56    8.88    31.55   40.43    7.44   -32.99           0.00   0.17
       4                                0.944  0.284  0.584   1.67   83.3  88.60   27.41   127.29  154.70  105.79   -48.92            0.0    0.0
     W/S  31.486  20.251  17.34   2.74                                                                                      156.72
130    1                                0.990  0.214    0.0   1.64    8.2    0.0     0.0      0.0     0.0     0.0      0.0            0.0    0.0
       2                                0.975  0.235    0.0   1.77    8.9    0.0     0.0      0.0     0.0     0.0      0.0            0.0    0.0
       3                                0.969  0.223  0.993   2.50   33.4    0.0     0.0      0.0     0.0     0.0      0.0           0.00   0.17
       4                                0.944  0.284    0.0   2.07  103.5    0.0    0.03      0.0    0.03     0.0    -0.03           0.20    0.0
     W/S   0.468   8.230   4.35   0.23                                                                                        0.03
```

```
DAILY ZONE SNOW SUMMARIES FOR YEAR 1940
             ZONE 1                             ZONE 2                              ZONE 3                              ZONE 4
DAY  MELTRATE  SNOWMELT SNOW ON GRD  MELTRATE  SNOWMELT SNOW ON GRD  MELTRATE  SNOWMELT SNOW ON GRD  MELTRATE  SNOWMELT SNOW ON GRD
111    0.050    0.0         3.720     0.060    0.0         2.226     0.005    0.0        11.444     0.020    0.0         8.938
112    0.050    0.0         3.720     0.060    0.0         2.226     0.005    0.0        11.444     0.020    0.0         8.938
113    0.050    0.0         3.720     0.060    0.0         2.226     0.005    0.0        11.444     0.020    0.0         8.938
114    0.050    0.185       3.535     0.060    0.219       2.007     0.005    0.018      11.426     0.020    0.066       8.922
115    0.050    0.0         3.535     0.060    0.0         2.007     0.005    0.0        11.426     0.020    0.0         8.922
116    0.050    0.0         3.535     0.060    0.0         2.007     0.005    0.0        11.426     0.020    0.0         8.922
117    0.050    0.0         5.313     0.060    0.0         3.785     0.005    0.0        13.204     0.020    0.0        10.700
118    0.050    0.629      12.558     0.060    0.744      10.916     0.005    0.062      21.015     0.020    0.226      18.348
119    0.050    4.481      10.871     0.060    5.286       8.424     0.005    0.438      23.321     0.020    1.640      19.501
120    0.050    9.769       1.102     0.060    8.424       0.0       0.005    0.967      22.354     0.020    3.507      15.995
121    0.050    1.102       0.0       0.063    0.0         0.0       0.005    0.950      21.404     0.020    3.445      12.550
122    0.050    0.0         0.0       0.124    0.0         0.0       0.005    0.741      20.663     0.020    2.686       9.864
123    0.073    0.0         0.0       0.150    0.0         0.0       0.005    0.691      19.972     0.020    2.505       7.359
124    0.075    0.0         0.0       0.150    0.0         0.0       0.005    0.371      19.602     0.020    1.344       6.015
125    0.053    0.0         1.270     0.068    0.0         1.270     0.005    0.0        20.872     0.020    0.0         7.285
126    0.053    3.219       1.861     0.063    3.249       1.831     0.005    0.375      24.306     0.020    1.332       9.763
127    0.070    5.417       0.0       0.079    5.387       0.0       0.005    0.692      27.170     0.020    2.510      10.809
128    0.072    1.524       0.0       0.082    1.524       0.0       0.005    0.723      27.965     0.020    1.657      10.676
129    0.142    0.0         0.0       0.146    0.0         0.0       0.005    2.230      25.735     0.035    8.364       2.312
130    0.150    0.0         0.0       0.150    0.0         0.0       0.005    0.529      25.206     0.113    2.312       0.0
131    0.150    0.0         0.0       0.150    0.0         0.0       0.006    0.302      24.404     0.148    0.0         0.0
132    0.150    0.0         0.0       0.150    0.0         0.0       0.022    4.146      20.258     0.150    0.0         0.0
133    0.150    0.0         0.0       0.150    0.0         0.0       0.053    5.081      15.177     0.150    0.0         0.0
134    0.150    0.0         0.0       0.150    0.0         0.0       0.056    0.0        15.177     0.150    0.0         0.0
135    0.150    0.0         0.0       0.150    0.0         0.0       0.047    0.0        15.177     0.150    0.0         0.0
136    0.053    0.376       4.196     0.063    0.441       4.131     0.039    0.269      19.480     0.023    0.136       4.436
137    0.061    3.035       1.415     0.071    3.414       0.971     0.036    1.631      18.103     0.026    1.170       3.520
138    0.069    1.415       0.0       0.079    0.971       0.0       0.038    1.076      17.027     0.029    0.773       2.747
139    0.054    0.0         0.0       0.064    0.0         0.0       0.034    1.270      15.757     0.022    0.775       1.972
140    0.068    2.286       0.254     0.078    2.286       0.254     0.038    2.026      16.271     0.034    1.774       2.741
141    0.056    2.119       2.199     0.066    2.408       1.910     0.037    1.164      19.171     0.034    1.040       5.765
142    0.103    2.199       0.0       0.111    1.910       0.0       0.043    3.603      15.563     0.054    4.276       1.490
143    0.135    0.0         0.0       0.140    0.0         0.0       0.053    4.697      10.871     0.079    1.490       0.0
144    0.150    0.0         0.0       0.150    0.0         0.0       0.063    4.685       6.184     0.102    0.0         0.0
145    0.059    0.016       2.270     0.068    0.019       2.267     0.048    0.013       8.457     0.027    0.006       2.280
146    0.054    3.032       0.0       0.064    3.029       0.0       0.036    2.641       6.378     0.022    1.581       1.462
147    0.127    0.0         0.0       0.131    0.0         0.0       0.060    6.378       0.0       0.070    1.462       0.0
148    0.150    0.0         0.0       0.150    0.0         0.0       0.085    0.0         0.0       0.123    0.0         0.0
149    0.150    0.0         0.0       0.150    0.0         0.0       0.140    0.0         0.0       0.150    0.0         0.0
150    0.150    0.0         0.0       0.150    0.0         0.0       0.150    0.0         0.0       0.150    0.0         0.0
151    0.150    0.0         0.0       0.150    0.0         0.0       0.150    0.0         0.0       0.150    0.0         0.0
152    0.150    0.0         0.0       0.150    0.0         0.0       0.150    0.0         0.0       0.150    0.0         0.0
153    0.118    0.508       0.0       0.123    0.508       0.0       0.039    0.508       0.0       0.074    0.508       0.0
154    0.150    0.0         0.0       0.150    0.0         0.0       0.056    0.0         0.0       0.135    0.0         0.0
155    0.150    0.0         0.0       0.150    0.0         0.0       0.096    0.0         0.0       0.150    0.0         0.0
156    0.150    0.0         0.0       0.150    0.0         0.0       0.142    0.0         0.0       0.150    0.0         0.0
157    0.093    1.016       0.0       0.100    1.016       0.0       0.035    1.016       0.0       0.056    1.016       0.0
158    0.149    0.0         0.0       0.150    0.0         0.0       0.037    0.0         0.0       0.099    0.0         0.0
159    0.110    2.032       0.0       0.116    2.032       0.0       0.021    2.032       0.0       0.051    2.032       0.0
160    0.150    0.0         0.0       0.150    0.0         0.0       0.036    0.0         0.0       0.097    0.0         0.0
161    0.150    0.0         0.0       0.150    0.0         0.0       0.029    0.0         0.0       0.079    0.0         0.0
162    0.069    0.0         0.0       0.079    0.0         0.0       0.009    0.0         0.0       0.029    0.0         0.0
163    0.066    0.508       0.0       0.076    0.508       0.0       0.008    0.325       0.183     0.028    0.508       0.0
164    0.082    0.0         0.0       0.092    0.0         0.0       0.011    0.183       0.0       0.036    0.0         0.0
165    0.129    0.0         0.0       0.134    0.0         0.0       0.028    0.0         0.0       0.078    0.0         0.0
```

```
 OVERLAND FLOW HYDROGRAPH FOR YEAP 1940 DAY 129

  TIME     RAINT    QO Z1    DI Z1    SF Z1    QO Z2    DI Z2    SF Z2    QO Z3    DI Z3    SF Z3    QO Z4    DI Z4    SF Z4
  1.000   1.3060  0.0      0.0       1.50218 0.23831  0.36213  1.06936 0.0      0.0       1.34850 0.0      0.0       2.88114
  1.250   1.0469  0.0      0.0       1.77646 0.29659  0.41282  1.23672 0.0      0.0       1.62011 0.0      0.0       3.71982
  1.350   0.0146  0.0      0.0       1.81017 0.27613  0.39552  1.23672 0.0      0.0       1.62321 0.0      0.0       3.97707
  1.583   0.0141  0.0      0.0       2.06207 0.09391  0.20735  1.38691 0.0      0.0       1.63010 0.0      0.0       4.75787
  2.500   3.3850  0.43932  0.43211   3.43144 2.22922  1.38137  2.35728 0.0      0.0       4.05540 3.88153  1.22222   8.28106
  3.083   2.2192  0.77949  0.60913   4.25461 1.61568  1.13920  2.92645 0.0      0.0       5.54036 7.16677  1.76451  10.45517
  3.333   5.1611  2.56558  1.24314   4.53288 3.44005  1.79115  3.09665 0.46914  0.39080   6.10518 13.09949 2.53087  11.30628
  4.167   2.7920  1.29453  0.82533   5.76574 2.40719  1.44639  3.96747 0.92950  0.58853   8.28864 6.12354  1.60588  14.49474
  5.000   2.7937  1.26604  0.81441   6.99432 2.20289  1.37158  4.83631 0.93087  0.58905  10.45870 8.36217  1.93527  17.63773
  5.889   3.5910  2.27210  1.15592   8.31143 3.32348  1.75456  5.77214 2.06393  0.94888  12.77620 11.61619 2.35623  20.99893
  6.778   3.5993  2.34690  1.17856   9.62727 3.36787  1.76855  6.70712 2.09032  0.95615  15.09025 13.43873 2.57109  24.35321
  7.667   3.6106  2.31297  1.16832  10.94274 3.39235  1.77624  7.64204 2.19610  0.98434  17.40317 13.34260 2.56006  27.70561
  7.767   0.0202  1.47082  0.89091  11.10199 2.65384  1.53339  7.75930 1.10303  0.65205  17.67271 11.10798 2.29395  28.07287
  8.067   0.0220  0.24502  0.30461  11.46012 1.01344  0.86160  7.98731 0.0      0.0      18.37654 10.19545 2.17917  29.11453
  8.250   0.0232  0.0      0.0      11.63010 0.76189  0.72629  8.07748 0.0      0.0      18.75931 4.69916  1.37027  29.69639
  8.958   2.2285  0.51692  0.47631  12.65997 1.27326  0.98778  8.79867 0.0      0.0      20.60114 2.19373  0.86847  32.33359
  9.667   2.2391  0.85723  0.64482  13.68758 1.44677  1.06631  9.51937 0.0      0.0      22.43246 4.78287  1.38501  35.05596
  9.917   1.0784  0.57575  0.50808  13.96488 1.04927  0.87972  9.68903 0.0      0.0      22.99532 6.85039  1.71394  35.89757
 10.017   0.0373  0.45630  0.44203  13.99962 0.96434  0.83636  9.68903 0.0      0.0      23.14482 7.37915  1.79564  36.15678
 10.317   0.0402  0.0      0.0      14.36344 0.38136  0.48027  9.92149 0.0      0.0      23.59299 2.59273  0.95987  37.21935
 10.917   0.0463  0.0      0.0      15.21824 0.0      0.0     10.51380 0.0      0.0      23.61780 0.19126  0.20151  39.48309
 11.000   0.0472  0.0      0.0      15.35295 0.0      0.0     10.61257 0.0      0.0      23.62128 0.31005  0.26911  39.80482
 11.500   3.1925  0.0      0.0      16.04312 0.69076  0.68490 11.08465 0.0      0.0      24.88647 4.63820  1.35977  41.65596
 11.833  10.2692  5.34204  1.92863  16.46065 7.05937  2.75473 11.35681 4.54020  1.52139  25.68526 29.62727 4.12769  42.86151
 12.167   1.6326  1.76089  0.99230  16.87930 3.17224  1.70630 11.62951 1.62040  0.82093  26.43448 17.08446 2.96851  44.05563
 12.267   0.0612  1.40197  0.86569  16.91534 2.79174  1.58062 11.62951 1.04075  0.62975  26.63475 10.63522 2.23510  44.33304
 12.567   0.0646  0.21714  0.28336  17.27983 1.04813  0.87915 11.86236 0.0      0.0      27.34229 3.24741  1.09841  45.40620
 13.167   0.0714  0.0      0.0      18.13495 0.0      0.0     12.45477 0.0      0.0      28.72728 0.0      0.0      47.67451
 14.167   0.0820  0.0      0.0      18.79550 0.0      0.0     13.52442 0.0      0.0      28.77953 0.0      0.0      51.50212
 16.167   0.0967  0.0      0.0      18.79550 0.0      0.0     13.76885 0.0      0.0      28.83322 1.91227  0.79992  58.85324
 18.167   0.0983  0.0      0.0      18.79550 0.0      0.0     13.76885 0.0      0.0      28.97563 0.56842  0.38686  65.90884
 20.167   0.0857  0.0      0.0      18.79550 0.0      0.0     13.76885 0.0      0.0      29.04898 0.16307  0.18316  72.72456
 22.167   0.0631  0.0      0.0      18.79550 0.0      0.0     13.76885 0.0      0.0      29.09985 0.0      0.0      79.50467
 24.000   0.0406  0.0      0.0      18.79550 0.0      0.0     13.76885 0.0      0.0      29.12888 0.0      0.0      85.73349
```

```
DETAILED SUMMARIES OF UPLAND EROSION SIMULATION FOR DAY129 IN WATER YEAR 1940
                       THROUGH INTERRILL                              THROUGH RILLS
TIME ZONE     QI   DEPW   DHR   DHF  SOLD    ATRF  IEROS     CR   DEPW   DHR   DHF  SOLD   ATRF  PEROS  TEROS  ZEROS  SEDBAL TOT LOSS
           MM/HR     MM  T/HR  T/HR  T/HR    T/HR   T/HR  MM/HR     MM  T/HR  T/HR  T/HR   T/HR   T/HR   T/HR   T/HR    T/HR     T/HR
 1.00   1    0.0    0.0   0.1   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        2   0.20   0.49   0.2   0.0   0.0    16.8    0.2   0.03   2.04   0.0   0.1   0.1    4.1    0.1    0.3    0.0    -0.3
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        4    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.3     0.3      0.0
 1.25   1    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.01   0.80   0.0   0.0   0.0    0.1    0.0    0.0    0.0    -0.0
        2   0.25   0.56   0.1   0.0   0.0    23.2    0.1   0.05   2.47   0.0   0.1   0.1    5.8    0.1    0.2    0.0    -0.2
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        4    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.16   2.90   0.0   0.1   0.1    2.0    0.4    0.4    0.2    -0.2      0.4
 1.35   1    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.01   0.58   0.0   0.0   0.0    0.1    0.0    0.0    0.0     0.0
        2   0.24   0.53   0.0   0.0   0.0    21.0    0.0   0.04   2.31   0.0   0.1   0.1    5.2    0.1    0.1    0.0    -0.1
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        4    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.11   2.36   0.0   0.1   0.1    1.3    0.8    0.8    0.1    -0.8      0.8
 1.58   1    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.00   0.32   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        2   0.08   0.28   0.0   0.0   0.0     3.6    0.0   0.01   1.22   0.0   0.0   0.0    1.6    0.0    0.0    0.0    -0.0
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        4    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.04   1.35   0.0   0.0   0.0    0.4    0.2    0.2    0.0    -0.2      0.2
 2.50   1   0.38   0.58   0.5   0.0   0.0     5.0    1.1   0.06   2.45   0.0   0.0   0.2    1.7    0.2    1.3    0.0    -1.3
        2   1.90   1.86   1.3   4.8   5.7   260.3    6.1   0.33   7.80   0.0   0.2   1.1   39.7    1.1    7.2    0.9    -6.3
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.7     0.7
        4   3.22   1.63   0.0   0.9   7.5    36.4   19.0   0.66   6.81   0.0   0.1   3.7    9.8    3.7   22.7    6.8   -15.9     22.7
 3.08   1   0.67   0.82   0.2   0.0   0.0    12.9    0.2   0.11   3.45   0.0   0.1   0.1    3.2    0.1    0.3    0.0    -0.3
        2   1.38   1.54   0.6   4.1   4.3   182.4    4.2   0.24   6.47   0.0   0.1   0.8   30.0    0.8    5.0    0.2    -4.8
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.3     0.3
        4   5.94   2.35   0.0   3.6   8.2    82.0    6.9   1.33  10.32   0.0   0.2   1.5   20.6    1.5    8.4    4.7    -3.6      8.4
 3.33   1   2.22   1.68   1.1   2.1   2.1    64.7    2.7   0.35   7.11   0.0   0.1   0.5   11.6    0.5    3.2    0.0    -3.2
        2   2.94   2.42   2.9   5.7   8.0   416.5    9.4   0.51  10.15   0.0   0.2   1.7   59.5    1.7   11.1    2.3    -8.8
        3   0.37   0.53   0.0   1.1   2.6    33.9   27.4   0.13   2.61   0.0   0.1   6.6   13.3    6.9   34.3    1.5   -32.8
        4  10.85   3.38   0.0   5.5  47.2   167.7   39.8   2.36  14.57   0.0   0.2   7.8   37.6    7.8   47.6   43.1    -4.5     47.3
 4.17   1   1.12   1.12   0.3   0.0   0.0    27.3    0.3   0.18   4.68   0.0   0.1   0.1    5.6    0.1    0.4    0.0    -0.4
        2   2.05   1.95   0.9   5.0   5.2   283.1    5.3   0.36   8.17   0.0   0.2   1.0   43.1    1.0    6.3    0.3    -6.0
        3   0.74   0.79   0.0   2.5   2.9    77.2    7.9   0.19   3.32   0.0   0.1   2.0   20.5    2.0    9.9    0.4    -9.5
        4   5.07   2.14   0.0   3.0  18.0    67.6   15.1   1.05   8.95   0.0   0.2   3.1   16.1    3.1   18.2   15.4    -2.8     18.7
 5.00   1   1.09   1.10   0.3   0.0   0.0    26.5    0.3   0.17   4.61   0.0   0.1   0.1    5.5    0.1    0.4    0.0    -0.4
        2   1.88   1.85   0.9   4.8   5.1   256.9    5.1   0.33   7.75   0.0   0.2   1.0   40.0    1.0    6.1    0.3    -5.8
        3   0.74   0.80   0.0   2.5   3.0    77.3    2.4   0.19   3.32   0.0   0.1   0.7   20.7    0.7    3.1    0.4    -2.7
        4   6.92   2.58   0.0   4.1  12.6    98.9   10.6   1.45  10.78   0.0   0.2   2.2   22.5    2.2   12.8    8.8    -4.0     13.0
 5.89   1   1.96   1.57   0.5   1.8   1.8    55.9    2.0   0.31   6.55   0.0   0.1   0.4   10.2    0.4    2.4    0.0    -2.4
        2   2.83   2.37   1.5   5.7   7.3   401.2    7.6   0.50   9.92   0.0   0.2   1.4   58.5    1.4    9.0    1.7    -7.3
        3   1.63   1.28   0.0   3.9   5.0   190.5    4.1   0.43   5.35   0.0   0.2   1.2   43.3    1.2    5.2    1.2    -4.1
        4   9.59   3.14   0.0   5.1  18.3   145.9   15.3   2.02  13.13   0.0   0.2   3.2   32.6    3.2   18.5   13.6    -5.0     18.8
 6.78   1   2.02   1.60   0.5   1.9   1.9    58.1    2.1   0.33   6.68   0.0   0.1   0.4   10.7    0.4    2.5    0.0    -2.5
        2   2.86   2.39   1.5   5.7   7.4   406.9    7.7   0.51   9.99   0.0   0.2   1.4   59.6    1.4    9.1    1.8    -7.4
        3   1.65   1.29   0.0   3.9   5.1   193.2    4.1   0.44   5.39   0.0   0.2   1.2   44.2    1.2    5.3    1.2    -4.1
        4  11.08   3.43   0.0   5.6  13.8   172.8   15.8   2.36  14.33   0.0   0.2   3.3   37.6    3.3   19.1   13.7    -5.4     19.4
 7.67   1   1.99   1.58   0.5   1.8   1.8    57.1    2.1   0.32   6.62   0.0   0.1   0.4   10.6    0.4    2.5    0.0    -2.5
        2   2.88   2.40   1.5   5.7   7.4   410.1    7.7   0.51  10.04   0.0   0.2   1.4   60.4    1.4    9.1    1.7    -7.4
        3   1.73   1.33   0.0   4.0   5.2   204.0    4.2   0.47   5.55   0.0   0.2   1.2   46.5    1.2    5.4    1.2    -4.2
        4  10.98   3.42   0.0   5.6  18.9   171.4   15.8   2.36  14.27   0.0   0.2   3.4   37.6    3.4   19.2   13.8    -5.4     19.5
 7.77   1   1.26   1.21   0.0   0.0   0.0    32.7    0.0   0.22   5.21   0.0   0.1   0.1    6.9    0.1    0.1    0.0    -0.1
        2   2.25   2.07   0.0   5.2   5.2   314.6    4.5   0.41   8.71   0.0   0.2   0.9   48.8    0.9    5.4    0.1    -5.4
        3   0.87   0.88   0.0   2.8   3.1    94.1    2.5   0.34   4.60   0.0   0.2   0.8   34.9    0.8    3.3    0.3    -3.0
        4   9.14   3.06   0.0   5.0  13.0   138.5   10.9   2.24  13.82   0.0   0.2   2.4   35.8    2.4   13.2    8.3    -5.0     13.4
 8.07   1   0.21   0.41   0.0   0.0   0.0     1.6    0.0   0.04   1.83   0.0   0.0   0.0    1.0    0.0    0.0    0.0    -0.0
        2   0.86   1.16   0.0   3.2   3.2   107.4    2.8   0.16   4.69   0.0   0.1   0.6   20.2    0.6    3.3    0.0    -3.3
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.2     0.2
        4   8.39   2.91   0.0   4.7   7.8   125.2    6.5   1.89  12.48   0.0   0.2   1.5   30.6    1.5    8.0    3.2    -4.8      8.0
 8.25   1    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.00   0.46   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        2   0.65   0.98   0.0   2.6   2.6    77.0    2.2   0.12   4.13   0.0   0.1   0.5   15.5    0.5    2.7    0.0    -2.7
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.1     0.1
        4   3.87   1.83   0.0   1.9   4.4    47.9    3.7   0.93   8.17   0.0   0.2   0.9   14.1    0.9    4.6    2.6    -2.0      4.6
 8.96   1   0.44   0.64   0.2   0.0   0.0     6.6    0.2   0.07   2.70   0.0   0.0   0.1    2.1    0.1    0.2    0.0    -0.2
        2   1.08   1.33   0.5   3.6   3.8   139.4    3.7   0.19   5.57   0.0   0.1   0.7   24.8    0.7    4.5    0.2    -4.3
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.3     0.3
        4   1.60   1.16   0.0   0.0   4.1    15.2    3.5   0.39   4.83   0.0   0.1   0.8    5.5    0.8    4.3    4.3    -0.0      4.3
 9.67   1   0.74   0.87   0.2   0.0   0.0    14.9    0.2   0.12   3.65   0.0   0.1   0.1    3.7    0.1    0.3    0.0    -0.3
        2   1.23   1.44   0.5   3.9   4.1   161.0    4.0   0.22   6.02   0.0   0.1   0.8   28.0    0.8    4.8    0.2    -4.6
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.3     0.3
        4   3.93   1.85   0.0   2.1   6.4    49.1    5.4   0.85   7.71   0.0   0.2   1.2   12.8    1.2    6.6    4.5    -2.1      6.6
 9.92   1   0.49   0.69   0.0   0.0   0.0     8.0    0.0   0.09   3.01   0.0   0.1   0.1    2.6    0.1    0.1    0.0    -0.1
        2   0.89   1.19   0.1   3.2   3.3   111.8    2.9   0.16   5.02   0.0   0.1   0.6   21.2    0.6    3.5    0.1    -3.5
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.05   1.40   0.0   0.1   0.1    4.5    0.2    0.2    0.2     0.0
        4   5.64   2.29   0.0   3.4   6.8    77.7    5.7   1.38  10.31   0.0   0.2   1.3   21.5    1.3    7.0    3.5    -3.5      7.0
10.02   1   0.39   0.60   0.0   0.0   0.0     5.4    0.0   0.07   2.60   0.0   0.0   0.0    2.0    0.0    0.0    0.0    -0.0
        2   0.82   1.13   0.0   3.1   3.1   101.4    2.7   0.15   4.75   0.0   0.1   0.5   19.5    0.5    3.2    0.0    -3.2
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.03   0.99   0.0   0.1   0.1    2.4    0.9    0.9    0.2    -0.8
        4   6.07   2.39   0.0   3.6   7.5    84.9    6.2   1.43  10.53   0.0   0.2   1.4   22.3    1.4    7.7    3.9    -3.7      7.7
10.32   1    0.0    0.0   0.0   0.0   0.0     0.0    0.0   0.00   0.12   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
        2   0.32   0.65   0.0   0.8   0.8    33.2    0.7   0.06   2.71   0.0   0.1   0.2    7.3    0.2    0.9    0.0    -0.9
        3    0.0    0.0   0.0   0.0   0.0     0.0    0.0    0.0    0.0   0.0   0.0   0.0    0.0    0.0    0.0    0.0     0.0
```

LITERATURE CITED

Chow, V.T. and T.E. Harbaugh, 1965
Raindrop production for laboratory watershed experimentation.
Journal of Geophysical Research 70(24):6111-6119.

Cowan, W.L., 1956
Estimating hydraulic roughness coefficients.
Agricultural Engineering 37(7):473-475.

Crawford, N.H. and R.K. Linsley, 1966
Digital simulation in hydrology: Stanford Watershed Model IV.
Technical Report, No. 39, Department of Civil Engineering, Stanford University, Stanford, California.

David, W.P., 1972
Digital simulation of sheet erosion.
Ph.D. dissertation, Iowa State University of Science and Technology., Ames.

David, W.P. and C.E. Beer, 1975
Simulation of soil erosion - Part I. Development of a mathematical erosion model, Part II. Streamflow and suspended sediment simulation results.
Transactions, American Society of Agricultural Engineers 18(1):126-133.

Davis, Darryl J. and Myron Molnau, 1973
The water cycle on a watershed in the Palouse region of Idaho.
Transactions of the American Society of Agricultural Engineers 16(3):587-598.

Dunn, Irving S., 1959
Tractive resistance of cohesive channels.
Proceedings, American Society of Civil Engineers 85(SM3):1-24.

Ellison, W.D., 1945
Some effects of raindrops and surface flow on soil erosion and infiltration.
Transactions, American Geophysical Union 26(3):415-429.

Ellison, W.D., 1947
Soil erosion studies.
Agricultural Engineering 28:145-146 (Part I), 197-201 (Part II), 245-248 (Part III), 297-300 (Part IV), 349-351 (Part V).

Foster, G.R., L.D. Meyer and C.A. Onstad, 1973
Erosion equations derived from modeling principles
American Society of Agricultural Engineers Paper No. 73-2550,
St. Joseph, Michigan.

Foster, G.R. and L.D. Meyer, 1975
Mathematical simulation of upland erosion using fundamental erosion mechanics.
In: Present and Prospective Technology for Predicting Sediment Yields and Sources. United States Department of Agriculture, Agricultural Research Service, ARS-S-40.

← In: colon

Frere, M.H., C.A. Onstad and H.N. Holtan, 1975
ACTMO, an Agricultural Chemical Transport Model.
United States Department of Agriculture, Agricultural Research Service, ARS-H-3.

Gilbert, K.G., 1914
The transportation of debris by running water.
United States Department of the Interior, Geological Survey, Professional Paper 86.

Graf, W.H., 1971
Hydraulics of Sediment transport.
McGraw-Hill Book Co., New York.

Holton, H.N., G.J. Stiltner, W.H. Henson and N.C. Lopez, 1974
USDAHL-74 revised model of watershed hydrology.
United States Department of Agriculture, Agricultural Research Service, Technical Bulletin No. 1518.

Horner, G.M., A.G. McCall and G.F. Bell, 1944
Investigations in erosion control and the reclamation of eroded land at the Palouse Conservation Experiment Station, Pullman, Washington.
United States Department of Agriculture, Technical Bulletin No. 860.

Horton, R.E., 1945
Erosion development of streams and their drainage basins; Hydrophysical approach to quantitative morphology.
Bulletin, The Geological Society of America 56:275-370.

Kilinc, M., 1972
Mechanics of soil erosion from overland flow generated by simulated rainfall.
Ph.D. dissertation, Colorado State University.

King, David L., 1976
Simulation of the snow hydrology of the Palouse Prairie
Master of Science Thesis, Agricultural Engineering, University of Idaho, Moscow.

Klages, K.W., 1965
Climate of the Palouse area of Idaho.
Idaho Agricultural Experiment Station Bulletin 448.

Laws, J.O., 1941
Measurements of the fall velocity of water drops and raindrops.
Transactions, American Geophysical Union 22:709-721.

Laws, J.O. and D.A. Parsons, 1943
The relation of raindrop-size to intensity.
Transactions, American Geophysical Union, 24 (II):452-459.

McCool, D.K., Myron Molnau, R.I. Papendick and F.L. Brooks, 1976
Erosion research in the dryland grain region of the Pacific Northwest: Recent developments and needs. In: Soil erosion: Prediction and control, Soil Conservation Society of America. Special Publication No. 21.

Meyer, L.D. and W.H. Wischmeier, 1969
Mathematical simulation of the process of soil erosion by water.
Transactions, American Society of Agricultural Engineers 12:754-758.

Molnau, Myron and Kyung Hak Yoo, 1977
Application of runoff models to a Palouse watershed
American Society of Agricultural Engineers Paper No. 77-2048
St. Joseph, Michigan.

Negev, M., 1967
A sediment model on a digital computer.
Technical Report No. 76, Civil Engineering, Stanford University, California.

O'Brien, M.P. and B.D. Rindlaub, 1934
Transportation of bed-load by streams
Trans. of American Geophysica Union 15(II):593-603.

Onstad, C.A. and G.R. Foster, 1975
Erosion modeling on a watershed.
Transactions, American Society of Agricultural Engineers 18(2):288-292.

Pawson, W.W., O.L. Brough, Jr., J.P. Swanson and G.M. Horner, 1961
Economics of cropping systems and soil conservation in the Palouse
Pacific Northwest Regional Publication 2:82.

Rowlison, D.L. and G.L. Martin, 1971
Rational model describing slope erosion.
Proceedings, American Society of Civil Engineers 97(IR1):39-50.

Smerdon, Ernest T. and Robert P. Beasley, 1961
Critical tractive forces in cohesive soils.
Agricultural Engineering 42(1):26-29.

Vanoni, Vito A., P.C. Benedict, D.C. Bondurant, J.E. McKee, R.F. Piest and J. Smallshaw, 1966
Sediment transport mechanics; initiation of motion.
Proceedings, American Society of Civil Engineers 92(HY2):291-314.

Vanoni, Vito A., editor, 1975
Sedimentation Engineering
American Society of Civil Engineers manuals and reports on engineering practice No. 54
New York.

Williams, J.R. and H.D. Berndt, 1977
Sediment yield prediction based on watershed hydrology
Transaction of the American Society of Agricultural Engineers 20(6):1100-1104.

Wischmeier, W.H. and D.D. Smith, 1965
Predicting rainfall-erosion losses from cropland east of the Rocky Mountains.
United States Department of Agriculture Handbook No. 282.

Yalin, Y.S., 1963
An expression for bed-load transportation.
Proceedings, American Society of Civil Engineers 89(HY3):221-250.

Yoo, Kyung Hak and Myron Molnau, 1976
Modeling of runoff for erosion studies.
Partial Technical Completion Report, Project A-047-IDA,
Idaho Water Resources Research Institute, University of Idaho, Moscow.

Yoo, Kyung Hak, 1978
Computer simulation model of soil erosion and deposition from agricultural watersheds in the Palouse prairie of the Pacific Northwest.
Unpublished Ph.D. dissertation
Department of Agricultural Engineering, University of Idaho, Moscow.