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Sediment deposition in lakes using AGNPS

by

John H. Kittelson

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

Department: Civil and Construction Engineering
Co-Majors: Civil Engineering (Geotechnical Engineering)
Water Resources

Signatures have been redacted for privacy

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Iowa State University
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DESCRIPTIVE ABSTRACT

A computer model's ability to predict sediment yield is analyzed as an estimator of lake sedimentation. The model simulates sediment yield at any point within a watershed for individual rainfall events. The results of sedimentation delivered to a lake from each event predicted by the model are summed and then compared to data collected from lake bathymetric studies. Inputs into the model are then modified to predict the amount of reduction in sediment into the lake if best management practices are implemented in the watershed.

Results from two watersheds indicate close correlation between measured and estimated sedimentation in one case, but a difference by a factor of 10 in the other. The application of best management practices showed a substantial reduction in lake sedimentation and revealed the need to relate the location of best management practices in the watershed to lake deposition.

PROBLEM STATEMENT

Preservation of our natural and artificial lakes is becoming more of a public concern. While natural processes degrade these lakes over time, cultural activities in the lake's watershed tend to accelerate this natural degradation by increasing the watershed's susceptibility to erosion. Also, agricultural activities in the form of feedlots as point sources of pollution and herbicides, pesticides, and fertilizers as non-point sources of pollution introduce pollutants into watersheds.

The economic burden of sediment is substantial. A study conducted by the Center for Agriculture and Rural Development (CARD, 1985) concluded that over 32 million dollars is spent annually in Iowa to ease problems caused by sediment. The results, as shown in Table 1, also reveal that an addition 54 million dollars is needed annually to correct "off-site" damages caused by sediment.

Sediment from agricultural basins is inherently fertile and encourages prolific aquatic plant growth. Spawning areas for certain species of fish are destroyed as a result of this growth. Lakefront property loses its appeal as the lake becomes choked with aquatic weeds or algae. Recreational use is curtailed as people are reluctant to enter the water to swim and to use the lake for boating.

Table 1. Total annual offsite damages from sediment for Iowa (CARD, 1985)

Item	Annual Current Expenditures	Annual Additional Needed Expenditures
	(million dollars)	
1. Transportation costs	8.0	20.2
2. Urban water quality costs	1.0	0.0
3. Fish, wildlife and recreation	10.3	18.8
4. Water Management	.2	?
5. On farm costs	12.7	15.5
Total	32.2	54.5

Most artificial lakes are built for flood control, water supply, irrigation, power, recreation, or a combination of these uses. When sediment is deposited in a lake or reservoir the subsequent loss of storage capacity can greatly reduce its ability to perform the tasks for which it was constructed.

The amount of sediment deposited in a lake depends on the amount of sediment delivered to it and the lake's ability to retain the sediments. An accurate estimate of the amount of sediment retained in a lake is needed to predict the useful life of a lake and to plan remedial measures for lake restoration.

APPROACH TO THE PROBLEM

Various methods of estimating erosion rates have been developed over the past few decades. The Universal Soil Loss Equation (Wischmeir and Smith, 1960) is probably the most popular in use today. Recently, computer models have been developed which not only predict the amount of sedimentation, but also the amount of pollutants generated within a watershed. These models offer a great amount of flexibility to the user who is interested in evaluating several possible land management scenarios. The model used in the analyses in this thesis is the Agricultural Non-Point Source Pollution Model (AGNPS) (USDA-ARS, 1987).

The model bases its estimates on single rainfall events. Lake bathymetric surveys are done at intervals of decades. In order to compare sedimentation rates from the model with sedimentation rates from bathymetric surveys it is necessary to run the model for several representative storms and sum the sedimentation results using the precipitation records as a guide. This summation of sedimentation deposition is then compared to the results of the bathymetric surveys.

While the model does not specifically model deposition behind impoundments, the trap efficiency of a lake can be simulated by setting the land slope of the cell, channel slope, P-factor, C-factor, and K-factor to zero. Manning's roughness coefficient is set to 0.99 if simulating water. AGNPS inputs are explained in detail in Appendix A.

The model is run for storm events of 1,2,3,4,5, and 7.5 inch storms in the watersheds under investigation. A relationship is then derived equating storm size and deposition in cells that represent lakes. From known precipitation records over the period of time between bathymetric surveys an amount of deposition into the lake for each storm event can be determined. These amounts of deposition are then summed to arrive at the total amount of deposition estimated by the model in the time period between surveys. This amount is then compared to the amount of deposition estimated by the bathymetric surveys.

It should be realized that only one set of AGNPS inputs is used for this experiment. The inputs should vary with time of year and over a period of years as land use in the watershed changes. It is assumed that the majority of erosion that occurs during the year happens in late spring and early summer. It is also assumed that the changes in land use during the relatively short period of time in question does not have a significant effect on lake deposition.

The impact of conservation measures on lake deposition was observed by applying best management practices (BMPs) to the cells in the watershed with the highest amount of soil erosion. The BMPs are applied at three different levels.

First the BMPs are applied to worst 10% of the cells in regard to cell soil erosion. The second level took the next worst 10% of the cells, for a total of 20%, and applied BMPs. The third level took the next worst 10% of the cells, for a total of 30%, and applied BMPs. Comparisons are then made to determine the effectiveness of the BMPs and the level of greatest return.

LITERATURE REVIEW

Basin Morphology

Any investigation into lake sedimentation can naturally begin at the source of the sediment, the erosional drainage basin. A drainage basin is the area that gathers water from precipitation and delivers it to a lake. It is limited by the drainage divide and is occupied by a drainage network which supplies water and sediment to a lake. The drainage network reflects the upstream geologic and hydrologic character of the watershed.

A system of analysis of the drainage network was introduced by Horton (1945) and slightly modified by Strahler (1952). This system of stream ordering is based on two first order streams joining to form a second order channel, where two second order streams join a third order channel is formed and so forth. The trunk stream through which all discharge of water passes is therefore the stream segment of highest order.

Streve (1967) further modified the system by considering the streams as links in a network, with the magnitude of each link representing the sum of the link numbers of all tributaries that feed it. That is, networks in which the downstream segments are of the same magnitude have equal numbers of links within their basins. Shreve's link system gives a number that at any point within the basin is equal to the number of first order streams upstream from that point. These stream ordering systems are illustrated in Figure 1.

After the drainage network elements have been assigned their order numbers, the segments of each order are counted to yield the number N_u of segments of the given order u. The number of segments of a given order N_u to the number of segments of the higher order $N_u + 1$ is termed the bifurcation ratio R_b, $N_u/N_u + 1$. Bifurcation ratios characteristically range from 3.0 to 5.0 for watersheds in which the geologic structures do not distort the drainage pattern. Lohnes (1964) found bifurcation ratios ranging from 2.33 to 5.00 in Iowa basins developed in three geologic materials.

Strahler (1964) classified the features of the erosional drainage basin into linear, areal, relief, and gradient attributes. These features were further defined by Chorley (1985).

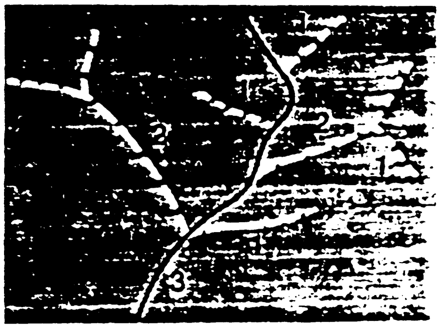
Important geometric basin linear measurements are:

L_u, the length of a stream segment of a given order.

L_c, the total length of the channel system within a basin.

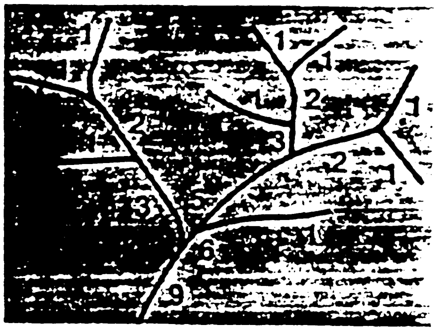
L_B, the overall maximum basin length measured from the mouth.

L_g, the length of overland flow. This the distance from a point of a divide orthogonally (i.e. down the direction of maximum land slope) to the adjacent stream channel.



Horton (1945)

Strahler (1952)



Shreve (1967)

.gure 1. Methods of ordering streams. (Ritter, 1986, p.164)

X_c, the critical length or the belt of no sheet erosion. It is the width from the watershed divide to the point of gully formation.

P, the perimeter of the drainage basin.

Areal measurements used in basin morphometry are:

A, the total area of the drainage basin.

A_u, the area of a drainage basin of a given order.

D, the drainage density, is equal to L_c/A. It expresses the texture of fluvial dissection in terms of the average stream channel length per unit area. Values of D can vary widely, from 2 km/km^2 in chalk terrain to >600 for unvegetated clay badlands. In Iowa values of 3 to 10 for drainage densities have been reported (Lohnes, 1964).

F, the stream frequency, is equal to $\Sigma N_u/A$. It expresses the number of stream segments of all orders per unit area.

A_c, the area of a circle having a perimeter P. This circle has a diameter, d_A.

R_c, the circularity ratio, is equal to A/A_c. Values of R_c in Iowa typically range from 0.67 to 0.96(Lohnes, 1964).

R_e, the elongation ratio, is equal to d_A/L_B. Values of R_e range from 0.6 for areas of high relief to 1.0 for areas of low relief.

Gradient measures which help define a basin are:

S_g, is the maximum slope of the ground surface at a given point.

θ_{max}, is the maximum angle of a given valley-side slope profile.

S_c, is the slope of a stream channel at a point or averaged over a reach.

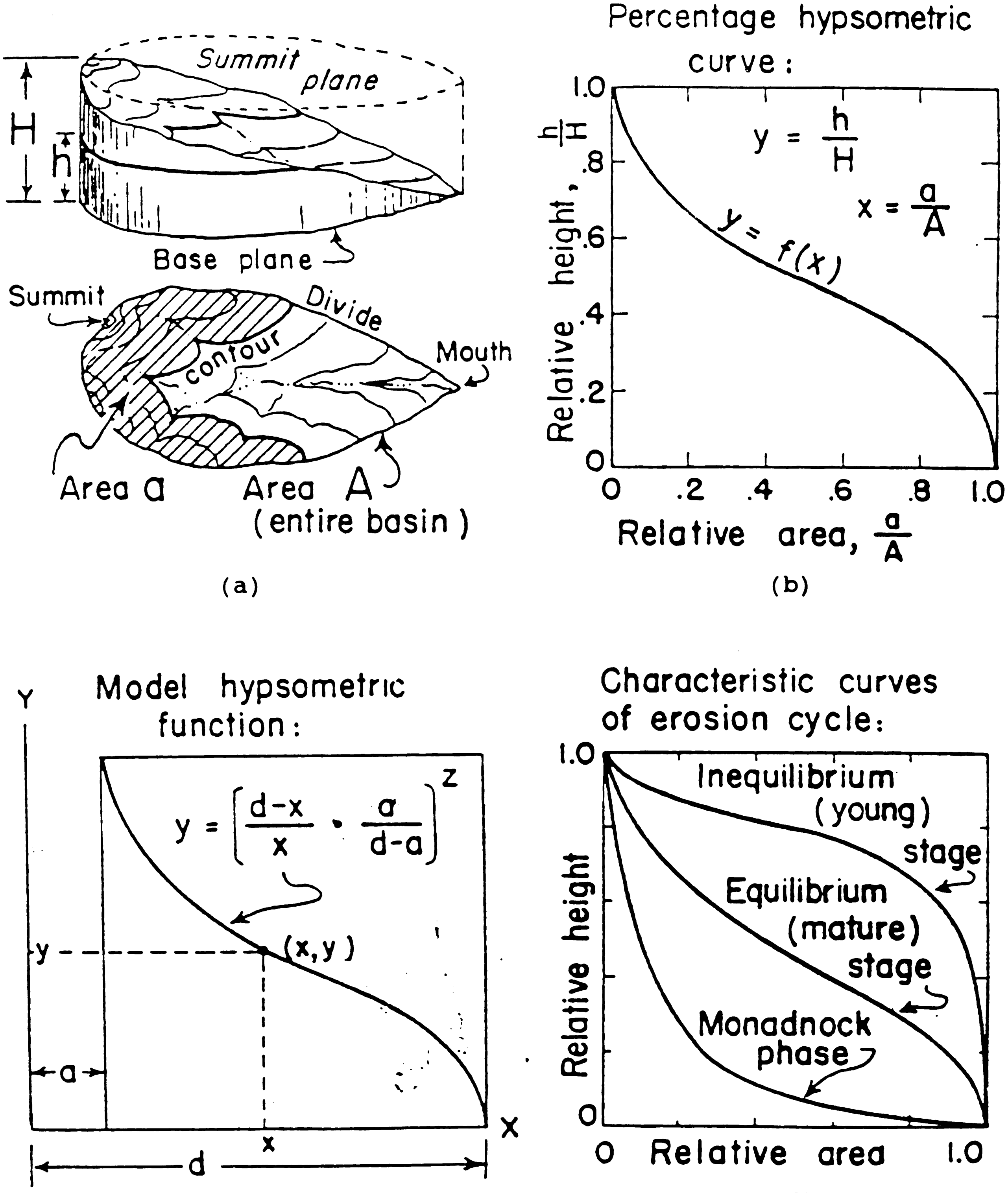
Relief of a basin may be described by:

H, the relief, which expresses the elevation difference between the high and low points. The relief is an index of the potential energy available in the drainage basin. The greater the relief the greater are the erosional forces acting on the basin.

R_h, the relief ratio, is equal to H/L_b. It measures the overall steepness of a drainage basin and is an indicator of the intensity of erosion processes operating on the slopes of a basin.

R_n, the ruggedness number, equal to $H*D$. Values range from 0.06 for the coastal plain of Louisiana to over 1.0 for the South Dakota badlands.

$\int$, the hypsometric integral, was initially developed by Langbein (1947), is the percentage area under the dimensionless curve relating relative height, h/H, and relative area, a/A. Figure 2 illustrates the definition of the two dimensionless variables involved. Figure 2d shows how the shape of the hypsometric curve varies in the early geologic stages of development of the basin, but once a steady state is attained at the mature stage, tends to vary



(a) (b)

(c) (d)

Figure 2. Illustration of hypsometric analysis of watersheds (Strahler, 1957, p.919)

little thereafter, despite lowering of the relief (Stralher, 1957). Isolated bodies of resistant rock may form prominent hills (monadnocks) rising above a generally subdued surface, the result is a distorted hypsometric curve, called a monadnock phase. Figure 3 is an example of basin development in till sheets of decreasing age in western Iowa. The Kansan till being the oldest and the Cary till being the youngest.

The lithologic character of the drainage basin can significantly control the morphology because it determines the erodibility of the surface materials and to a large extent determines the infiltration capacity of the drainage basin materials. Basins of highly resistant material will have low drainage densities and high runoff. Basins with a high infiltration capacity will have high drainage densities and low runoff.

The climate of the region can also have a significant effect on the hydrology and drainage pattern of a basin. Drainage density is greatest in semi-arid regions. The higher values in semi-arid regions are due to the protective influence of vegetation in humid regions and the lack of water to form channels in arid regions. Melton (1957) studied many drainage basins in the southwestern United States and found that drainage density varies directly with per cent of bare area and runoff intensity-frequency, but inversely with precipitation-effectiveness index infiltration capacity.

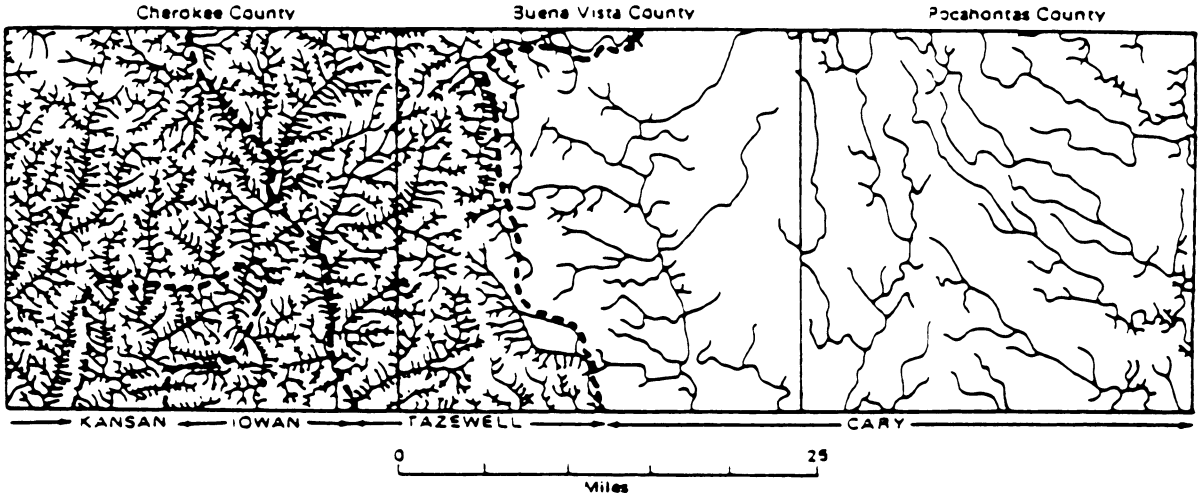


Figure 3. Example of drainage basin development in western Iowa (Ruhe, 1953)

Erosion

By definition erosion is the wearing away of land by wind, water, ice, and gravity. Geologic erosion is a natural process of weathering and removal of material. Accelerated erosion occurs when human activities such as mining, agriculture, highway construction, and urbanization increase the amount of erosion.

In Iowa most erosion is caused by water. Water erosion is divided into sheet, rill, ephemeral, gully, and channel erosion. Sheet erosion is the wearing away of a thin layer of soil. It is usually interpreted to include rill erosion. Rill erosion is the removal of soil by water in small but well defined channels. Rills are small enough to be removed by normal tillage operations. Ephemeral erosion occurs where rills come together to form channels of ephemeral streams, ephemeral streams being non-permanent streams that exist during and shortly after rainstorms. Areas of ephemeral erosion can be transversed by field equipment.

Gully erosion is an advanced state of erosion. Gully channels are permanent streams and cannot be removed by normal tillage methods. Channel erosion includes stream bed and stream bank erosion of permanent streams. Accelerated stream bed erosion can cause the lowering of the water table and trigger downcutting of tributary channels to form gullies.

Universal Soil Loss Equation

Controlled studies on experimental plots and small watersheds since the 1930's have provided knowledge of the relationships between the factors that cause soil loss. This knowledge has been incorporated into the popular empirical model know as the Universal Soil Loss Equation (USLE). Developed by Wischmeier and Smith (1960, 1978) it is in the form:

$$E = R\ K\ L\ S\ C\ P$$

where, E is the computed soil loss per unit area, expressed in the units selected for K and for a period selected for R.

R is a factor expressing the erosion potential of average annual rainfall in the area.

K is a soil erodibility factor and represents the average soil loss, in kg/ha per unit of rainfall factor, R, from a particular soil in cultivated continuous fallow, with a standard plot length and percentage slope arbitrarily selected as 22.1 meters and 9% respectively in kg/ha/unit.

L is slope length factor and is the ratio of soil loss from the field slope length to that from a 22.1 meter length under identical conditions.

S is the slope-steepness factor and is the ratio of soil loss from the field slope gradient to that from a 9% slope under identical conditions.

C is a cropping management factor, it represents the ratio of soil loss for given conditions to soil loss from cultivated continuous fallow.

P is the conservation practice factor, which is the ratio of soil loss for a given practice to that for up and down slope straight row farming.

Sediment Transport and Deposition Models

Much of the sediment developed in the upper reaches of a water course is deposited in intermediate locations rather than reaching the sea. Often, waterways immediately adjacent to the sediment source can retard 75% or more of the eroded soil (Forest Service, 1965; Williams and Bernt, 1972). The portion of the gross erosion within a basin that is not deposited before being transported from the basin is termed the sediment yield. In other words it is "the total sediment outflow from a catchment or drainage basin, measurable at a point of reference and a specific period of time" (Vanoni, 1977).

Onstad (1984) grouped sediment yield prediction methods into five categories: 1) sediment delivery ratio procedures,

2) sediment rating curves, 3) statistical equations, 4) deterministic models, and 5) stochastic approaches.

The change in downstream sediment movement from the source to any given measuring point is termed the delivery ratio. It is the fraction of gross erosion that is transported from the basin as sediment yield. It is expressed as follows:

$$D = Y/T$$

where, Y is the sediment yield at the measuring point,

T is the gross erosion from the drainage system upstream of the measuring point.

This is a fairly accurate technique of predicting downstream sediment yields if delivery ratios are estimated accurately. Often delivery ratios are estimated by comparing measured sediment yields to predicted gross erosion.

The relationship between water discharge and sediment discharge rate is termed the sediment rating curve (Campbell and Bauder, 1940). Using flow frequency distributions and sediment rating curves, sediment yield frequency distributions can then be established. This method is time consuming, costly, and changing land management practices alter the relationships.

Statistical equations usually relate sediment yield to one or more basin characteristics or climatic factors. They require large quantities of data on basin characteristics and sediment discharge. They are used for problems requiring sediment yield averages over long periods of time. The basins studied are usually used for water supplies and are relatively large. Wallis and Anderson (1965) found that one of the limitations of statistical approaches is that they cannot be used without re-calibration due to changes in land use.

Deterministic models introduce parameters to quantify the factors affecting erosion, sediment transport and sediment deposition. These parameters can be derived empirically or calibrated using curve fitting techniques. An example of a parameter model that describes erosion or sediment detachment is the USLE described earlier.

Williams (1975) modified the USLE to predict storm sediment yield for basins. His modified universal soil loss equation takes the form:

$$Y = 95(Qq_p)^{0.56}KLSCP$$

Where Y is the sediment yield(kg),

Q is the runoff volume(m^3),

q_p is the peak runoff rate(m^3/s).

This equation replaces the rainfall energy factor with a runoff factor and eliminates the need for a delivery ratio to determine sediment yield.

Meyer and Wischmeier (1969) developed a soil detachment-soil transport concept, shown in Figure 4. The steady state sediment continuity equation is a mathematical description of this model and is the basic governing equation of erosion is as follows:

$$dq_s/dx = D_L + D_F$$

where q_s is the sediment load(mass/unit width/unit time).

x is the distance(unit length).

D_L is the lateral inflow of sediment(mass/unit area/unit time).

D_F is the detachment or deposition by flow(mass/unit area/unit time).

Models which use this concept are called sediment routing models and usually use the USLE in the detachment phase.

Sediment routing allows the determination of subbasin contributions to the total sediment yield. Also sediment sources can be located and ranked within the basin. In addition, changes in particle size distribution of the sediment can be considered in routing models.

Foster et al. (1981) expanded on this model as shown in Figure 5. They divided a watershed into areas or elements of overland flow, channel flow and impounded runoff. Each type of flow has its own specific set of equations.

Detachment on the interrill and rill areas in the overland flow element is described by a modified USLE (Foster

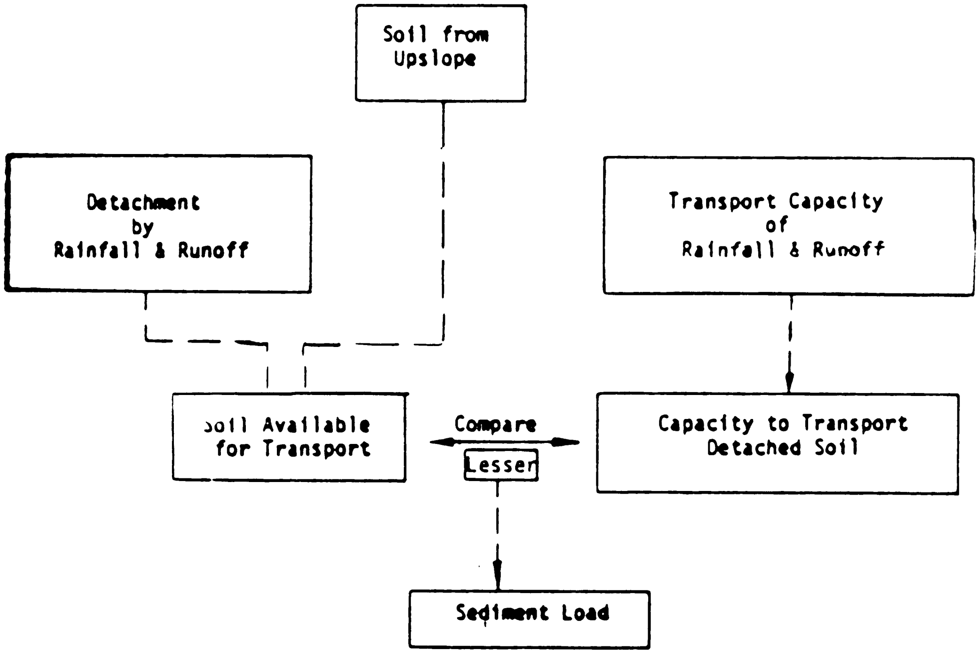


Figure 4. Conceptual model which simulates the soil erosio process (Meyer and Wischmeier, 1969)

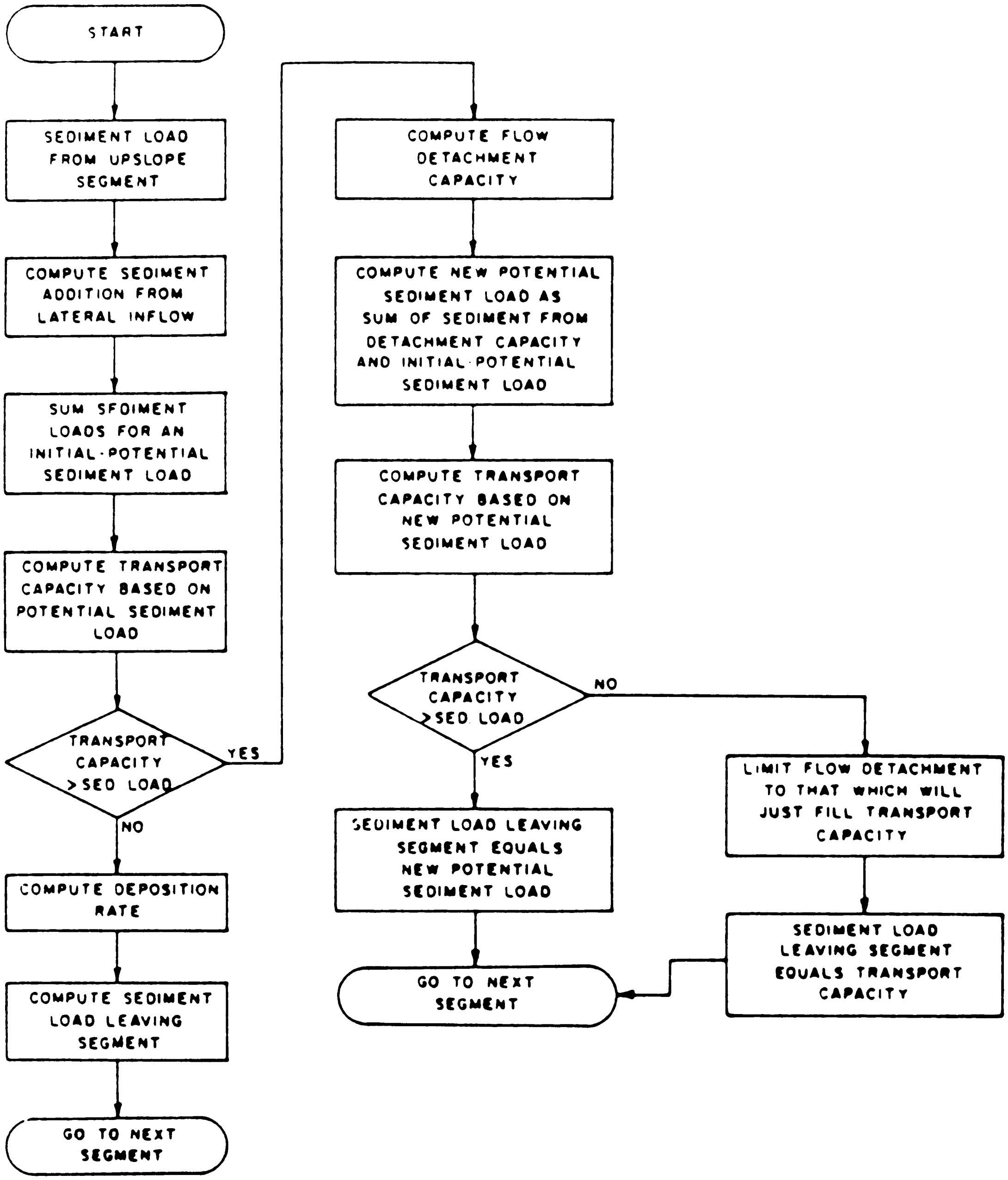


Figure 5. Flow chart for detachment-transport-deposition computations within a segment of an overland flow or channel element (Foster et al., 1981)

et al., 1977). Transport and deposition of sediment can occur in rill flow in overland flow areas.

Channel flow describes the detachment, transport, and deposition which occurs in grassed waterways, terrace channels, road ditches, and other channels that the topography has caused overland flow to converge.

Lake Sediment Deposition

A common method of measuring the amount of sediment deposited in a lake compares two bathymetric surveys taken over some time interval. The U.S. Army Corps of Engineers (1961) defines the survey as "an individual reservoir sedimentation investigation, interpreted broadly to include office work, laboratory analysis of sediment samples, field measurements, and processing and analysis of data." The volume change of the lake volume of sediment deposited in the lake; and dividing this volume by the time interval gives the sedimentation rate.

Lake sediment samples should be collected if possible because the bulk density of the sediment is important to compute the volume of sediment in the lake from the weight of sediment delivered to the lake from the watershed. The bulk density of the sediment when combined with the trap efficiency of the lake is used to determine the sediment yield of the watershed.

The trap efficiency of lake is a measurement of the relationship between the sediment retained in the lake. In some large reservoirs the trap efficiency may approach 100%. A dry, small reservoir may have a very low trap efficiency. Brune, (1953) developed a set of curves which relate trap efficiency to the ratio of reservoir capacity to mean annual inflow.

Computer Models

Computer models developed in the last decade often use a combination of these processes. The Areal Nonpoint Source Watershed Environment Response Simulation (ANSWERS) was developed by Beasley et al. (1980) at Purdue University, simulates the hydraulic components and sediment yield of a watershed. The Chemical, Runoff, and Erosion from Agricultural Management Systems (CREAMS) was developed by USDA-SEA-AR scientists under the leadership of Knisel (USDA-ARS, 1980), uses USLE relationships for determining soil erodibility parameters and makes use of USLE crop-storage-soil-loss ratios. The Erosion-Productivity Impact Calculator (EPIC) (Williams et al., 1985) was developed by the Agricultural Research Service (ARS) in 1983 and determines the relationship between soil erosion and soil productivity. EPIC applies only to small drainage basins of less than one hectare, because soils and management are assumed to be spatially homogeneous.

The USDA-Water Erosion Prediction Project (WEPP) (USDA-ARS, 1987) was initiated in 1985, uses a steady state sediment continuity equation as the basis for computing net erosion detachment and deposition. WEPP differs from other models because: it does not rely upon USLE relationships, partitions rill and interrill areas, and calculates shear stresses based on rill flow and rill hydraulics rather than sheet flow.

This thesis applies Agricultural Non-Point Source Pollution (AGNPS) (USDA-ARS, 1987) model, developed by the Agricultural Research Service (ARS) in cooperation with the Minnesota Pollution Control Agency and the Soil Conservation Service (SCS). AGNPS estimates runoff, sediment, and nutrient transport from agricultural watersheds for single storm events. The watersheds in AGNPS applications may vary in size from a few hectares to 20,000 hectares. Nutrients considered in AGNPS include nitrogen (N) and phosphorus (P) which are major contributors to surface water pollution.

AGNPS also considers point sources such as gullies, animal feedlots, and springs. Inputs from these point sources could be water,sediment,nutrients, and chemical oxygen demand

(COD). *COD* can be used as an indictor of the degree of pollution in surface water.

AGNPS operates on a cell basis. The watershed is divided into uniform square areas or cells that define the level of information placed in the model. The smaller the cells the more accurate the model; however, small cells mean increased time and labor to set up the model.

Runoff volume estimates are based on the SCS curve number method (USDA, 1972) and the rainfall. The curve number, an input into this model, is based on land use, soil type, and hydrologic soil condition. Peak runoff rate for each cell is estimated using an empirical relationship proposed by Smith and Williams (1980). Channel slope, drainage area, and watershed length are inputs into this relationship as is the runoff volume calculated above.

Soil erosion is estimated using a modified version of the USLE. Sediment transport and deposition are determined from equations derived from steady-state continuity equation. These equations are explained in more detail in Appendix A.

Since AGNPS's introduction it has been tested by several researchers. Setia and Magleby (1985) used the model to estimate changes in concentrations of sediment, nutrients (N,P), and chemical oxygen demand in runoff waters. Annualized results were obtained by running the model for seven storm events of varying magnitudes and weighing results according to storm frequency. No summary of these results is given in the paper. Several best management practices (BMP) are used and economic analyses of each option is conducted and the cost benefit ratios are compared.

Prato et al. (1989) used AGNPS to evaluate water quality effects of optimal resource management systems. AGNPS was used in conjunction with a linear programming model to select a resource management system that maximized farm income on 16 farms that were subject to a specified reduction in total erosion. Prato et al. found that net farm income increased 1.5% when total erosion was reduced 40% and decreased 34.7% when erosion was reduced 70%. Total net farm income declined rapidly beyond 40% erosion reduction.

Panuska et al. (1991) demonstrated how terrain analysis methods and digital elevation models (DEMs) data bases could be combined with water quality models, including AGNPS, to improve their prediction capabilities and decrease the time and effort required to assemble the input data sets. An additional objective was to examine the sensitivity of selected terrain attributes to cell size. A contour-base version and a grid-based version are analyzed using five storm events and compared to observed data. Panuska et al. found that contour- and grid-based terrain enhancements of the AGNPS model give predicted sediment and peak flow values consistent with those predicted by AGNPS version 2.52. The sensitivity analysis shows that over a range of cell sizes the flow path length and upslope contributing area depend on the cell size and to some degree the method of terrain analysis. Computed slopes did not display this same dependence.

DESCRIPTION OF WATERSHEDS STUDIED

Pine Lakes Watershed

Pine Lakes watershed is located in central Iowa near the city of Eldora in Hardin County as shown in Figure 8. There are two lakes in the watershed. Lower Pine Lake was built in 1922 and Upper Pine Lake in 1935. Both lakes have a surface area of about 26 hectares (65 acres), are relatively shallow with an average depths of 2.2 meters (7.2 feet) for Upper Pine and 1.6 meters (5.4 feet) for Lower Pine. Both lakes are planned to be dredged in the near future.

The lakes' watershed is in an area called the Iowa Erosional Surface consisting of glacial till with a thin, discontinuous layer of overlaying loess (Prior, 1976). The watershed has an area of 3920 hectares (9560 acres). The topography varies from gently rolling uplands to steep slopes near the lakes. Figure 7 is a geologic map of the watershed showing that about 78% of the area is underlain by loess and 18% by alluvium. Glacial till, sandstone, and eolian sand comprise the remainder of the watershed.

Figure 8 shows the land use of the watershed. Currently 84% of the watershed is used for row crop agriculture. The remainder is divided between woodland, pasture, and the Conservation Reserve Program (CRP). Over 800 hectares (2000

State of Iowa

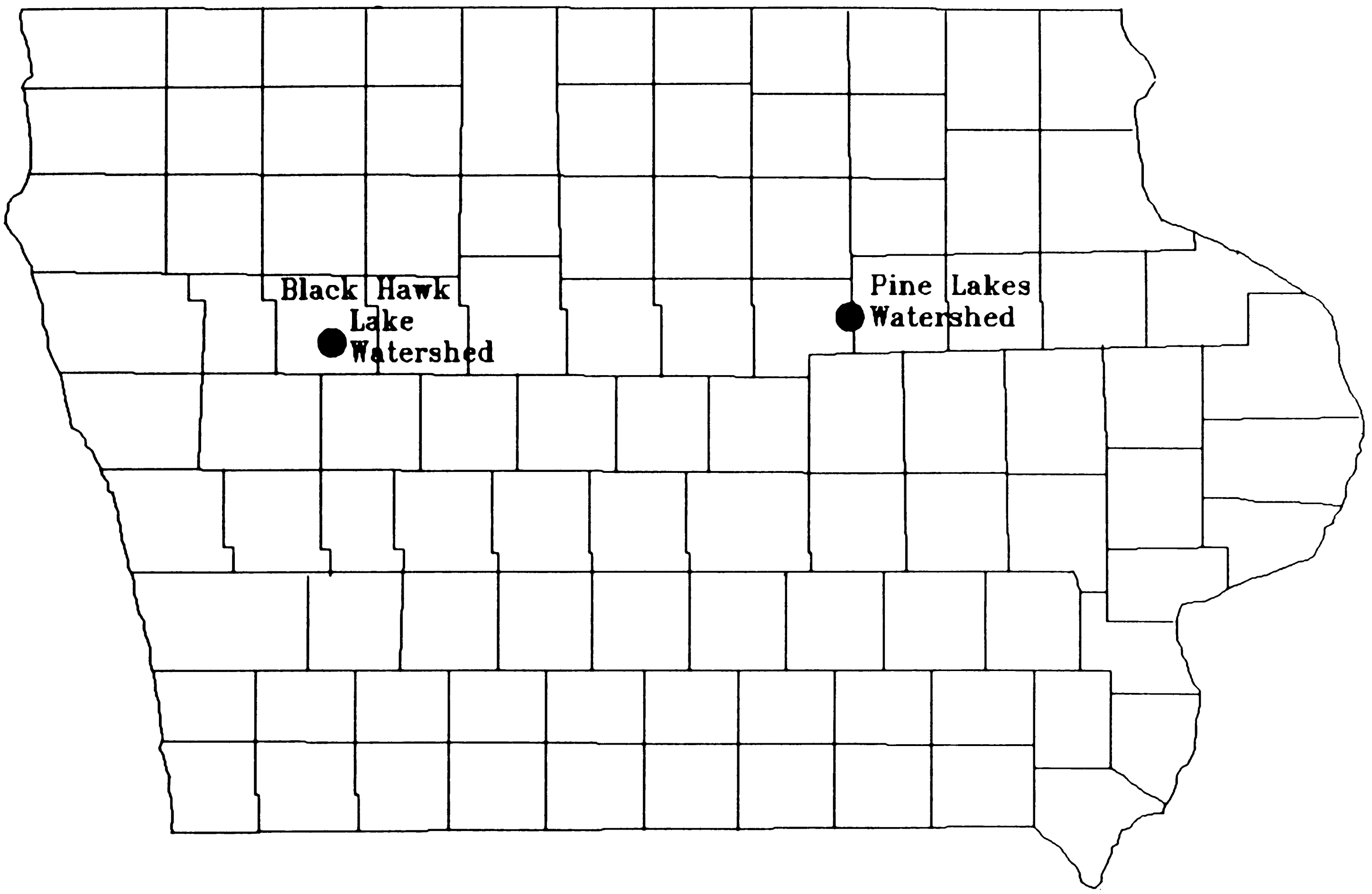


Figure 6. Location of watersheds studied in Iowa

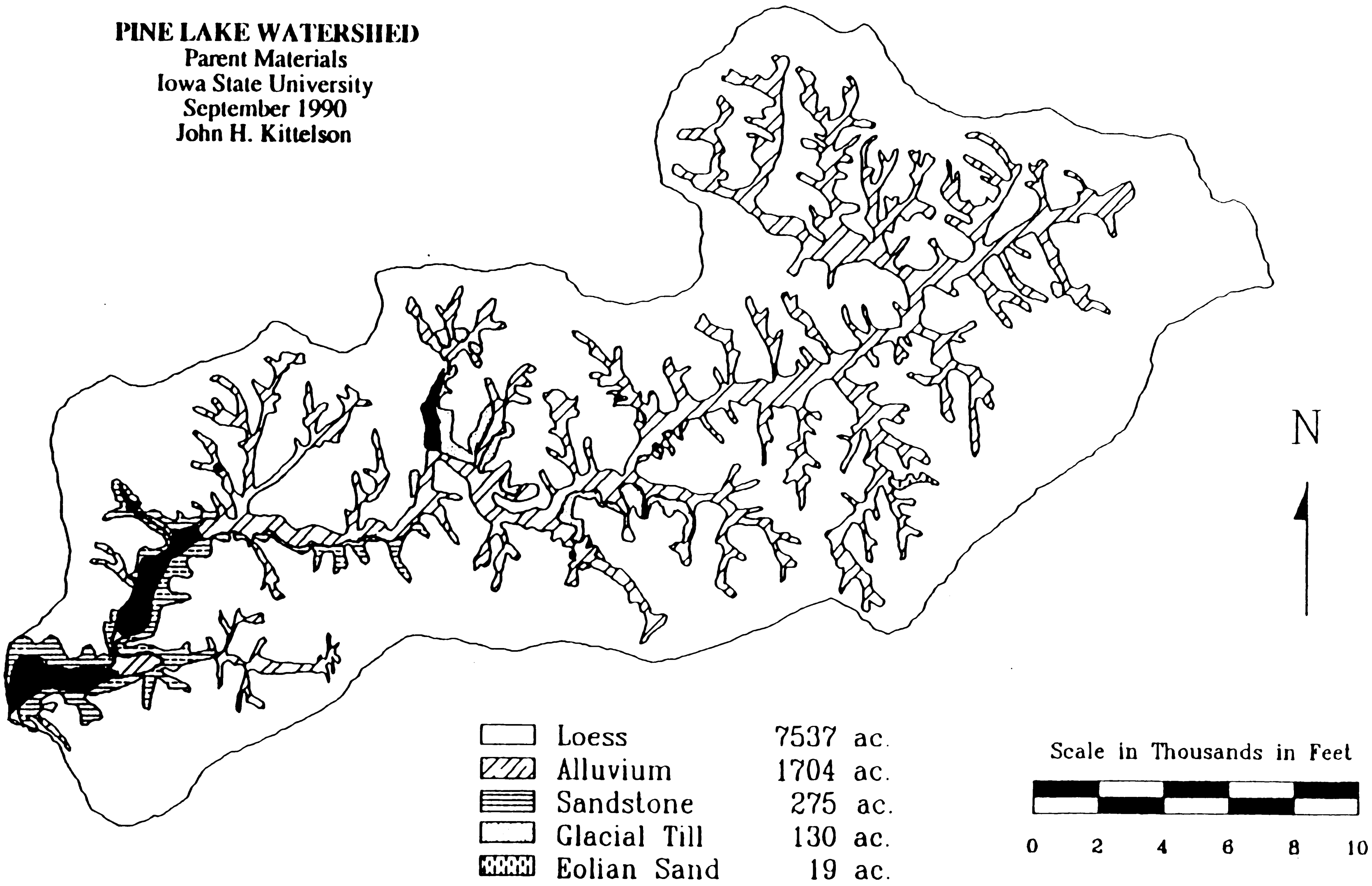


Figure 7. Surficial geologic map of Pine Lakes watershed (Bachmann et al., 1990)

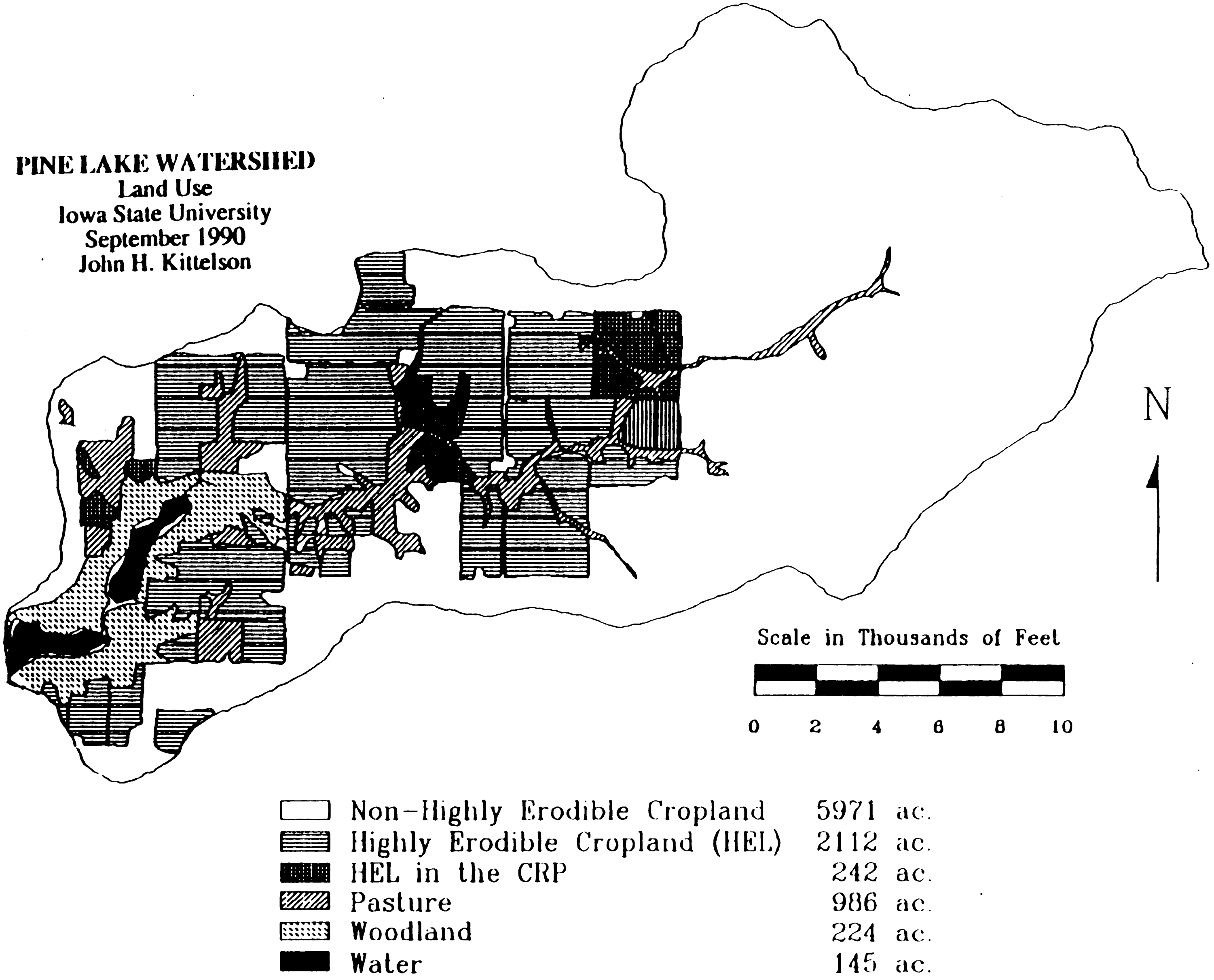


Figure 8. Land use map of Pine Lakes watershed (Bachmann et al., 1990)

acres) of the land currently being cropped is designated highly erodible land (HEL) and must have a conservation management plan in place by 1993.

According to Bachmann et al (1990) Upper Pine Lake receives 88% of its inflow from groundwater. Lower Pine Lake is about 370 meters (1200 feet) downstream from Upper Pine and receives most of its inflow directly from Upper Pine. 39% of the inflow does come from groundwater, however.

Bachmann also found that Upper Pine Lake is silting in at the annual rate of 0.93 ha-m/yr (7.5 ac-ft/yr). Lower Pine Lake was estimated to have a sedimentation rate of 0.41 ha-m/yr (3.3 ac-ft/yr). These and various other lake and watershed characteristics are summarized in Table 2.

Black Hawk Lake Watershed

Black Hawk Lake is located in west central Iowa adjacent to the town of Lakeview in Sac County as shown in Figure 6. The lake is a natural lake and has an area of 4880 hectares (755 acres). The lake is currently being restored under the Iowa Clean Lakes program.

The watershed is located on the western edge of the Des Moines lobe and has an area of 4880 hectares (12,060 acres). The surficial geology of the watershed is shown in Figure 9 and shows that nearly two-thirds of the watershed is composed

Table 2. Characteristics of Pine Lakes and Black Hawk Lake watersheds

Lake	Drainage Area		Lake Area		Watershed/Lake Ratio
	ha	(ac)	ha	(ac)	
Upper Pine	3497	(8640)	26	(65)	144.0
Lower Pine	372	(920)	26	(65)	15.3
Black Hawk	4856	(12000)	291	(720)	16.7

Watershed	Total Area		Watershed Shape Ratio		Drainage Density (DD)		Basin Relief Ratio (RR)
	ha	(ac)	1/km	(1/mi)	km/km^2	(mi/mi^2)	%
Pine Lakes	3920	(9680)	0.28	(0.45)	1.22	(1.96)	0.39
Black Hawk	5147	(12720)	0.31	(0.49)	0.67	(1.08)	0.41

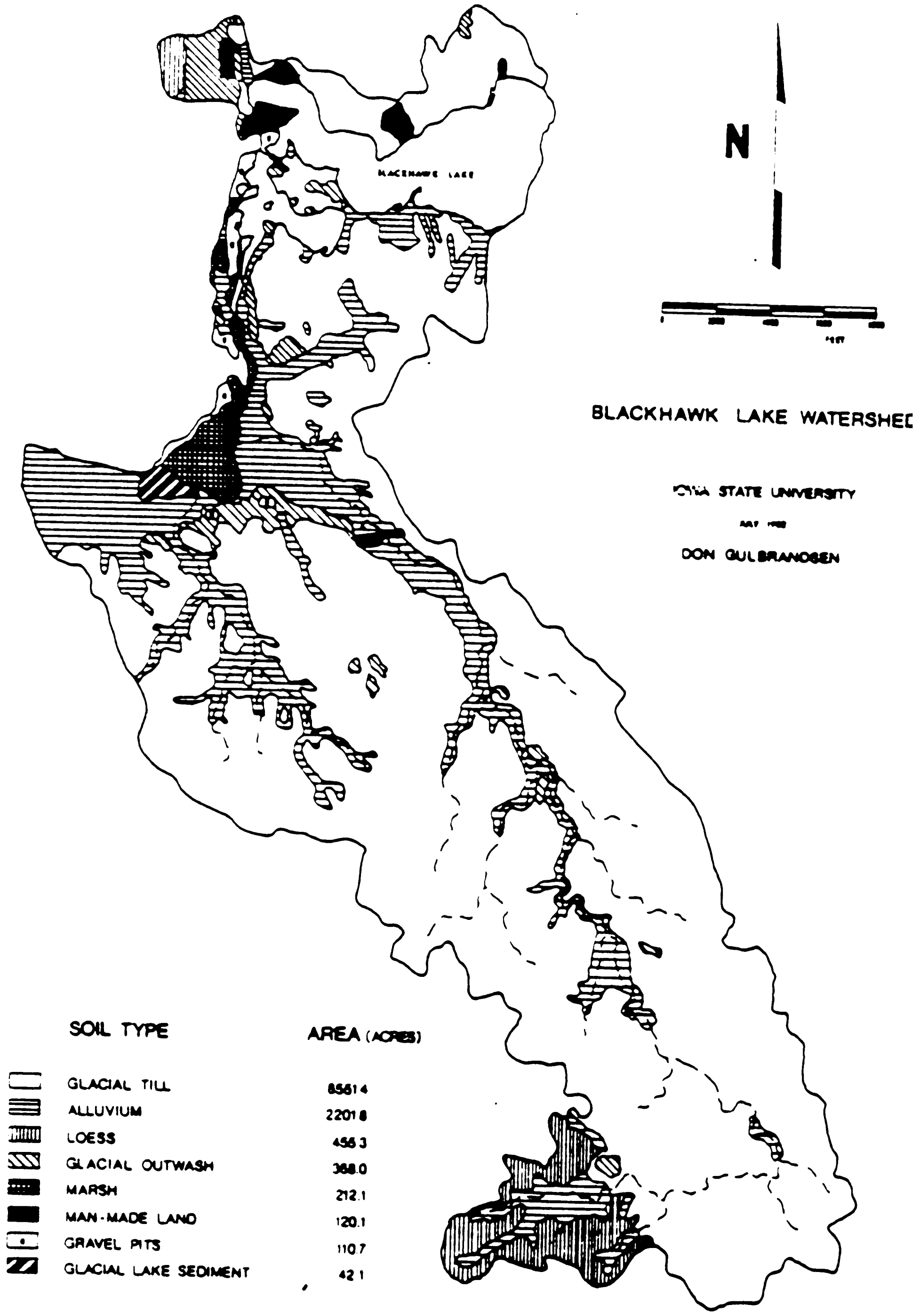


Figure 9. Surficial geology map of Black Hawk Lake watershed (Bachmann et al., 1983)

of glacial till. 20% of the watershed consists of alluvium and loess, glacial outwash and marsh make up most of the remainder.

The majority of the watershed, as shown in Figure 10, is used for farmland with almost 80% used for row crops. Because parts of Lakeview and Bredar are within the watershed 7% is considered urban. The remainder is woodland, pasture, and other uses.

Bachmann et al. (1983) found that 80% of Black Hawk Lake's inflow was from groundwater. They also estimated the sedimentation rate in Black Hawk lake to be about (26 ac-ft/yr). These and other relevant watershed data are summarized in Table 2.

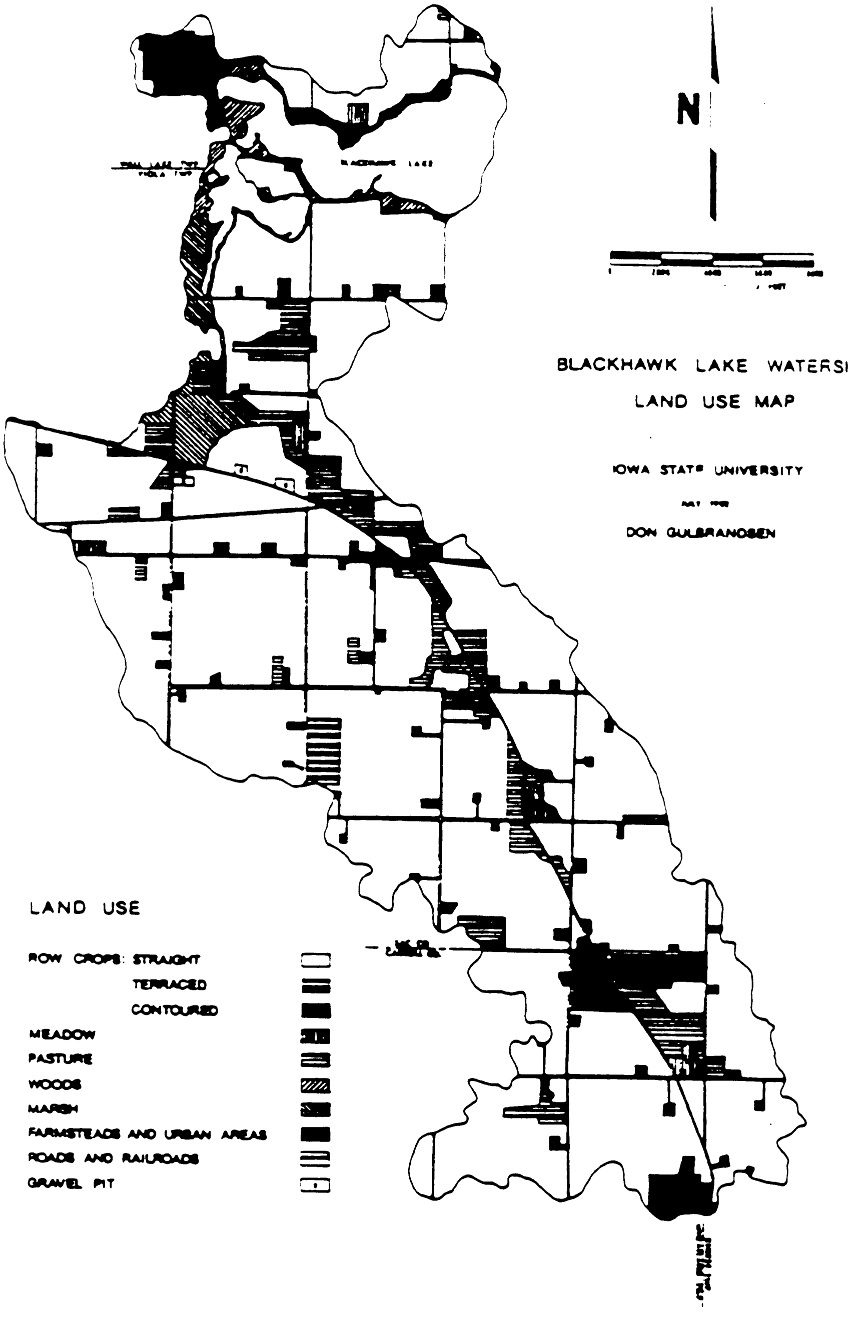


Figure 10. Land use map of Black Hawk Lake watershed (Bachmann et al., 1983)

APPLICATION OF AGNPS TO LAKE SEDIMENTATION

The data bases for the two watersheds are compiled using soil surveys, topographic maps, and the AGNPS manual. Initial cell areas are 40 acres and 160 acres for Pine Lake and Black Hawk Lake watersheds, respectively. Storms are assumed to be 24 hour events and SCS designated Type I events. Computer runs are made using 1,2,3,4,5, and 7.5 inch precipitation totals.

The results are analyzed for each event to determine the net deposition in cells designated to represent the lakes. These results are shown in Figures 11,12, and 13. Equations are developed that relate the deposition in the lakes to the size of the precipitation event. The equations take the form:

$$S = a * R^n$$

where,

S = the net deposition in acre-feet,

R = the amount of precipitation in inches,

a and n = constants which are unique to each lake.

The units of the AGNPS output for deposition is in tons. To convert to acre-feet the bulk density for the lake sediment must be estimated. The bulk density for Lower Pine Lake was measured by the author and found to be 78 lbs/ft^3. Bachmann et al. (1983) found the bulk density for Black Hawk Lake to be 44.5 lbs./ft^3.

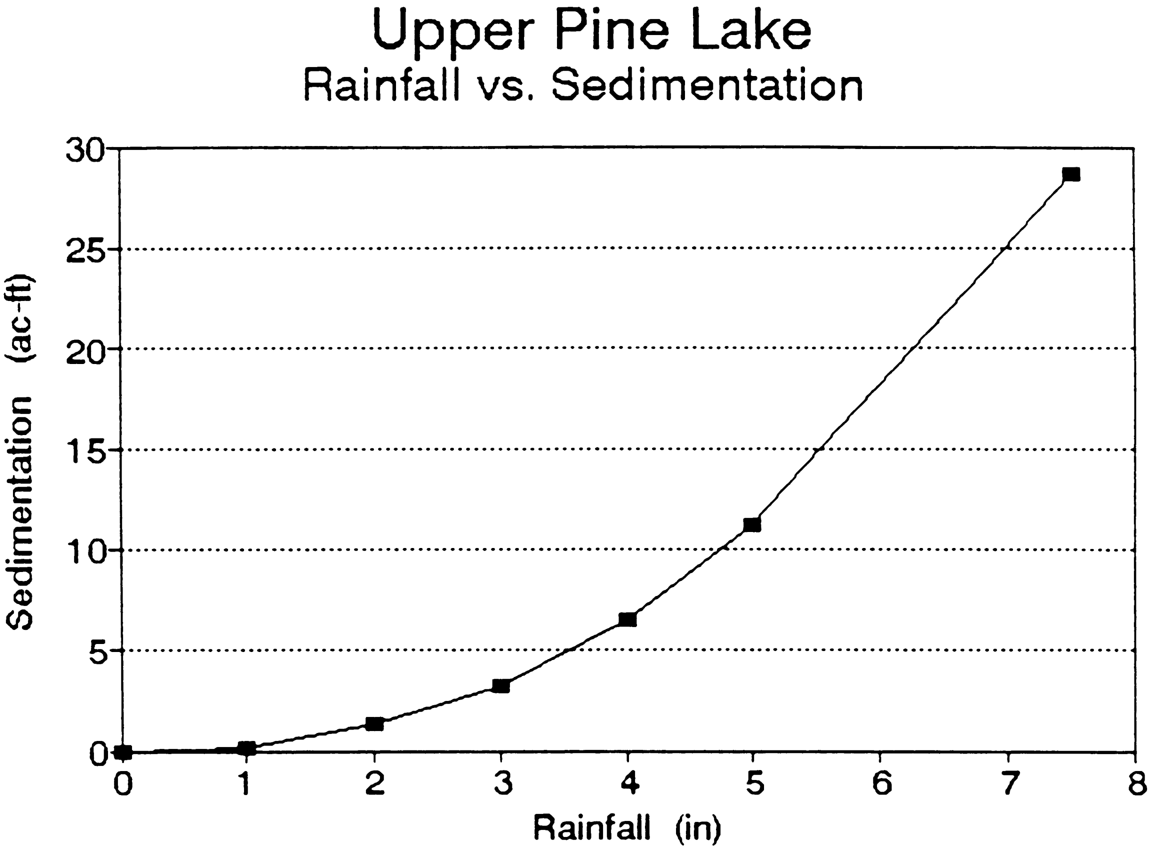


Figure 11. Graph of deposition versus precipitation for Upper Pine Lake

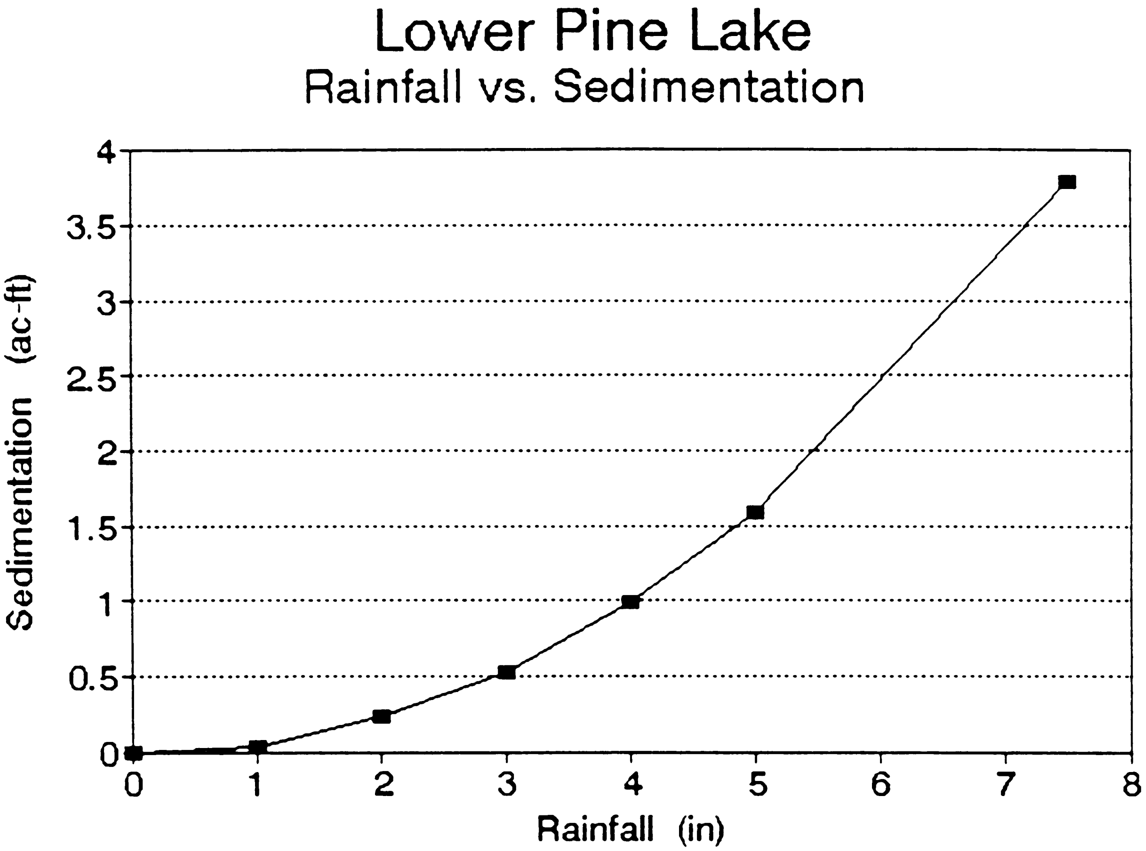


Figure 12. Graph of deposition versus precipitation for Lower Pine Lake

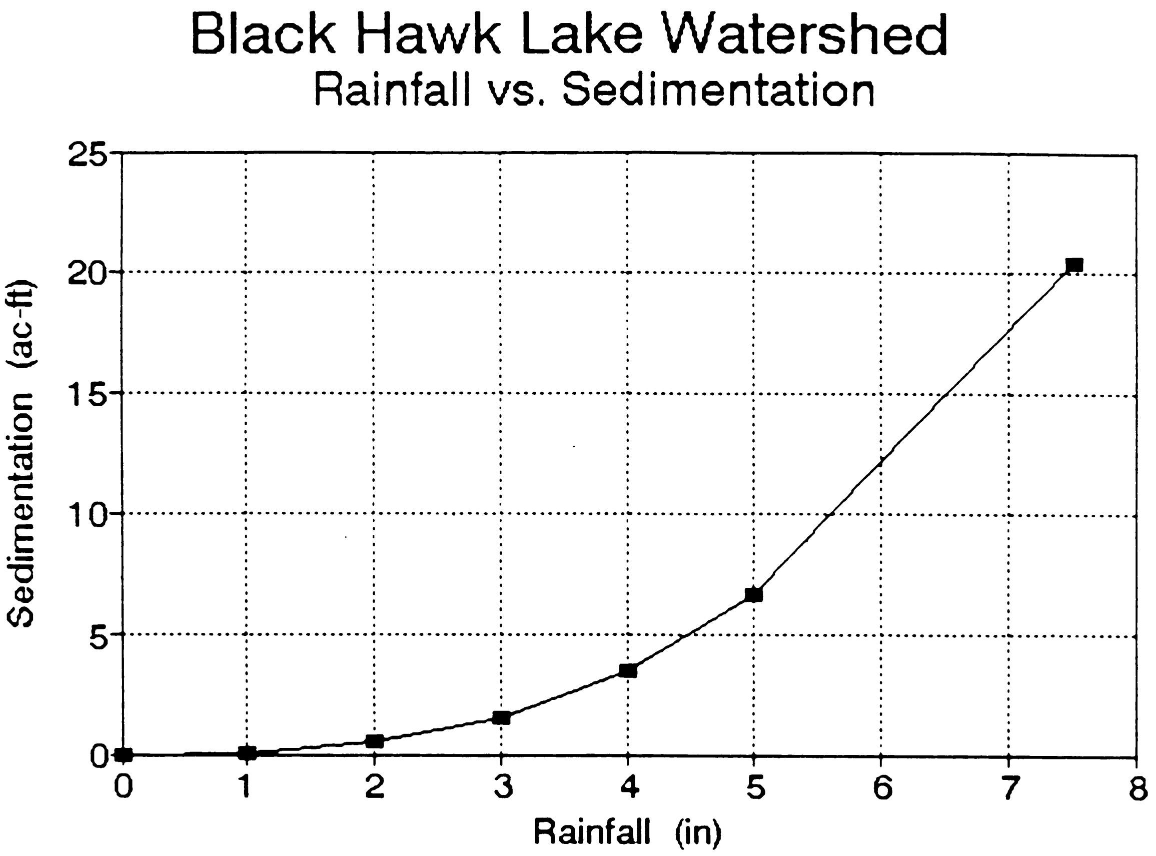


Figure 13. Graph of deposition versus precipitation for Blac

Hawk Lake

The total deposition for each lake is estimated using the above precipitation-deposition equations. Precipitation data for the time period 1953 to 1990 is used for the Pine Lakes analysis. Data for the period 1973 to 1982 is used for the Black Hawk Lake analysis. These time periods correspond to bathymetric surveys of the lakes. The equations are applied to the precipitation data and resulting depositions summed to arrive at an estimated total deposition for the time periods under investigation. The AGNPS total estimated deposition is compared to the measured deposition from the bathymetric surveys.

The analysis reducing the amount of deposition in each lake is based on the cell soil erosion results from the five inch storm events are used to determine the cells to which BMPs are to be applied. The BMPs are assumed to be terraces are represented in the input as a change in the P-factor from 1.0 to 0.3. Cells are ranked from highest to lowest by cell soil erosion. The BMP's are then applied to 10% of the cells with the highest cell soil erosion. The process is repeated using the highest 20% and 30% of the cells.

RESULTS FROM STUDIED WATERSHEDS

The results in Table 3 show that AGNPS model overestimated the deposition in Upper Pine by about 25% and underestimated the deposition in Lower Pine by about 50%. This is compared to measured amounts from Bachmann et al. (1990) which were determined from bathymetric surveys conducted in 1953 and 1990. The combined deposition in the two lakes is however, nearly equal to the measured amount. This suggests that the model accurately predicts the total sediment yield to Upper Pine, then overestimates the deposition in that lake as previously stated. The increased amount of deposition in Upper Pine means less sediment available to deposit in Lower Pine, therefore AGNPS underestimates the deposition in Lower Pine. Figure 14 graphically shows the results.

The amount of deposition estimated by AGNPS is much less than the measured amount of deposition in Black Hawk Lake as shown in Table 3 and Figure 14. The measured amount of deposition was determined by Bachmann et al. (1983) from bathymetric surveys conducted in 1973 and 1982.

Table 4 and Figure 15 show the results of applying Best Management Practices (BMPs) in the watershed as described in the Approach to the Problem section of this thesis. The BMPs are applied to the worst cells by soil erosion. Figures 16-21

Table 3. Measured and AGNPS sedimentation results for Pine Lakes and Black Hawk Lake watersheds

Lake	Measured Sedimentation Rate		AGNPS Sedimentation Rate	
	ha-m/yr	(ac-ft/yr)	ha-m/yr	(ac-ft/yr)
Upper Pine	0.9	(7.5)	1.2	(10.1)
Lower Pine	0.4	(3.3)	0.2	(1.6)
Black Hawk	4.1	(33.0)	0.5	(3.7)

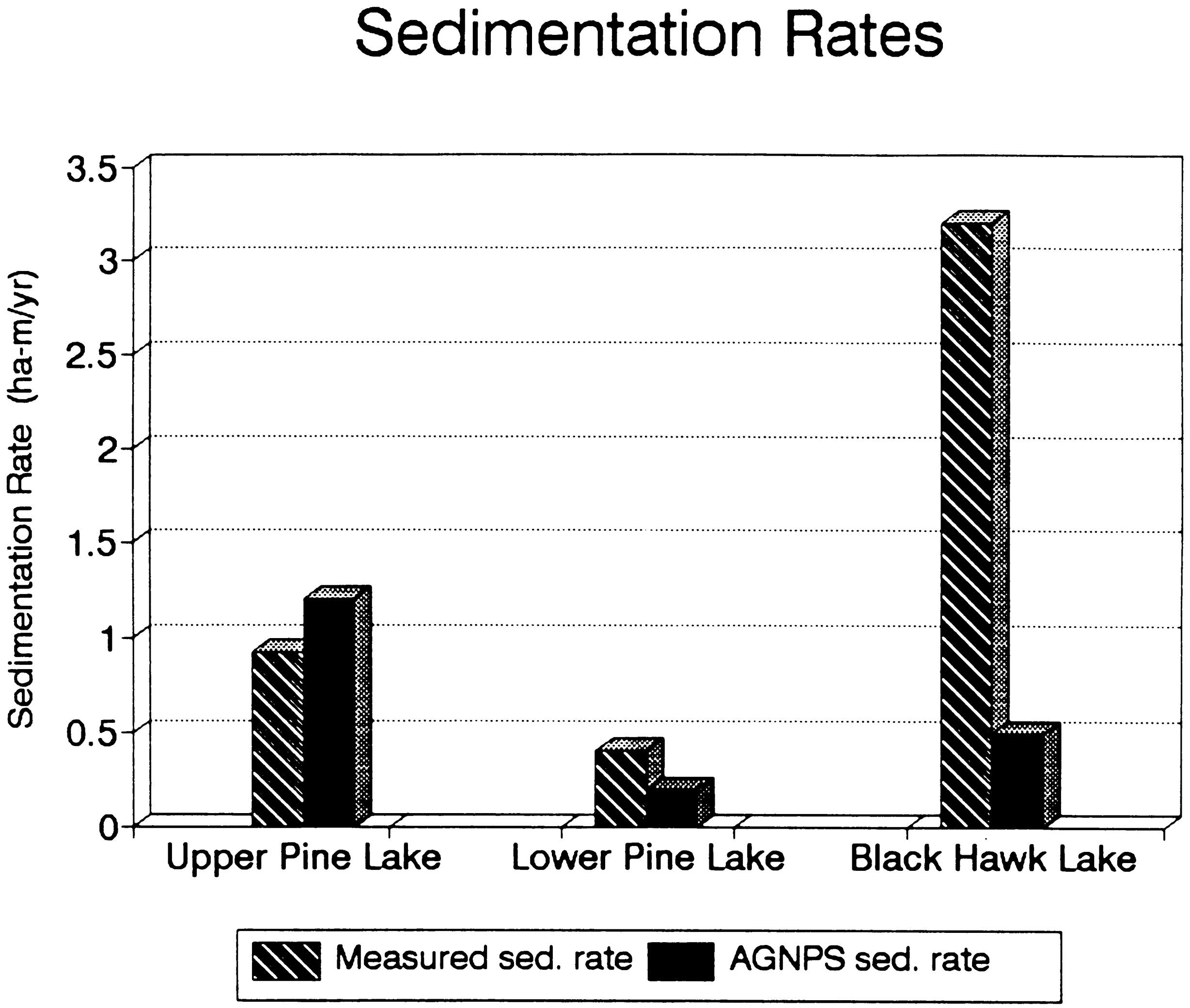
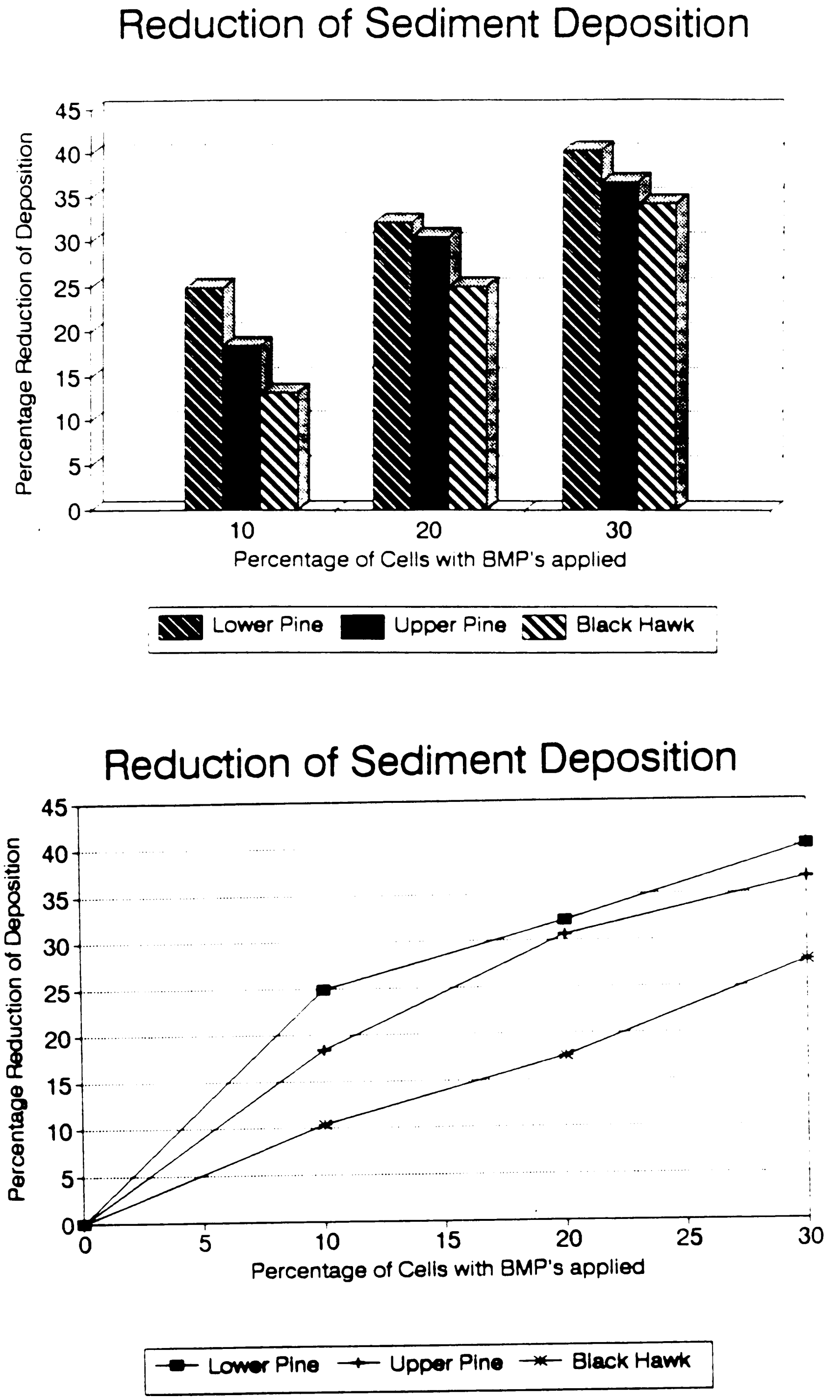


Figure 14. Graphical presentation measured and AGNPS sedimentation results

Table 4. Results of applying BMPs to the studied watersheds

Lake	Best Management Practices applied beginning with the cell with the highest soil loss			
	Percentage of cells with BMPs			
	0	10	20	30
	Sedimentation in tons from a 5-inch storm			
Upper Pine	2698	2026	1830	1612
Lower Pine	18869	15409	13086	11947
Black Hawk	6478	5811	5343	4684
	Percentage improvement			
Upper Pine	0	24.9	32.2	40.3
Lower Pine	0	18.3	30.6	36.7
Black Hawk	0	10.3	17.5	27.7


Reduction of Sediment Deposition

Reduction of Sediment Deposition

Figure 15. Percentage reduction in deposition due to application of BMPs

show the location of the cells with BMPs in the Pine Lake and Black Hawk Lake watersheds.

As BMPs were applied in the Pine Lake watershed the amount of deposition in the lakes decreased. The first 10% decreased the deposition in Upper Pine Lake by 18.3%, next 10% by 12.5%, and the next 10% by 6.1%. Similarly the first 10% decreased deposition in Lower Pine Lake by 24.9%, the next 10% decreased deposition by 7.3%, the next 10% decreased deposition by 8.1%.

In the Black Hawk Lake watershed the first 10% of applied BMPs deceased the deposition by only 10.3%, the next 10% decreased the deposition by another 7.2%, and the next 10% decreased the deposition by another 10.2%.

It can be seen in the case of Lower Pine and Black Hawk Lakes that cell soil erosion alone does not predict the most effective placement of BMPs. Lower Pine Lake and Black Hawk Lake had a increase of effectiveness between the 20% and 30% levels. This was due to the close proximity of some of the 30% cells to lakes. These cells have a lower cell erosion than other cells in the watershed but contribute more sediment to the lake.

An important step in the analysis of AGNPS is to relate this proximity factor to the cell soil loss to predict each cell's influence on lake sedimentation. This would enable the

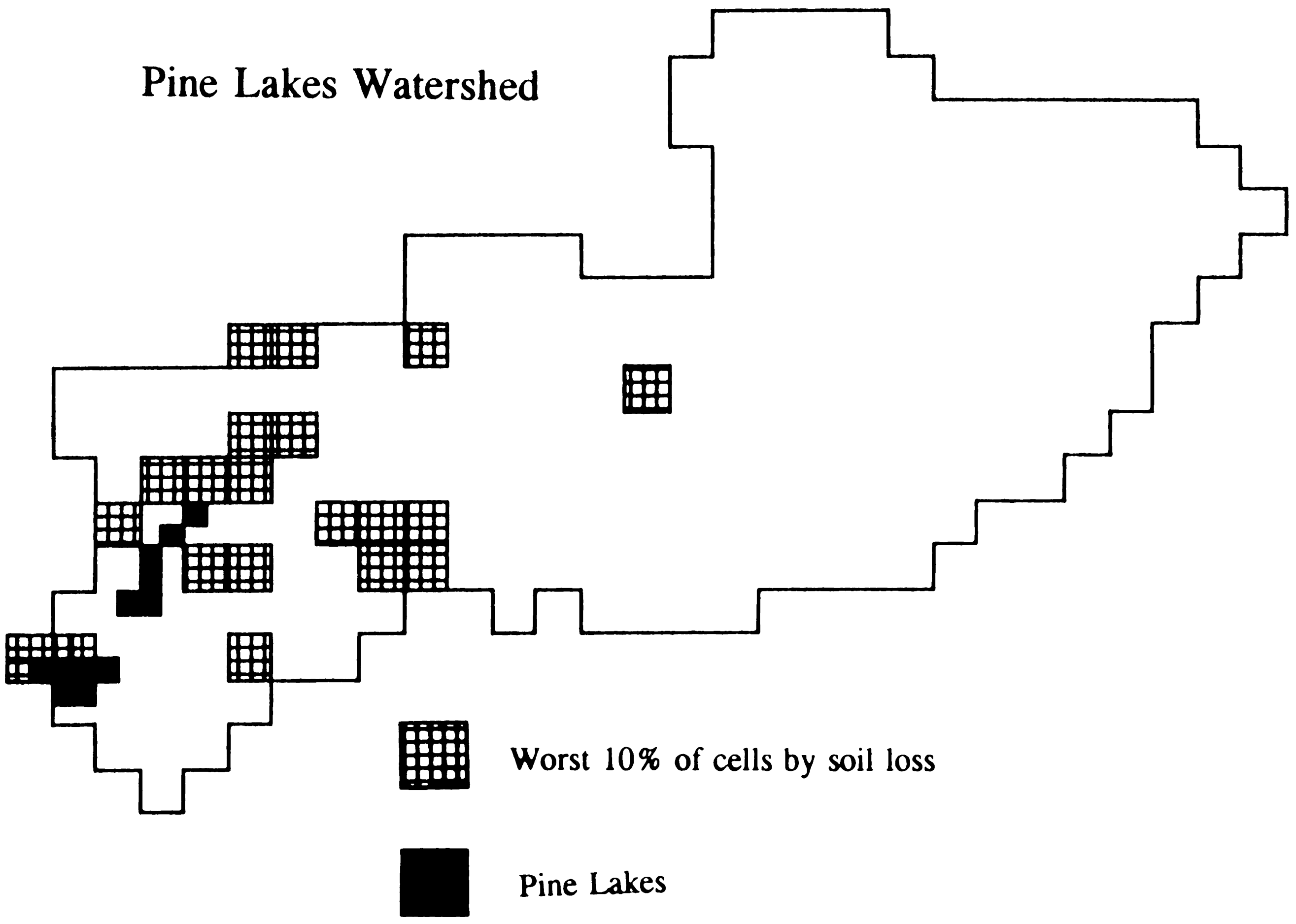


Figure 16. Location of the highest 10% of cells by soil erosion in the Pine Lakes watershed

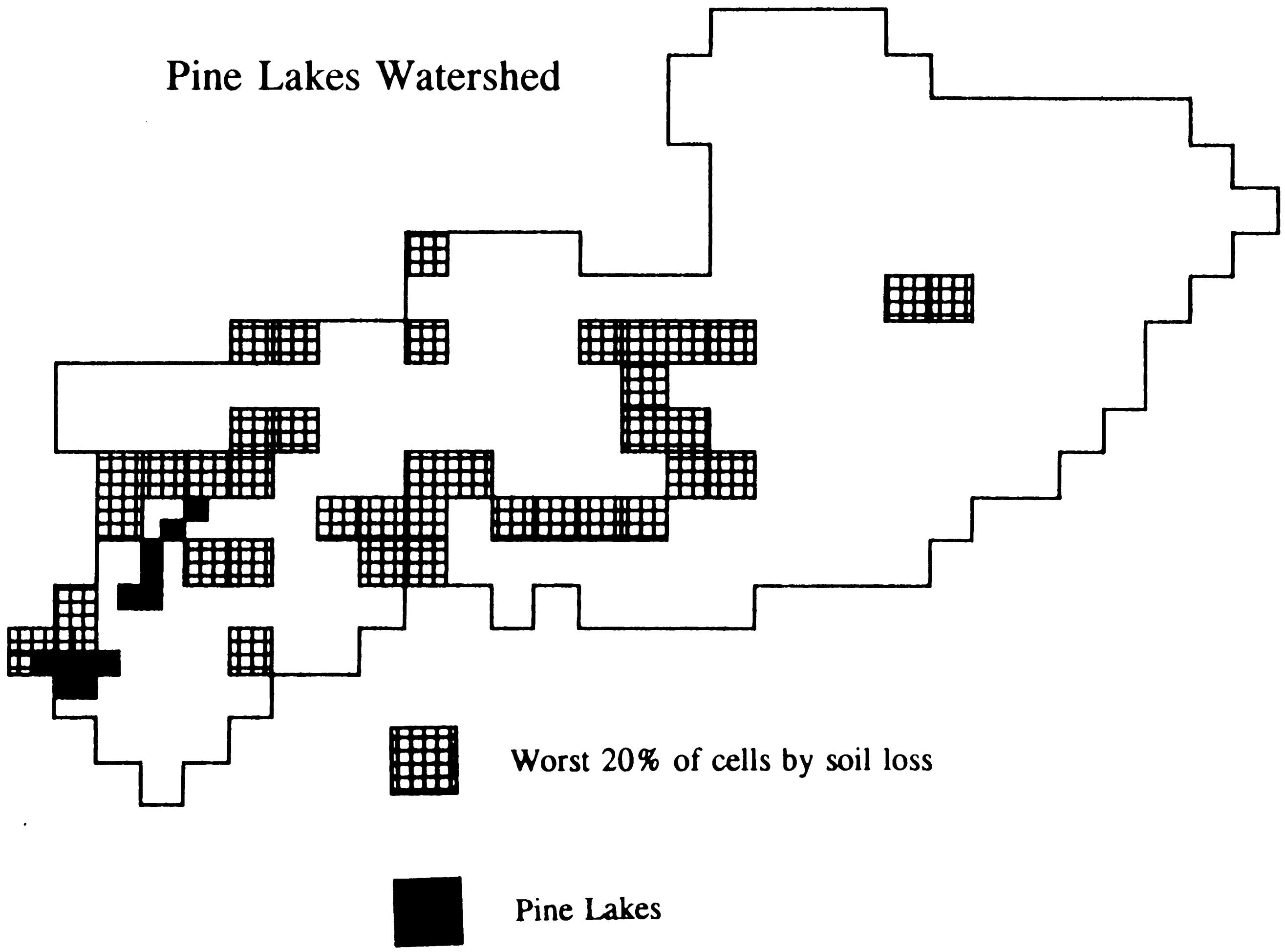


Figure 17. Location of the highest 20% of cells by soil erosion in the Pine Lakes watershed

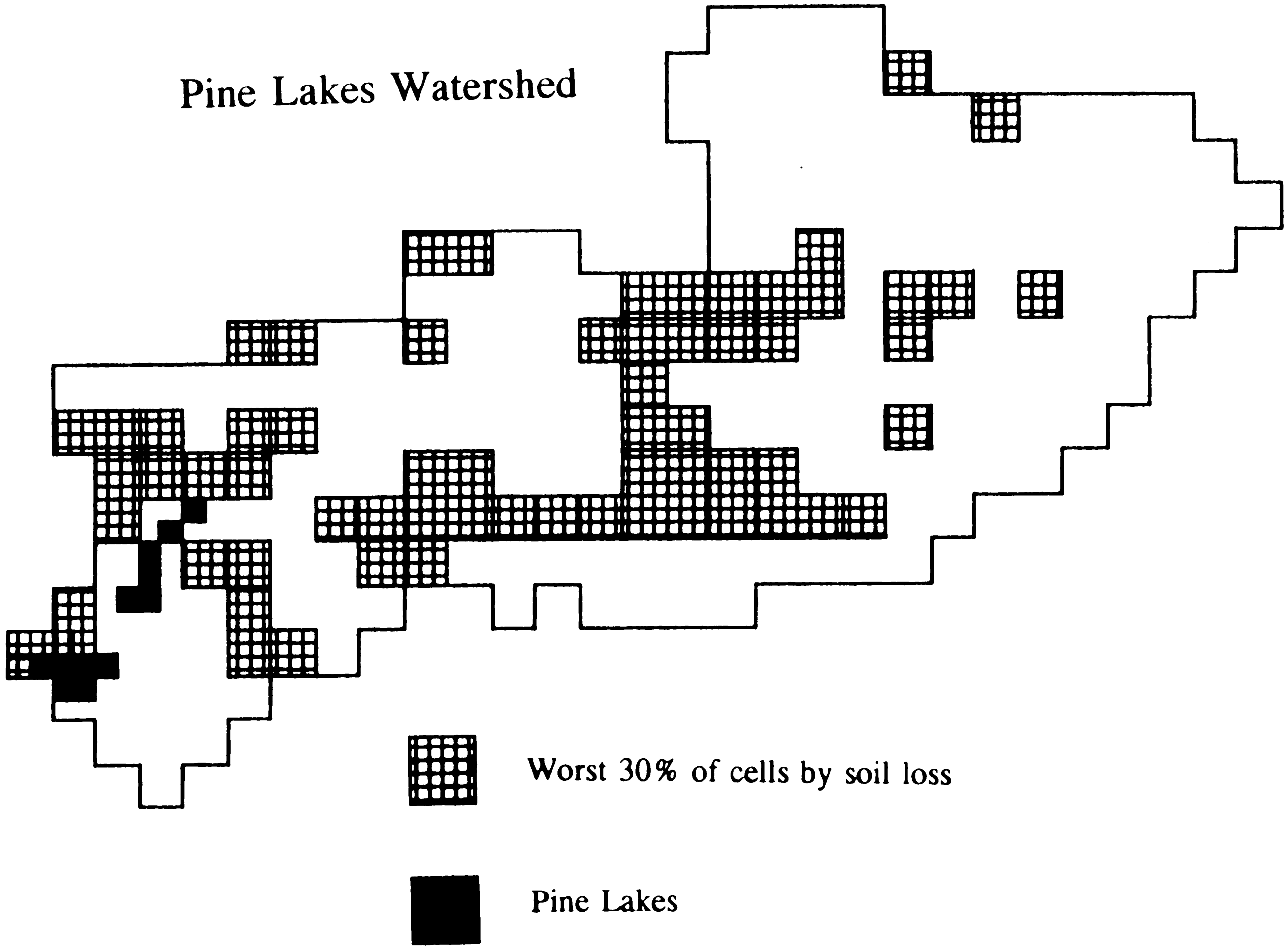


Figure 18. Location of the highest 30% of cells by soil erosion in the Pine Lakes watershed

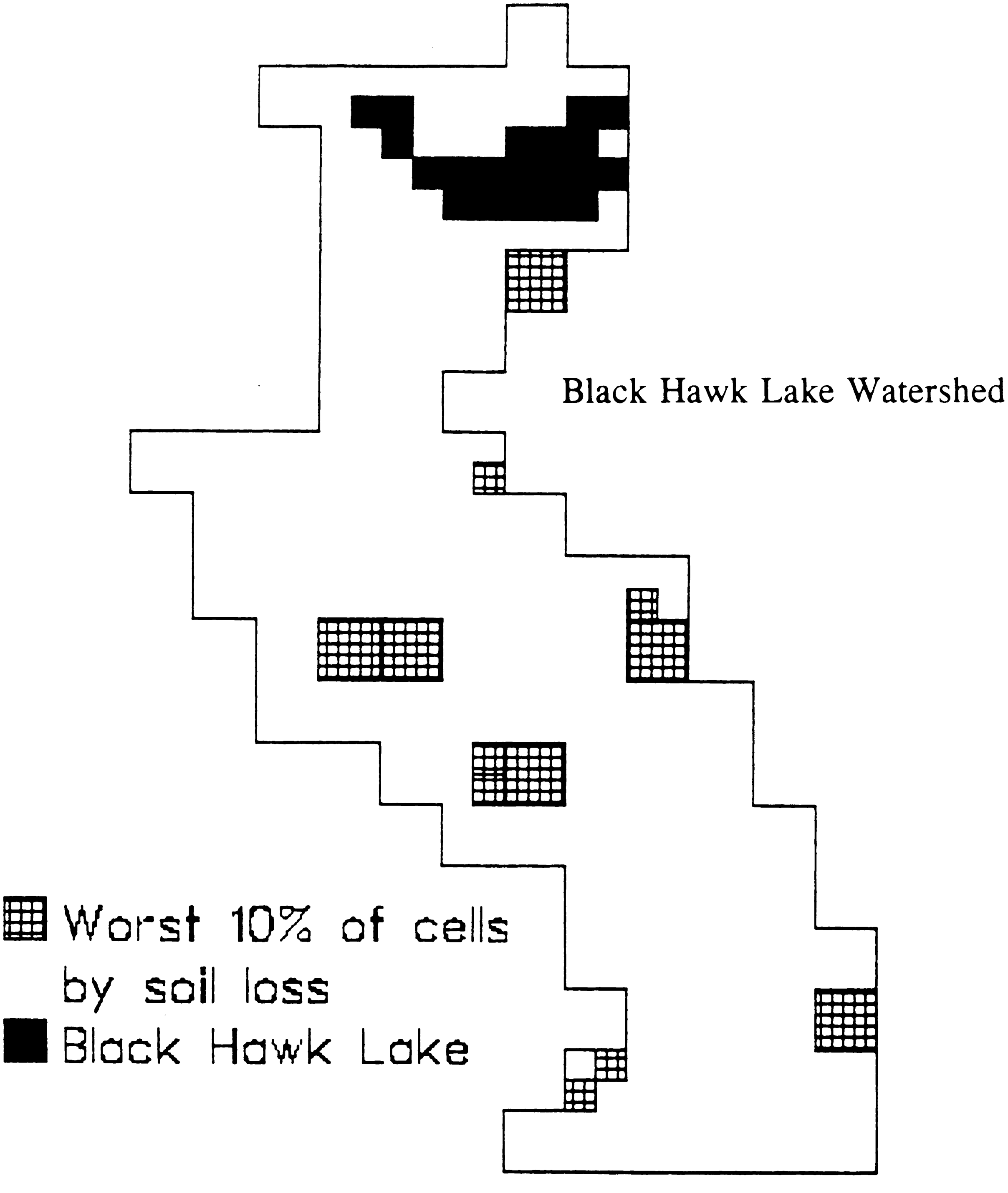


Figure 19. Location of the highest 10% of cells by soil erosion in the Black Hawk Lake watershed

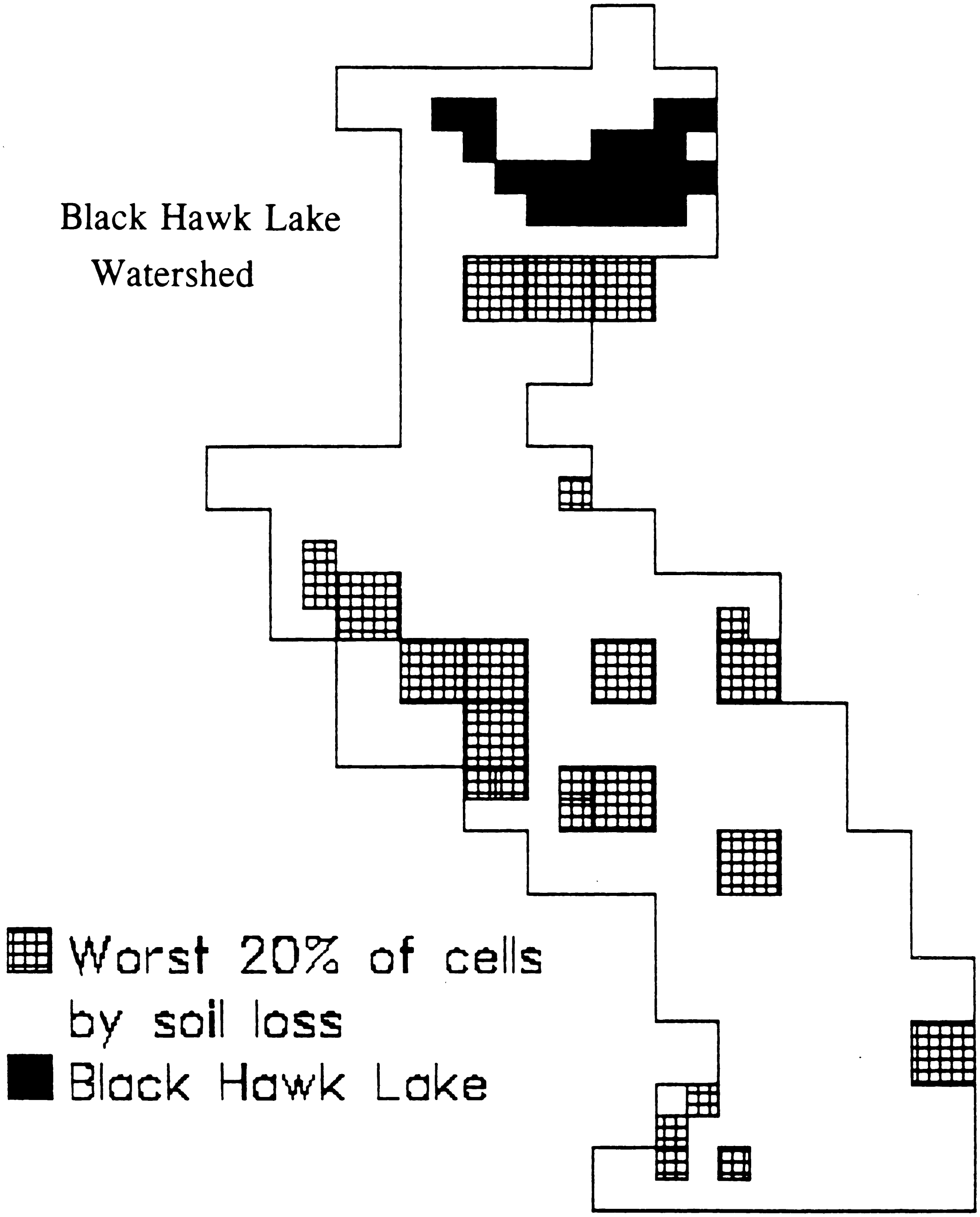


Figure 20. Location of the highest 20% of cells by soil erosion in the Black Hawk Lake watershed

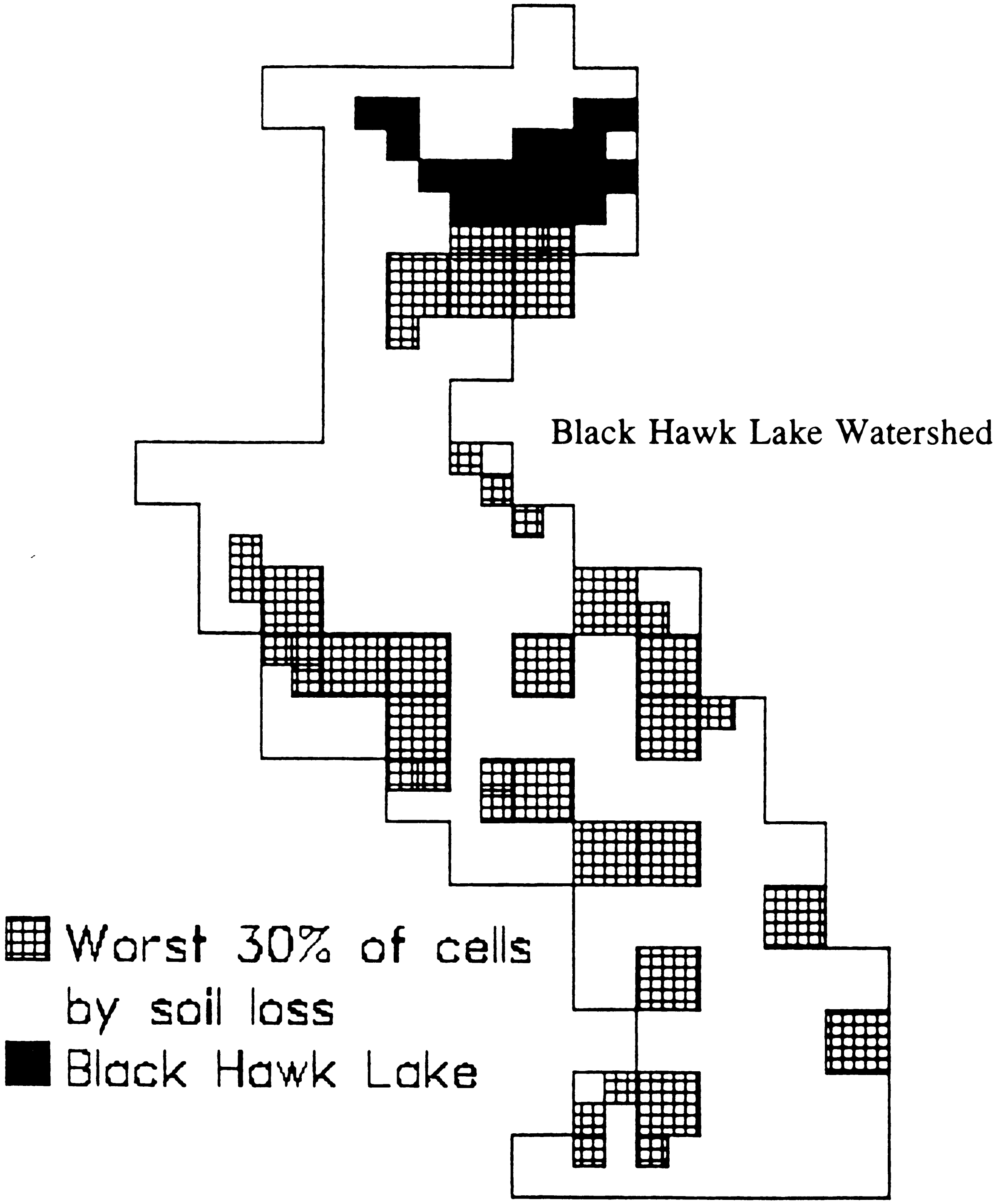


Figure 21. Location of the highest 30% of cells by soil erosion in the Black Hawk Lake watershed

modeler to place the BMPs in manner that would maximize the BMPs effectiveness in relation to lake sedimentation.

Table 5 shows an analysis of three groups of cells. Cell 21 has high soil erosion rate and was in the group first 10% with applied BMPs. Cell 20 has the same high soil erosion rate and was in the second group of applied BMPs. Cells 15.3, 15.4, 16.3, and 16.4 are each 40 acres in size and are in Black Hawk Lake located next to each other. Figure 22 shows the path to the outlet for each of these cells. In Table 5 the "before" column represents the amount of sediment that the cell contributed to the lake before BMPs were applied. The "after" column represents the amount of sediment that the cell contributed after BMPs were applied. The "savings" column is the amount of reduction in deposition caused by the application of BMPs.

While cells 15 and 16 have an initial lower soil erosion rate the amount of sediment that reaches Black Hawk Lake is the highest for this 160 acres. These cells are located adjacent to Black Hawk Lake. Cells 20 and 21 are close to the lake. Cell 21 drains through one cell to reach the lake. Cell 20 drains to the west first, drains through six cells before its sediment reaches the lake.

Table 5. Selected cells' contribution to sediment deposition

Cell number	Size in ac	Sedimentation in tons			Cell soil erosion	Priority by soil erosion	Priority by lake deposition
		Before	After	Savings	tons/ac		
21	160	273	86	187	3.56	1	2
20	160	235	75	160	3.56	1	3
15.3 & .4 16.3 & .4	160	344	105	239	3.13	3	1

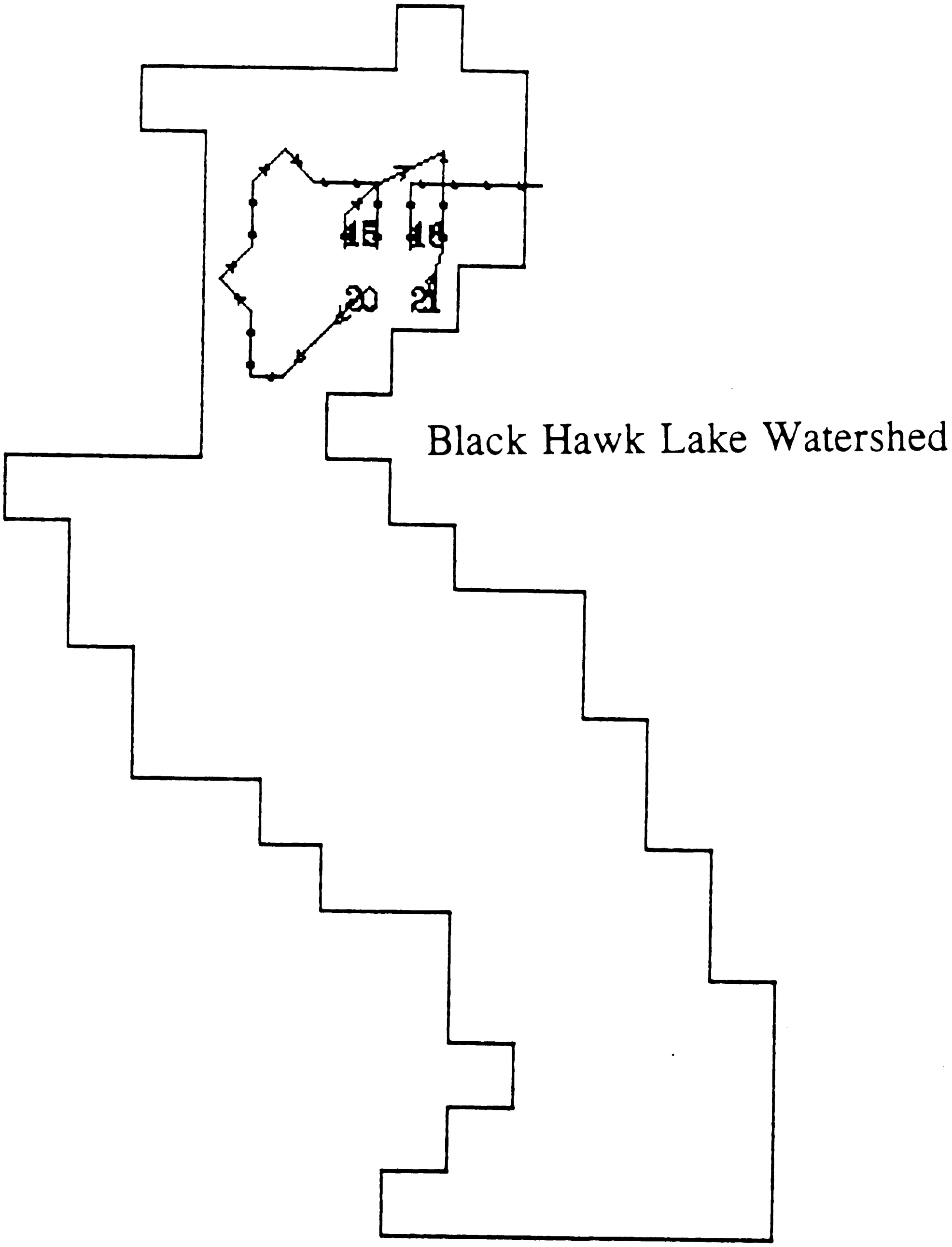


Figure 22. Flow routes of selected cells in the Black Hawk Lake watershed

CASE STUDIES

The advantage of a computer model like AGNPS is its ability to generate solutions to many different watershed scenarios. However, for large watersheds like the two studied in this thesis, it involves a considerable amount of work to run many different combinations of scenarios. It is desirable to vary the parameters in the watersheds quickly and also to possibly change the shapes of the watersheds to see how AGNPS will respond to these changes. A few, smaller, idealized watersheds are created to better investigate the possible reasons for the discrepancy between the lake deposition results in the previous section. Certain parameters of these watersheds are varied and results compared and contrasted with the actual watersheds studied.

The possibilities to vary the AGNPS inputs are almost boundless, for this thesis three variations are investigated.
1) It is possible that the shape of the watersheds studied could have an effect on the AGNPS output. Case studies with different watershed shape parameters may help the modeler to understand the results from AGNPS.
2) It appears that Pine Lakes watershed is a young watershed and Black Hawk watershed is a mature watershed. Figures 23 and 24 show the hypsometric curves of Pine Lakes and Black

Hawk lake watersheds. This study compares youthful versus mature watersheds.

3) AGNPS will automatically assign a channel slope value of one-half the land slope if no value for channel slope is given. Hack (1957) developed an exponential function for channel slope. Ideal case studies provide a method to evaluate the effect of channel slope on sedimentation.

Small, idealized watersheds may also be useful in the evaluation of the placement of BMPs. The decision of where to use BMPs within a watershed is often based solely on the criterion of cell soil erosion. If the goal is to most effectively reduce sediment deposition in a lake with a minimum amount of BMPs, then it may be necessary to include other criteria. It is hypothesized that the effect of each cell on the amount of lake sediment deposition is related not only to its erosion rate, but also the cell's position in the watershed. It is further hypothesized that the AGNPS program can be used to achieve the goal of most effectively reducing deposition.

To test this hypothesis with actual watersheds is burdensome. The AGNPS model solves for cell erosion, sediment generated above and within each cell, sediment yield, and percent deposition. Therefore, a general statement about a cell's contribution to lake sedimentation can be made with respect to the cell's erosion rate; but as shown in the

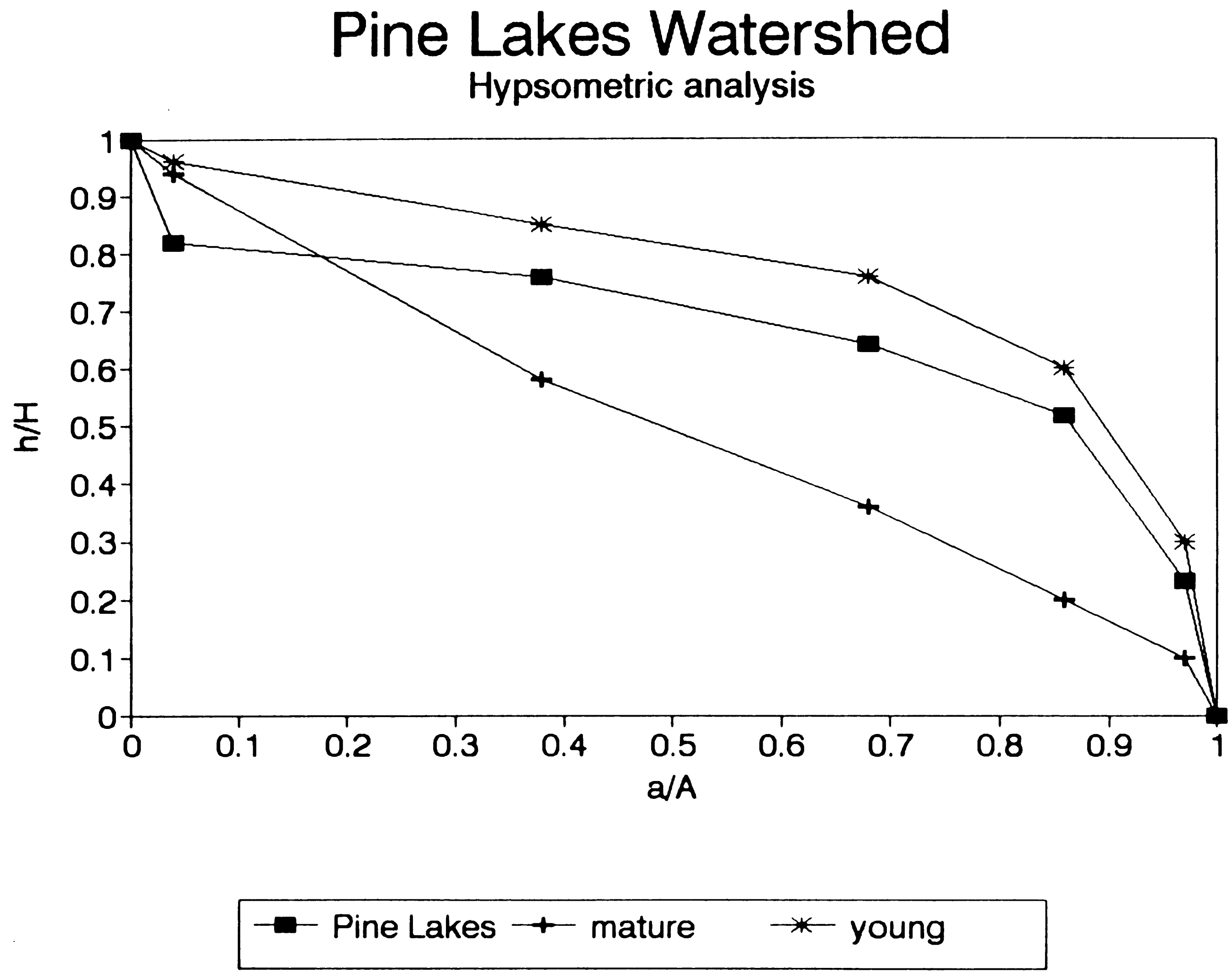


Figure 23. Hypsometric analysis of Pine Lakes watershed

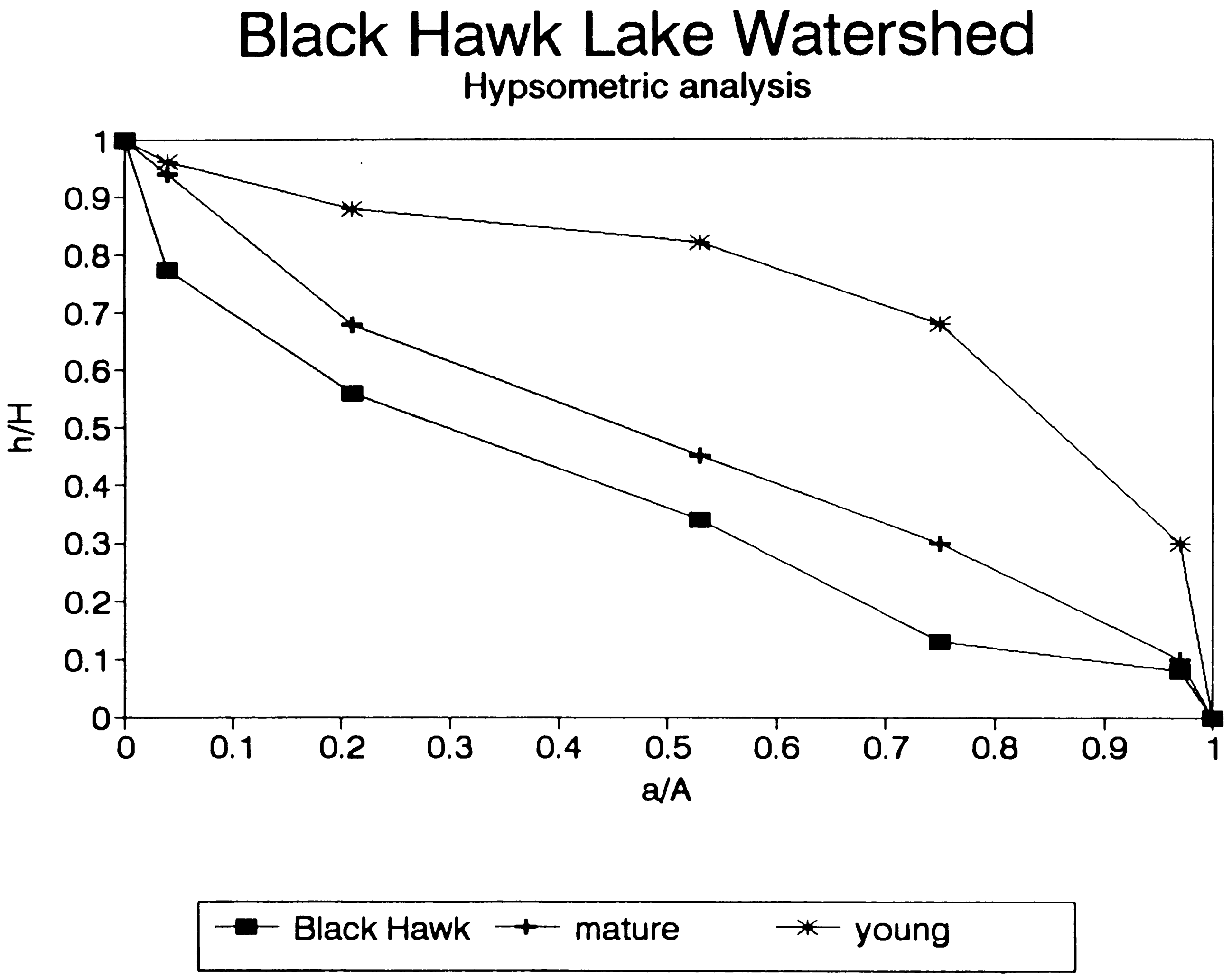


Figure 24. Hypsometric analysis of Black Hawk Lake watershed

previous section, other factors could be involved. It is impossible to know precisely how an individual cell in the watershed affects the lake's total sediment deposition because no provision exists in AGNPS for describing one cell's relationship to another in the output.

The contribution of an individual cell to a lake's sediment deposition can be determined from the AGNPS sediment solution if the flow route of the cell to the lake and the lake's trap efficiency are known. The flow route for a cell can be found by using the graphics display, for example the flow route for cell no.1 of the Pine Lake watershed is shown in Figure 25.

An equation can then be formed to solve for the cell's sediment contribution. Suppose a cell, cell C_i, is located in a lake's watershed. The sediment yield generated in cell C_i flows through cells C_n to the lake, cell C_L. The amount deposited in the lake (LD_i) from cell C_i, can be calculated by multiplying the sediment yield generated within the cell (SY_i) by one minus the percent deposition in decimal form ($\%depC_n$) for each cell it passes through, cells C_n and the lake's trap efficiency (LTE). This equation takes the form:

$$LD_i = SG_i * (1 - \%depC_n/100) * \ldots * LTE$$

where:

LD_i = the lake deposit from cell number i.

SG_i = the sediment generated from within cell number i.

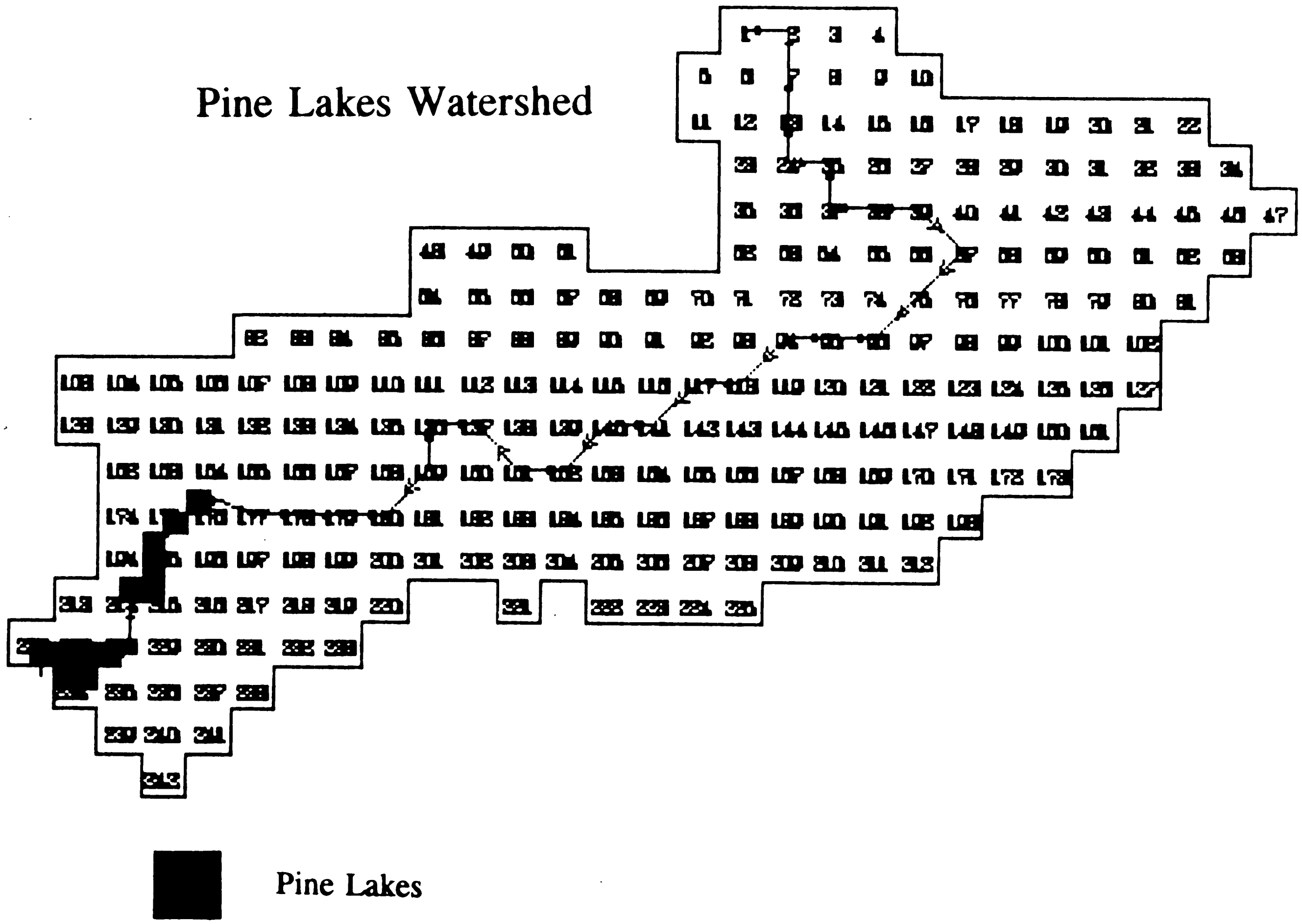


Figure 25. Flow route for cell no. 1 in the Pine Lakes watershed.

$\%depC_n$ = the percent deposition in each cell along the flow route. *LTE* = the lake' trap efficiency.

Table 6 shows an example watershed and the calculations necessary to compute the deposition from each watershed cell. Cell C is a lake and cells A and B are the lake's watershed. The example demonstrates that the cell with the highest soil erosion isn't always the cell with the highest contribution to lake deposition.

The Black Hawk and Pine Lakes watersheds each have about two hundred cells. If a unique equation is formulated for each cell, it is apparent that a tremendous amount of work is required to solve for each cell's sediment deposition contribution; therefore smaller, idealized watershed are used to analyze the contribution's of individual cells.

Description of Ideal Watersheds

Three ideal watersheds are generated to represent the range of watershed morphologies found in Iowa. These watersheds are termed diamond, parallel and dendritic; and for ease of discussion they are identified as DM, PR, and DR, respectively. Each basin is analyzed with five variations in land and channel slope, which are explained later. In each case, only the land and channel slopes are changed, all other AGNPS inputs remain constant. Cells with high numbers are able 6. Lake Example Watershed

A	B	C Lake Example

AGNPS Output					
Cell	Soil Erosion	Sediment		Yield	Deposition
		Above	Within		
	tons/ac	tons	tons	tons	%
A	5.00	0	200	120	40
B	4.00	120	160	168	40
C	0.00	168	0	33.6	80

eposition in C

From A: (200 tons)(1 - 0.4)(1 - 0.4)(0.80) = 57.6 tons

From B: (160 tons)(1 - 0.4)(0.80) = 76.8 tons

Total: 57.6 + 76.8 = 134.4 tons

r:

From cell C:

(Sediment Above + Sediment Within) - Yield = Deposition

(168 tons + 0 tons) - 33.6 tons = 134.4 tons

usually located close to the lakes in the watersheds and low numbers are in the high elevations.

The diamond (DM) watershed is formed by setting thirty-six 40 acre cells in a six by six block, shown in Figure 26. The lake occupies the cell in the lower right hand corner, no. 36. Flow lines are parallel to the sides of the block near the lake and diagonal down the center of the watershed.

The parallel (PR) watershed, shown in Figure 27, is formed by arranging thirty-six 40 acre cells in a three by twelve block. The lake is assumed to be in the center cell at one end of the block. Three main flow lines run longitudinally down the watershed.

The dendritic (DR) watershed of Figure 28 has a modified teardrop shape with the lake in the cell at the point of the teardrop. As with the other two watersheds, thirty-six cells of 40 acres are used. Flow lines in a dendritic watershed are random. Table 7 is a summary of the watershed parameters for these ideal watersheds and Pine Lakes and Black Hawk Lake watershed.

An initial run of AGNPS is made assuming a uniform slope of 2% and a channel slope of one-half the land slope. This is a simplifying assumption that is often used in AGNPS data collection. These runs will be classified with the case letters followed by 2%, e.g. DM2%.

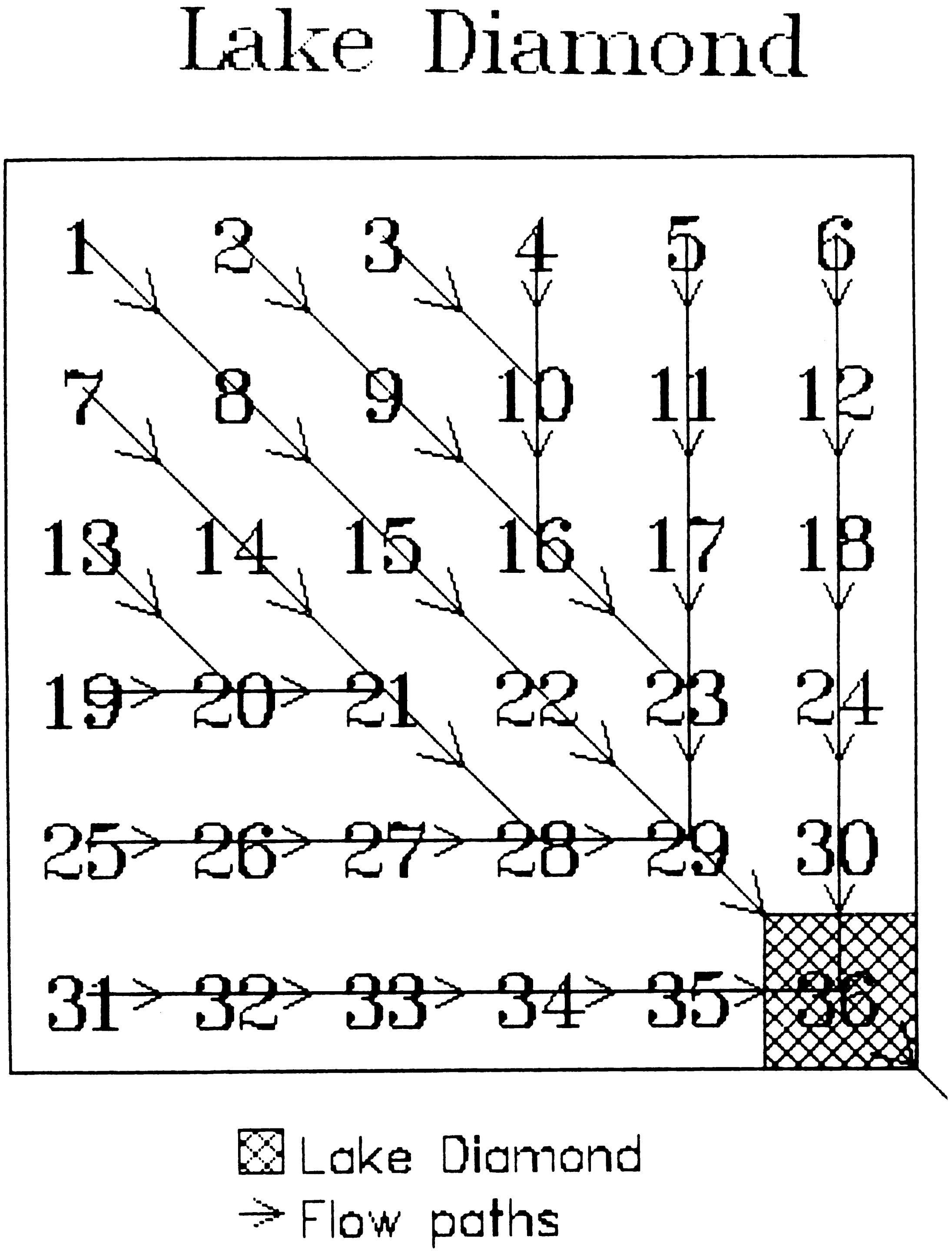


Figure 26. The Diamond Lake watershed from AGNPS.

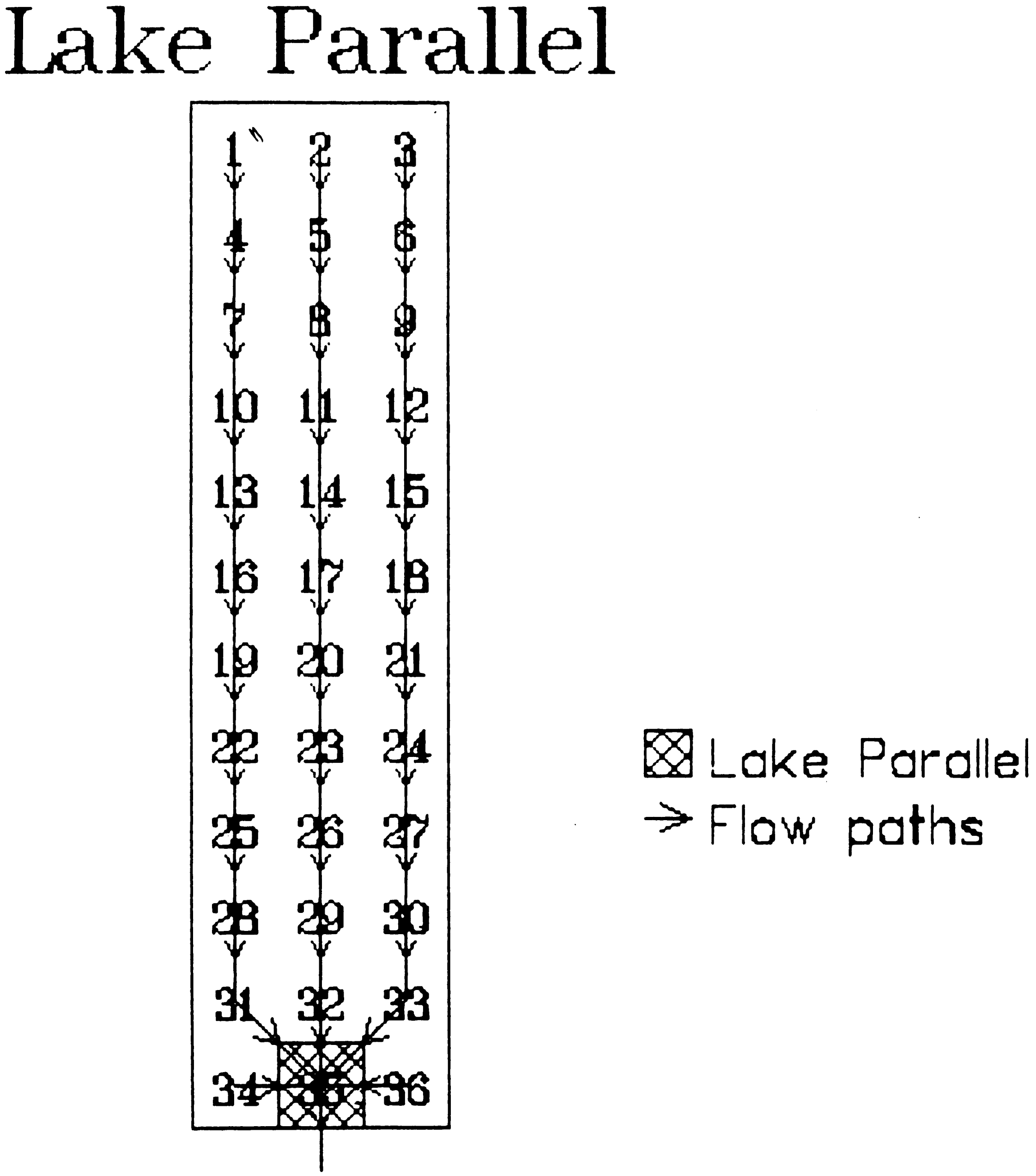


Figure 27. The Parallel lake watershed from AGNPS.

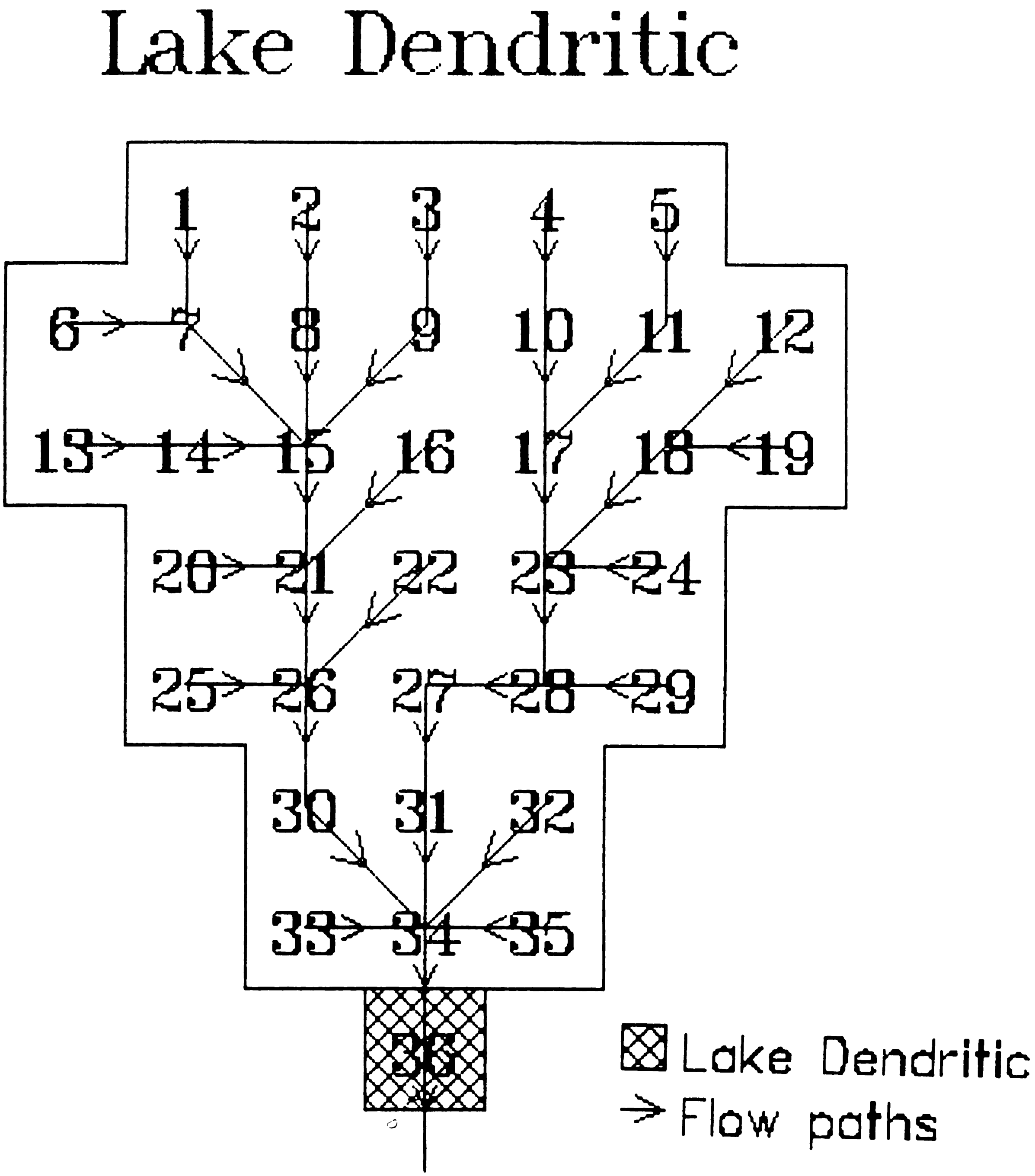


Figure 28. The Dendritic lake watershed from AGNPS.

Table 7. Watershed parameters for the actual and ideal watersheds

Watershed name	Watershed shape ratio		Drainage density (DD)	
	1/km	(1/mi)	km/km^2	(mi/mi^2)
Pine Lakes	0.28	(0.45)	1.22	(1.96)
Black Hawk	0.31	(0.49)	0.67	(1.08)
Parallel	0.33	(0.54)	0.94	(1.51)
Diamond	0.23	(0.37)	1.08	(1.74)
Dendritic	0.22	(0.35)	0.53	(0.85)

Additional computer runs are made assuming a mature and youthful watershed morphologies as described by Strahler (1957). This assumption varies the watershed hypsometry as shown in Figure 2. The channel slopes in both these cases are assumed to be one-half the cell slope. These cases are designated with a M5 or Y5 following the watershed designation.

The exponential function for channel slope (Hack, 1957) is used to describe the channel slope within the watershed. This function is described by the equation:

$$H = C - (k * \ln L)$$

where:

H = the elevation of the channel bottom at a point on the stream,

C = the elevation of the head of the stream,

L = the distance from the headwaters of the stream to that point.

k = a constant.

Computer runs are repeated using this function for channel slope combined with the mature and youthful watershed morphologies. The are designated with a ML or YL following the watershed designation.

Results of Case Studies

A spreadsheet program analyzes the AGNPS generated data with respect to each cell's contribution to lake sedimentation as shown in Table 8. Trap efficiencies for all cases are assumed to be 85% (Brune, 1953). The dendritic watershed has the least amount of deposition and the diamond shaped watershed has the greatest amount of deposition in this experiment.

Watersheds with mature morphology and exponential channel slope (DRML,DMML,PRML) have the least amount of deposition compared to the other land slope-channel slope combinations. The youthful watersheds with channel slopes that were one-half the land slopes (DRY5,DMY5,PRY5) have the greatest deposition among the land slope-channel slope combinations.

DR2%, DM2%, PR2% all have equal values of cell soil erosion. The youthful watersheds' cells with the highest amount of cell soil erosion are at the lower end of the watersheds near the lakes. The mature watersheds' cells with the highest amount of cell erosion are located at the upper end of the watersheds at the greatest distance from the lakes.

The cells with high amounts of deposition are clustered around the lakes in the youthful and uniform watersheds. This

Table 8. Results of the AGNPS computer runs on the case studies

Case	Deposition into lake (tons)	Rank in Subgroup	Overall Rank	Cells w/ highest deposition (tons)	Cell w/ highest erosion (tons/ac)
Diamond					
DM2%	5377	2	10	29,30,35	all
DMML	5547	3	12	3,4,13,19	1-7,13,19,25,31
DMM5	5850	5	14	13,19,3,4	1-7,13,19,25,31
DMYL	5269	1	9	29,30,35	29,30,35
DMY5	5605	4	13	35,30,31	29,30,35
Dendritic					
DR2%	5110	5	8	34,30,31	all
DRML	4707	3	5	1,6,2,3	1-7,12
DRM5	5040	4	7	1,6,2,3	1-7,12
DRYL	3915	1	1	34,31,35,33	34,31,33,35
DRY5	4145	2	2	34,31,35,33	34,31,33,35
Parallel					
PR2%	4532	2	4	31,32,33	all
PRML	4363	1	3	31,33,32	1-4,6
PRM5	4895	3	6	31,33,29	1-4,6
PRYL	5582	4	11	32,31,33	32,29,31,33,34
PRY5	6314	5	15	32,31,33	32,29,31,33,34

Rank of watersheds in decreasing order of deposition

	(tons)
1. Dendritic	22,917
2. Parallel	25,686
3. Diamond	27,648

Rank of slope-channel combinations in decreasing order of deposition

	(tons)
1. ML	14,617
2. YL	14,766
3. 2%	15,019
4. M5	15,785
5. Y5	16,064

is also true of the mature, parallel watershed. The mature dendritic and mature diamond watersheds have their cells with the maximum sediment deposition at the far reaches of the watershed near the watershed divide.

Therefore, in the cases of the two mature parallel watersheds (PRML,PRM5) the cells with maximum cell erosion and maximum lake deposition are completely different and are on opposite ends of the watershed. In all other cases, the cells with maximum lake deposition are either the cells with the maximum cell erosion or a subset of the cells with the maximum cell erosion.

A comparison between the youthful and mature ideal watersheds in Table 8 shows that the mature watersheds tended to have less deposition than the youthful watersheds. The Black Hawk Lake watershed is a mature watershed, as shown in Figure 24, therefore it is possible that AGNPS underestimates deposition in mature watersheds in comparison to youthful watersheds. This may be part of the reason why the AGNPS deposition estimate being less than the measured amount.

A third comparison is made between the use of channel slopes of one-half the land slope and Hack' exponential. In this case Hack's exponential had less deposition then the use of one-half the land slope in the ideal watersheds. Table 8 shows a comparison between the two methods in the mature, parallel case study. The one-half land slope for channel slopes assumption was used in both Pine Lakes and Black Hawk Lake watersheds analysis. In this case the use of Hack' exponential in Black Hawk Lake watershed would not appear to move the AGNPS estimated deposition closer to the measured deposition, it may in fact increase difference between the two.

The two methods of determining channel slope, one-half land slope and Hack's exponential are tested to see if there is a statistical difference between the two. The six pairs tested were: DMML-DMM5, DMYL-DMY5, DRML-DRM5, DRYL-DRY5, PRML-PRM5, PRYL-PRY5. The use of one-half the land slope for the channel slope increased the amount of estimated lake sediment deposition over the use of the Hack's exponential slope in each matched pair. Sufficient evidence by use of a matched pair hypothesis test (at $\alpha = 0.05$) to indicate that there is a difference between two methods. The statistical analysis is explained in Appendix B. Figure 29 is a hypsometric analysis of the exponential and one-half land slope channels for the mature parallel case study. Further tests using actual channel slope measurements are needed.

In the mature watersheds with a high watershed shape ratio like the parallel watersheds, the location of the cells that contribute the maximum amount of deposition shifts from the cells with high cell erosion in the upper reaches of the watershed to cells with moderately high cell erosion near the

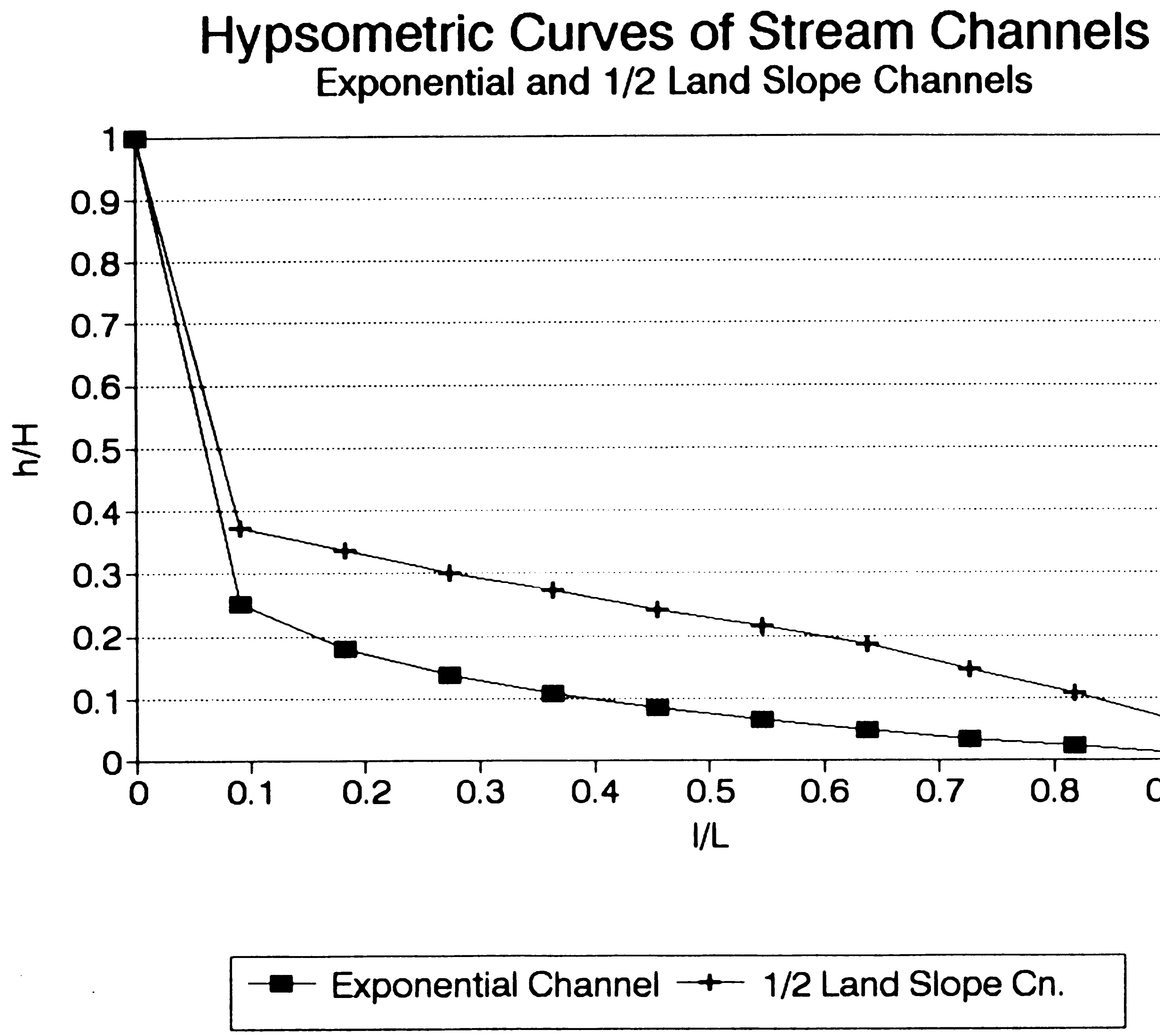


Figure 29. Channel curve for the mature, parallel case study

lake. More research is needed to determine if this is true of larger watersheds. Larger watersheds could also make it possible to determine if nearness to streams is also a factor in a cell's depositional relationship to the lake. No conclusion about stream-cell proximity can be drawn from the relatively small watersheds tested in this thesis because cells were never located less then two cells from a main channel.

The mature, parallel was the only ideal watershed age-watershed shape combination that has a significant change in the relationship between cell soil erosion and cell lake deposition contribution. A similar response is noted in the Black Hawk Lake watershed to the application of BMPs. The initial BMPs were applied to the cells with highest cell erosion. However, the greatest impact on lake deposition occurs when BMPs are applied to other cells with a lower cell erosion which were located closer to the lake. As concluded before with the mature parallel watershed, the cells with the highest cell soil erosion are not necessarily the cells with the greatest contribution to lake deposition.

CONCLUSION

The ability of AGNPS in its present form to model lake deposition is unclear. More study is required to determine the source of the wide discrepancy between the measured and AGNPS estimated lake deposition results. A possible reason has been postulated (mature watershed), but no conclusive evidence is forthcoming. It should be noted that the AGNPS program is being continuously modified with both an annualized model and a model especially for lakes, scheduled to be released in the near future.

Also it should be noted that AGNPS in its present form can estimate an individual cell's soil erosion; however the effect of that erosion on a downstream lake is unclear using the present output. A supplemental spreadsheet program enables the modeler to estimate each cell's contribution to the downstream lake's sediment deposition. Further tests of larger and more complex watersheds are needed to determine if the spreadsheet program is a useful addition to the AGNPS model.

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APPENDIX A

Overview of AGNPS

The Agricultural Non-Point Source Pollution (AGNPS) (USDA-ARS, 1987) model simulates runoff, sediment, and nutrient transport from agricultural watersheds for single storm events. The watersheds may vary in size from a few hectares to 20,000 hectares. The nutrients considered include nitrogen (N) and phosphorus (P). Both are popular fertilizers and can be sources of surface water pollution.

The model also considers point sources such as gullies, animal feedlots, and springs. Inputs from these point sources could be water,sediment,nutrients, and chemical oxygen demand (*COD*). *COD* measures the oxygen required to oxidize organic and oxidizable inorganic compounds in water and can indicate the level of surface water pollution.

The model operates on a cell basis. The watershed is divided into uniformly square areas. These areas or cells are the level in which information is placed in the model. The smaller the cells the more accurate the model. However, small cells mean increased time and labor to set up the model.

Runoff volume estimates are based on the SCS curve number method (USDA, 1972) and the rainfall. The curve number is an input into this model and is based on land use, soil type, and hydrologic soil condition. Peak runoff rate for each cell is estimated using an empirical relationship proposed by Smith and Williams (1980). Channel slope, drainage area, and watershed length are inputs into this relationship as is the runoff volume calculated above.

A modified version of the universal soil loss equation (USLE) is used to estimate upland erosion. This equation;

$$E = (EI)KLSCP(SSF)$$

uses an energy intensity (EI) factor which is the product of the storm total kinetic energy and maximum 30-minute intensity. Other inputs into the equation are the soil erodibility factor (K), topographic factor (LS), cover and management factor(C), supporting practice factor(P), and slope shape factor(SSF). These factors are calculated using procedures found in <u>Agricultural Handbook 537</u> (1978). This factors are described in detail in the literature review. Soil loss(E) is calculated for each cell in the watershed.

The detached sediment is routed through the watershed using procedures described by Foster and associates (1986) and Lane (1982). The basic routing equation is derived from the steady-state continuity equation as follows:

$$Q_s(x) = Q_s(O) + Q_{sl}(x/L_r) - {}_0\int^{x} (x)\,wdx$$

where $Q_s(x)$ is the sediment discharge at the downstream end of the channel reach.

$Q_s(O)$ is the stream discharge into the upstream end of the channel reach.

Q_{sl} is the lateral sediment inflow rate.

x is the downstream distance.

L_f is the reach length.

w is the channel width.

$D(x)$ is the deposition rate estimated as:

$$D(x) = [V_{ss}/q(x)]\ [q_s(x) - g_s(x)]$$

where V_{ss} is the particle fall velocity.

$q(x)$ is the discharge per unit width.

$q_s(x)$ is the sediment load per unit width.

$g'_s(x)$ is the effective transport capacity per unit width.

The effective transport capacity is calculated using a modification of the Bagnold stream power equation. It is:

$$g_s = \eta g_s = \eta k(\tau v^2/V_{ss})$$

where g_s is the transport capacity.

η is an effective transport factor.

k is the transport capacity factor.

τ is the shear stress.

v is the average channel flow velocity determined by Manning's equation.

The sediment load for each of the five particle size classes leaving a cell is defined as follows:

$$Q_s(x) = \left[\frac{2q(x)}{(2q(x) + \Delta x V_{ss})} \right] *$$
$$\left[Q_s(0) + Q_{sl}\frac{x}{L} - \frac{w\Delta x}{2} \left[\frac{V_{ss}}{q(0)}\right) [q_s(0) - g_s(0)] - \frac{V_{ss}}{q(x)} g_s(x)\right]\Big]$$

This equation is the basic routing equation that drives the AGNPS sediment transport model.

The model estimates transport of *N, P,* and *COD* by relationships adapted from Smith and Williams (1980) and a feedlot evaluation model (Young el al., 1982). Modifications have been made to account for the effects of soil texture variation. Chemical transport calculations are divided into soluble and sediment absorbed phases.

Explanation of Inputs into AGNPS

A) Cell number. Each cell in the watershed is identified by a number.

B) Cell division. Cells may be sub-divided into smaller cells.

C) Receiving cell number. The number of the cell into which the most significant portion of the runoff drains. It is derived from USGS topography maps.

D) Receiving cell division. Same as above.

E) Aspect. A single digit designating the principal direction of drainage from the cell. This can be one of eight possible directions, 1 being north and proceeding clockwise to 8 being northwest as shown in Figure 30.

F) SCS curve number. The runoff curve number or hydrologic soil-cover complex number used in the SCS equation for estimating direct runoff from storm rainfall. From Table 9 using soil group B and contoured row crop for soil condition a value of 75 was used for this analysis.

G) Land slope. The major slope, in percent rise, of the cell. It is derived from USGS topography maps.

H) Slope shape. An identification number used to indicate the dominant slope shape of the cell and can be uniform, concave, or convex as shown in Figure 31.

H) Slope length. Slope length is defined as the distance from the point of origin of overland flow to the point where either the slope decreases enough that deposition begins or runoff enters a well defined channel.

J) Manning's coefficient. Manning's roughness coefficient for channels is obtained from Table 10. A value of 0.05 is used throughout this analysis. This value is for cornstalks with

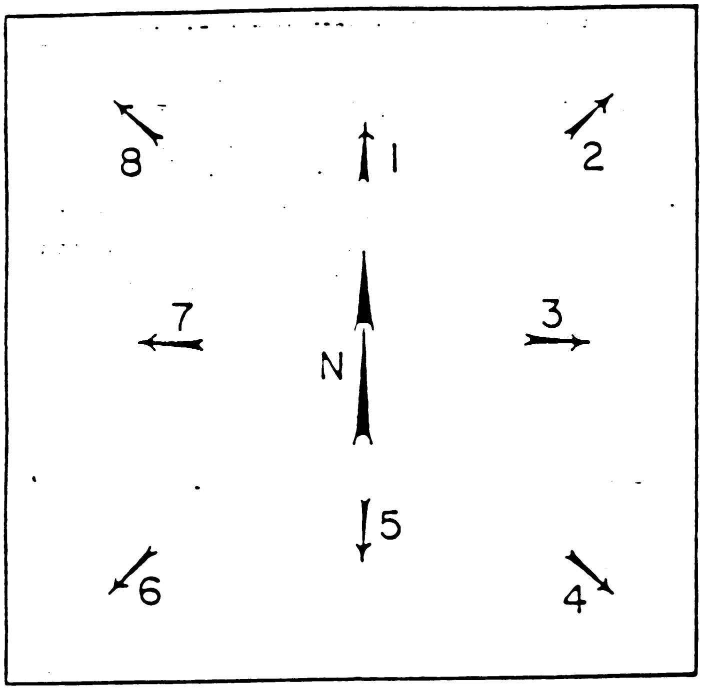

Figure 30. Identification number to indicate flow pa direction (USDA-ARS, 1987)

Table 9. Runoff curve numbers and surface-condition constants for various land-use situations (USDA-ARS, 1987)

Land-use condition	Surface-condition constant[1] c	Runoff curve number[2]			
		Soil group A	Soil group B	Soil group C	Soil group D
Fallow	0.22	77	86	91	94
Row crop					
Straight row	.05	67	78	85	89
Contoured	.29	65	75	82	86
Small grain	.29	63	74	82	85
Legumes or rotation meadow	.29	58	72	81	85
Pasture[3]					
Poor	.01	68	79	86	89
Fair	.15	49	69	79	84
Good	.22	39	61	74	80
Permanent meadow	.59	30	58	71	78
Woodland	.29	36	60	73	79
Forest with heavy litter	.59	25	55	70	77
Farmsteads	.01	59	74	82	86
Urban (21%-27% impervious surfaces)	.01	72	79	85	88
Grass waterway	1.00	49	69	79	84
Water	0	- - - - - - - - 100 - - - - - - - -			
Marsh	0	- - - - - - - - 85 - - - - - - - -			
Animal lot					
Unpaved		- - - - - - - - 91 - - - - - - - -			
Paved		- - - - - - - - 94 - - - - - - - -			
Roof area		- - - - - - - - 100 - - - - - - - -			

[1] Source: Young et al. (1982a).

[2] Source: U.S. Department of Agriculture, Soil Conservation Service (1976). Values given are for Antecedent Moisture Condition II.

[3] Pasture should be considered "poor" if it is heavily grazed with no mulch. "Fair" pasture has between 50% and 75% plant cover and is moderately grazed. "Good" pasture is lightly grazed and has more than 75% plant cover.

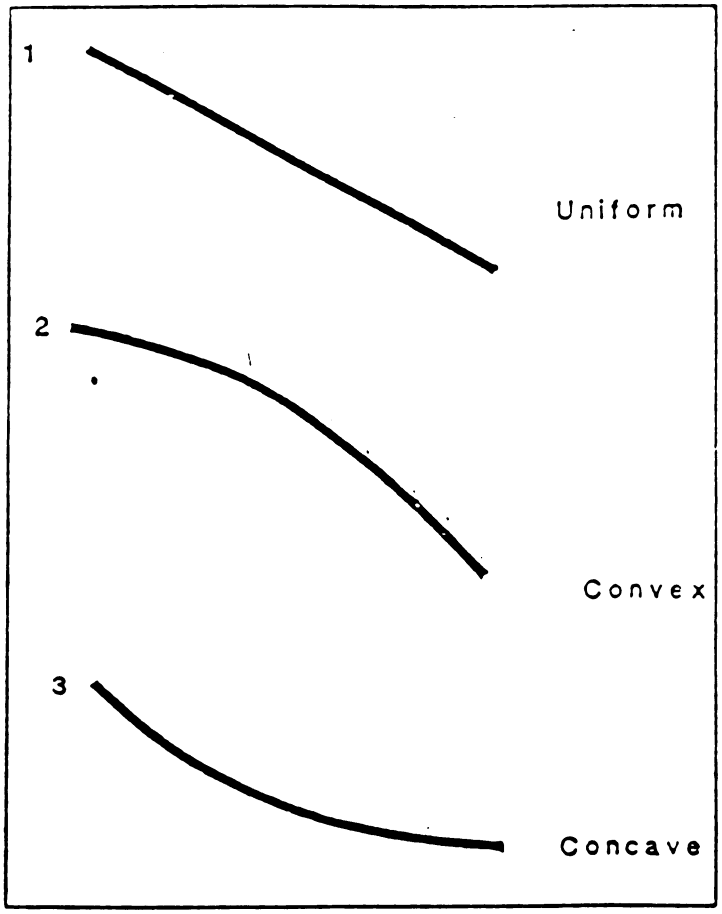

Figure 31. Identification numbers for slope shape (USDA-ARS, 1987)

Table 10. Manning's roughness coefficients for channelized flow (USDA-ARS, 1987)

Natural channels[1]

Description	n
Excavated or dredged channels	
Ordinary concrete	0.013
Earth, straight, uniform, and clean	.022
Same, but with some short grass or weeds	.027
Earth, winding and sluggish, with no vegetation	.025
Same, but with some grass or weeds	.030
Channels not maintained; weeds and some brush	.080
Natural streams	
Clean and straight; no rifts or deep pools	.030
Clean and winding; some pools and shoals	.040
Clean and winding; some weeds, stones, and pools	.048
Sluggish reaches with weeds and deep pools	.070

Cultivated land and waterways[2]

Cover and cover density	n
Smooth, bare soil	
less than 1 inch deep	0.030
1-2 inches deep	.033
2-4 inches deep	.038
4-6 inches deep	.045
Cornstalks (assumes residue stays in place and is not washed away)	
1 ton/acre	.050
2 tons/acre	.075
3 tons/acre	.100
4 tons/acre	.130
Wheat straw (assumes residue stays in place and does not wash away)	
1 ton/acre	.060
1.5 tons/acre	.100
2 tons/acre	.150
4 tons/acre	.250
Grass (assumes grass is erect and as deep as flow)	
Sparse	.040
Poor	.050
Fair	.060
Good	.080
Excellent	.130
Dense	.200
Very dense	.300

See footnotes at end of table.

Table 10. (continued) (USDA-ARS, 1987)

Cultivated land and waterways[2]	
Cover and cover density	n
Small grain (20% to full maturity--rows with flow)	
Poor, 7-inch rows	0.130
Poor, 14-inch rows	.130
Good, 7-inch rows	.300
Good, 14-inch rows	.200
Water or marsh[3]	.990

[1] Source: Chow (1959).

[2] Source: Foster et al. (1980).

[3] Value serves as a flag only to tell the computer that the surface is water.

one ton per acre of residue. It is also very close to the value (0.048) for natural streams that are clean and winding with some weeds, stones, and pools. A value of 0.99 is used for cells with marsh or water.

K) K-factor. The soil erodibility factor, the K-factor, is the same as the one used in the USLE. It is obtained from SCS soils data. If the cell is water or marsh a value of 0 is used.

L) C-factor. The C-factor is the cover and management factor used in the USLE. A value (0.68) corresponding to the worst case condition, fallow or seedbed periods, is used for cropland in this analysis. A value of 0.10 is used for woodland. If the cell is mainly marsh or water a value of 0 is used. Values are obtained from Wischmeier and Smith (1978).

M) P-factor. The support practice factor is the P-factor in the USLE. In the worst case situation a value of 1.0 is used. If the cell has terraces then a value is obtained from Table 11. Here a value of 0.29 is used for all cells with terraces. If the cell is mainly marsh or water 0 is used.

N) Surface condition constant. A value based on land use at the time of the storm to make adjustments for the time it takes overland runoff to channelize. Values are obtained from Table 9. For woodland and row crops a value of 0.29 is used.

Table 11. Sediment delivery, P-factor, for terraces (USDA-ARS, 1987)

Terrace grade (%)	P
Closed outlet[2]	[3]0.05
0 (level)	.10
.1	.13
.2	.17
.4	.29
.6	.49
.8	.83
≥.9	1.00

[1] Source: Foster and Highfill (1983). Potential for net erosion in terrace channels depending upon flow hydraulics and soil erodibility in the channels. If net erosion occurs, P>1.

[2] Includes terraces with underground outlet.

[3] Wischmeier and Smith (1978).

For pasture a value of 0.15 is used. For forest and permanent meadow a value of 0.59 is used.

O) Soil texture number. The major soil texture classification for the cell. The texture classes and their numbers to designate are;

Texture	Input value
Water	0
Sand	1
Silt	2
Clay	3
Peat	4

P) Fertilization level. A single digit designation of the level of fertilization. Range of input values is from 0 for no fertilizer to 4 for a high level of fertilization.

Q) Fertilizer availability factor. The percentage of fertilizer left in the top half inch of soil at the time of the storm. In this analysis a value of 25 is used for cells that are mainly cropland. Fertilizer availability factors for various tillage practices are shown in Table 12.

R) Point source indicator. A single digit designator of point sources in the cell, such as feedlots, springs, and waste treatment plants. A 0 indicates no point sources within the cell.

S) Gully source level. An estimate can be made of tons of gully erosion occurring within the cell. This amount would

Table 12. Fertilizer availability factors according

tillage practice (USDA-ARS, 1987)

Tillage practice[1]	Fertilizer availability factor (%)
Large offset disk	40
Moldboard plow	10
Lister	20
Chisel plow	67
Disk	50
Field cultivator	70
Row cultivator	50
Anhydrous applicator	85
Rod weeder	95
Planter	85
Smooth	100

[1] If more than one tillage has been made since the fertilizer application, use the product of the two factors divided by 100.

Source: Williams (1983).

then be included in the total amount of sediment eroded from the cell.

T) COD factor. The chemical oxygen demand (COD) factor is a value for the COD concentration from the cell. It is based of the land use of the cell. Values are determined from Table 13.

12. A value of 170 is used for cells that are in cropland. A value of 60 is used for cells that are in pasture. A value of 65 is used for cells that are forested. A value of 0 is used for cells that are water.

U) Impoundment factor. A factor indicating the presence of an impoundment terrace system within the cell. A zero would indicate no terrace in the cell. Any other number would be the number of impoundments in the terrace system. The area in acres draining into each impoundment and the diameter in inches of the outlet pipe are entered using the format (acres,inches).

V) Channel indicator. A single digit indicating the presence of a defined channel within the cell. A 0 indicates no defined channel, see Table 14.

Chemical oxygen demand (COD) factors for land-use situations (USDA-ARS, 1987)

Land use[1]	COD factor (mg/L)
Row crops	170
Small grain	80
Pasture and open	60
Alfalfa	20
Forested	65
Fallow	115
Farmsteads and urban nonresidential	80
Water	0
Marsh	25

[1] Sources of data are as follows: Row crops and fallow, Thompson et al. (1978), Harms et al. (1974); small grain and alfalfa, Harms et al. (1974); pasture and open land, Crow et al. (1979), Thompson et al. (1978), Harms et al. (1974); forested land, Timmons et al. (1977), R. A. Young, unpublished data; and farmstead and urban nonresidential, Weibel (1969).

Table 14. Identification numbers for channel types (USDA-ARS, 1987)

0 - water
1 - no definitive channel
2 - drainage ditch
3 - road ditch
4 - grass waterway
5 - ephemeral stream
6 - intermittent stream
7 - perennial stream

APPENDIX B

Statistical Tests of Hypothesis

Statistical tests of hypothesis are used to decide if a particular statement about population parameters is true. The elements of a statistical test are:

1) Null hypothesis, H_o, is a statement about one or more population parameters.

2) Alternative hypothesis, H_a, is a statement that will be accepted if the null hypothesis is rejected.

3) Test statistic is computed from the sample data.

4) Rejection region is the range of values of the test statistic in which the null hypothesis will be rejected.

The statistical test can result in only two outcomes, rejection or acceptance (not rejecting) of the null hypothesis. This can result in two errors summarized below.

		True State of Nature	
		H_o true (H_a false)	H_o true (H_a false)
Decision	Reject H_o	Type I error	Correct decision
	Do not reject H_o	Correct decision	Type II error

Rejecting the null hypothesis if it is true is a Type I error and the probability of making this error is denoted by the symbol α. If the null hypothesis is false and is not rejected then a Type II error has occurred and is denoted by the symbol β.

In this experiment a small sample hypothesis test about the difference between two population means where the populations are matched pairs is used. The null hypothesis is that there is no difference between populations using the exponential and one-half land slope channel shapes in the case studies.

$H_{\underline{o}}: (u_1 - u_2) = 0$

$H_{\underline{a}}: (u_1 - u_2) \neq 0$

where;

u^1 = the first population,

u^2 = the second population.

The test statistic is:

$t = \bar{a}/(s_d/(n)^{0.5})$

where;

$\bar{a}$ = the mean of the population differences,

s_d = the standard deviation of the population differences,

n = number of data points in the population.

The rejection region is:

$$t < t_{\alpha/2} \quad \text{or} \quad t > t_{\alpha/2}$$

From statistical tables for n-1 degrees of freedom $t_{\alpha/2} = 2.571$.

From Table 15, $t = 5.34$.

Therefore, reject null hypothesis, there is sufficient evidence that there is a difference between the two populations.

Table 15. Statistical analysis between two types of channel slopes

Statistical Analysis of Difference between log and 1/2 channels

	DMM	DMY	DRM	DRY	PRM	PRY	mean
1/2	5850.0	5605.0	5040.0	4145.0	4895.0	6314.0	5308.2
log	5269.0	5269.0	4707.0	3915.0	4363.0	5582.0	4850.8
	581.0	336.0	333.0	230.0	532.0	732.0	457.3
	337561.0	112896.0	110889.0	52900.0	283024.0	535824.0	
d-mean	123.7	-121.3	-124.3	-227.3	74.7	274.7	0.0
d-mean^2	15293.5	14721.7	15458.7	51680.3	5575.2	75442.0	35634.3
					standard deviation		188.8
						t=	5.9344

APPENDIX C

Sample Output in AGNPS for Pine Lakes Watershed

Cell Num	Cell Div	RCell Num	RCell Div	Asp	Crv Num	Lnd Slp	Slp Shp	Slp Len	Man Coef	K Fact	C Fact	P Fact	Surf Cons	Soil Text	Fert Lev	Avl Ft	Pnt Src	Gul Src	COD	Imp	Chn Ind
1	0	2	0	3	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
2	0	7	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
3	0	8	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
4	0	9	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
5	0	6	0	3	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
6	0	12	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
7	0	13	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
8	0	9	0	3	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
9	0	15	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
10	0	16	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
11	0	12	0	3	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
12	0	24	0	4	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
13	0	24	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
14	0	15	0	3	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
15	0	26	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
16	0	27	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
17	0	28	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
18	0	29	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
19	0	30	0	5	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
20	0	31	0	5	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
21	0	32	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
22	0	32	0	6	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
23	0	24	0	3	75	1.0	1	100.	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
24	0	25	0	3	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
25	0	37	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
26	0	38	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
27	0	39	0	5	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
28	0	27	0	7	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
29	0	30	0	3	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
30	0	41	0	6	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
31	0	42	0	6	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
32	0	31	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
33	0	32	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
34	0	33	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
35	0	24	0	2	75	0.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
36	0	24	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
37	0	38	0	3	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
38	0	39	0	3	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
39	0	57	0	4	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
40	0	57	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	3

Cell Num	Cell Div	RCell Num	RCell Div	Asp	Crv Num	Lnd Slp	Slp Shp	Slp Len	Man Coef	K Fact	C Fact	P Fact	Surf Cons	Soil Text	Fert Lev	Avl Ft	Pnt Src	Gul Src	COD	Imp	Chn Ind
41	0	57	0	6	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
42	0	41	0	7	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
43	0	31	0	1	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
44	0	43	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
45	0	33	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
46	0	45	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
47	0	46	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
48	0	64	0	5	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
49	0	65	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
50	0	65	0	6	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
51	0	50	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
52	0	71	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
53	0	72	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
54	0	73	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
55	0	75	0	4	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
56	0	75	0	5	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
57	0	75	0	6	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
58	0	57	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
59	0	41	0	8	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
60	0	42	0	8	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
61	0	43	0	8	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
62	0	45	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
63	0	45	0	8	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
64	0	86	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
65	0	86	0	6	75	3.0	1	100	0.050	0.32	0.68	1.00	0.15	3	3	25	0	0	170	0	5
66	0	65	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
67	0	66	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
68	0	91	0	4	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
69	0	70	0	3	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
70	0	92	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
71	0	93	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
72	0	94	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
73	0	74	0	3	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
74	0	96	0	5	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
75	0	96	0	6	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
76	0	75	0	7	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
77	0	76	0	7	75	2.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
78	0	99	0	6	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
79	0	78	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
80	0	79	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
81	0	61	0	8	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
82	0	107	0	5	75	4.0	2	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
83	0	107	0	6	75	4.0	2	125	0.050	0.32	0.68	1.00	0.15	2	3	25	0	0	60	0	4
84	0	109	0	5	75	2.0	2	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	1
85	0	111	0	4	75	3.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	1
86	0	111	0	5	75	3.5	2	125	0.050	0.32	0.68	1.00	0.05	2	3	25	0	0	170	1	7
87	0	86	0	7	75	5.0	2	125	0.050	0.32	0.68	0.29	0.15	2	3	25	0	0	170	0	7

Cell Num	Cell Div	RCeil Num	RCell Div	Asp	Crv Num	Lnd Slp	Slp Shp	Slp Len	Man Coef	K Fact	C Fact	P Fact	Surf Cons	Soil Text	Fert Lev	Avl Ft	Pnt Src	Gul Src	COD	Imp	Chn Ind
88	0	113	0	5	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
89	0	114	0	5	75	2.5	3	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
90	0	91	0	3	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
91	0	117	0	4	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
92	0	117	0	5	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
93	0	118	0	5	75	3.5	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
94	0	118	0	6	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
95	0	94	0	7	75	3.0	3	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
96	0	95	0	7	75	2.0	3	100	0.050	0.32	0.68	1.00	0.15	3	3	25	0	0	170	0	7
97	0	96	0	7	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
98	0	99	0	3	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
99	0	77	0	1	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
100	0	99	0	7	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
101	0	100	0	7	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
102	0	101	0	7	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
103	0	129	0	4	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
104	0	129	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	1
105	0	130	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	1
106	0	107	0	3	75	2.0	2	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	5
107	0	132	0	5	75	2.0	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	6
108	0	133	0	5	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
109	0	133	0	6	75	3.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	2	4
110	0	135	0	5	75	1.0	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	1
111	0	136	0	5	75	1.5	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	7
112	0	111	0	7	75	1.5	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	4	5
113	0	137	0	6	75	1.5	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	1	4
114	0	140	0	4	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
115	0	140	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
116	0	141	0	5	75	4.5	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
117	0	141	0	6	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
118	0	117	0	7	75	1.5	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	7
119	0	94	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
120	0	95	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
121	0	120	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
122	0	96	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
123	0	122	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
124	0	99	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
125	0	100	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
126	0	100	0	8	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
127	0	126	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
128	0	129	0	3	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	6
129	0	152	0	5	75	3.0	1	125	0.050	0.32	0.68	1.00	0.59	2	1	25	0	0	60	0	6
130	0	152	0	6	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	4
131	0	155	0	4	75	4.5	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	4	6
132	0	155	0	5	75	5.0	1	125	0.050	0.32	0.68	1.00	0.59	2	2	25	0	0	60	0	6
133	0	155	0	6	75	5.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	6
134	0	133	0	7	75	4.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	6	5

Cell Num	Cell Div	RCell Num	RCell Div	Asp	Crv Num	Lnd Slp	Slp Shp	Slp Len	Man Coef	K Fact	C Fact	P Fact	Surf Cons	Soil Text	Fert Lev	Avl Ft	Pnt Src	Gul Src	COD	Imp	Chn Ind
135	0	158	0	5	75	4.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	4	5
136	0	159	0	5	75	4.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	2	7
137	0	136	0	7	75	5.0	3	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	2	7
138	0	137	0	7	75	4.0	2	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	1	5
139	0	162	0	5	75	4.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	5
140	0	162	0	6	75	4.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	5
141	0	140	0	7	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	7
142	0	141	0	7	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
143	0	166	0	5	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
144	0	119	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
145	0	120	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
146	0	122	0	2	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
147	0	122	0	1	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
148	0	122	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
149	0	148	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
150	0	149	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
151	0	126	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
152	0	175	100	4	75	10.0	1	100	0.050	0.32	0.68	0.29	0.15	2	0	0	0	0	60	1	6
153	0	175	200	5	75	8.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
154	0	176	200	5	75	8.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
155	0	177	0	5	75	8.0	1	100	0.050	0.32	0.68	1.00	0.15	2	0	0	0	0	60	0	6
156	0	155	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
157	0	158	0	3	75	3.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	5	5
158	0	179	0	6	75	3.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	1
159	0	180	0	6	75	4.0	1	125	0.050	0.32	0.68	1.00	0.15	2	1	25	0	0	60	0	7
160	0	137	0	1	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	1
161	0	137	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	7
162	0	161	0	7	75	2.0	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	2	7
163	0	162	0	7	75	3.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	7
164	0	140	0	8	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	7
165	0	141	0	8	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
166	0	165	0	7	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
167	0	166	0	7	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
168	0	145	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
169	0	170	0	3	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
170	0	147	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
171	0	147	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
172	0	149	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
173	0	172	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
174	0	194	0	5	75	8.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
175	100	175	400	4	75	8.0	1	100	0.050	0.32	0.10	1.00	0.59	3	0	0	0	0	60	0	5
175	200	175	400	5	75	8.0	1	100	0.050	0.32	0.10	1.00	0.59	3	0	0	0	0	60	0	5
175	300	175	400	3	75	8.0	1	100	0.050	0.32	0.10	1.00	0.59	3	0	0	0	0	60	0	5
175	400	195	100	6	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	3	0	0	0	0	0	0	0
176	100	175	400	6	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
176	200	176	100	7	75	1.0	1	100	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
176	300	175	400	7	75	6.0	1	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5

Cell Num	Cell Div	RCell Num	RCell Div	Asp	Crv Num	Lnd Slp	Slp Shp	Slp Len	Man Coef	K Fact	C Fact	P Fact	Surf Cons	Soil Text	Fert Lev	Avl Ft	Pnt Src	Gul Src	COD	Imp	Chn Ind
176	400	176	100	8	75	6.0	1	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
177	0	176	200	7	75	6.0	1	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
178	0	177	0	7	75	6.0	3	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	3
179	0	178	0	7	75	6.0	3	125	0.050	0.32	0.68	1.00	0.29	2	2	25	0	0	170	0	5
180	0	179	0	7	75	8.0	3	100	0.050	0.32	0.68	1.00	0.15	2	1	25	0	0	60	0	5
181	0	180	0	7	75	8.0	3	100	0.050	0.32	0.68	1.00	0.15	2	3	25	0	0	60	0	6
182	0	159	0	8	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
183	0	161	0	1	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
184	0	162	0	1	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
185	0	162	0	8	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
186	0	185	0	7	75	4.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
187	0	165	0	1	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
188	0	166	0	1	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
189	0	166	0	8	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
190	0	167	0	8	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
191	0	170	0	2	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
192	0	170	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
193	0	171	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
194	0	195	100	3	75	9.0	2	100	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
195	100	195	300	5	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	3	0	0	0	0	0	0	0
195	200	195	100	7	75	8.0	3	4	0.050	0.32	0.10	1.00	0.29	3	0	0	0	0	60	0	5
195	300	215	100	5	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	3	0	0	0	0	0	0	0
195	400	195	300	7	75	8.0	3	0	0.050	0.32	0.10	1.00	0.29	3	0	0	0	0	60	0	5
196	0	195	400	7	75	6.0	2	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
197	0	217	0	5	75	4.0	2	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
198	0	217	0	6	75	4.0	2	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	5
199	0	179	0	1	75	4.0	2	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	2	5
200	0	180	0	1	75	4.0	2	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
201	0	181	0	1	75	4.0	2	125	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
202	0	201	0	7	75	3.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
203	0	183	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
204	0	185	0	2	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
205	0	185	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
206	0	185	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
207	0	206	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	6
208	0	188	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
209	0	188	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
210	0	190	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
211	0	191	0	1	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
212	0	191	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	4
213	0	227	100	5	75	4.0	1	125	0.050	0.32	0.68	1.00	0.59	2	3	25	0	0	170	0	5
214	100	214	200	3	75	6.0	2	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
214	200	214	400	5	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
214	300	228	200	4	75	6.0	2	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
214	400	228	200	5	75	6.0	2	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	1	7
215	100	214	200	7	75	0.0	2	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
215	200	215	100	7	75	6.0	2	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5

Cell Num	Cell Div	RCell Num	RCell Div	Asp	Crv Num	Lnd Slp	Slp Shp	Slp Len	Man Coef	K Fact	C Fact	P Fact	Surf Cons	Soil Text	Fert Lev	Avl Ft	Pnt Src	Gul Src	COD	Imp	Chn Ind
215	300	215	100	1	75	6.0	2	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
215	400	215	300	7	75	6.0	2	125	0.050	0.32	0.10	1.00	0.29	2	0	0	0	0	60	0	5
216	0	230	0	5	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
217	0	230	0	6	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	6
218	0	217	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
219	0	232	0	6	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
220	0	200	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
221	0	203	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
222	0	205	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
223	0	206	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
224	0	206	0	8	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	5
225	0	224	0	7	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	3	3	25	0	0	170	0	1
226	100	226	400	4	75	5.0	1	125	0.050	0.32	0.68	1.00	0.29	2	0	0	0	0	60	0	5
226	200	226	400	5	75	5.0	1	125	0.050	0.32	0.68	1.00	0.29	2	0	0	0	0	60	0	5
226	300	226	400	3	75	5.0	1	125	0.050	0.32	0.68	1.00	0.29	2	0	0	0	0	60	0	5
226	400	243	0	5	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	1	0
227	100	227	300	5	75	5.0	1	125	0.050	0.32	0.68	1.00	0.29	2	0	0	0	0	60	0	5
227	200	227	400	5	75	5.0	1	125	0.050	0.32	0.68	1.00	0.29	2	0	0	0	0	60	0	5
227	300	226	400	7	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
227	400	234	200	5	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
228	100	228	300	5	75	4.0	1	125	0.050	0.32	0.10	1.00	0.59	2	0	0	0	0	60	0	5
228	200	228	400	5	75	4.0	1	125	0.050	0.32	0.10	1.00	0.59	2	0	0	0	0	60	0	5
228	300	227	400	7	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
228	400	228	300	7	75	4.0	1	125	0.050	0.32	0.10	1.00	0.59	2	0	0	0	0	60	0	5
229	0	228	400	7	75	6.0	1	125	0.050	0.32	0.10	1.00	0.59	2	3	0	0	0	60	0	5
230	0	229	0	7	75	6.0	1	125	0.050	0.32	0.68	0.29	0.29	2	1	25	0	0	170	2	7
231	0	230	0	7	75	5.0	1	125	0.050	0.32	0.68	1.00	0.29	2	0	0	0	0	60	0	6
232	0	231	0	7	75	3.0	1	125	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	6
233	0	232	0	7	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	4
234	100	227	300	1	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
234	200	234	100	7	75	0.0	1	0	0.990	0.00	0.00	0.00	0.00	2	0	0	0	0	0	0	0
234	300	234	100	1	75	6.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	1	5
234	400	234	200	1	75	6.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	2	5
235	0	234	200	7	75	6.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	4	5
236	0	229	0	1	75	6.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	5
237	0	229	0	8	75	2.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	6
238	0	231	0	1	75	1.0	1	100	0.050	0.32	0.68	1.00	0.29	2	3	25	0	0	170	0	5
239	0	235	0	1	75	3.0	1	125	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	6
240	0	235	0	8	75	2.0	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	5
241	0	236	0	8	75	1.0	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	1	1
242	0	239	0	8	75	1.0	1	100	0.050	0.32	0.68	0.29	0.29	2	3	25	0	0	170	3	1

Sample Output Summary for Pine Lakes Watershed

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                              Watershed Summary

Watershed Studied                                        Pine Lake
The area of the watershed is                                  9680 acres
The area of each cell is                                     40.00 acres
The characteristic storm precipitation is                     5.00 inches
The storm energy-intensity value is                             80

                        Values at the Watershed Outlet
Cell number                                                    226 400
Runoff volume                                                  2.3 inches
Peak runoff rate                                              3424 cfs
Total Nitrogen in sediment                                    0.80 lbs/acre
Total soluble Nitrogen in runoff                              1.44 lbs/acre
Soluble Nitrogen concentration in runoff                      2.76 ppm
Total Phosphorus in sediment                                  0.40 lbs/acre
Total soluble Phosphorus in runoff                            0.25 lbs/acre
Soluble Phosphorus concentration in runoff                    0.49 ppm
Total soluble chemical oxygen demand                         88.48 lbs/acre
Soluble chemical oxygen demand concentration in runoff         169 ppm
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ample Condensed Soil Loss Output for Pine Lakes Watershed

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                          Condensed Soil Loss
                   RUNOFF                                SEDIMENT
          Drainage        Generated Peak   Cell      Generated
Cell        Area  Volume  Above    Rate  Erosion  Above   Within    Yield   Depo
Num Div  (acres) (in.)    (%)     (cfs)   (t/a)  (tons)  (tons)    (tons)   (%)

  1 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
  2 000     80   2.45    50.0     194    2.24     58.38   89.79    112.40   24
  3 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
  4 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
  5 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
  6 000     80   2.45    50.0     158    2.24     58.38   89.79     92.15   38
  7 000    120   2.45    66.7     254    2.24    112.40   89.79    159.74   21
  8 000     80   2.45    50.0     158    2.24     58.38   89.79     92.15   38
  9 000    160   2.45    75.0     279    2.24    150.53   89.79    196.58   18
 10 000     40   2.45     0.0     140    5.33      0.00  213.26    144.40   32
 11 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
 12 000    160   2.45    75.0     320    3.49    150.53  139.63    253.81   13
 13 000    160   2.45    75.0     365    4.21    159.74  168.29    289.16   12
 14 000     40   2.45     0.0     136    4.21      0.00  168.29    113.03   33
 15 000    240   2.45    83.3     451    4.21    309.61  168.29    431.08   10
 16 000     80   2.45    50.0     168    4.21    144.40  168.29    182.77   42
 17 000     40   2.45     0.0     259    4.21      0.00  168.29    138.48   18
 18 000     40   2.45     0.0     140    5.33      0.00  213.26    144.40   32
 19 000     40   2.45     0.0     240    3.49      0.00  139.63    112.52   19
 20 000     40   2.45     0.0     132    3.49      0.00  139.63     93.17   33
 21 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
 22 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
 23 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
 24 000    480   2.45    91.7     731    2.24    709.02   89.79    690.95   14
 25 000    520   2.45    92.3     749    2.24    690.95   89.79    709.83    9
 26 000    280   2.45    85.7     440    2.24    431.08   89.79    464.42   11
 27 000    200   2.45    80.0     333    2.84    382.86  113.46    436.36   12
 28 000     80   2.45    50.0     311    2.84    138.48  113.46    200.09   21
 29 000     80   2.45    50.0     158    2.24    144.40   89.79    141.55   40
 30 000    160   2.45    75.0     279    2.24    254.07   89.79    277.26   19
 31 000    640   2.45    93.8     972    2.24    975.51   89.79    957.87   10
 32 000    400   2.45    90.0     674    2.24    523.17   89.79    546.79   11
 33 000    280   2.45    85.7     524    2.24    386.36   89.79    406.42   15
 34 000     40   2.45     0.0     118    2.24      0.00   89.79     58.38   35
 35 000     40   2.45     0.0     102    1.72      0.00   68.62     42.95   37
 36 000     40   2.45     0.0     166    2.24      0.00   89.79     64.73   28
 37 000    560   2.45    92.9     875    3.49    709.83  139.63    803.56    5
 38 000    880   2.45    95.5    1183    2.84   1267.99  113.46   1295.11    6
 39 000   1120   2.45    96.4    1445    2.84   1731.47  113.46   1778.42    4
 40 000     40   2.45     0.0     282    4.21      0.00  168.29    142.26   15
 41 000    960   2.45    95.8    1551    4.21   1481.63  168.29   1588.20    4
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Condensed Soil Loss

		RUNOFF					SEDIMENT			
Cell Num	Div	Drainage Area (acres)	Volume (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
42	000	720	2.45	94.4	1219	4.21	1016.24	168.29	1145.99	3
43	000	160	2.45	75.0	401	4.21	205.57	168.29	335.55	10
44	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
45	000	200	2.45	80.0	470	3.49	229.15	139.63	327.98	11
46	000	80	2.45	50.0	194	2.24	58.38	89.79	112.40	24
47	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
48	000	40	2.45	0.0	147	7.60	0.00	303.98	208.04	32
49	000	40	2.45	0.0	140	5.33	0.00	213.26	144.40	32
50	000	80	2.45	50.0	238	4.21	93.17	168.29	221.59	15
51	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
52	000	40	2.45	0.0	136	4.21	0.00	168.29	113.03	33
53	000	40	2.45	0.0	136	4.21	0.00	168.29	113.03	33
54	000	40	2.45	0.0	140	5.33	0.00	213.26	144.40	32
55	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
56	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
57	000	2200	2.45	98.2	2596	2.84	3602.04	113.46	3559.89	4
58	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
59	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
60	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
61	000	80	2.45	50.0	194	2.24	58.38	89.79	112.40	24
62	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
63	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
64	000	80	2.45	50.0	168	4.21	208.04	168.29	178.08	53
65	000	240	2.45	83.3	629	4.99	560.89	199.45	690.05	9
66	000	80	2.45	50.0	229	3.49	93.17	139.63	194.90	16
67	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
68	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
69	000	40	2.45	0.0	140	5.33	0.00	213.26	144.40	32
70	000	80	2.45	50.0	189	5.33	144.40	213.26	237.36	34
71	000	80	2.45	50.0	174	5.33	113.03	213.26	196.50	40
72	000	80	2.45	50.0	261	5.33	113.03	213.26	317.93	3
73	000	80	2.45	50.0	189	5.33	144.40	213.26	237.36	34
74	000	120	2.45	66.7	221	4.21	237.36	168.29	284.22	30
75	000	2920	2.45	98.6	4013	7.60	4962.14	303.98	5188.49	1
76	000	600	2.45	93.3	1014	7.60	993.24	303.98	1215.92	6
77	000	560	2.45	92.9	896	4.21	877.46	168.29	993.24	5
78	000	120	2.45	66.7	419	5.33	171.08	213.26	334.89	13
79	000	80	2.45	50.0	296	3.49	64.73	139.63	171.08	16
80	000	40	2.45	0.0	166	2.24	0.00	89.79	64.73	28
81	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
82	000	40	2.45	0.0	766	9.88	0.00	395.18	388.29	2
83	000	40	2.45	0.0	319	9.88	0.00	395.18	323.38	18
84	000	40	2.45	0.0	132	4.54	0.00	181.52	106.42	41

Condensed Soil Loss

			RUNOFF				SEDIMENT			
Cell Num	Div	Drainage Area (acres)	Volume (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Depo (%)
85	000	40	2.45	0.0	140	4.99	0.00	199.45	119.19	40
86	000	400	1.53	93.5	717	8.10	1001.96	324.02	1105.60	17
87	000	40	2.45	0.0	359	3.92	0.00	156.86	133.84	15
88	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
89	000	40	2.45	0.0	136	3.70	0.00	148.10	99.55	33
90	000	40	2.45	0.0	267	7.60	0.00	303.98	249.08	18
91	000	120	2.45	66.7	369	7.60	342.25	303.98	545.28	16
92	000	120	2.45	66.7	279	7.60	237.36	303.98	485.74	10
93	000	120	2.45	66.7	251	6.23	196.50	249.25	395.64	11
94	000	4200	2.45	99.0	5109	5.33	8024.15	213.26	8106.42	2
95	000	4000	2.45	99.0	4946	4.69	7433.16	187.67	7511.32	1
96	000	3800	2.45	98.9	4482	3.07	7095.44	122.87	7043.28	2
97	000	40	2.45	0.0	255	5.33	0.00	213.26	173.48	19
98	000	40	2.45	0.0	124	2.84	0.00	113.46	74.68	34
99	000	520	2.45	92.3	765	2.84	863.46	113.46	877.46	10
100	000	280	2.45	85.7	450	2.84	330.30	113.46	395.52	11
101	000	80	2.45	50.0	154	2.84	74.68	113.46	106.05	44
102	000	40	2.45	0.0	124	2.84	0.00	113.46	74.68	34
103	000	40	2.45	0.0	166	2.24	0.00	89.79	57.69	36
104	000	40	2.45	0.0	118	2.24	0.00	89.79	51.24	43
105	000	40	2.45	0.0	118	2.24	0.00	89.79	51.24	43
106	000	40	1.01	0.0	111	1.32	0.00	52.64	18.44	65
107	000	160	1.20	83.1	483	1.01	730.11	40.49	507.87	34
108	000	40	2.45	0.0	240	3.49	0.00	139.63	103.48	26
109	000	80	1.73	58.6	216	1.55	106.42	61.85	130.73	22
110	000	40	1.44	0.0	74	0.65	0.00	26.04	9.68	63
111	000	520	1.39	95.0	688	0.82	1232.06	32.90	1126.45	11
112	000	40	0.55	0.0	55	0.82	0.00	32.90	7.27	78
113	000	80	2.08	54.1	194	0.82	93.17	32.90	100.08	21
114	000	80	2.45	50.0	142	2.24	99.55	89.79	94.84	50
115	000	40	2.45	0.0	166	2.24	0.00	89.79	64.73	28
116	000	40	2.45	0.0	340	8.69	0.00	347.62	305.90	12
117	000	4640	2.45	99.1	4658	2.84	9393.97	113.46	9262.91	3
118	000	4360	2.45	99.1	4483	2.84	8502.06	113.46	8362.95	3
119	000	80	2.45	50.0	229	3.49	93.17	139.63	194.90	16
120	000	160	2.45	75.0	497	3.49	305.83	139.63	389.88	12
121	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
122	000	680	2.45	94.1	1054	3.49	1414.46	139.63	1449.25	7
123	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
124	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
125	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
126	000	120	2.45	66.7	279	2.24	116.75	89.79	165.87	20
127	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
128	000	40	2.45	0.0	285	5.33	0.00	213.26	168.02	21

Condensed Soil Loss

			RUNOFF					SEDIMENT		
		Drainage		Generated	Peak	Cell	Generated			
Cell		Area	Volume	Above	Rate	Erosion	Above	Within	Yield	Depo
Num	Div	(acres)	(in.)	(%)	(cfs)	(t/a)	(tons)	(tons)	(tons)	(%)
129	000	160	2.45	75.0	443	5.33	276.95	213.26	375.55	23
130	000	80	2.45	50.0	237	5.33	51.24	213.26	193.94	27
131	000	40	0.78	0.0	99	2.52	0.00	100.81	30.21	70
132	000	200	2.45	74.4	626	10.40	507.87	416.08	829.17	10
133	000	200	2.45	74.9	472	10.40	259.90	416.08	556.86	18
134	000	40	0.68	0.0	87	2.20	0.00	88.16	25.70	71
135	000	80	1.27	53.2	152	2.20	9.68	88.16	48.04	51
136	000	6880	1.49	99.6	7310	2.20	14742.04	88.16	14624.52	1
137	000	6320	1.61	99.6	7170	2.65	13727.52	106.18	13615.59	2
138	000	40	2.09	0.0	233	2.87	0.00	114.60	75.80	34
139	000	40	1.01	0.0	123	2.20	0.00	88.16	31.25	65
140	000	5400	1.19	99.6	6274	2.20	11875.50	88.16	11718.26	2
141	000	5200	2.45	99.2	6166	7.60	11457.77	303.98	11547.91	2
142	000	40	2.45	0.0	267	7.60	0.00	303.98	249.08	18
143	000	40	2.45	0.0	185	3.49	0.00	139.63	102.45	27
144	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
145	000	80	2.45	50.0	296	3.49	112.52	139.63	193.31	23
146	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
147	000	360	2.45	88.9	861	5.33	831.57	213.26	965.66	8
148	000	200	2.45	80.0	358	3.49	192.93	139.63	277.90	16
149	000	160	2.45	75.0	275	2.24	154.58	89.79	192.93	21
150	000	40	2.45	0.0	152	2.24	0.00	89.79	62.44	30
151	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
152	000	280	1.55	90.4	828	6.94	569.49	277.62	609.01	28
153	000	40	2.45	0.0	387	17.28	0.00	691.30	596.82	14
154	000	40	2.45	0.0	387	17.28	0.00	691.30	596.82	14
155	000	520	2.45	90.2	1152	17.28	1519.72	691.30	2060.57	7
156	000	40	2.45	0.0	240	3.49	0.00	139.63	103.48	26
157	000	40	0.67	0.0	86	1.55	0.00	61.85	17.50	72
158	000	160	1.24	73.1	157	1.55	65.54	61.85	56.01	56
159	000	6960	2.45	99.4	7337	7.60	14792.54	303.98	14978.37	1
160	000	40	2.45	0.0	147	7.60	0.00	303.98	183.83	40
161	000	6120	2.45	99.3	6828	3.49	13355.29	139.63	13367.81	1
162	000	5960	1.98	99.4	6016	1.01	13158.40	40.49	12933.95	2
163	000	40	1.19	0.0	151	1.55	0.00	61.85	26.36	57
164	000	40	2.45	0.0	285	5.33	0.00	213.26	168.02	21
165	000	440	2.45	90.9	1122	7.60	1447.74	303.98	1639.88	6
166	000	360	2.45	88.9	970	7.60	1063.46	303.98	1268.05	7
167	000	120	2.45	66.7	488	5.33	278.43	213.26	426.89	13
168	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
169	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
170	000	240	2.45	83.3	590	3.49	569.63	139.63	623.04	12
171	000	80	2.45	50.0	345	3.49	112.52	139.63	208.52	17
172	000	80	2.45	50.0	158	2.24	58.38	89.79	92.15	38

Condensed Soil Loss

			RUNOFF						SEDIMENT	
		Drainage		Generated	Peak	Cell	Generated			
Cell		Area	Volume	Above	Rate	Erosion	Above	Within	Yield	Depo
Num	Div	(acres)	(in.)	(%)	(cfs)	(t/a)	(tons)	(tons)	(tons)	(%)
173	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
174	000	40	2.45	0.0	431	17.28	0.00	691.30	637.55	8
175	100	290	2.45	96.4	810	2.54	609.01	25.42	607.36	4
175	200	50	2.45	80.0	384	2.54	596.82	25.42	518.06	17
175	300	10	2.45	0.0	124	2.54	0.00	25.42	22.21	13
175	400	8480	2.45	99.9	4202	0.00	4080.90	0.00	2563.96	37
176	100	8110	2.45	99.9	4435	0.00	18568.63	0.00	2918.15	84
176	200	8090	2.45	99.9	6294	0.33	19444.93	3.30	18553.50	5
176	300	10	2.45	0.0	106	1.92	0.00	19.23	15.13	21
176	400	10	2.45	0.0	106	1.92	0.00	19.23	15.13	21
177	000	8040	2.45	99.5	7131	1.92	19265.89	76.93	18848.11	3
178	000	7480	2.45	99.4	8135	1.69	17305.00	67.70	17205.33	1
179	000	7440	2.45	99.4	8138	11.51	17016.00	460.34	17305.00	1
180	000	7200	2.45	99.4	8417	15.21	16387.21	608.35	16890.69	1
181	000	120	2.45	66.7	651	15.21	488.30	608.35	1006.09	8
182	000	40	2.45	0.0	285	5.33	0.00	213.26	168.02	21
183	000	120	2.45	66.7	444	7.60	171.08	303.98	421.34	11
184	000	40	2.45	0.0	319	7.60	0.00	303.98	263.30	13
185	000	400	2.45	90.0	952	7.60	909.51	303.98	1119.23	8
186	000	40	2.45	0.0	319	7.60	0.00	303.98	263.30	13
187	000	40	2.45	0.0	285	5.33	0.00	213.26	179.69	16
188	000	120	2.45	66.7	358	5.33	186.34	213.26	354.43	11
189	000	40	2.45	0.0	285	5.33	0.00	213.26	179.69	16
190	000	80	2.45	50.0	387	5.33	112.52	213.26	278.43	15
191	000	120	2.45	66.7	358	5.33	205.69	213.26	363.94	13
192	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
193	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
194	000	80	2.45	50.0	632	3.91	637.55	156.57	703.40	11
195	100	8580	2.45	99.9	3998	0.00	3271.45	0.00	2469.90	25
195	200	10	2.45	0.0	124	0.45	0.00	4.47	4.08	9
195	300	8640	2.45	99.9	3839	0.00	2970.70	0.00	2353.10	21
195	400	50	2.45	80.0	406	0.22	603.02	2.24	500.80	17
196	000	40	2.45	0.0	412	17.00	0.00	680.05	603.02	11
197	000	40	2.45	0.0	319	9.88	0.00	395.18	323.35	18
198	000	40	1.18	0.0	169	2.87	0.00	114.60	50.27	56
199	000	40	1.73	0.0	235	2.87	0.00	114.60	69.30	40
200	000	80	2.45	50.0	348	9.88	64.73	395.18	402.74	12
201	000	80	2.45	50.0	443	9.88	168.12	395.18	488.30	13
202	000	40	2.45	0.0	285	4.99	0.00	199.45	168.12	16
203	000	80	2.45	50.0	296	3.49	64.73	139.63	171.08	16
204	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
205	000	80	2.45	50.0	229	3.49	58.38	139.63	164.65	17
206	000	200	2.45	80.0	470	3.49	283.30	139.63	369.04	13

Condensed Soil Loss

		RUNOFF					SEDIMENT			
Cell Num	Div	Drainage Area (acres)	Volume (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
207	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
208	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
209	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
210	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
211	000	40	2.45	0.0	132	3.49	0.00	139.63	93.17	33
212	000	40	2.45	0.0	240	3.49	0.00	139.63	112.52	19
213	000	40	2.45	0.0	319	7.60	0.00	303.98	248.73	18
214	100	10	2.45	0.0	118	2.50	0.00	25.00	20.51	18
214	200	8700	2.45	99.9	3647	0.00	2269.17	0.00	2145.78	5
214	300	10	2.45	0.0	106	2.50	0.00	25.00	19.61	22
214	400	8710	1.95	99.9	6256	2.50	2145.78	25.00	2199.05	-1
215	100	8680	2.45	99.9	3742	0.00	2407.88	0.00	2248.66	7
215	200	10	2.45	0.0	106	2.50	0.00	25.00	19.61	22
215	300	20	2.45	50.0	153	2.50	19.61	25.00	35.17	21
215	400	10	2.45	0.0	106	2.50	0.00	25.00	19.61	22
216	000	40	2.45	0.0	166	2.24	0.00	89.79	57.69	36
217	000	160	2.45	71.3	539	5.33	465.32	213.26	540.64	20
218	000	40	2.45	0.0	185	3.49	0.00	139.63	91.70	34
219	000	40	2.45	0.0	166	2.24	0.00	89.79	64.73	28
220	000	40	2.45	0.0	166	2.24	0.00	89.79	64.73	28
221	000	40	2.45	0.0	166	2.24	0.00	89.79	64.73	28
222	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
223	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
224	000	80	2.45	50.0	194	2.24	58.38	89.79	112.40	24
225	000	40	2.45	0.0	118	2.24	0.00	89.79	58.38	35
226	100	10	2.45	0.0	103	10.40	0.00	104.02	80.44	23
226	200	10	2.45	0.0	103	10.40	0.00	104.02	80.44	23
226	300	10	2.45	0.0	103	10.40	0.00	104.02	80.44	23
226	400	9680	1.97	99.9	3424	0.00	2050.59	0.00	1738.35	15
227	100	50	2.45	80.0	324	10.40	248.73	104.02	285.19	19
227	200	10	2.45	0.0	103	10.40	0.00	104.02	80.44	23
227	300	9640	2.45	99.9	3475	0.00	2156.69	0.00	1809.28	16
227	400	9380	2.45	99.9	3639	0.00	2229.53	0.00	2045.62	8
228	100	10	2.45	0.0	77	1.12	0.00	11.18	7.78	30
228	200	8730	2.45	99.9	5856	1.12	2218.66	11.18	2226.37	0
228	300	9360	2.45	99.9	3716	0.00	3704.60	0.00	2149.09	42
228	400	9340	2.45	99.9	6187	1.12	3725.58	11.18	3696.82	1
229	000	600	2.45	92.6	1520	1.92	1507.66	76.93	1499.20	5
230	000	440	1.60	93.6	1399	3.79	1310.64	151.70	1321.96	10
231	000	200	2.45	80.0	759	10.40	374.58	416.08	712.31	10
232	000	120	2.45	66.7	470	5.33	168.21	213.26	316.89	17
233	000	40	2.45	0.0	240	3.49	0.00	139.63	103.48	26

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                                Condensed Soil Loss
                   RUNOFF                                           SEDIMENT
          Drainage        Generated Peak   Cell      Generated
Cell        Area  Volume  Above    Rate  Erosion  Above  Within    Yield   Depo
Num Div (acres) (in.)   (%)     (cfs)   (t/a)  (tons) (tons)    (tons)   (%)

 234 100   9580  2.45   99.9     3522   0.00  1984.38   0.00   1871.50    6
 234 200   9560  2.45   99.9     3590   0.00  2150.33   0.00   1964.53    9
 234 300     10  1.47    0.0       69   3.79     0.00  37.93     19.85   48
 234 400     10  0.04    0.0        3   3.79     0.00  37.93      5.50   86
 235 000    160  0.76   84.1      264   3.79    54.20 151.70     99.21   52
 236 000     80  1.18   64.2      199   3.79    13.52 151.70     82.21   50
 237 000     40  2.45    0.0      240   3.49     0.00 139.63    103.48   26
 238 000     40  2.45    0.0      166   2.24     0.00  89.79     57.69   36
 239 000     80  1.19   54.8      143   1.55     9.68  61.85     35.46   50
 240 000     40  1.38    0.0      145   1.01     0.00  40.49     18.75   54
 241 000     40  2.11    0.0      104   0.65     0.00  26.04     13.52   48
 242 000     40  1.44    0.0       74   0.65     0.00  26.04      9.68   63
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