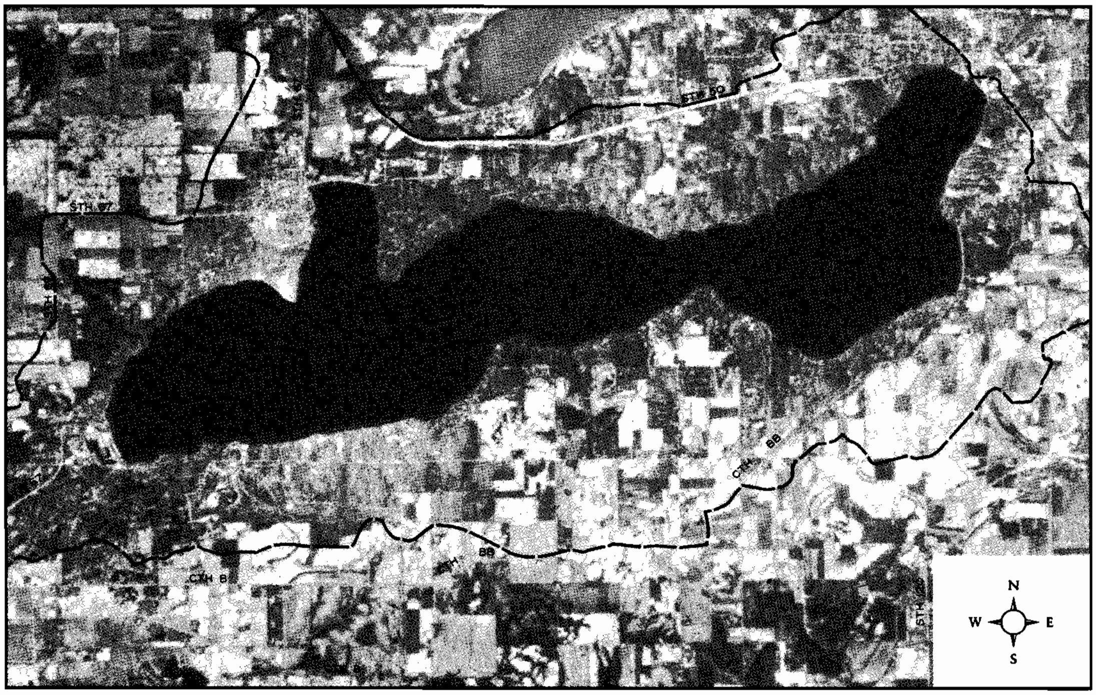
THE USE OF THE AGNPS MODEL WITHIN THE GENEVA LAKE WATERSHED WALWORTH COUNTY, WISCONSIN

MARCH, 1994



Source: SEWRPC

by
Theodore W. Peters and Karl Gustavson
Geneva Lake Environmental Agency
and Mary King, Geneva Lake Conservancy

Geneva Lake Environmental Agency

WISCONSIN DEPT. OF NATURAL RESOURCES

GENEVA LAKE CONSERVANCY INC.

ACKNOWLEDGMENTS

This study was the result of a grant by the Wisconsin Department of Natural Resources and a working agreement between the Geneva Lake Conservancy and the Geneva Lake Environmental Agency. The assistance of Dr. Robert Young and the other AGNPS people at the USDA, ARS North Central Soil Conservation Research Lab at Morris Minnesota was most helpful.

The assistance of the Southeastern Wisconsin Regional Planning Commission, especially Tami Drake, was beneficial in understanding the program and getting the project started.

The Walworth County SCS District Conservationist, Greg Igle and the Walworth County Land Conservation Committee staff saved us time and assisted us in understanding agricultural practices.

Discussion on the AGNPS program with Dr. Earl Spangenberg of UW-Stevens Point was helpful in understanding the workings of the model.

The work and patience of intern student Karl Gustavson is recognized as being vital to the project.

The Board of Directors of the Geneva Lake Environmental Agency are:

The Board of Directors of the Geneva Lake Conservancy are:

THE USE OF THE AGNPS MODEL WITHIN THE GENEVA LAKE WATERSHED WALWORTH COUNTY, WISCONSIN

Prepared by the
Geneva Lake Environmental Agency
P.O. Box 200
Fontana, WI 53125
Phone 414-276-6310
Director: Theodore W. Peters
Resource Manager: George W. Johnson

and the
Geneva Lake Conservancy
P.O. Box 356
Fontana, WI 53125
Phone 414-248-3358
Fax 414-248-0501
Executive Director: Mary D. King

This project was financed by a Lake Planning Grant from the
Wisconsin Department of Natural Resources and the
financial support of the Geneva Lake Environmental Agency
and the Geneva Lake Conservancy.

Cover photo compliments of Southeast Wisconsin Regional Planning Commission

March 1994

TABLE OF CONTENTS

SUMMARY

A. INTRODUCTION

In 1992 the Geneva Lake Conservancy received a Wisconsin Lake Management Planning Grant from the Wisconsin Department of Natural Resources to assess the hydrologic and pollution loading to Geneva lake. The assessment was made using a computer model which relied on field data for input.

B. STUDY AREA

Three watersheds within the Geneva Lake watershed were evaluated: the Big Foot subwatershed, the Birches subwatershed and the Southwick subwatershed. These three subwatersheds together represent 25% of the lake's total watershed. They were chosen primarily because of their size, however other unique conditions within each watershed were considered.

C. METHODS

A computer model called AGNPS (Agricultural Non-point Source Pollution) was used to assess the hydrologic and pollution loading to Geneva Lake. AGNPS documents a watershed's response to a specific rainfall event by estimating and evaluating run-off quality and quantity from that watershed and compares the effects of various pollution control practices that could be incorporated into the management of watersheds. Watersheds are divided into square working areas called cells. In the model, pollutants are routed from the top of the watershed to the outlet so that flow and water quality may be examined.

The AGNPS model was used to evaluate the quantity and quality of storm water produced from five different sized storms. The parameters used to evaluate the quality of the storm water included dissolved nitrogen and phosphorus, sediment, and nitrogen and phosphorus associated with sediment.

D. RESULTS

According to the model the Big Foot subwatershed exhibited the least pollutant response and the greatest hydrological response to different storm intensities of the three watersheds. However, visual observation of the subwatershed's response over the last three years do not substantiate the model's projections. The large percentage of wetland within the subwatershed may directly impact its pollutant and hydrological response, raising suspicion of the model's ability to program these wetland occurrences accurately. This watershed responded with the highest peak run-off rates and volume for all five storm intensities, however it had a variable concentration of nutrients in the storm water relative to other subwatersheds.

The Birches subwatershed contributed the highest soluble nutrient loading and concentration of the three subwatershed. The AGNPS model was used to assess the impact of changed land use on a 160 acre section within the Birches watershed. The parcel is presently in "open" undisturbed land use. Scenarios were programmed into the model with the 160 acre parcel being used as single family residential and as row crop agricultural. Both scenarios showed a significant increase in sediment and nutrient loading to the lake over present loading.

The Southwick subwatershed contributed the highest sediment and sediment related nutrient loading of the three subwatersheds. The storm water conveyance system in the urban area was very efficient at transporting sediment and nutrient to the lake.

E. CONCLUSIONS

AGNPS can be helpful when looking at hydrologic and pollutant loading to a lake. The different responses of the three subwatershed to the various run-off events points to the importance of proper storm water management, erosion control practices, and the influence of the different land uses. The model worked better on agricultural land than on mixed urban-agricultural land uses. The model has some difficulty dealing with existing retention/detention ponds and wetlands. The results for subwatersheds with these characteristics needs to be interpreted with caution.

F. RECOMMENDATIONS

To get a complete look at event based non-point source pollution into Geneva Lake, the entire watershed needs to be inventoried and assessed. In view of limited dollars and personnel, computer modeling should be used to achieve this end as long as field data is collected to calibrate or compensate the models shortcomings. Updates of the AGNPS program should be acquired and applied new data as well as data already collected.

This report should be used as a reference for municipal governments in making land use decisions. Valuable information regarding storm water conveyance systems and changes in land use are addressed in this report. Agency and Conservancy staff should be contacted for assistance in adapting this report to different municipalities.

I. INTRODUCTION

On January 21, 1992 a Wisconsin Lake Management Planning Grant was awarded by the State of Wisconsin Department of Natural Resources, Bureau of Community Assistance Management to the Geneva Lake Conservancy (formerly the Committee to Save Geneva Lake).The grant was to be used to assist in the use of the Agricultural Non-Point Source (AGNPS) computer model to inventory and assess hydrological, and pollutant loading to Geneva Lake.

To assist the Geneva Lake Conservancy (GLC) the Geneva Lake Environmental Agency (GLEA) agreed to be the project manager. Under the terms of the grant the State of Wisconsin provided $5,833.50, and the local share of $1,944.50 was divided between the GLC and the GLEA.

The Committee to Save Geneva Lake was formed in 1977 in response to a pollution problem entering Geneva Lake. In the fall of 1992 it merged with the Geneva Lake Land Conservancy and changed its name to the Geneva Lake Conservancy, Inc. It is supported by a broad base of Geneva Lake area citizens. Its objectives are land protection, maintenance of water quality and public awareness of threats to the quality of life.

The Geneva Lake Environmental Agency was formed in 1972 under section 66.30, Wis. Stats. It is supported by the local communities and residents within the Geneva Lake watershed for the purpose of providing lake management for Geneva Lake. Community members of the Agency include the City of Lake Geneva, Village of Fontana, the Village of Williams Bay, the Town of Linn and the Town of Walworth.

In 1976-1977 an extensive watershed monitoring program funded under the Clean Waters Act established nutrient and hydrologic budgets for Geneva Lake. Changes in land use patterns and recent attempts to address non-point source pollution required an update of land uses and their subsequent impacts on watershed pollution loading to Geneva Lake. Developments in computer modeling offered a cost-effective and representative means of conducting the needed watershed inventories.

The Wisconsin Department of Natural Resources Southeast District Office suggested the use of computer modeling for this updating. The DNR staff was familiar with several models from their use in other southeastern Wisconsin lake management efforts.

The objective of the project was to identify sources and extent of event based major non-point pollution loading to Geneva Lake. As the study progressed it became apparent that due to the time needed to collect and document the large data base required, only a few subwatersheds could be inventoried within the allowed grant time.

II. WATERSHED INVENTORY

Figure 1, Geneva Lake and its watershed Source: SEWRPC ———— = Watershed

Table 1: 1990 Exising Land Use within the Geneva Lake Watershed

Land Use Categories	Acres	Percent of Study Area
Residential	2940	23
Commercial	131	1
Industrial	26	0.1
Governmental and Instutional	158	1.2
Transportation, Communication and Utilities / a	927	7.2
Recreational	733	5.7
Prime Agriculture	2318	18.1
Other Agriculture	1538	12
Water / b	26	0.2
Wetlands	569	4.4
Woodlands	2468	19.3
All Other Open Lands	972	7.6
TOTAL	**12,806**	**99.9**

/a Parking included with associated use category
/b excludes surface area of Geneva Lake

Source: G.L.E.A.

Geneva Lake is a 5,425 acre headwater lake fed by numerous small tributary streams and is drained by the White River (Figure 1). It has a watershed of 12,806 acres with mixed land uses (Table 1). Geneva Lake has 9 perennial streams and numerous intermittent streams draining its watershed.

Three subwatersheds were chosen to be analyzed with the AGNPS model. Subwatershed selection was based upon the watershed size, amount of agricultural land use within the watershed and the amount of existing subwatershed information. The subwatersheds chosen were: Birches, Big Foot and Southwick (Figure 2). 3220 acres of the lake's watershed were modeled with AGNPS in this study, representing 25% of the total Geneva Lake drainage area.

The Big Foot subwatershed is the largest subwatershed (1,205 acres) within the Geneva Lake basin. It is located in the southeastern portion of the lake's watershed and lies primarily in the Town of Linn with a small portion in the Town of Bloomfield. Agriculture is the dominant land use. (Table 2)

Figure 2, Selected Geneva Lake subwatersheds for AGNPS study. Source: SEWRPC - - - - - - = Watershed

Within this subwatershed, there are several unique conditions: large areas of wetland, a state park, and an old landfill . There was an interest in learning how well the model might address these types of land uses and interest on the sensitivity of the models to show changes within these areas. This subwatershed may also include a major residential development within the next few years.

The Birches subwatershed is the second largest subwatershed within the Geneva Lake drainage basin. It has a total of 1,175 acres and is located on the lake's south shore totally within the Town of Linn. Agriculture is the major land use within the Birches subwatershed (Table 2). The AGNPS model was designed for this type of watershed. The project managers desired to study the hydrologic and pollution loading impact that might result from a change in land use in a 160 acre parcel within the Birches watershed.

The Southwick subwatershed was chosen because of its size. At 840 acres, it is the third largest within the lake basin. It is located in the northwestern portion of the lake's watershed and lies within Delavan, Geneva, and Walworth Townships, with the majority of the watershed within the Village of Williams Bay. It has a substantial area of urban land use (Table 2).

Table 2: Land Use In Selected Subwatersheds of Geneva Lake, Wisconsin

Land Use	Big Foot	Southwick Creek	Birches
100 Residential	80	258	169
200 Commercial	3	35	0
300 Industrial	12	73	0
700 Recreational	105	34	0
800 Agricultural	627	164	757
900 Natural Areas	378	276	249
Totals	1,205	840	1,175

Source: G.L.E.A.

Although there were several areas within the drainage basin with agricultural land use, many of these areas are either presently undergoing or will soon be undergoing urbanization. The impact of two gravel pit mining operations was of concern, and it was hoped that the model could assess the extent of their impact. A visual sediment and turbidity problem within Southwick Creek results in obvious sediment loading to Geneva Lake.

III. AGRICULTURAL NON-POINT POLLUTION

A. NON POINT POLLUTION PROCESSES

Non-point pollution in the agricultural community is generally understood to be the breakdown of soil particles by water action and the subsequent transport of that soil into adjoining surface waters. Nutrients, fertilizers, pesticides and other pollutants associated with the soil, can cause water quality problems when allowed to enter either surface or groundwater supplies.

Three physical processes are involved in water caused soil erosion and sedimentation. First there is the detachment of small particles from larger clods or chunks. This process breaks down the soil structure to a point where it can be carried away by the run-off water. This breakdown process can be from numerous activities including plowing, tilling or cultivating, or compaction. The impact of falling rain on bare soil can also destroy soil structure.

The second physical process is the transport by suspension of small soil particles in the run-off water. This process is a function of particle size, type of run-off and rate of run-off. Particle size is relative to the type of soil, soil texture and the amount of energy involved in the structure breakdown. Run-off rates and types are based upon the interaction of many variables including soil type, precipitation type, slope type, vegetation, and existing soil moisture conditions.

The third process, sedimentation, is the result of lost energy in the erosion and transport process, causing the soil particles to settle out from the run-off water. This step is usually the most visible and occurs in slower moving waters at the bottom of hills, wide surface water channels, in lakes, or on streets, sidewalks and lawns.

Soil erosion and sedimentation are a function of energy from the falling raindrops and the run-off water as it flows downhill. Good soil and water management addresses the dissipation of this energy through vegetative cover, different farming practices, and the controlling of run-off velocity and location.

B. AGRICULTURAL NON-POINT SOURCE MODEL - AGNPS

The AGNPS model was developed to obtain uniform and accurate estimates of runoff quality with primary emphasis on sediments and nutrients and to compare the effects of various pollution control practices that could be incorporated into the management of watersheds.

It documents a watershed's response to a rainfall event by estimating and evaluating run-off quality and quantity from the watershed. It computes watershed response to rainfall events with a given set of variables. AGNPS is a cell based model. Each watershed is subdivided into small, homogenous cells. All watershed data is collected at the cell level. The model evaluates the erosion, sediment and nutrient transport within each cell. Pollutants are routed through the cells in a continuous manner following the natural drainage patterns of the whole watershed. It is an event based model, meaning that it will give output information based upon a single predefined precipitation event.

To accomplish these tasks the AGNPS model uses strategies developed from previous studies and models to predict soil losses and simulate sediment and nutrient routing [1] It uses two categories of analysis: (1) pollutant generation and (2) pollutant routing. It gives output data of hydrology, sediment and chemical loading rates and concentrations. (Table 3).

Table 3: AGNPS Output Data

Hydrology Output
- Runoff volume (inches)
- Peak runoff rate (cubic feet/second)
- Fraction of runoff generated within the cell

Sediment Output
- Sediment yield (tons)
- Sediment concentration (ppm)
- Sediment particle size distribution
- Upland soil erosion (tons/acre)
- Amount of deposition (%)
- Sediment generated within the cell (tons)
- Enrichment ratios by particle size
- Delivery ratios by particle size

Chemical Output
- Nitrogen
  - Sediment associated mass (pounds/acre)
  - Concentration of soluble material (ppm)
  - Mass of soluble material (pounds/acre)
- Phosphorus
  - Sediment associated mass (pounds/acre)
  - Concentration of soluble material (ppm)
  - Mass of soluble material (pounds/acre)
- Chemical Oxygen Demand
  - Concentration (ppm)
  - Mass (pounds/acre)

Source: R.A. Young, C.A. Onstad, D.D. Bosch, W.P. Anderson, "AGNPS: A Non-point Source Pollution Model For Evaluating Agricultural Watersheds." Journal of Soil and Water Conservation Vol. 44 No. 22 p. 170.

The model can produce results in both tabular or graphic formats. Output data can be generated on a cell basis, as well as on a portion of a subwatershed or on a total subwatershed basis.

---

[1] J.K. Koelliker, C.E. Humbert," Applications of the AGNPS Model to watershed in Northeast Kansas:" Final Report on Joint Agreement #65-6215-8-1, Between USDA_SCS Kansas, and Kansas State University, Jan. 1990.

IV. DATA INPUT

The AGNPS model generates values for peak flow, sediment, and nutrient concentration using equations which require inputs. These data inputs are developed to simulate watershed conditions and the desired type of rainfall event (Table 4).

Table 4: AGNPS Input Data

Data

Watershed Input
- Watershed identification
- Cell area (acres)
- Total number of cells
- Precipitation (inches)
- Energy-intensity value

Cell Parameter
- Cell Number
- Number of the cell into which it drains
- SCS curve number
- Average land slope (%)
- Slope shape factor (uniform, convex, or concave)
- Average field slope length (feet)
- Average channel slope (%)
- Average channel side slope (%)
- Manning's roughness coefficient for the channel
- Soil erodibility factor (K) from USLE*
- Cropping factor (C) from USLE*
- Practice factor (P) from USLE*
- Surface condition constant (factor based on land use)
- Aspect (one of 8 possible directions indicating the principal drainage direction from the cell)
- Soil texture (sand, silt, clay, peat)
- Fertilization level (zero, low, medium, high)
- Incorporation factor (% fertilizer left in top 1 cm of soil)
- Point source indicator (indicates existence of a point source input within a cell)
- Gully source level (estimated tons of gully erosion in a cell)
- Chemical oxygen demand factor
- Impoundment factor (indicating presence of an impoundment terrace system within the cell)
- Channel indicator (indicating existence of a defined channel within a cell)

* Universal Soil Loss Equation

Source: R.A. Young, C.A. Onstad, D.D. Bosch, W.P. Anderson, "AGNPS: A Non-point Source Pollution Model For Evaluating Agricultural Watersheds." Journal of Soil and Water Conservation Vol. 44 No. 2 p. 170.

The inputs are obtained from a variety of sources and often have to be "custom fit" to a particular watershed. A general summary of input values was given in the AGNPS manual, but these values were often altered or other values were used to represent more accurately the conditions within the watershed. The input data was entered as either a representative value or as an actual value. An example of a representative value is the fertilizer level input value where a number is entered which represents a level of fertilizer application. Representative values are used for the following input data; aspect, slope shape, C-factors, P-factor, K-factor, surface condition constant, soil texture and fertilizer level.

Actual values are used when the input figure is the actual measured value, as in the slope input variable. Other actual values used are: slope, SCS curve number, slope length, gully source level, fertilizer availability, COD factor, impoundment factor, and channel indicator.

Watersheds were first delineated on USGS 1:24,000 topographic maps and enlarged 100% to facilitate use.

The basins were divided into ten acre cells. The cells were numbered from west to east, starting at the northwest corner and ending at the southeast corner of the watershed. Cells with less than 50% of the land within the watershed were not included.

The model inputs are grouped into four basic categories: topographic inputs, soil characteristics, land use and precipitation characteristics.

A. TOPOGRAPHIC INPUTS

Obtaining the topographic inputs was relatively simple. Most inputs could be derived directly from the topographic maps. The topographic maps furnished the following inputs: cell numbers, slope shape factor, aspect, and channel slope.

Cell Number: When the cells are initially divided on topographic maps a drainage pattern between them is established. This pattern is determined by noting the lay of the topographic lines and the direction water will flow from the area. The cell that receives the most significant portion of the overland runoff is the receiving cell.

Slope Shape Factor: This factor is a function of the slope within the cell. If the slope is uniform, the input is 3. If the slope is concave, i.e. steeper at the top and less below, the input is 2. If the slope is convex, i.e. the slope increases at the bottom, the input is 1.

Aspect: This value designates the drainage direction from the cell, with a value of 1-8 determining the direction. The digits correspond to the directions on an 8-point compass.

Channel Slope: The channel slope is the average slope on the channel within the cell. This value was obtained by locating the channel on the topographic maps and determining the slope by the amount of rise in 100 ft.

B. SOIL INPUTS

Soils information was readily available through use of soil type maps obtained from the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and USDA SCS Walworth County Soil Survey[1]. The main sources of data for these inputs were the SEWRPC maps and keys. The scale of these maps was identical to the enlarged topographic maps, allowing the use of the same cell overlays. Since the Soil Survey was scaled differently it was used as a secondary source or information.

Soil information was obtained by determining the types of soil within each cell from the soils maps. The maps give the soil's number, which is converted to its name, the slope of the land, and the eroded state of the soil. A listing of characteristics for each soil is shown in Table 5. The inputs include the following: land slope, K-factor, soil texture, and field slope length.

Land Slope: Although land slope could be obtained from topographic maps, they were taken from the soil survey maps. Each designated soil area had a corresponding slope, and these slopes were weighted averages for the entire cell. This method was chosen because the values did not vary significantly from those obtained by using the topographic method and were easier to obtain.

K-factor: The K-factor is the soil erodibility factor. The value was a weighted average from the soil types in the cell with information taken from the map in the Walworth County Soil Survey.

Table 5: Selected Soil Characteristics of Common Soils in the Geneva Lake Watershed

Soil Number	Soil Abbreviation	Slope Length	K-factor
155-2-1	MpB	150	.37
161-4-1	DdA	200	.37
191-6-1	GsB	150	.28
243-4-1	ScB	150	.37
282-8-1	CeC2	100	.32
342-8-1	MyC	150	.37
358-2-1	MyA	150	.37
361-4-1	MyB	150	.37
420-15-2	MwD2	100	.32
450-A-1	Ht	300	.10

Source: G.L.E.A.

Soil Texture: The soil texture is designated by a value of 1–4, with each number defining a soil type. The number 1 represented sand, 2 silt, 3 clay and 4 peat. The soils were determined by the name from the soils maps. Soil designated "loam" on the maps was considered a silt.

Field Slope Length: This value is the distance from the point of origin of overland flow to a point where deposition occurs. The major soil type in the cell was used to determine the slope length of the cell. These were obtained from a listing of slope lengths in the soil survey map's key.

C. LAND USE INPUTS

Obtaining land use inputs was the most time consuming task in data collection. The importance of these inputs required extensive field work. The land use inputs were determined by the use of 1:4800 aerial photos taken in March of 1990. From these photos, land use percentages were determined and applicable inputs were then assigned. Since the watersheds were small and local, the data could be field checked to confirm information from the photos. The land use inputs established were: Manning roughness coefficient, cropping management factor or C-factor, erosion control practice factor or P-factor, SCS curve numbers, surface condition constant, fertilizer level, fertilizer availability, COD factor, channel indicator. Explanation of the inputs follow:

Manning Roughness Coefficient: This is a relative value which expresses the condition of the river channel present in the cell. Each condition was assessed by field visit and the value determined by choosing the appropriate description from Table 6. The Manning's coefficient for all non-river channel cells was designated as .30 for cells within the Birches watershed. Values for Big Foot and Southwick Creeks were obtained from Georgia Stream Assessment AGNPS Interface Land Management Data.[2]

---

[1] USDA –SCS and UW-Wisconsin Geological and Natural History Survey, Soil Dept. and Wisconsin Agricultural Experiment Station, "Soil Survey, Walworth County". Feb. 1971.

[2] Corrispondance with Evlalie A. Ogden, Research Coordinator, D.B. Warnell School of Forestry, University of Georgia-1992.

Table 6: Manning's Roughness Coefficients For Channelized Flow

Excavated or dredged channels	
Ordinary concrete	.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 short 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

Source: V.T. Chow (1959) Open Channel Hydraulics, pages 7-25, McGraw-Hill, New York

<u>C-Factor:</u> The C-factor is the cropping management factor. It is a measure of the combined effect of vegetative cover and management practices at the time of the rainfall or, when possible from conservation farm plans. These plans had specific C-factors for certain areas within the watershed. (Table 7)

Table 7: Example of C-Factor Determination Table

Cropping Systems	None	20	30	40	50
	Percent of ground cover after planting				
Soybeans (drilled) following soybeans					
no-till		0.20	0.16	0.15	
spring chisel, spring disk		0.28	0.26		
fall chisel, spring disk		0.31	0.29		
spring moldboard plow	0.32				
fall moldboard plow	0.38				
Soybeans (wide row) following soybeans					
no-till		0.27	0.22	0.16	
till plant contour rows		0.30	0.26		
till plant straight rows		0.33	0.29		
ridge till plant contour rows		0.22	0.19		
ridge till plant straight rows		0.33	0.29		
spring chisel, spring disk		0.33	0.29		
fall chisel, spring disk		0.37	0.32		
spring moldboard plow	0.43				
fall moldboard plow	0.48				

Source: Personal communications with Greg Igel, USDA, Soil Conversationist Walworth County (SCS), 1992.

<u>P-Factor:</u> The P-factor is the erosion control practice factor. This factor varies with the type of cropping practice used, such as contouring or terracing. Since these alternate conditions weren't prevalent in the study areas, the factor was standardized at 1 for all farmlands, .9 for woodlands, and .8 for permanent meadow and mature forest conditions.

<u>SCS curve numbers:</u> The SCS curve number is a function of land use and soil type used to determine the percent runoff during a rainfall event. Land use conditions and soil type were needed to obtain the SCS curve number. These values were obtained from field check and soil maps, respectively (Table 8).

Table 8: SCS Runoff Curve Numbers

Land-use Condition	Soil Group A		Soil Group B		Soil Group C		Soil Group D
	Values given are for Antecedent Moisture Condition II						
Follow	77		86		91		94
Row crop							
Straight row	67		78		85		89
Contoured	65		75		82		86
Small grain	53		74		82		85
Legumes or rotation meadow	58		72		81		85
Pasture							
Poor	68		79		86		89
Fair	49		69		79		84
Good	39		61		74		80
Permanent Meadow	30		58		71		78
Woodland	36		60		73		79
Forest with heavy litter	25		55		70		77
Farmsteads	59		74		82		86
Urban (21% - 27% impervious surfaces)	72		79		85		88
Grass waterway	49		69		79		84
Water	---	---	---	100	---	---	---
Marsh	---	---	---	85	---	---	---
Animal lot							
Unpaved	---	---	---	91	---	---	---
Paved	---	---	---	94	---	---	---
Roof area	---	---	---	100	---	---	---
Urban commercial[1]	84		86		89		91
Recreation[2]			79				

Source: USDA, SCS (1976) Hydrology Guide for Minnesota, St. Paul, MN

[1] Source: SEWRPC (1992) Personal Communication

[2] Source: Geneva Lake Environmental Agency - personal interpretation

<u>Surface Condition Constant:</u> The surface condition constant is dependent on the land use and surface condition of the surface at the storm time. These values were taken from the surface condition constant table (Table 9) and from information obtained by field checks of the area. Residential areas within the watershed were considered urban.

Table 9: Surface Condition Constant

Land-use Condition	Surface Condition Constant
Fallow	0.22
Row crop	
Straight row	0.05
Contoured	0.29
Small grain	0.29
Legumes or rotation meadow	0.29
Pasture	
Poor	0.01
Fair	0.15
Good	0.22
Permanent meadow	0.59
Woodland	0.29
Forest with heavy litter	0.59
Farmsteads	0.01
Urban (21% - 27% impervious surfaces)	0.01
Grass waterway	1.00

Source: Young, R.A., Otterby, A.M., and Roos, A., 1982. <u>An Evaluation System To Rate Feed By Pollutional Potential</u>. USDA - Agricultural Res. Ser. AGRIC Rev. Man. North Central ARM-NC-17, 788.

Fertilizer Level: Fertilizer level is an input expressing the amount of nitrogen (N) and phosphorus (P) in pounds per acre applied to the soil. AGNPS has predetermined values of 1=low, 2=medium, 3=high. An input of 4 required entry of specific values for pounds of N and P, dependent on crop type. (Table 10)

Table 10: Fertilization Levels of Selected Crops

Crop	Nitrogen (lbs./acre)	Phosphorus (lbs./acre)
Alfalfa	0	40
Corn	150	40
Residential Lawn	60	10
Oats	35	15
Pasture	80	20
Red clover	0	40
Soybean	0	30

Source: Personal Communication with Greg Igel, USDA - SCS, Soil Conservationist, Walworth County, 1992.

Fertilizer Availability: The fertilizer availability factor represents the percentage of fertilizer left in the top half inch of soil at the time of the storm. The type of tillage practice is the most important factor. Input values can range from 100% for a worst case where no fertilizer incorporation has taken place, to 10% for fertilizer incorporation by moldboard plow (Table 11).

Table 11: Fertilizer Availibility Factors

Tillage Practice	Fertilizer Availibity 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

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

Source: Young et al (1987).

COD: The chemical oxygen demand (COD) factor is a pollution indicator used as a measure of the organic matter in run-off that is susceptible to oxidation. The value for COD is based upon land use (Table 12).

Table 12: Chemical Oxygen Demand (COD) Factors for Various Land-uses

Land-use	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

Source: Young, Robert A., Charles A. Onstad, David D. Bosch, and Wayne P. Anderson. AGNPS, Agricultural Non-Point-Source Pollution Model. A Watershed Analysis Tool, 1987. U.S. Department of Agriculture, Conservation Research Report 35, p. 80.

Channel Indicator: The channel indicator determines the type of channel within a cell by designating it with a number of 1-8. Each number corresponds to a different type which is determined by field checks.

D. PRECIPITATION INPUTS

Since AGNPS simulates on the per-event basis, the entered data is for a single rainfall event. The required inputs are for precipitation in inches, duration and type of storm. The storm type is a regional classification of rainfall characteristics. In Wisconsin all storm types are type II. The characteristic storm used was the 1 year rainfall (1.2 inches in 24 hours).[3]

Since many cells had non-uniform characteristics, the values were either weight averaged or the cells further divided into four 2.5 acre cells to obtain a homogenous unit. For instance, if 80% of a cell had a slope of 6%, while the remaining slope was 2%, the cell input would be weight averaged to 5.2%. On the other hand, if the cell was composed of distinct areas with particular characteristics, such as two crop fields divided by a fence, the cell would be divided to better represent the conditions. Cells were divided on the basis of drainage within a cell or water retention area.

---

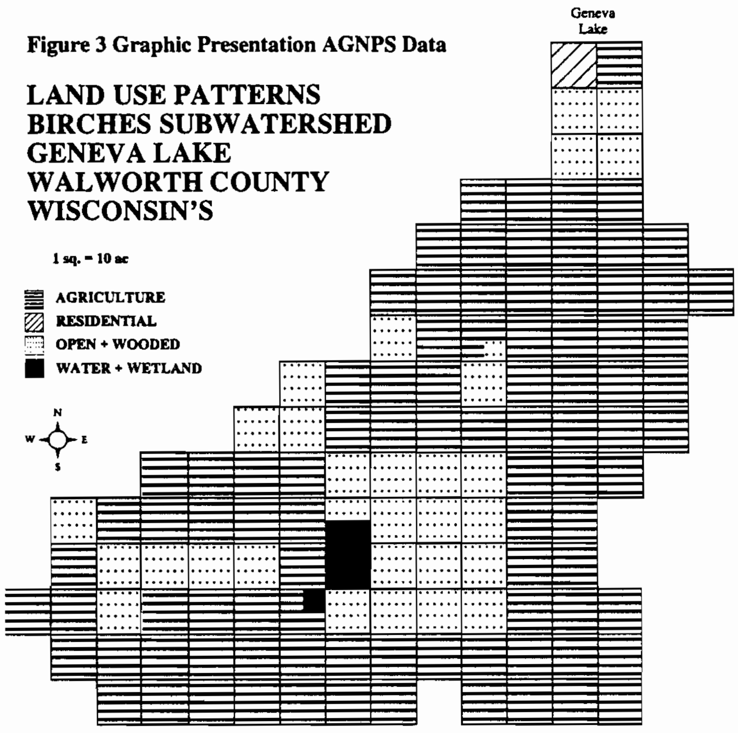
[3] USDA –SCS "Minimizing Erosion in Urbanizing Areas", 1971.

V. RESULTS

A. DATA INVENTORY

The AGNPS model can be used for several purposes. The simplest is the inventory of existing conditions within a watershed. This data, once collected and entered into the program, can be presented in either graphic (Figure 3) or tabular format. (Table 13)

Figure 3 Graphic Presentation AGNPS Data



Source: G.L.E.A.

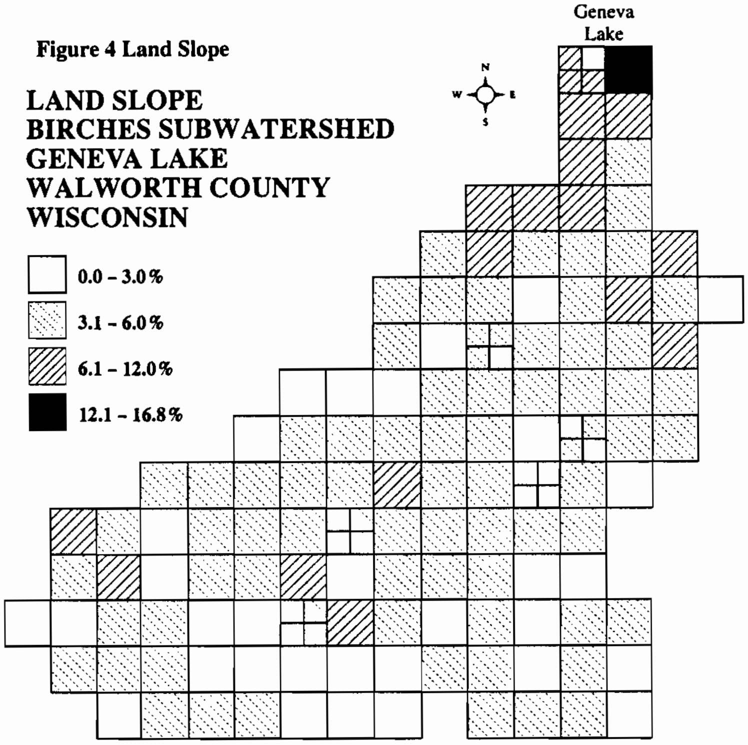
Table 13: Tabular Presentation of AGNPS Data

Rec. Cell Number	1	500	1	1	1	2	1
Rec. Cell Div.	100	000	300	200	200	200	400
Aspect	0	1	0	1	7	0	7
SCS Curve Number	79	79	79	79	68	68	62
Land Slope (%)	8.5	2.7	8.5	7.2	15.0	15.0	16.8
Slope Shape	1	1	1	3	3	3	3
Slope Length (ft)	200	200	200	200	75	75	100
Manning's Coef.	0.030	0.030	0.030	0.030	0.300	0.300	0.300
K - Factor	0.28	0.31	0.28	0.28	0.37	0.37	0.37
C - Factor	0.01	0.01	0.01	0.01	0.01	0.01	0.01
P - Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Surf. Cond. Const.	0.01	0.01	0.01	0.01	0.18	0.18	0.26
Soil Texture #	2	2	2	2	2	2	2
Fert. Level	0	4	4	4	4	4	4
Availability Factor	0	34	34	34	34	34	34
Point Source Ind.	0	0	0	0	0	0	0
Gully Source (tons)	0	0	0	0	0	0	0
COD Factor	80	80	80	80	71	71	67
Impoundment Fact.	0	0	0	0	0	0	0
Channel Indicator	1	7	1	7	1	1	1

Source: G.L.E.A.

When using the graphic format for data presentation, each input variable can be presented on an outline of the watershed. Figure 4 shows the slope graphed for the whole Birches subwatershed. The average slope within each cell is presented. When all the cells are put together the range of slope for the whole watershed can be viewed. Different slope averages can be represented by different colors or by different graphic patterns.

Figure 4 Land Slope



Source: G.L.E.A.

A more useful application of the AGNPS model is the identification of hydrologic and nutrient loading. This can be done on either an individual cell or a watershed basis. The AGNPS model can be used to identify "hot spots" which contribute to excessive pollution from any given cell.

All these assessments are done on a single storm event basis. Different event intensities can be programmed in with the respective data output being presented for each storm event intensity.

B. SUBWATERSHED LOADING TO THE LAKE

(One Year Frequency Storm Event)

The AGNPS output data includes 11 parameters. This report looks at only the hydrologic, nutrient and sediment parameters. For the purpose of comparing each watershed's outlet data, a one year frequency storm event was used. A one year frequency storm event is a storm event that will deposit 1.2 inches of precipitation within a 24 hour period. It has a frequency of occurring once every year.

It was not clear from the data that watershed size was a significant factor in pollution loading to the lake. Land use and the location of land use relative to the outlet cell played a bigger role in influencing outlet cell loading to the lake.

BIRCHES WATERSHED. When the three watersheds were compared, Birches watershed contributed the highest soluble nutrient loading to the lake (Table 14). It had the highest per acre soluble nitrogen and phosphorus concentrations and loading. Birches watershed has the largest amount of agricultural land use in actual acres and in percentages.

Several different methods were used to assess the soluble nutrient loading data. A review of the tabular and graphic data did not show any significant cell or set of cells responsible for the soluble nutrient loading.

When the soluble nitrogen and phosphorus data was looked at closely, uncertainty arose over what the model computed to be happening within each cell. The interaction of cells and their soluble nutrient levels seemed to be less obvious and difficult to interpret. In some cells there was an assimilation of nutrients, with the amount being discharged from the cell less than the combined amount generated within the individual cell and the amount being received from the upflow cell. During the growing season incell soluble nitrogen and phosphorus reductions may represent the uptake of these nutrient forms by vegetation.

Data output for nutrients was also expressed in concentration (ppm.). Outlet concentrations were related to flow. No relationship to upflow cells could be identified. Cells that yielded high levels of soluble nitrogen also yielded high soluble phosphorus.

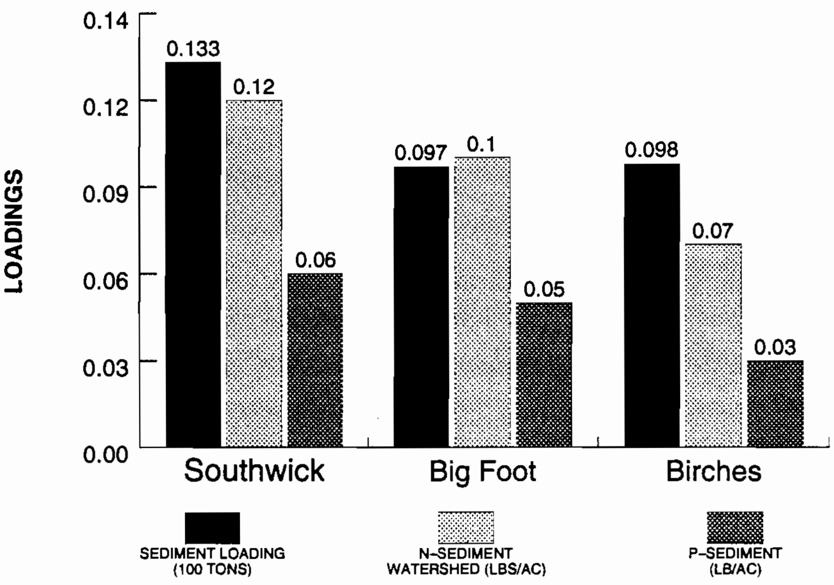
SOUTHWICK WATERSHED. Southwick watershed had the highest sediment nitrogen, sediment phosphorus and highest total sediment yield (Figure 5, Table 14). When looking at soil erosion and sediment yield for each cell within the Southwick watershed two influencing factors become apparent: 1) Southwick watershed has the highest amount of urban land use, and 2) it has two gravel pit operations located within its drainage basin. The model indicated that although the gravel pits generate substantial amounts of sediment, downstream transport was not significant. One gravel pit has a series of sediment traps and the other has been designed to drain into itself. Both practices trap much of the eroded soil from these cells, preventing the downstream transportation of the eroded sediment. Another area of concern over soil erosion was found in a cluster of cells in the southwestern portion of the watershed. The soil eroded from this area of the watershed appears to be from farm land and an area under development. The amount of hard surface and manner of storm water conveyance within the watershed's urban area results in little sediment retention within any down flow cells. Thus the eroded sediment is carried through the watershed and discharged into the lake.

BIG FOOT. While Big Foot subwatershed is the largest-subwatershed in the Geneva Lake basin with 1,205 acres, the model did not show it to be a significant source of major pollutant loading. It was shown to have the highest peak runoff rates and discharge for all storm frequencies.

FIGURE 5

SEDIMENT LOADING TO GENEVA LAKE FROM THREE SUBWATERSHEDS

FROM A 1 YEAR STORM EVENT



Source: G.L.E.A. and AGNPS

Table 14: Storm Event Lake Loadings from the Geneva Lake Subwatersheds

One Year Frequency

Watershed Event Amount	Southwick 1.2"	Big Foot 1.2"	Birches 1.2"
Watershed Area (ac)	840	1205	1175
Runoff Volume (in)	0.1	0.1	0.1
Peak Runoff Rate (CFS)	28	54	27
Total Nitrogen in Sediment (lbs/ac)	0.12	0.1	0.07
Soluble Nitrogen Conc. in Runoff (mg/L)	1.01	6.72	12.94
Total Phosphorus in Sediment (lb/ac)	0.06	0.05	0.03
Total Soluble Phosphorus in Runoff (lb/ac)	0.00	0.02	0.02
Soluble Phosphorus Conc. in Runoff (mg/L)	0.05	1.10	2.05
Sediment Yield (tons)	13.30	9.65	9.80
Total Solube COD (lb/ac)	1.35	1.92	1.62
Soluble COD Conc. in Runoff (mg/L)	75	89	138

Source: G.L.E.A. and AGNPS

The large amount of wetlands, 21% of the subwatershed may have made the application of the AGNPS model on the Big Foot watershed somewhat tenuous. The model addresses wetlands as flow through systems. From a hydrological and pollutional perspective this may not represent what actually happens in wetlands. The Big Foot wetlands seem to be atypical for wetlands as a whole. Observation over the last few years indicates that some portions of these Big Foot's wetlands may be purging themselves more frequently than expected. Even after light storm events of less than 1" the discharge from the Big Foot watershed has been observed to be very reddish brown in color. Additional studies and sampling are being conducted to further understand this water quality phenomenon.

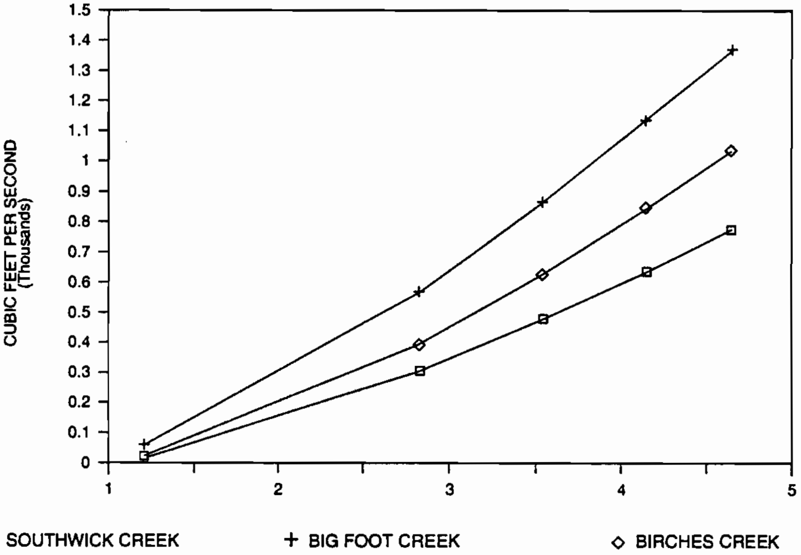
Big Foot's watershed size, the amount of wetlands, and the way the model addresses wetlands may explain why this watershed had some of the highest discharge and peak flow rates. The hydrological data from this watershed indicates that the values were too excessive for what has historically happened.

Although the model's output data was used for the purpose of this study, an exercise was conducted to lower the peak run-off rates from the AGNPS program (Appendix A). Marsh values in the input data section were altered to better represent the detention and flow moderating effects that most wetlands have. Different scenarios for the wetland cells were run by altering the marsh inputs. A simulated one cell study was conducted to determine which data inputs AGNPS was most sensitive to. Of the variables chosen for manipulation, changing the Runoff Curve number was the most influential in altering the peak runoff rate.

FIGURE 6

PEAK RUNOFF RATE TO GENEVA LAKE

FOR DIFFERENT STORM FREQUENCIES.

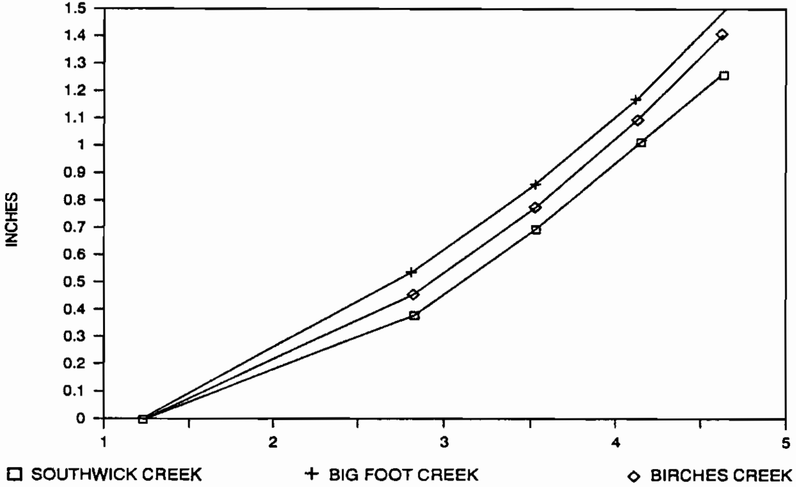


SOURCE: G.L.E.A. PRECIP / 24 HRS.

FIGURE 7

RUNOFF IN INCHES TO GENEVA LAKE

FOR DIFFERENT STORM FREQUENCIES.



SOURCE: G.L.E.A. PRECIP / 24 HRS.

C. LOADING TO GENEVA LAKE FROM DIFFERENT STORM FREQUENCY

Different storm intensities were entered into the model to assess the response of each watershed to different storm event types. One, two, five, ten and twenty-five year frequency storm events were used. Table 15 shows the different amounts of precipitation to fall within 24 hours for each of the different storm frequency events.

Table 15: Precipitation Amounts for Different Storm Events in Walworth County, Wisconsin

Storm Event	Rainfall within a 24 hour period
1 year	1.2"
2 year	2.8"
5 year	3.5"
10 year	4.1"
25 year	4.6"

Source: United States Department of Agriculture Soil Conservation Service, Madison, Wisconsin, 1972: "Minimizing Erosion in Urban Areas."

The hydrologic data indicated that for all five different event frequencies Big Foot had both the highest peak runoff rate and the highest runoff volume (Figure 6 and 7). The rate of increase for each subwatershed under different events did not appear to be linear, even when corrected for the non linear precipitation increase.

The amount of increase in the runoff volume was similar from event to event. For all three subwatersheds the greatest increase in runoff volume occurred between the one year event (1.2") and the two year event (2.4"). This seemed to be more a function of the precipitation amount than the nature of the watershed. The runoff rate in cubic feet per second for each watershed showed the greatest increase between the one year and the two year events (Table 16).

Total sediment nitrogen and sediment phosphorus loading to the lake increased similarly to the hydrologic increase. The rates of increase loading of sediment nitrogen and sediment phosphorus from different storm frequencies were identical with only the actual lb/ac. being different (Figures 8 and 9). The greater the flow and discharge the greater the ability of the water to carry sediment. Southwick Creek delivered the largest sediment nitrogen and sediment phosphorus in all five event types, followed by Big Foot and Birches respectively.

The response of soluble nitrogen and soluble phosphorus loading from each watershed was not as simple (Figure 10 and 11). The rate of increase differed significantly from watershed to watershed and from event to event. The greatest increase occurred between the one year event and the two year event for all but the soluble phosphorus loading from Southwick Creek. Soluble phosphorus loading from Southwick Creek showed little increase despite the storm frequency.

Table 16: Response of Three Different Geneva Lake Watersheds to Four Different Storm Frequencies

	1 Year 1.2"	2 Year 2.8"	5 Year 3.5"	10 Year 4.1"	25 Year 4.6"
Southwick Subwatershed					
Runoff Volume (in)	0.10	0.60	1.00	1.40	1.70
Peak Runoff Rate (cfs)	28.00	272.00	427.00	572.00	699.00
Total Nitrogen in Sediment (lb/ac)	0.12	0.52	0.87	1.25	1.61
Total Soluble Nitrogen in Runoff (lb/ac)	0.02	0.59	0.72	0.82	0.90
Soluble Nitrogen Conc. in Runoff (mg/L)	1.01	4.18	3.13	2.59	2.28
Total Phosphorus in Sediment (lb/ac)	0.06	0.26	0.44	0.62	0.81
Total Solube Phosphorus in Runoff (lb/ac)	0.00	0.09	0.11	0.12	0.13
Soluble Phosphorus Conc. in Runoff (mg/L)	0.05	0.64	0.47	0.38	0.32
Total Soluble COD (lb/ac)	1.35	17.53	27.80	37.57	46.24
Soluble COD Conc. in Runoff (mg/L)	75.00	123.00	120.00	118.00	117.00

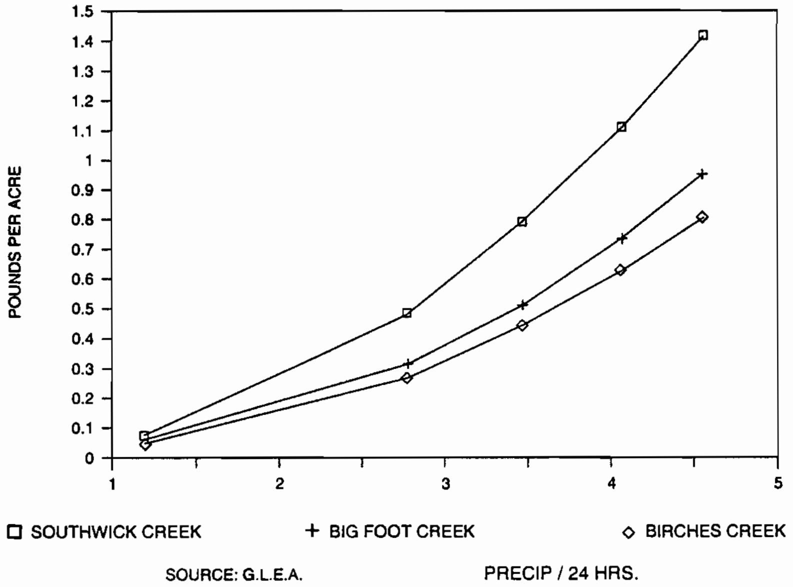
	1 Year 1.2"	2 Year 2.8"	5 Year 3.5"	10 Year 4.1"	25 Year 4.6"
Big Foot Subwatershed					
Runoff Volume (in)	0.10	0.80	1.20	1.60	2.00
Peak Runoff Rate (cfs)	54.00	388.00	582.00	761.00	916.00
Total Nitrogen in Sediment (lb/ac)	0.10	0.61	1.01	1.45	1.89
Total Soluble Nitrogen in Runoff (lb/ac)	0.15	0.55	0.68	0.79	0.87
Soluble Nitrogen Conc. in Runoff (mg/L)	6.72	3.07	2.45	2.11	1.90
Total Phosphorus in Sediment (lb/ac)	0.05	0.30	0.51	0.73	0.95
Total Solube Phosphorus in Runoff (lb/ac)	0.02	0.09	0.10	0.11	0.12
Soluble Phosphorus Conc. in Runoff (mg/L)	1.10	0.48	0.37	0.31	0.27
Total Soluble COD (lb/ac)	1.92	17.97	27.93	37.93	45.53
Soluble COD Conc. in Runoff (mg/L)	89.00	99.00	100.00	100.00	100.00

	1 Year 1.2"	2 Year 2.8"	5 Year 3.5"	10 Year 4.1"	25 Year 4.6"
Birches Subwatershed					
Runoff Volume (in)	0.10	0.60	1.00	1.40	1.70
Peak Runoff Rate (cfs)	27.00	272.00	427.00	572.00	699.00
Total Nitrogen in Sediment (lb/ac)	0.07	0.52	0.87	1.25	1.61
Total Soluble Nitrogen in Runoff (lb/ac)	0.15	0.59	0.72	0.82	0.90
Soluble Nitrogen Conc. in Runoff (mg/L)	12.94	4.18	3.13	2.59	2.28
Total Phosphorus in Sediment (lb/ac)	0.03	0.26	0.44	0.62	0.81
Total Solube Phosphorus in Runoff (lb/ac)	0.02	0.09	0.11	0.12	0.13
Soluble Phosphorus Conc. in Runoff (mg/L)	2.05	0.64	0.47	0.38	0.32
Total Soluble COD (lb/ac)	1.62	17.53	27.80	35.57	46.24
Soluble COD Conc. in Runoff (mg/L)	138.00	123.00	120.00	118.00	117.00

Source: G.L.E.A.

FIGURE 8 TOTAL SEDIMENT NITROGEN TO GENEVA LAKE

FOR DIFFERENT STORM FREQUENCIES.

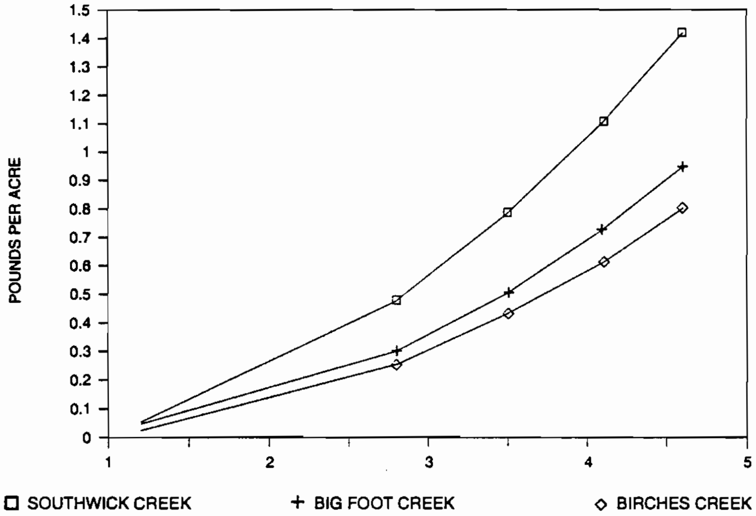


SOURCE: G.L.E.A.

FIGURE 9

TOTAL SEDIMENT PHOSPHORUS LOADING TO GENEVA LAKE

FOR DIFFERENT STORM FREQUENCIES.

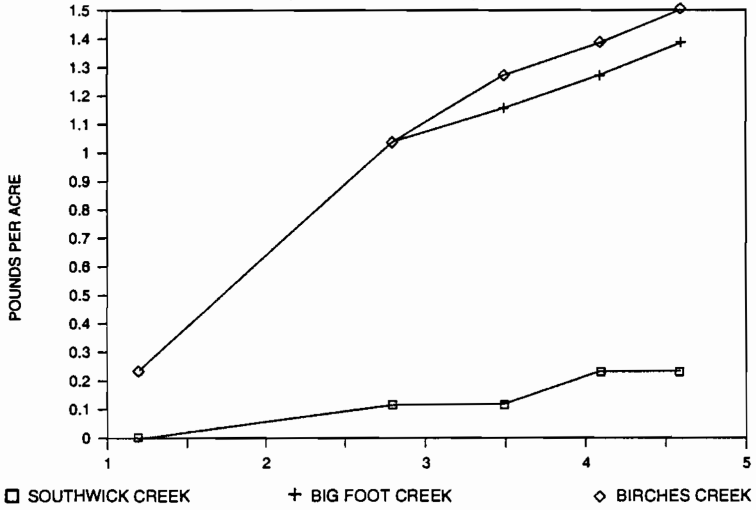


SOURCE: G.L.E.A.

FIGURE 10

TOTAL SOLUBLE PHOSPHORUS LOADING TO GENEVA LAKE

FOR DIFFERENT STORM FREQUENCIES.

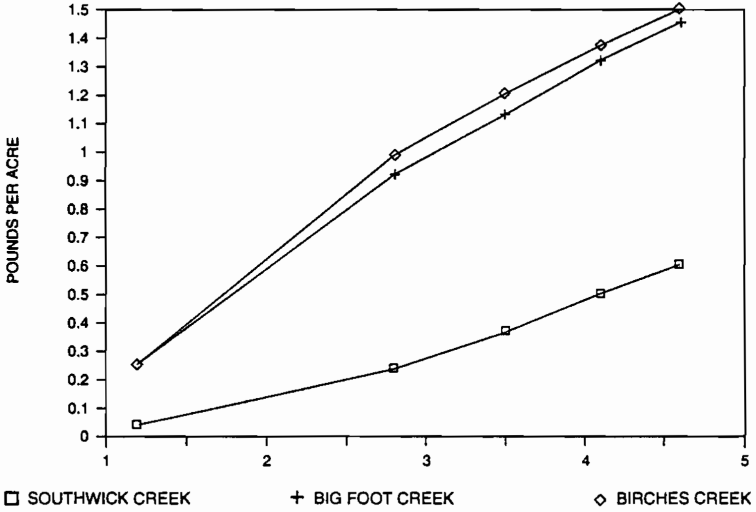


SOURCE: G.L.E.A.

FIGURE 11

TOTAL SOLUBLE NITROGEN LOADING TO GENEVA LAKE

FOR DIFFERENT STORM FREQUENCIES.



SOURCE: G.L.E.A.

VI. MODEL USE FOR LAKE MANAGEMENT

A. EVALUATION OF SEDIMENT LOADING FROM SOUTHWICK CREEK

A review of the sediment loading data from AGNPS confirms previously collected sediment loading data for Southwick Creek. During 1976-77 nine major perennial streams within the Geneva Lake watershed were monitored monthly as part of a comprehensive Geneva Lake study. That study found Southwick Creek to be the leading perennial stream for sediment loading. (Table 17). Visual observation during precipitation events over the years confirms that Southwick Creek is a substantial contributor of sediment to Geneva Lake.

Soil and water management are closely interrelated. Soil conservation attempts to minimize soil erosion and soil loss from a given site. Water management attempts to keep any lost soil out of surface waters. In looking at the Southwick Creek sediment problem it is important to look at both the erosion of soil and the movement of that lost soil.

The highest incell erosion within the watershed was from gravel pit operations. Because of onsite practices that were initiated since the original field study they no longer yield large amounts of sediment to down-flow cells (Figure 12).

Other cells that yielded high sediment loads within the Southwick subwatershed were in the southwest portion of the watershed. This area contains a farm field and woods that were undergoing urban development and cropland with minimal soil conservation practices in effect. Soil erosion on these areas was not as high as the gravel pits and in fact were no different than many of the other areas of similar land use in the Geneva Lake basin. This was especially true with the farm land.

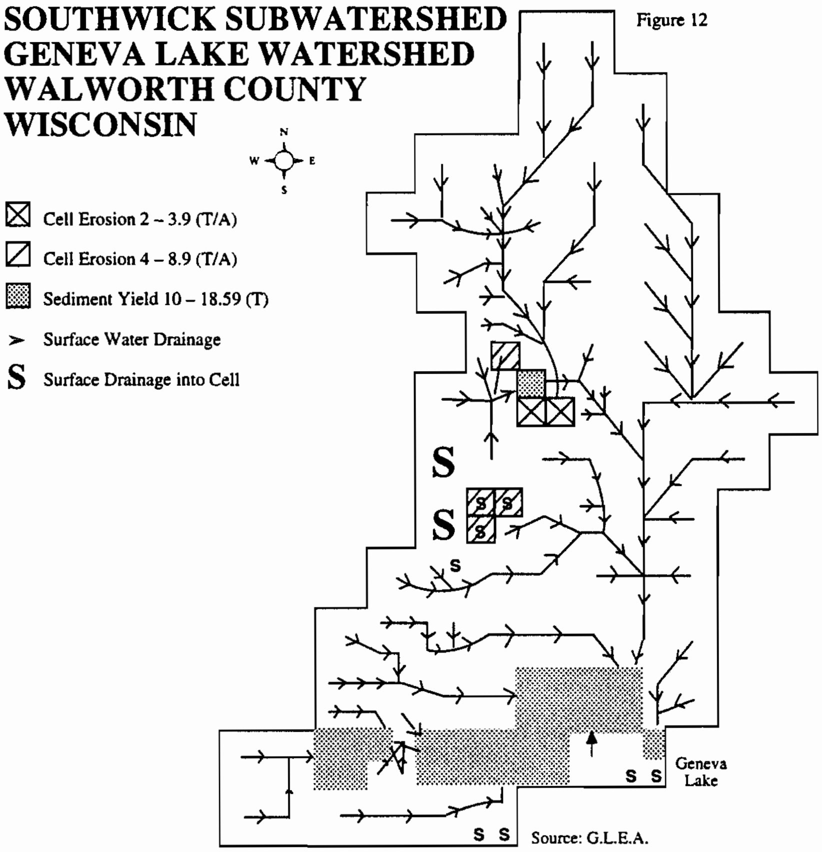


Figure 12

Source: G.L.E.A.

Table 17: Average Annual Concentrations/Values of Selected Water Quality Parameters for Nine Perennial Stream Inlets and the White River Outlet of Geneva Lake: May 1976-May 1977

	Name of Stream									
Parameter[a]	Pottawatomie	Buena Vista	Gardens	Southwick	Harris	Buttons Bay	Hillside	Trinke	Birches	White River
Hydrogen-ion Concentration (pH - standard units)	8.0	8.4	8.0	8.1	7.6	7.4	7.9	7.6	7.7	8.2
Specific Conductance (micromhos per square centimeter at 25°C)	737	1080	687	661	720	756	772	610	653	481
Chloride	39.4	168.0	21.3	28.5	19.3	47.8	48.4	14.9	15.6	35.9
Suspended Solids	9.9	12.5	5.1	17.9	9.8	6.4	17.2	7.8	6.9	5.1
Ammonia Nitrogen	0.047	0.353	0.026	0.096	0.069	1.220	0.226	0.471	0.124	0.112
Nitrate and Nitrite Nitrogen	0.49	1.34	4.73	0.46	0.38	0.68	0.24	0.32	0.13	0.05
Total Kjedahl Nitrogen	0.340	0.992	0.194	0.389	0.339	5.570	0.556	1.090	0.350	0.456
Dissolved Phosphorus (filtered)	0.014	0.868	0.012	0.071	0.016	0.879	0.040	0.074	0.034	0.027
Total Phosphorus	0.036	0.935	0.024	0.083	0.032	1.430	0.078	0.112	0.048	0.052
Biochemical Oxygen Demand (milligrams per liter of oxygen)	1.2	2.1	1.1	1.5	1.2	1.5	2.2	2.0	1.8	2.2
Fecal Coliform Bacteria (colonies per 100 milliliters)	141	116	52	265	26	55	526	273	29	225
Fecal Streptococcus Bacteria (colonies per 100 milliliters)	156	213	100	535	135	179	421	387	147	199
Fecal Coliform - Fecal Streptococcus Ratio[b]	0.90	0.54	0.50	0.50	0.19	0.31	1.25	0.71	0.20	1.13

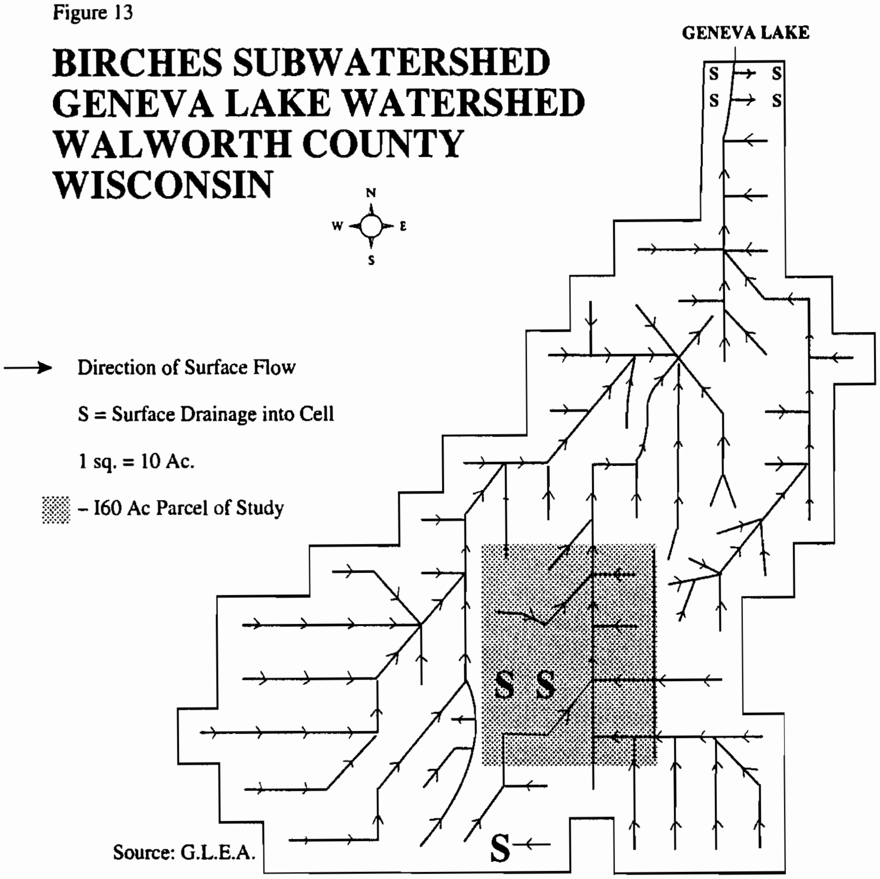
[a] All values are presented in milligrams per liter unless otherwise specified.

[b] Average fecal coliform-fecal streptococcus of each sample data.

Source: G.L.E.A.

Figure 13

BIRCHES SUBWATERSHED
GENEVA LAKE WATERSHED
WALWORTH COUNTY
WISCONSIN



Source: G.L.E.A.

During 1991-1992 approximately 60 acres of land within the southwest portion of Southwick watershed underwent preliminary development with road and utility installation and preliminary grading. Heavy rains during the early 1992 summer resulted in substantial erosion and sediment transportation in the storm water runoff. As a result a permanent detention pond was installed at the outlet of this development. During the early summer of 1993 heavy rains again lead to heavy sediment loading from Southwick Creek.

In studying the watershed and by running numerous different scenarios with different variables at the input level, one thing became obvious. Although the erosion from this site was not extremely high, whatever did erode was leaving the site and within 100 meters was entering a storm sewer. Once in the storm sewer this sediment is flushed through the remaining portion of the watershed with little if any retention and subsequent deposition. For all practical purposes, what ever left the site was being delivered all the way to the lake. The problem was not excessive erosion but a problem of a high percentage of delivery. Unfortunately the AGNPS model could not accurately simulate a detention pond or construction site erosion control practices in its data input. Thus there was no opportunity to accurately assess the changes resulting in the use of these erosion and sediment control practices in this portion of the Southwick Creek subwatershed.

B. USE OF THE AGNPS MODEL AS A PLANNING TOOL

Within the center of the Birches watershed is a 160 acre square parcel of land that is relatively undisturbed (Figure 13). The parcel was farmed and pastured more than 10 years ago but now lies fallow with natural succession occurring. The parcel offers a tremendous amount of varied wildlife habitat. It contains a stream, pond, woods, open field and uplands areas that all add up to a wide variety of native plants and animals. There are areas of groundwater recharge and discharge within the parcel.

In the spring of 1992 the Geneva Lake Conservancy considered purchasing this parcel to help maintain water quality to Geneva Lake. The parcel had been for sale for many years and a year earlier a golf course / residential development had been proposed for the parcel. The Conservancy requested the GLEA to use the ANPS model and look at the impact of different land uses on the watershed's loading to the lake.

Three different scenarios were developed using different potential land uses on the parcel. The first scenario was an "as is" scenario. The second scenario involved the parcel being developed into a sub-division with one acre lots. The third scenario involved the land returning back to farm land similar to the adjacent land.

Seven of the input data were changed for each scenario (Table 18). The agricultural data was based upon con-

Table 18: Input Data Changes For Special Study Within Birches Subwatershed, Walworth Co., WI.

Initial Data

Watershed Identification	BIRCHES-MAC POHN
Description	Suwatershed of Geneva Lake
Area of each cell (acres)	10
Number of cells	16
Precipitation (inches)	2.8 (Two year frequency)
Energy-Intensity Value	45.3
or Duration (hours)	24
Storm Type (I, Ia, II, III)	2

The Different Scenarios Were Expressed by Changing the Following Variables for Each Different Land Use:

Variable	As Is	Agricultural	Residential
Curve Number	58/59	75	74
Manning's Coeff.	0.3/0.03	0.27/0.027	0.27/0.027
P Factor	0.9	0.9	1.0
Surface Com. Constant	0.9	0.05	0.01
Fert. Level	0	1	1
Fert. Avail.	0	34	100
COD Factor	60/62	170	80

Source: G.L.E.A.

Table 19: Changes in Water Quality and Quantity Loading to Geneva Lake Resulting from Land Use Changes.
Special Study Parcel: Birches Subwatershed, Walworth Co., WI.

Runoff of Nitrogen, Phosphorus, and Oxygen	As Is	Residential	% Change	Agricultural	% Change
Runoff Volume (inches)	0.6	0.7	17	0.7	17
Peak Runoff Rate (cfs)	272	310	14	301	11
Total Nitrogen in Sediment (lbs/ac)	0.52	0.54	4	0.69	33
Total Soluble Nitrogen in Runoff (lbs/ac)	0.59	0.80	36	0.73	24
Soluble Nitrogen Concentration in Runoff (mg/L)	4.18	4.91	17	4.58	10
Total Phosphorus in Sediment (lbs/ac)	0.26	0.27	4	0.34	31
Total Soluble Phosphorus in Runoff (lbs/ac)	0.09	0.13	44	0.11	22
Soluble Phosphorus Concentration in Runoff (mg/L)	0.64	0.81	27	0.68	6
Total Soluble Chemical Oxygen Demand (lbs/ac)	17.53	19.27	10	20.93	19
Soluble Chemical Oxygen Demand Concentration in Runoff (mg/L)	123	118	-4	132	7

Source: G.L.E.A. and AGNPS

tinuous corn cropping. The program was run using a two year frequency storm event (2.4"). Data output was prepared for both the parcel's outlet cell (cell 57) and for the whole watershed's outlet to the lake (cell 1).

At the parcel outlet the model showed that the significant changes in the hydrology would result in changes from both residential or agricultural land use. Both the amount of runoff and the peak flow would increase between 40 to 50% from both land use changes. The amount of soil loss generated within the watershed and the amount yielded showed a significant change for the agricultural lands use with residential showing only a minor change. The amount of onsite deposition increased for the agricultural land use but decreased for the residential. As expressed in the Southwick Creek section of this report, the storm water conveyance systems associated with residential areas does not afford much "instream" deposition. Both land use scenarios also showed increases in the sediment nitrogen and phosphorus and soluble nitrogen and phosphorus at the parcel's outlet.

At the watershed outlet to the lake the different scenarios also resulted in changes to the hydrologic, sediment and nutrient loading to the lake (Table 19). Although the changes were not as significant as at the parcel's outlet, the changes resulted in increased loading of total sediment, sediment nitrogen and phosphorus and soluble nitrogen and phosphorus. The difference in loading from the parcel's outlet to the watershed outlet was due in part to the assimilative ability of the watershed and stream channel between the two points.

The results of this exercise in the use of the AGNPS model for land use decisions led the GLEA to encourage the Geneva Lake Conservancy to purchase this parcel. Although the actual values generated by the AGNPS model may be questionable the comparative value of the model in this decision making process was valuable.

C. IDENTIFYING THE SERIOUSNESS OF SOIL LOSS AND TRANSPORT

Attempts have been made to annualize the single event output data from the AGNPS model.[1] The AGNPS developers are presently fine tuning their own annualized AGNPS[2]. To make the model more useful it would be helpful to look at the erosion and transport data on an annualized basis rather than on a single storm event. The single event approach catches an event in time with all the input data being representative for that specific time and event only. Thus the output data is limited to only representing the loading at that specific time and under those specific conditions.

A simple way to assess the soil loss output data from the AGNPS model would be to compare the given soil loss from a specific storm event with the tolerable annual soil loss relative to the annual precipitation. Discussion with the local SCS personnel indicates that tolerable soil loss for this area of Wisconsin would be between 3-5 tons per acre depending upon the soil types. Using the higher end of the range, 5 tons per acre, per year and assuming the annual precipitation for this part of Wisconsin to be 34 inches, we come to the conclusion that for every inch of rain to fall, a soil loss of 0.15 ton would be tolerable. For a 1.2 inch rain event, 0.18 tons or 360 pounds of soil loss would be tolerable.

D. TOLERABLE SOIL LOSS AND TRANSPORT WITH-IN THE THREE WATERSHEDS

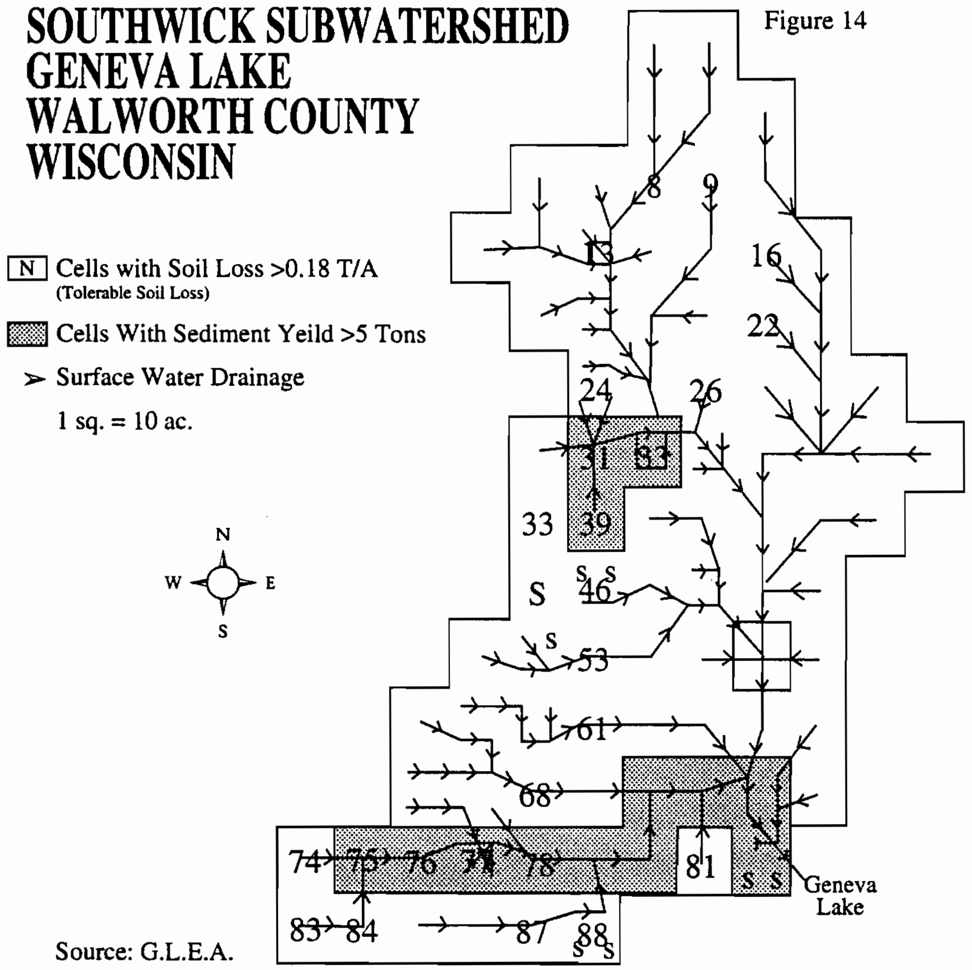
Using the above rationale for defining tolerablesoil loss, cells that exceeded the tolerable soil loss of 0.18 tons per acre for a 1.2 inch storm event were identified for each watershed (Figures 14, 15, and 16). Those cell numbers shown exceeded the tolerable soil loss of 0.18 tons per acre for a 1.2 inch storm event.

---

1. J.K. Koelliker and C.E. Humbert, "Applications of AGNPS Model to Watersheds in Northeast Kansas. Joint Agreement #65-6215-8-1, between USDA-SCS Kansas Office and Kansas State University.

2 USDA-ARS, North Central Soil Conservation Research Lab. "AGNPS Newsletter, A Quarterly Report", Spring 1993.

Figure 14



Source: G.L.E.A.

Identifying the high soil loss cell does not necessarily indicate what may actually be leaving the cell or entering the surface waters. To understand what impacts soil loss may have on adjacent surface waters it is important to know what happens to that lost soil and where it goes. Included in Figures 14, 15, and 16 are cells with high sediment yield rates and the surface transport routes of the yielded sediment. Using these figures we can identify cells that have high rates of erosion and better understand the fate of the transplanted soil.

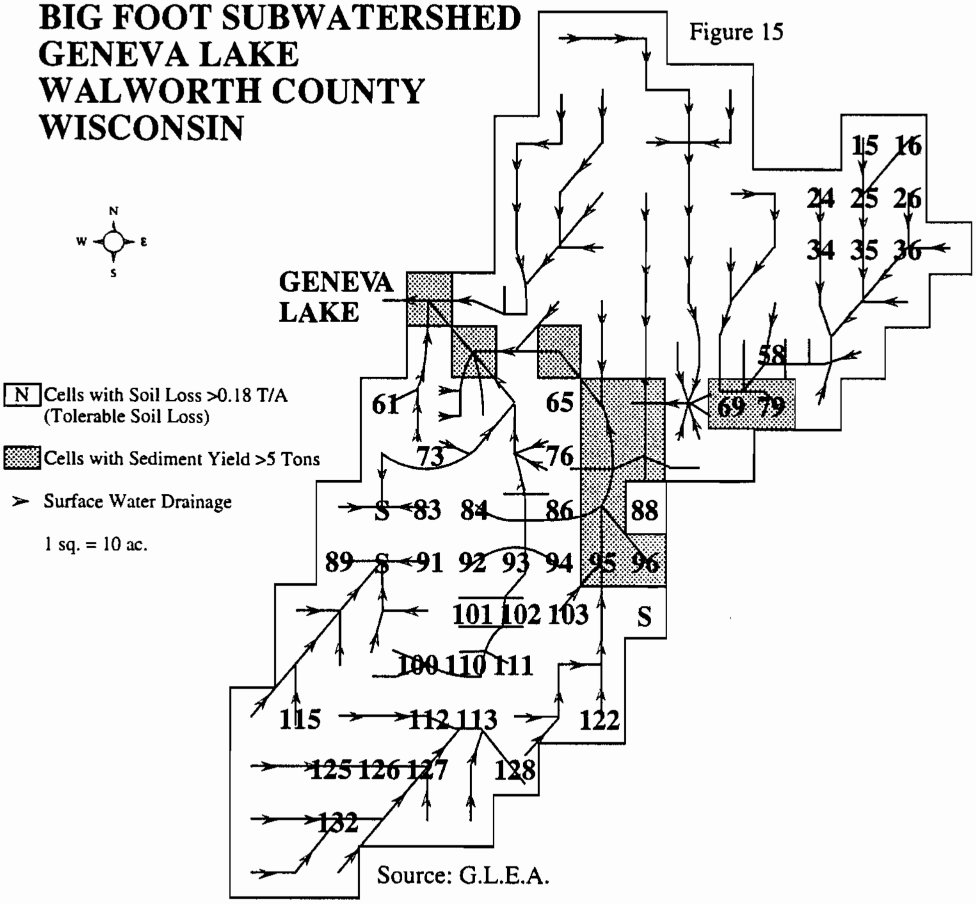
- Southwick – At several places within the Southwick watershed soil loss was in excess of the calculated tolerable soil. The transport of that sediment through the watershed and eventually to the lake appears to be a problem only in the southern portion of the watershed. Both the rates of soil loss and the means of conveying the storm water runoff through storm sewers are responsible for the sediment loading to Geneva Lake from Southwick Creek.

- Big Foot – The Big Foot watershed had the highest number of cells that exceeded the calculated tolerable soil loss. Big Foot watershed also showed a high sediment yield at the outlet cell. This yield appears to be carried downflow from an area located in the central portion of the watershed that is in exceedence of the tolerable soil loss value.

- Birches – Within the Birches watershed major areas of soil loss appear to be in the southwestern portion, and the east central portion of the watershed. Major yields of sediment manifested themselves somewhat downstream from the high erosion cells. However the watershed outlet cell was yielding substantially lower sediment load. This indicates that somewhere in the storm water conveyance system there is some deposition taking place. This is different then what is happening in the Southwick and Big Foot subwatersheds.

BIG FOOT SUBWATERSHED
GENEVA LAKE
WALWORTH COUNTY
WISCONSIN

Figure 15



N Cells with Soil Loss >0.18 T/A (Tolerable Soil Loss)

▨ Cells with Sediment Yield >5 Tons

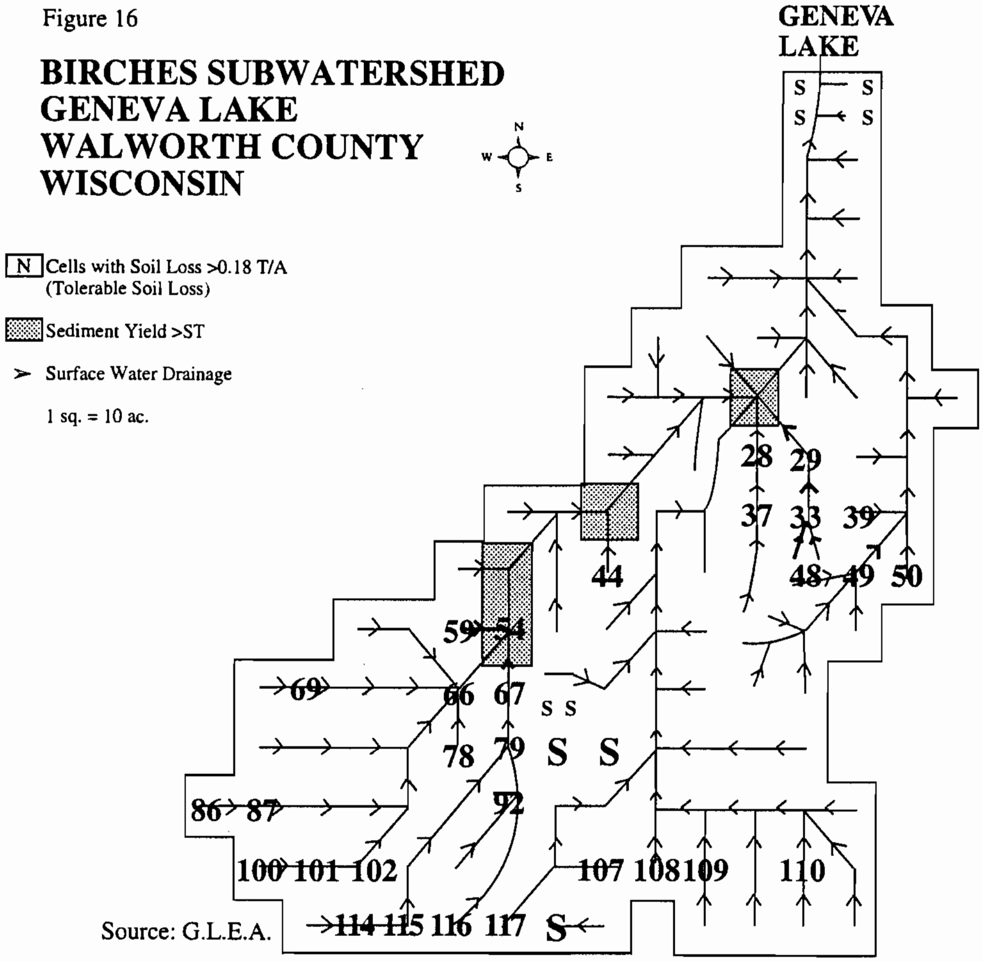
➢ Surface Water Drainage

1 sq. = 10 ac.

Source: G.L.E.A.

Figure 16

BIRCHES SUBWATERSHED
GENEVA LAKE
WALWORTH COUNTY
WISCONSIN



N Cells with Soil Loss >0.18 T/A (Tolerable Soil Loss)

▨ Sediment Yield >ST

➢ Surface Water Drainage

1 sq. = 10 ac.

Source: G.L.E.A.

VII. CONCLUSIONS

The AGNPS model was helpful in determining the sediment nutrient and hydrologic loading from three subwatersheds to Geneva Lake. The model tracks the movement of soil and water through a watershed and can be used to evaluate the potential impacts of different land uses on a lake.

The model accurately represents what happened during a storm event in the Birches subwatershed, the most agricultural of the three subwatersheds. Birches contributed the highest soluble nutrient loading to the lake, in part due to the large amount of fertilizer runoff from adjacent agricultural land. The model also predicted a significant increase in sediment and nutrient loading to Geneva Lake from the Birches watershed if undeveloped land is changed to single family or agricultural land. This exercise showed the utility of the model in evaluating the impact of proposed land use changes on Geneva Lake.

Southwick subwatershed contributed the highest sediment and related nitrogen and phosphorus sediment sources. This watershed has both urban and agricultural land uses and both were sediment sources. The loading of sediment to Geneva Lake was more a result of the storm water conveyance system than soil erosion. Curb, gutters, and storm sewers address water quantity problems in removing storm water fast and effectively but does nothing to improve water quality. The model did not accurately evaluate the effects of the retention / detention ponds.

The Big Foot subwatershed showed the greatest hydrologic response to the modeled storm events. It was not clear if this was from the watershed's size or the way the model handled the watershed's wetlands. The model addressed wetlands as a flow through system which is contrary to the belief that wetlands act as filters slowing down the flow and allowing sediment and nutrient assimilation. Ironically this wetland has shown signs of purging itself shortly after heavy rains. More study of the model's finding and the wetlands response to storms is needed.

VIII. RECOMMENDATIONS

The Following recommendations are made as a result of this project:

1. The level of non-point source pollution to Geneva Lake is partially know as a result of this work. It is recommended that the entire Geneva Lake watershed be inventoried and assessed using a combination of computer model and field verification.

2. The Big Foot subwatershed produced some anomalies in the model that need further evaluation. The wetland complexes need to be re-evaluated to get a better understanding in their importance in protecting the water quality of Geneva Lake.

3. The AGNPS model's ability to accurately assess urban lands needs to be evaluated.

4. When reviewing proposed development projects, careful consideration should be given to the best storm water run-off conveyance systems. Systems that allow for retention, assimilation infiltration absorption, and detention should be encouraged specifically when the storm waters are discharged to the other surface waters. Consideration should be given to the quality and quantity of runoff and to where the runoff is discharged.

5. Municipalities around Geneva Lake should be made aware of this report and encouraged to use the information. Sound land use practices in the watershed of Geneva Lake will help ensure its water quality and economic stability of surrounding communities.

In addition Geneva Lake Environmental Agency staff and Geneva Lake Conservancy staff are available to discuss the report with anyone interested in its findings.

APPENDIX

In an attempt to lower the peak runoff rate in the AGNPS data output for Big Foot subwatershed, the marsh values in the input section were altered. The changes were to better represent the detention and flow moderating effects that wetlands have. Since the watershed is approximately 21% wetland and the AGNPS model does not effectively deal with them, a plan to better represent these areas was devised and implemented. It is as follows:

1. Marsh cells were identified by location of the .99 Mannings coefficient.
2. Cell with soil type entered as water were eliminated because they indicated ponds or actual surface waters.
3. Different scenarios were run using different marsh inputs:

Scenario A: Change Mannings Coefficient to .30 for all marsh cells (Table A-1)

```
              INITIAL DATA - TABLE A-1 OUTPUT CHANGES
Watershed Identification                                   Big Foot - A
Option
Description                                            Marsh Manning's
altered
Area of each cel (acres)
10.0
Number of cells
138
Precipitation (inches)
3.0
Energy-Intensity Value OR
52.6
Duration (hours)
24.0
Storm Type (I, Ia, II, III)
2
                      WATERSHED SUMMARY
Watershed Studied                          BIG FOOT - A option
The area of the watershed is                            1205   acres
The area of each cell is                               10.00   acres
The characteristic storm participation is               3.00   inches
The storm energy-intensity value is                       53
                VALUES AT THE WATERSHED OUTLET
Cell Number                                               38   000
Runoff Volume                                            0.9   inches
Peak Runoff Rate                                         441   cfs
```

Scenario B: Change Surface Condition Constant to 1.0, maintain Runoff Curve number at 85 (Table A-2).

```
              INITIAL DATA - TABLE A-2 OUTPUT CHANGES
Watershed Identification                                   Big Foot - B
Option
Description                                                  Marsh SCC
altered
Area of each cel (acres)
10.0
Number of cells
138
Precipitation (inches)
3.0
Energy-Intensity Value OR
52.6
Duration (hours)
24.0
Storm Type (I, Ia, II, III)
2
                      WATERSHED SUMMARY
Watershed Studied                          BIG FOOT - A option
The area of the watershed is                            1205   acres
The area of each cell is                               10.00   acres
The characteristic storm participation is               3.00   inches
The storm energy-intensity value is                       53
                VALUES AT THE WATERSHED OUTLET
Cell Number                                               38   000
Runoff Volume                                            0.9   inches
Peak Runoff Rate                                         441   cfs
```

Scenario C: Change Surface Condition Constant to 1.0, Change Runoff Curve number to 69 (Table A-3).

```
              INITIAL DATA - TABLE A-3 OUTPUT CHANGES
Watershed Identification                                   Big Foot - C
Option
Description                                          Marsh SCC and RCN
altered
Area of each cel (acres)
10.0
Number of cells
138
Precipitation (inches)
3.0
Energy-Intensity Value OR
52.6
Duration (hours)
24.0
Storm Type (I, Ia, II, III)
2
                      WATERSHED SUMMARY
Watershed Studied                          BIG FOOT - C option
The area of the watershed is                            1205   acres
The area of each cell is                               10.00   acres
The characteristic storm participation is               3.00   inches
The storm energy-intensity value is                       53
                VALUES AT THE WATERSHED OUTLET
Cell Number                                               38   000
Runoff Volume                                            0.9   inches
Peak Runoff Rate                                         398   cfs
```

Scenario D: Change Surface Condition Constant to 1.0 maintain Runoff Curve Number at 85 but change Mannings Coefficient to 0.3 (Table A-4).

```
              INITIAL DATA - TABLE A-4 OUTPUT CHANGES
Watershed Identification                                  Big Foot - D
Option
Description                                             Marsh SCC and
Manning's
Area of each cel (acres)
10.0
Number of cells
138
Precipitation (inches)
3.0
Energy-Intensity Value OR
52.6
Duration (hours)
24.0
Storm Type (I, Ia, II, III)
2
                        WATERSHED SUMMARY
Watershed Studied                         BIG FOOT - D option
The area of the watershed is                             1205  acres
The area of each cell is                                10.00  acres
The characteristic storm participation is               3.00  inches
The storm energy-intensity value is                        53
                  VALUES AT THE WATERSHED OUTLET
Cell Number                                              38  000
Runoff Volume                                           0.9  inches
Peak Runoff Rate                                        441  cfs
```

Scenario E: Change Surface Condition Constant to 1.0, change Runoff Curve Number to 69, and change Mannings Coefficient to .30 (Table A-5).

```
              INITIAL DATA - TABLE A-5 OUTPUT CHANGES
Watershed Identification                                  Big Foot - E
Option
Description                                             Marsh SCC and
Manning's
Area of each cel (acres)
10.0
Number of cells
138
Precipitation (inches)
3.0
Energy-Intensity Value OR
52.6
Duration (hours)
24.0
Storm Type (I, Ia, II, III)
2
                        WATERSHED SUMMARY
Watershed Studied                         BIG FOOT - E option
The area of the watershed is                             1205  acres
The area of each cell is                                10.00  acres
The characteristic storm participation is               3.00  inches
The storm energy-intensity value is                        53
                  VALUES AT THE WATERSHED OUTLET
Cell Number                                              38  000
Runoff Volume                                           0.9  inches
Peak Runoff Rate                                        398  cfs
```

In an attempt to further reduce the peak flow value from the AGNPS model for the Big Foot subwatershed, a simulated one cell study was conducted. A single cell was designed to simulate a wetland condition.with the intent of altering the values for wetland simulation. The variables were chosen to determine which data inputs AGNPS reflected to be most sensitive. Variably altered were; Surface Condition Constant, Mannings Coefficient, and the Runoff Curve Number. Five trials were run with the following discharge outputs.

VARIABLES

Trial	Mannings	SCC	RCN discharge	(CFS)
1	.99	1.00	69	29
2	.99	.99	69	29
3	.99	.59	69	29
4	.30	.99	58	13
5	.30	.99	.69	29

According to the data the Runoff Curve number is the only input of the three which significantly reduces the peak flow. Specific manipulations of data values were done for the following reason

Mannings: The AGNPS manual says to put in .99 as a value to simulate water or wetlands, this value only serves as a flag for a water surface. A value of .3 indicates a surface of dense grass which is more indicative of wetlands.

SCC: The AGNPS manual gives 1.0 as a value for wetlands, the .99 value was used to determine if this was just a flag similar to the Mannings value. The .59 simulates permanent meadow conditions.

RCN: The AGNPS manual gives 85 to simulate a wetland condition, this flow was seemingly to high to accurately depict the retention capabilities of wetlands. It was lowered to 65, which is the permanent meadow condition.

LIST OF FIGURES

LIST OF TABLES