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Abstract

The Agricultural Nonpoint Source Pollution (AGNPS) model was developed by the Agricultural Research Service (ARS) in cooperation with the Minnesota Pollution Control Agency and Soil Conservation Service. As part of a project to model the effects of land management alternatives in the polders of the Nemunas River Delta of Lithuania, the AGNPS model input parameters are modified here to reflect Lithuanian conditions.

Disciplines

Agriculture | Water Resource Management

An Adaptation of the Agricultural Nonpoint Source Pollution Model to Lithuania

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AN ADAPTATION OF THE AGRICULTURAL NONPOINT SOURCE POLLUTION MODEL TO LITHUANIA

Introduction

Computer models developed to estimate watershed response to rainfall events include Erosion/Productivity Impact Calculator (EPIC), Aerial Nonpoint Source Watershed Environmental Response Simulation (ANSWERS), and Simulator for Water Resources in Rural Basins (SWRRB). But these models are either limited in watershed size capability, require very extensive data input, or rquire a mainframe computer.

The Agricultural Nonpoint Source Pollution (AGNPS) model was developed by the Agricultural Research Service (ARS) in cooperation with the Minnesota Pollution Control Agency and Soil Conservation Service (SCS). It was developed to analyze water quality of Minnesota runoff watershed. The model predicts runoff volume and peak rate, eroded end delivered sediment, and nitrogen, phosphorus, and chemical oxygen demand concentrations in runoff end sediment for single storm events for all points of watersheds. It was developed to analyze and provide estimates of runoff water quality in agricultural watersheds ranging in size from a few hectares to upwards of 20,000 ha. It is relatively simple to use and runs on an IBM-compatible personal computer. After a watershed has been identified, remedial measures can be recommended by varying the alternative management practices input data and analyzing the resulting watershed responses.

The model operates on a cell basis; cells are uniformly square areas subdividing the watersheds, allowing analysis at any point within the watershed. Potential pollutants are routed through cells from the watershed divide to the outlet in a stepwise manner so that flow at any point between cells may be examined. For watersheds exceeding 800 hectares, a cell size of 16 hectares is recommended. Smaller cell sizes are recommended for smaller watersheds. Currently, AGNPS is used in more than 45 countries around the world. As part of a project to model the effects of land management alternatives in the polders of the Nemunas River Delta of Lithuania, the AGNPS model input parameters were modified to reflect Lithuanian conditions.

Model Structure

Basic model components include hydrology, erosion and sediment, and chemical transport. In addition, the model considers nutrients and chemical oxygen demand (COD) from animal feedlots, springs, and other point sources.

Since climate and hydrology conditions in Lithuania are different from those in Minnesota where the model was developed, we needed to verify initial and input data for the model and, where necessary, change them to reflect local conditions. The adaptation can be used as a guide to define initial data and input parameters for AGNPS models in other regions.

Runoff volume estimates are based on the Soil Conservation Service curve number method, which was developed to be used with rainfall and watershed data that are ordinarily available. It is widely used for estimating floods on small and medium ungauged watersheds. It is not possible to define precisely what is "small" or "medium" sized, but an upper limit of 25 km^2 and 500 km^2 can be considered as general guides.

The basic equation derivation was made on the assumption that no runoff occurs until rainfall equals an initial value I_a. After allowing for I_a, the depth of the runoff Q remainds after subtracting F, the infiltration or water retained in the drainage basin (excluding I_a) from the rainfall P. The potential retention S is the value that $(F+I_a)$ would reach in a very long storm. If P_a is the effective storm rainfall, equal to $(P-I_a)$, the basic assumption in the method is

$$\frac{F}{S}=\frac{Q}{Pa} \tag{1}$$

where

F = infiltration or water retained in the drainage basin (excluding I_a),

S = potential retention,

Q = actual runoff,

P_a- = potential maximum runoff $(P-I_a)$,

P = rainfall.

After substituting $I_a = 0.2\,S$, which is the best approximation from observed data, the equation becomes

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (2)$$

For convenience and standardized application of this equation, the potential retention S is expressed as a dimensionless runoff curve number CN:

$$\text{CN} = \frac{1000}{S + 10} \qquad (3)$$

Changing S to CN in equation (2) gives the basic SCS relationship for estimating Q from P and CN. The advantage of this equation is it has only one parameter. This method is widespread in the Unitec States because of its simplicity. The value of CN depends on the soil, cover and hydrologic condition of the land surface.

In the model, soil is divided into four classes:

- A - high infiltration and low runoff, as in deep sand or loess, aggregated silts or gravel
- B - moderate infiltration, as in moderately coarse-textured soils such as sandy loam
- C - slow infiltration, as in fine-textured soil such as clay loam, shallow sandy loam, and soil low in organic content; and
- D - very slow infiltration, as in swelling and plastic clays, and claypan.

Effectively drained soils can be placed in an alphabetically higher group.

CN also depends on the antecedent wetness of the soil. The three classes of antecedent moisture (AMS) are defined as dry, average, and wet. According to this classification, most of the soils in the River Nemunas lowland are class B. For an accurate classification, we used 1:10,000 scale soil maps for every polder.

In the SCS method of runoff estimation, the effected surface conditions of a watershed are evaluated by soil cover conditions. Cover condition includes all vegetation, litter and mulch, fallow (bare soil), water surfaces (lakes, swamps, etc.), and impervious surfaces (roads, roofs, etc.). Cover condition also includes land treatment such as contouring or terracing. Because of flat surface in the

River Nemunas lowland, we assumed straight-row soil treatment. Surface runoff also depends on management practices such as grazing control or crop rotation.

Hydrologic conditions evaluate vegetation density, organic matter and soil structure. Drained soils have better hydrological conditions and infiltration and lower runoff.

The SCS curve number is determined when the soil, cover and hydrological condition are classified. To determine SCS curve numbers for lowlands of the Nemunas River, we selected cover and hydrological conditions typical of this region, and average antecedent moisture conditions (AMC II).

Table 1. SCS runoff curve numbers for various land use situations in lowlands of the Nemunas River

Cover	Hydrologic condition	Hydrologic soil group A	B	C
Fallow (bare soil)		77	86	91
Row crops (sugar beet, potatoes, corn)	Poor	72	81	88
	Good	67	78	85
Small grain (wheat, oats, barley, flax, rye)	Poor	65	76	84
	Good	63	75	83
Close seeded legumes or rotation meadow (alfalfa, sweetclover, timothy)	Poor	66	77	85
	Good	58	72	81
Pasture for grazing	Poor (heavily grazed)	68	79	86
	Fair (not heavily grazed)	49	69	79
	Good (lightly grazed)	39	61	74
Permanent meadow for hay, protected from grazing	Good	30	58	71
Woodland	Poor (grazed, no litter)	45	66	77
	Fair (grazed, some litter)	36	60	73
Forest protected from grazing	Good (litter and shrubs cover the soil)	25	55	70
Farmsteads		59	74	85

Table 1. continued

Cover	Hydrologic condition	Hydrologic soil group A	B	C
Water		100	100	100
Marsh		85	85	85
Animal lot (unpaved)		91	91	91
(paved)		94	94	94
Roof area		100	100	100

Peak discharge for each cell is estimated using an empirical relationship proposed by Smith and Williams (1980) which is also used in the CREAMS model.

$$Q_p = \frac{3.79A^{0.7}CS^{0.16}\left(\frac{RO}{25.4}\right)^{(0.903A^{0.017})}}{LW^{0.19}}, \tag{4}$$

where

Q_p = peak flow rate, m^3/s,

A = drainage area, km^2,

CS = channel slope, m/km,

RO = runoff volume, mm,

LW = watershed length width ratio, calculated by

$$\frac{L^2}{A}, \tag{5}$$

where L is the watershed's length.

A modified Universal Soil Equation (USLE) is used to predict upland erosion for single storm events. The soil loss equation used in the model is

$$A = EIKLSCP, \tag{6}$$

where

A = soil loss per unit area, tons per acre year,

EI = rainfall erosion index (value of the erosive potential),

K = soil readability factor,

L = slope-length factor,

S = slope steepness factor,

C = cover and management factor,

P = support practice factor,

The value of EI for a given rainstorm event equals the product of total storm energy (E) times the maximum 30 minute intensity (I_{30}) , where E is expressed in hundreds of foot-tons per acre and I_{30} is expressed in inches per hour. EI is actually E x I_{30}, and the term should not be considered simply an energy parameter. Rainfall itself is not a good indicator of erosion potential. The storm energy (E) indicates the volume of rainfall and runoff, but raindrop erosion increases with rain intensity. The I_{30} component indicates the prolonged peak rates of detachment and runoff. EI reflects how total energy and peak intensity are combined in a particular storm.

Storm intensity and energy depend on climate, so we had to separately determine the rainfall erosion index for Lithuania.

Rainfall energy is directly related to rain intensity. The relationship is expressed by the equation

$$E = 210+89 \lg I, \qquad (7)$$

where

E = kinetic energy, metric ton meters per hectare,

I = maximum 30 minute rainfall intensity, centimeters per hour.

To determine EI, we first took data of storm rainfall depth for various frequencies in Lithuania (Table 2).

Table 2. Storm rainfall depth for various frequencies in Lithuania

Probability (percent)	Storm frequency (one per N year)	Storm duration (min) 10	20	60	720	1440	2880
3.3	30	18.9	24.5	38.4	57.9	66.4	71.7
4	25	17.8	24.2	37.6	56.4	<u>65.2</u>	70
5	20	17.8	23.9	37.2	56.2	64.2	69.4
6.7	15	16.7	23.5	36.2	53.8	61.5	67.2
10	10	16.2	22.3	33.3	48.4	57.6	64.5
20	5	13.3	17.8	22.9	41.1	48.1	57.5
50	2	9.1	11.8	16.3	29.8	34.9	41.8

Note: Precipitation has been calculated according Ðventoji, Telðiai, Dûsetai, Sovietskas, Kaunas, Vilnius, Gvardeiskas, Lazdijai and Druskininkai weather station data.

From Table 2, we determined that the 24 hour precipitation depth for a 25 year frequency in Lithuania is 65.2 mm.

We next found the intensity of the single daily storm and its energy. For this purpose we plotted a 25 year frequency storm increment chart (Figure 1).

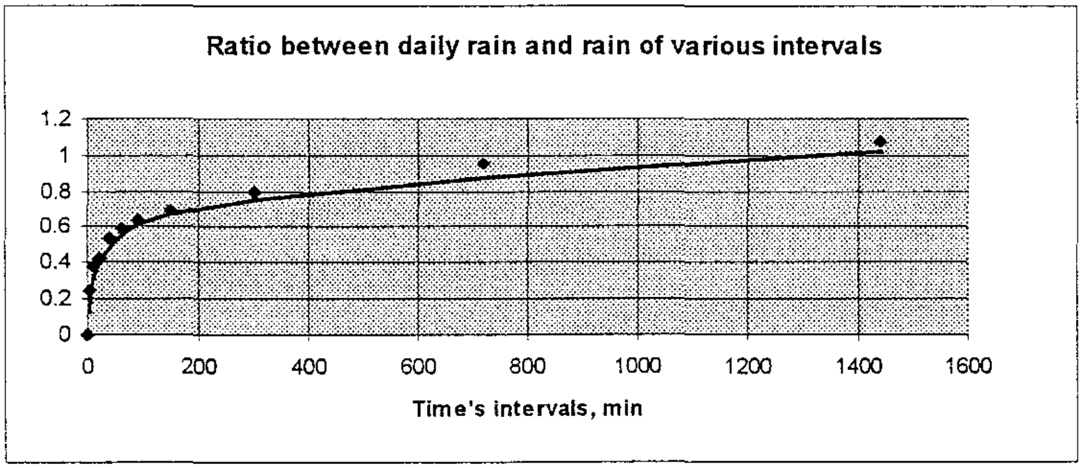


Figure 1. Ratio between daily and various interval rain

For a more exact definition of the 30 minute storm intensity I_{30}, we plotted a storm increment chart for the first hour of the storm (Figure 2).

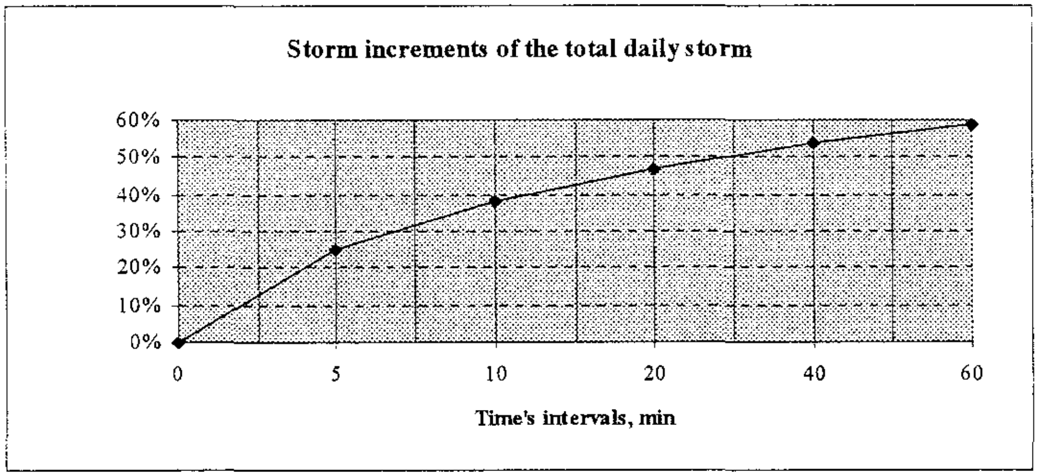


Figure 2. Twenty-five year frequency storm increment in Lithuania

From Figure 2, we see that the 30 minute storm intensity I_{30} is 50 percent of the daily storm, therefore

$I_{30} = 65.2*0.5*2 = 6.52$ cm/h.

Using equation (7), the kinetic energy of the rainfall at a storm intensity of 6.52 cm/h is 283 tm/ha per cm of rain. The constant factor of 0.01 used for the English system should also be applied here. Therefore, kinetic energy $E = 2.83$.

Energy intensity $EI = 2.83*6.52=18.45$.

The AGNPS model initial data requires that EI be in American units. Kinetic energy of rainfall expressed in foot-tons per acre per inch of rain must be computed by the equation

$$E = 916+331\lg I, \quad (8)$$

where

E = kinetic energy, foot-tons per acre per inch of rain,

I = Maximum 30 minute rainfall intensity, inches per hour.

From Table 2, it can be determined that the 24-hour precipitation depth for a 25-year frequency in Lithuania is 2.57 inches.

The 30 minute storm intensity I30 makes up 50 percent of the daily storm (Figure 2).

$I30 = 2.57*0.5*2 = 2.57$ in/h.

Kinetic energy for rainfall is 2.57 in/h is E-10.53 foot-tons per acre inch of rain:

$El = 10.53*2.57 = 27.1$;

EL = 27.1 and precipitation of 2.57 inches will be used for the AGNPS model in Lithuania.

Erodibility is numerous complex interactions of soil's physical and chemical properties, and often varies within a standard texture class. Usually a soil type becomes less erodible with a decrease in silt fraction, regardless of whether the corresponding increase is in the sand or clay fraction. Soil erodibility also depends on soil structure, permeability, and organic matter quantity. For soils containing less than 70 percent silt and very fine sand, the soil erodibility factor K can be computer by the following equation:

$$100K \approx 2.1*M^{1.14}(10^{-4})(12 - a)+3.25*(c-3), \qquad (9)$$

where

M = particle size parameter in top soil,
a = percent of organic matter,
b = top soil structure code,
c = top soil profile permeability class.

The particle size parameter M was derived from direct measurements of the soil erosion. For major soils on which erosion plot studies are conducted, the particle size parameter M depends on mechanical composition of the soil and is defined by the equation

$$M = (si+vfs)(100-cl), \qquad (10)$$

where

si = percent of silt,
vfs = percent of very fine sand,
cl = percent of clay.

$$cl = 100 - si - s - vfs, \tag{11}$$

where

s = percent of sand.

Top soil structure code b:

1. very fine granular,
2. fine granular,
3. medium or coarse granular,
4. blocky, platy, or massive.

Top soil profile permeability class c:

6. very slow,
5. slow,
4. slow to moderate,
3. moderate,
2. moderate to rapid,
1. rapid.

Soil erodibility factor's K calculation for Rusne island:

si+vfs = 50%

si = 10%

cl = 100-(40+20) = 40%

a = 2.5%

b = 2

c = 4

K = 0.21

Topographic factor LS is the expected ratio of soil loss per unit area from a field slope to that from a 72.6 (22.13 m) length of uniform 9 percent slope under otherwise identical conditions. To calculate LS values for a uniform gradient slope, the following equation is used:

$$LS = \left(\frac{\lambda}{72.6}\right)^{m} (65.41\ \sin^2\Theta + 4.56 \sin\Theta + 0.065)\ , \tag{12}$$

where

λ = slope length, feet,

Θ = angle of slope,

m = 0.5 when slopes are 5% or more,

m = 0.4 when slopes are 3.5-4.5%,

m = 0.3 when slopes are 1- 3%,

m = 0.2 when slopes are less than 1%.

L is the ratio of field soil loss to the corresponding loss from a 72.6 foot slope length; its value may be expressed as:

$$L=\left(\frac{\lambda}{72.6}\right)^{m} \tag{13}$$

Slope length λ is defined as the distance from the overland flow point origin to the point where either the slope gradient decreases enough that deposition begins, or runoff water enters a defined channel that may be a part of a drainage network or constructed channel. Field slope length cannot exceed 300 feet. The average field slope length in feet is based on recommended land slope.

Table 3. Field slope length

	Slope steepness category			
Field slope length	**0-2**	**3-6**	**7-12**	**>13**
		percent		
Field slope length, ft	100	125	100	75
Field slope length, m	30.5	38.1	30.5	21.9

Because the polder area is flat, we adopted a field slope length of 100 ft and a value of m = 0.2. Input of this data in the equation (13) gives us a slope length factor S = 1.066 for Rusnë polders.

The slope steepness factor may be expressed as

$$S = 65.41 \sin 2\Theta + 4.56 \sin\Theta + 0.065 \tag{14}$$

or as

$$S= 65.41 \sin^2\Theta+4.56\sin\Theta+0.065 \tag{15}$$

where i is field slope in percent. Since the field slope in Rusnë island is 0.5%, S = 0.09. To predict upland erosion for single storm events using the universal soil loss equation (USLE), the topographic factor (LS) for Rusnë island polders should be

$$LS = 0.096.$$

A field slope length λ = 100 ft has to be used as input data for the AGNPS model.

Cover and management factor C in the soil loss equation is the ratio of soil loss from land cropped under local conditions to the corresponding loss from clean-tilled, continuously fallow land. This factor combines the effect of all cover and management variables in the watershed. It also depends on the stage of growth and development of the vegetation cover at the time of the storm event for which the model is used. Since we are working on a storm event basis, the value used is the cover and management factor corresponding to the appropriate period of the growing season. The worst season in Lithuania is the seedbed period (May-June), because storms are the most intense, the soil is bare, and plants are not actively growing or using nutrients. We developed Table 4 for Lithuania from the U.S. Department of Agriculture "Predicting Rainfall Erosion Losses" (1978).

Table 4. Cover and management factor C

Cover, crop sequence, and management	Spring residue, kg/ha	Cover after plant, %	Fallow period	Seed bed period
Grain after grain or corn in disked residues				
	5040	70	-	0.12
	3808	60	-	0.16
		50	-	0.22
		40	-	0.27
		30	-	0.32
		20	-	0.38
	2912	40	-	0.29
		20	-	0.43

Table 4. continued

Cover, crop sequence, and management	Spring residue, kg/ha	Cover after plant, %	Fallow period	Seed bed period
		10	-	0.52
	2240	30	-	0.38
		20	-	0.46
		10	-	0.56
Grain after grain, in disked stubble, crop residues removed	-	-	-	0.79
Winter grain after fall plow, residues left	High production	-	0.31	0.55
	Good production	-	0.36	0.6
	Fair production	-	0.43	0.64
	Low production	-	0.53	0.68
Grain, after summer fallow, grain residues	224	10	-	0.7
	560	30	-	0.43
	840	40	-	0.34
	1120	50	-	0.26
	1680	60	-	0.2
	2240	70	-	0.14
Grain, after summer fallow, row crop residues	336	5	-	0.82
	560	15	-	0.62
	840	23	-	0.5
	1120	30	-	0.4
	1680	45	-	0.31
	2240	55	-	0.23
	2800	65	-	0.17
Potatoes or sugar beet rows with slope	-	-	0.43	0.64

Table 4. continued

Cover, crop sequence, and management	Spring residue, kg/ha	Cover after plant, %	Fallow period	Seed bed period
Established meadow				
grass and legumes mix for hay	3-5 t	-	0.004	0.004
grass and legumes mix for hay	2-3 t	-	0.006	0.006
grass and legumes mix for hay	1 t	-	0.01	0.01
Red clover	-	-	0.015	0.015
Alfala, lespedeza, and second-year sericea	-	-	0.02	0.02
Sweetclover	-	-	0.025	0.025
Bushes, with drop fall height 2 m, at mostly grass at ground surface, bushes cover 50% of the area		0	0.0034	
		20	0.0016	
		40	0.0008	
		60	0.0004	
		80	0.0001	
Trees, with drop fall height 4 m, mostly grass at ground surface, bushes cover 50% of the area		0	0.0039	
		20	0.0018	
		40	0.0009	
		60	0.0004	
		80	0.0001	

Note: For meadow seedlings without nursery crop, apply values given for small grain seedlings.

Support practice factor P evaluates measures taken to slow runoff water and thus reduce the soil amount removed. The most important supporting cropland practices are contour tillage, strip cropping along the contour, and terrace systems. Since these measures are not used in Lithuania, we adopted $P = 1$ for all polders.

The surface condition constant c is a value based on land use at the time of the storm. Values are shown in Table 5.

Soil texture according to particle size breakdown is shown in Table 6.

Table 5. Surface condition constant *c* for various land use situations

Cover c	c
Fallow (bare soil)	0.22
Row crops (sugar beet, potatoes, corn)	0.05
Small grain (wheat, oats, barley, flax, rye)	0.29
Close seeded legumes or rotation meadow (alfalfa, sweetclover, timothy)	0.29
Pasture for grazing	
Poor	0.01
Fair	0.15
Good	0.22
Permanent meadow for hay, protected from grazing	0.59
Woodland	0.29
Forest protected from grazing	0.59
Farmsteads	0.01
Urban (21-27% impervious surface)	0.01
Grass waterway	1.00
Water	0
Marsh	0

Table 6. Soil texture according particle to size breakdown in the United States and Lithuania

Soil texture	U.S. particle range, mm	Lithuanian particle range, mm
Clay	<0.002	<0.005
Silt	0.002-0.050	0.005-0.05
Sand	0.05-2.00	0.05-2.00

Table 6 shows that Lithuanian clay, with large size particles (0.002 - 0.005 mm), has to be classified as silt soil according to the U.S. classification.

The advanced AGNPS versions 4.03 and 5.00 allows input for the initial nitrogen concentration in rainfall. Average yearly ammonium nitrogen (NH^4-N) and nitrate nitrogen (NO^3-N) concentrations in precipitation in Lithuania are presented in Table 7.

Table 7. Ammonium nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N) concentration in precipitation

	Molëtai		Þuvintas	
Year	NH_4-N, mg/l	NO_3-N, mg/l	NH_4-N, mg/l	NO_3-N, mg/l
1981	0.84	0.80	0.68	0.88
1982	0.91	0.81	0.69	0.88
1983	0.99	0.82	0.71	0.89
1984	1.06	0.82	0.71	0.89
1985	1.14	0.82	0.72	0.89
1986	1.22	0.83	0.74	0.89
1987	1.29	0.83	0.74	0.89
1988	1.37	0.84	0.75	0.89
1989	1.44	0.84	0.76	0.90
1990	1.52	0.85		0.90
1994	1.09	0.55	1.08	0.47
Average	1.17	0.8	1.08	0.85

The average nitrogen concentration in Lithuania precipitation is 1.95 mg/l.

Since other model input parameter values and methods of determination in Lithuania do not differ from those described in the AGNPS model user's manuals, we suggest following the recommendations of those manuals for defining the parameters.

Verification of the AGNPS Model in Rusne Island Polders

The AGNPS model has been tested for runoff estimation, sediment yield, and nutrient concentration in the United States. Verification for water runoff from a 25-year, 24-hour storm event was done with data from 20 different watersheds in the north central United States. A regression of estimated values on the observed values of peak flow was expressed by the equation

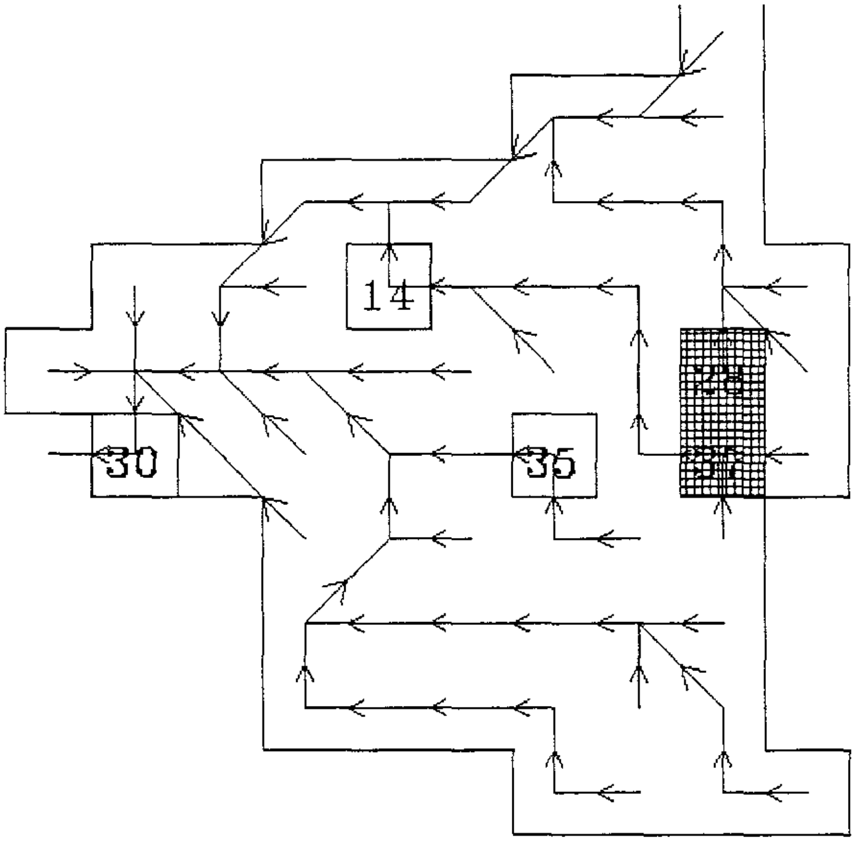
$$\text{Estimated} = \text{Observed} * 0.984. \qquad (16)$$

The equation has a coefficient of determination (r_2) of 0.81.

Parts of the model have also been tested for sediment yield estimates with data from two experimental watersheds in Iowa and Nebraska. Sediment yield compared favorably with the measured values. Since the AGNPS model uses the CREAMS model's method to predict nitrogen and phosphorus yields, nutrient runoff modeling by AGNPS had underwent some basic testing on land slopes during the development of the CREAMS model. Rainfall runoff data measurement in seven Minnesota watersheds over a three year period were used to test the chemical components of the AGNPS model. Unfortunately, during this test period only a relatively small (1-year, 24-hour) runoff event was measured. The data were insufficient to test either the sediment yield estimates or sediment particle size relationship with AGNPS. However, a comparison of measured versus estimated nitrogen and phosphorus concentrations from twenty different sampling points in the seven watersheds indicates that, on the average, AGNPS provided realistic estimation of nutrient concentrations in runoff water, at least from smaller rainfall events. Young, Bosch, and Anderson (1989) indicate that additional data are needed for further testing of all model components.

We had a more difficult task—test the AGNPS model for a polder. We did not have special experimental watersheds for testing the model and it was impossible to measure water runoff from the polder because there is no open water flow through a polder's outlets. Water discharge from the polder depends on a pumping station's capacity; water runoff from polders always exceeds the pumping station's capacity in a storm event. Therefore, we can only compare the model's estimated chemical components' changes with the measured values in the polders.

More detailed field investigations were carried out in the Rusne and Vorusne polders of Rusne Island in the lower reach of the Nemunas River. The field trials were established for nutrient leaching and water regime investigations, but not for the evaluation of nutrient runoff. The testing was difficult because of diverse sampling conditions for the model's input data. The model was created for water runoff from a 25-year, 24-hour single storm event. Water quality was analyzed monthly, regardless of storm intensity. It was impossible to conduct a precise evaluation, nevetherless, we tried to determine if we were able to conduct a realistic estimation using the AGNPS model. We compared the water quality changes related to nutrient load within the polder and to water quality in different polders. Seeking to trace a relationship between the model output and observed data, we selected cells with very different nutrient loads. We compared the data from the model with the field data for the same cells and attempted to compare them in the areas with the same land management practices and also under other conditions that influence water quality (Figures 3 and 4).



14 Cell of water quality measurement

▦ 28 Cell of water quality measurement with a large animal farm

← water flow vector

Figure 3. The Rusne polder watershed and location of water quality sampling points

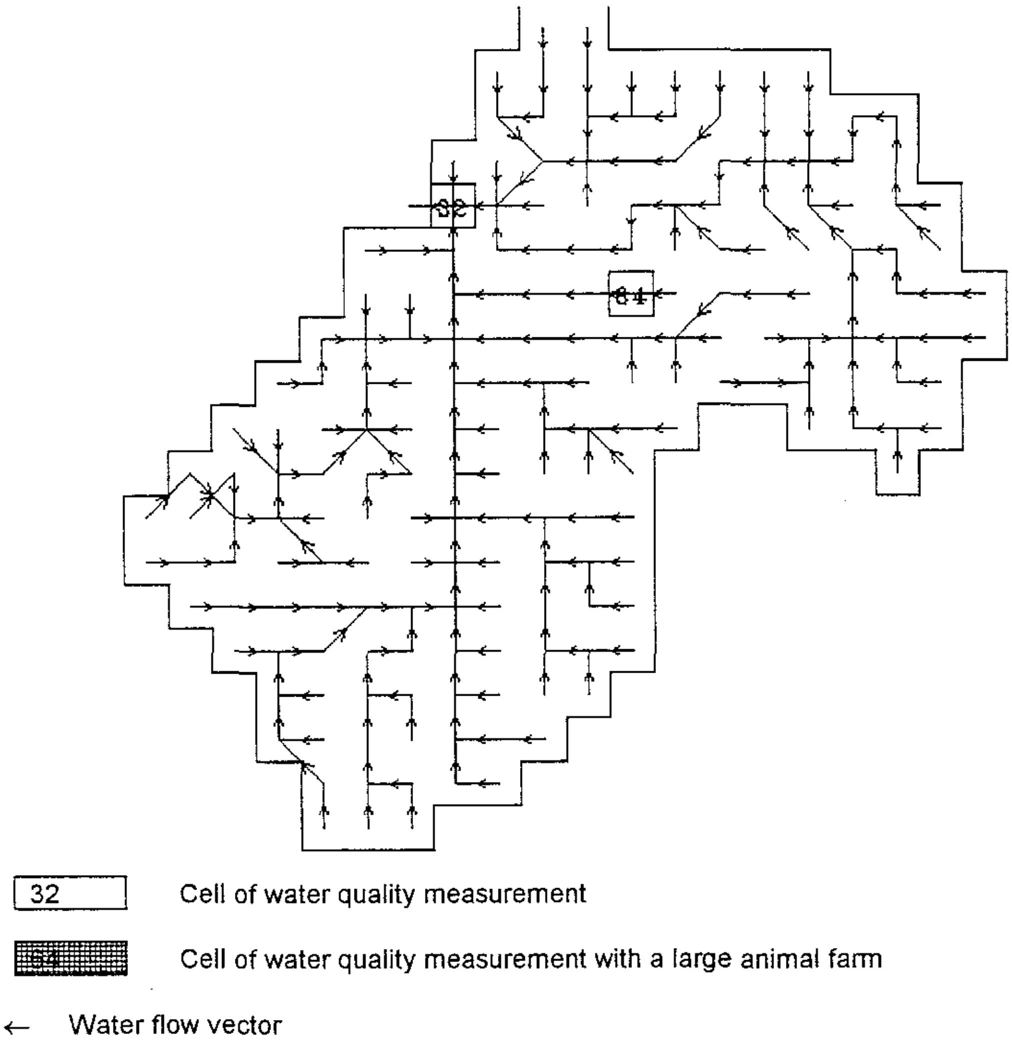


Figure 4. The Vorusne polder watershed and location of the water quality sampling point

The data for nitrogen, phosphorus and BOD5 observed in the winter polders of Rusne and Vorusne for 1993 through 1995, and the data calculated by the the AGNPS model, are presented in Appendix A.

Since the polder area is very flat, there is no danger of soil erosion. Therefore, the emphasis was on analyzing nitrogen concentration. Another reason for this emphasis is that the Lithuanian Government has signed an agreement to reduce the nitrogen load to the Baltic Sea by 50 percent.

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When the 25-year frequency storm event (recommended for the AGNPS model), was used for modeling, the calculated nitrogen concentration (r^2=0.35-0.67) was much higher than the observed values. More accurate comparisons were obtained when the observed data were compared to the estimated 5-year frequency 24-hour storm event. (Figures 3, 4 and 5). The nitrogen concentrations in cells 14, 28, 32, 35, 37 differ because of feedlots in cells 28 and 37, and also because of different agricultural management practices and drainage areas.

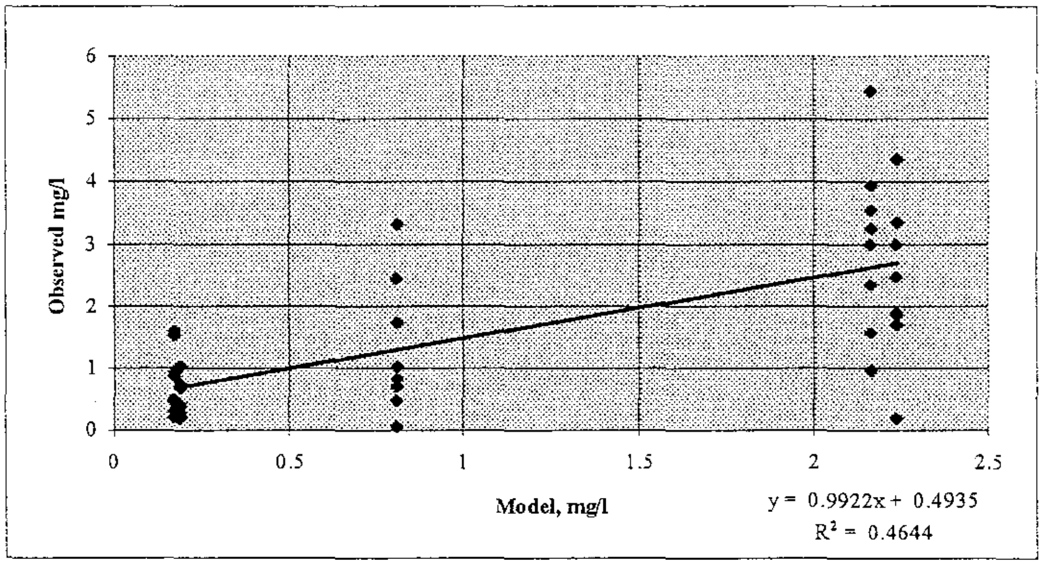

Figure 5. Modeled nitrogen concentration versus observed in 1993

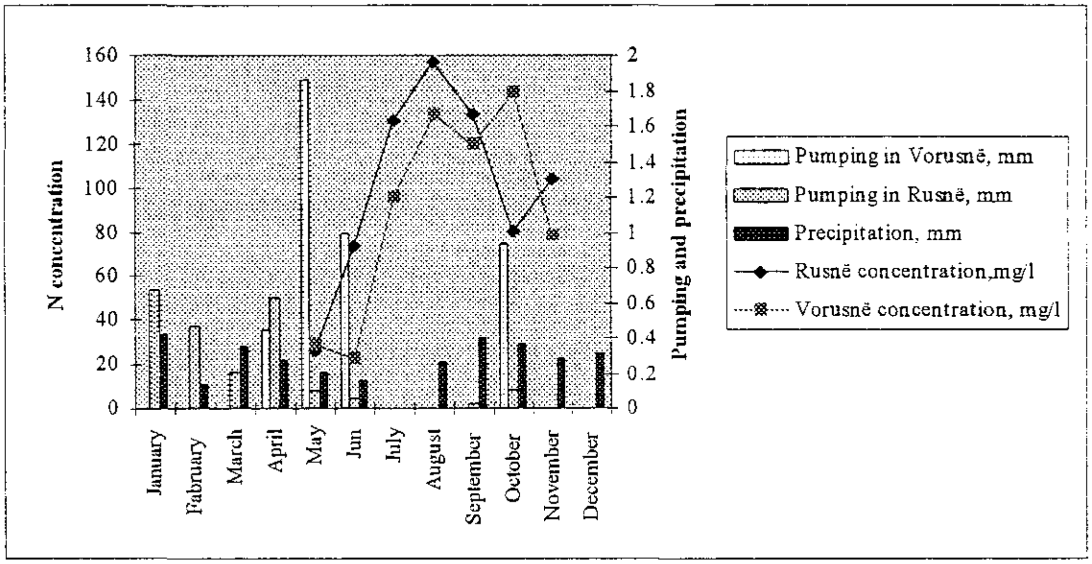

Figure 6. The relationship of precipitation and water pumping with nitrogen concentration in the Rusne and Vorusne polders in 1994

A more detailed investigation is needed to determine the causes of the nitrogen concentration's variation in the polders (Figure 6), but the data is sufficient to indicate that the AGNPS model allows a realistic estimation of nitrogen concentration in the polder area (Figure 7).

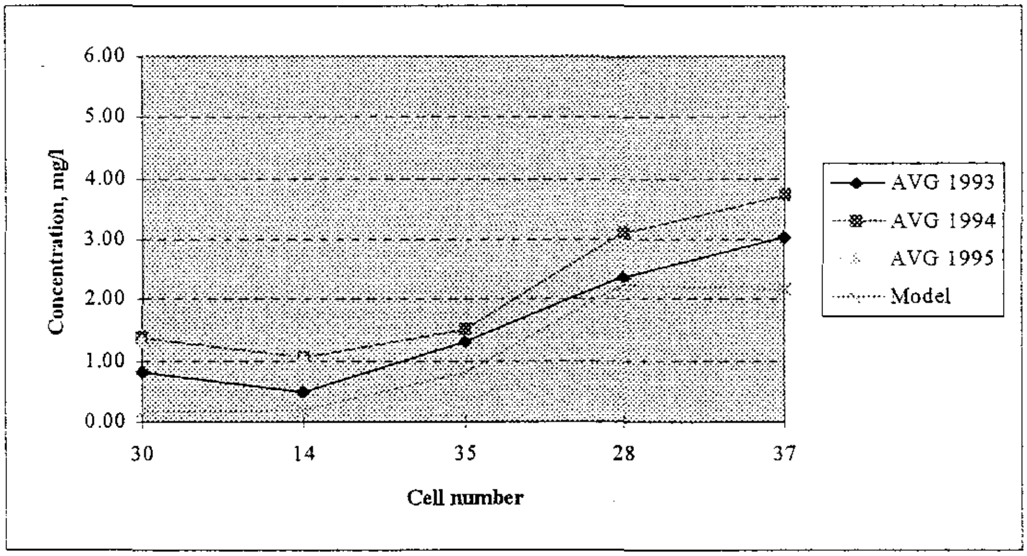

Figure 7. The AGNPS model's nitrogen concentration versus the average observed in the Rusne polder, 1993–95

No correlation was found between observed and modeled phosphorus data in the Rusne (Figure 8) and Vorusne polders (Appendix B). The observed phosphorus concentration trend does not agree with the nitrogen concentration trend in the Rusne polder. The main reason could be errors in water sampling and analysis; the phosphorus concentration in cells 28 and 37 is less than in the cell 35 where the nutrient load is much less. There are some doubts about the model's data in the cells 28 and 37. The analysis of the model's input data shows that its results are more sensitive to changes in drainage area and land cover than to number of animals in a feedlot. More observed data are needed to verify the model for phosphorus concentration in the polders.

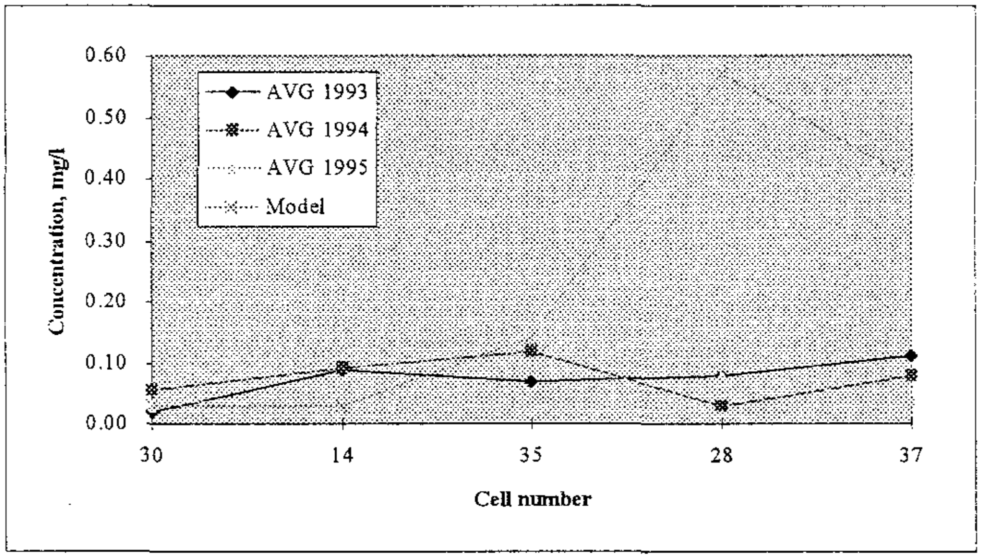

Figure 8. The AGNPS model's phosphorus concentration versus the average observed in the Rusne polder, 1993–95

Where nutrient load is very low, there is agreement between the chemical oxygen demand calculated by the AGNPS model and that observed in the cells. but the values get very high in the cells that drain a small area (Figure 9). AGNPS seems to overestimate the CHOD concentration for cells that drain a small area, like cells 28 and 37 in the Rusne polder. The model results for different rain frequencies, observed data and variation coefficients are presented in Appendix C.

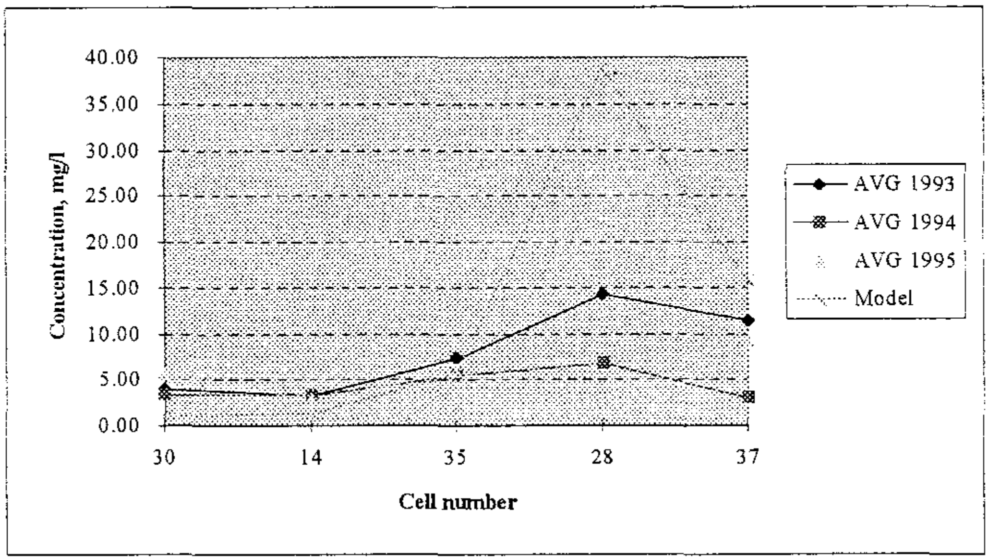

Figure 9. The AGNPS model's CHOD concentration versus the average observed in the Rusne polder, 1993–95

The AGNPS model provides a realistic estimation of nutrient concentrations in a polder. The observed nitrogen concentrations correspond well with the results of the AGNPS model for different agricultural management practices and land cover regimes in the polders. A large dispersion of nitrogen, phosphorus and BOD_5 concentrations does not allow for precise evaluation of the data from the AGNPS model. It appears that the AGNPS model overestimates the phosphorus and BOD_5 concentration for the polder areas remote from the outlet. Due to its simplicity and ability to closely approximate nutrient losses, the AGNPS model is good for land management modeling and optimization of land use. In an attempt to promote best management practices, it would be useful to test the AGNPS model for other areas sensitive to human activities, such as the Lithuanian karst region and hilly lands.

APPENDIX A

Polder Rusne in 1993

Table A.1. NH_4-N concentration, mg/l

Cell						Date			
Number	6.05	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG
30	0.33	0.40	1.55	0.15	0.65	0.07	0.16	0.81	0.52
14	0.39	0.43	0.29	0.19	0.24	0.30	0.22	00.19	0.28
35	1.69	0.05	0.48	0.21	0.22	0.28	3.20	3.20	1/07
28	1.70	0.34	0.19	2.51	2.51	0.88	4.30	4.30	2.07
37	1.31	2.05	3.37	2.27	2.27	2.46	5.39	5.39	2.53

Table A.2. NO_3-N concentration, mg/l

Cell					Date				
Number	6.05	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG
30	0.00	0.07	0.00	0.37	0.97	0.86	0.07	0.07	0.30
14	0.00	0.00	0.00	0.49	0.50	0.73	0.00	0.00	0.22
35	0.04	0.00	0.00	0.49	0.61	0.73	0.11	0.11	0.25
28	0.19	0.00	0.00	0.49	0.61	0.98	0.06	0.06	0.29
37	0.28	0.32	0.17	0.98	0.61	1.47	0.06	0.06	0.49

Table A.3. (NH_4-N) + NO_3-N) concentration, mg/l

Cell					Date					Coef. of	Model 5
Number	6.05	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG	variation, %	day rain
30	0.33	0.47	1.55	0.52	1.62	0.93	0.23	0.88	0.82	60.81	0.17
14	0.39	0.43	0.29	0.68	0.74	1.03	0.22	0.19	0.50	55.06	0.19
35	1.73	0.05	0.48	0.70	0.83	1.04	2.44	3.31	1.32	77.64	0.81
28	1.89	3.34	0.19	3.00	1.71	1.86	2.50	4.36	2.36	49.67	2.24
37	1.59	2.37	3.54	3.25	0.96	3.93	3.01	5.45	3.02	43.44	2.17

Polder Rusne in 1994

Table A.4. NH_4-N concentration, mg/l

Cell					Date				
Number	17.05	1.06	22.06	13.07	16.08	21.09	18.10	15.11	AVG
30	0.29	0.23	0.45	1.25	2.40	1.30	0.82	1.17	0.99
14	0.16	0.23	0.44	1.25	1.10	1.06	0.37	0.50	0.64
35	0.88	0.23	0.47	1.49	1.28	0.94	0.48	2.65	1.05
28	2.78	0.40	3.08	0.00	1.35	3.62	3.85	6.46	2.69
37	1.83	0.88	4.80	5.00	1.13	2.22	5.04	4.91	3.23

Table A.5. NO_3-N concentration, mg/l

Cell					Date				
Number	17.05	1.06	22.06	13.07	16.08	21.09	18.10	15.11	AVG
30	0.10	0.18	0.86	0.39	0.23	0.46	0.43	0.65	0.41
14	0.10	0.17	1.16	0.39	0.21	0.52	0.40	0.27	0.40
35	0.09	0.14	0.96	1.03	0.60	0.34	0.29	0.39	0.48
28	0.09	0.24	0.92	0.65	0.09	0.49	0.31	0.37	0.40
37	0.00	0.83	0.79	0.72	0.18	0.59	0.37	0.43	0.49

Table A.6. (NH_4-N) + NO_3-N) concentration, mg/l

Cell					Date					Coef. of	Model
Number	25.05	2.06	24.06	10.07	8.09	11.10	4.11	15.11	AVG	variation, %	1994
30	0.39	0.41	1.31	1.64	2.63	1.76	1.25	1.82	1.40	49.92	0.17
14	0.26	0.40	1.60	1.64	1.31	1.58	0.77	0.77	1.04	50.45	0.19
35	0.97	0.37	1.43	2.52	1.88	1.28	3.04	3.04	1.53	55.13	0.81
28	2.87	0.64	4.00	0.65	1.44	4.11	6.83	6.83	3.09	64.45	2.24
37	1.83	1.71	5.59	5.72	1.31	2.81	5.34	5.34	3.72	49.59	2.17

Polder Rusne in 1995

Table A.7. NH_4-N concentration, mg/l

Cell				Date				
Number	22.03	13.04	10.05	2.06	7.07	21.08	7.09	AVG
30	0.34	0.33	0.29	0.27	0.34	0.21	0.64	0.35
14	0.26	0.41	0.24	0.25	0.32	0.03	0.12	0.23
35	2.75	2.10	0.28	0.28	2.00	0.08	0.89	1.21
28	3.22	3.95	0.00	0.00	4.65	0.00	3.87	3.07
37	4.77	4.69	3.00	3.00	1.54	6.20	4.30	3.75

Table A.8. NO_3-N concentration, mg/l

Cell				Date				
Number	22.03	13.04	10.05	2.06	7.07	21.08	7.09	AVG
30	2.34	1.37	1.06	0.89	1.20	0.31	0.38	1.08
14	0.68	1.44	0.62	0.72	1.47	0.34	0.41	0.81
35	2.58	4.12	2.06	1.13	1.22	0.48	0.48	1.72
28	1.92	2.58	0.00	0.82	1.23	0.00	0.48	1.00
37	2.06	2.23	2.06	1.20	1.71	0.21	0.65	1.45

Table A.9. (NH_4-N) + NO_3-N) concentration, mg/l

Cell				Date					Coef. of	Model
Number	22.03	13.04	10.05	2.06	7.07	21.08	7.09	AVG	variation, %	1994
30	2.68	1.70	1.35	1.16	1.54	0.52	1.02	1.32	47.25	0.17
14	0.94	1.85	0.86	0.97	1.79	0.37	0.53	1.04	51.07	0.19
35	5.33	6.22	2.34	1.53	3.22	0.56	1.37	2.94	66.83	0.81
28	5.14	6.53	0.00	6.64	5.88	0.00	4.35	4.08	21.20	2.24
37	6.83	6.92	5.06	2.98	3.25	6.41	4.95	5.20	29.98	2.17

Polder Vorusne in 1993

Table A.10. $(NH_4\text{-}N)+(NO_3\text{-}N)$ concentration, mg/l

Cell	Date								Model
Number	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG	1994
32	0.60	0.61	0.72	0.45	1.01	0.12	0.67	0.60	0.29
64		0.43	0.65	0.22	1.04	0.17		0.50	0.53
38		1.55	1.52	0.45	0.80		0.23	0.91	0.02

Polder Vorusne in 1994

Table A.11. $(NH_4\text{-}N)+(NO_3\text{-}N)$ concentration, mg/l

Cell	Date								Model
Number	1.06	22.06	13.07	16.08	21.09	18.10	15.11	AVG	1994
32	0.42	0.39	1.29	1.64	1.35	1.69	0.97	1.11	0.29
64	0.31	0.18	1.11	1.69	1.65	1.91	0.99	1.12	0.53

Polder Vorusne in 1995

Table A.12. $(NH_4\text{-}N) + NO_3\text{-}N)$ concentration, mg/l

Cell	Date									Model
Number	22.03	13.04	10.05	2.06	7.07	21.08	7.09	5.10	AVG	1994
32	1.59	0.96	0.77	0.59	0.44	0.28	0.24	0.23	0.64	0.29
64	1.23	0.85	1.00	0.57	1.02	0.28	0.16		0.73	0.53

APPENDIX B

Polder Rusne in 1993

Table B.1. PO_4-P concentration, mg/l

Cell	Date									Coef. of	Model
Number	6.05	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG	variation, %	1994
30	0.020	0.007	0.085	0.000	0.049	0.023	0.013	0.000	0.02	136.04	0.03
14	0.026	0.029	0.179	0.245	0.059	0.055	0.055	0.033	0.09	84.47	0.03
35	0.059	0.117	0.183	0.095	0.033	0.042	0.016	0.010	0.07	78.88	0.14
28	0.059	0.251	0.117	0.033	0.085	0.042	0.039	0.029	0.08	87.26	0.57
37	0.046	0.170	0.137	0.143	0.075	0.029	0.250	0.020	0.11	68.17	0.4

Polder Rusne in 1994

Table B.2. PO_4-P concentration, mg/l

Cell	Date									Coef. of	Model
Number	17.05	1.06	22.06	13.07	16.08	21.09	18.10	15.11	AVG	variation, %	1994
30	0.042	0.016	0.026	0.059	0.166	0.062	0.029	0.052	0.057	77.43	0.03
14	0.010	0.033	0.170	0.078	0.042	0.176	0.108	0.127	0.093	63.06	0.03
35	0.065	0.026	0.192	0.522	0.033	0.055	0.033	0.029	0.119	134.94	0.14
28	0.075	0.016	0.007	0.059	0.016	0.039	0.007		0.031	80.74	0.57
37	0.042	0.029	0.055	0.153	0.101	0.130	0.085	0.029	0.078	56.49	0.4

Polder Rusne in 1995

Table B.3. PO_4-P concentration, m/l

Cell	Date								Coef. of	Model
Number	22 03	13 04	10 05	2 06	7 07	21 08	7 09	AVG	variation, %	1994
30	0.1	0.13	0.127	0.033	0.064	0.031	0.255	0.03	77.42	0.03
14	0.09	0.06	0.135	176	0.168	0.224	0.51	0.06	75.00	0.03
35	0.05	0.06	0.107	0.224	0.064	0.316	0.107	0.04	75.41	0.14
28	0.18	0.2		0.586	0.135		0.138	0.08	69.61	0.57
37	0.07	0.06	0.117	79	0.066	0.064	0.311	0.04	67.97	0.4

Polder Vorusne in 1993

Table B.4. PO_4-P concentration, mg/l

Cell				Date					Model
Number	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG	1994
32		0.02	0.04	0.03	0.02	0.00	0.02	0.02	0
64		0.03	0.03	0.03	0.03	0.00	0.01	0.02	0.08
38		0.07	0.21	0.13	0.04	0.02	0.01	0.09	0

Polder Vorusne in 1994

Table B.5. PO_4-P concentration, mg/l

Cell				Date					Model
Number	1.06	22.06	13.07	16.08	21.09	18.10	15.11	AVG	1994
32	0.003	0.003	0.039	0.033	0.033	0.075	0.026	0.030	0.02
64	0.016	0.016	0.042	0.065	0.026	0.020	0.020	0.029	0.02

Polder Vorusne in 1995

Table B.6. PO_4-P concentration, mg/l

Cell					Date					Model
Number	22 03	13 04	10 05	2 06	7 07	21 08	7 09	5 10	AVG	1994
32	0.039	0.002	0.013	0.015	0.003	0.009	0.017	0.032	0.02	0.02
64	0.029	0.002	0.015	0.018	0.015	0.073	0.033		0.03	0.02

APPENDIX C

Polder Rusne in 1993

Table C.1. CHOD concentration, $\mathrm{mg_O/l}$

Cell					Date					Coef. of	Model
Number	6.05	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG	variation, %	1994
30	6.70	6.30	3.60	3.60	2.70	4.50	1.52	3.65	4.07	39.88	1.1
14	5.80	3.50	1.54	2.10	3.40	6.30	0.92	2.47	3.25	55.66	1.22
35	6.20	15.80	12.70	8.00	4.50	6.30	1.02	3.98	7.31	61.64	5.61
28	5.70	60.50	21.90	6.60	2.20	13.30	0.66	3.74	14.33	129.86	39
37	35.70	21.90	7.04	7.80	4.20	11.70	0.64	2.62	11.45	96.54	15.91

Polder Rusne in 1994

Table C.2. CHOD concentration, $\mathrm{mg_O/l}$

Cell					Date					Coef. of	Model
Number	17.05	1.06	22.06	13.07	16.08	21.09	18.10	15.11	AVG	variation, %	1994
30	2.06	5.00	2.90	2.25	3.40	2.66	2.79	7.14	3.53	45.58	1.1
14	2.06	2.64	1.20	1.10	3.80	3.35	8.48	4.45	3.39	65.61	1.22
35	0.60	3.24	2.97	3.50	6.02	2.66	8.14	16.40	5.44	85.63	5.61
28	1.48	4.50	2.06	12.62	5.90	10.50	5.62	11.90	6.82	59.52	39
37	0.58	2.64	1.00	3.78	0.88	2.66	10.20	2.95	3.09	93.65	15.91

Polder Rusne in 1995

Table C.3. CHOD concentration, mg_O/l

Cell	Date								Coef. of	Model
Number	22 03	13 04	10 05	2 06	7 07	21 08	7 09	AVG	variation, %	1994
30	3.71	5.2	4.1	5.7	6.66	9.86	2.24	5.80	41.93	1.1
14	2.23	3.72	3.78	3.55	1.67	3.05	2.48	2.93	25.88	1.22
35	2.32	5.46	2.56	19.7	3.22	2.98	4.68	5.85	98.36	5.61
28	2.57	4.86		39.4	3.3		12.3	12.49	111.24	39
37	2.12	6.61	2.5	35.7	1.28	10	5.7	9.13	122.78	15.9

Polder Vorusne in 1993

Table C.4. CHOD concentration, mg_O/l

Cell	Date								Model
Number	25.05	2.06	24.06	10.07	8.09	11.10	4.11	AVG	1994
32	2.02	2.64	3.10	1.30	1.60	1.10	2.37	2.02	0.52
64		2.85	3.20	8.80	1.30	0.50	2.71	3.23	15.35
38		2.41	3.70	1.10	1.90	1.20		2.06	0.52

Polder Vorusne in 1994

Table C.5. CHOD concentration, mg_O/l

Cell	Date								Model
Number	1.06	22.06	13.07	16.08	21.09	18.10	15.11	AVG	1994
32	7.4	4.41	1.08	1.98	3.22	2.9	2.48	3.35	0.52
64	2.4	2.36	7.65	3.96	3.5	2.6	3.42	3.70	15.35

Polder Vorusne in 1995

Table C.6. CHOD concentration, mg_O/l

Cell				Date						Model
Number	22 03	13 04	10 05	2 06	7 07	21 08	7 09	5 10	AVG	1994
32	2.14	4	3.8	5.55	3.34	2.81	2.08	9.14	4.11	0.52
64	2.89	6.46	4.72	6.35	2.6	6.84	3.54		4.77	15.35

REFERENCES

Baker, K.D., Theurer, F.D., and Witte, J. 1995. *AGNPS version 5.00 Verification: Science.*

Èeièys, J. 1965. *Agricultural land reclamation.* (In Lithuanian). 52

Hydrometeorological Service. *Resources of Surface Water.* (In Russian).1969.4: 344

Maidment D.R. 1992. *Handbook of Hydrology.* 9.20–9.26.

Smith, R.E., and Williams, J.R. 1980. Simulation of surface water hydrology. In CREAMS, A field Scale Model for Chemicals, Runoff, and Erozion from Agricultrual Managment Systems. U.S. Dep. Agric. Consrv. Res. Rep, 26, 1(2) 15.

USDA-ARS-MWA. 1994. North Central Soil Conservation Research Laboratory. *AGNPS Newsletter.* A quarerly report.

United States Department of Agriculture, Soil Conservation Service. 1972. Hydrology. National Engineering Handbook. Washington, DC. 10.1–10.24.

United States Department of Agriculture. Agricultural Research Service. 1987 *AGNPS, Agricultural Non-Point-Source Pollution Model. A Watershed Analysis Tool.* Conservation Research Report. 1–77.

U.S.Department of Agriculture, Science and Education Administration and Purdue Agricultural Experimental Station. 1978. *Predicting Rainfall Erosion Losses.* A Guide to Conservation Planning.

Young, R.A., C. A. Onstad, D. D. Bosch, and W. P. Anderson. 1989. AGNPS: A nonpoint-source pollution model for evaluating agricultural watersheds. *Journal of Soil and Water Conservation.* 44 (2)168–173.

_____. 1994. *Agricultural Non-Point-Source Pollution Model, Version 4.03. Users Guide. 3.10*