CHAPTER 6. Sensitivity Analysis and Decision Support

A sensitivity analysis is an essential process to understand how a model responds to parameter changes and, in particular, to identify the impact that the various parameters and processes have on the computed response. It is usually performed for single events and individual parameters. Of major importance is finding those parameters which have the largest impact and those which can be neglected from further analysis. The objective of this section is to explain the methods used in the sensitivity analysis and describe how they were implemented as a tool in the integrated system.

6.1 Sensitivity Analysis Methods

The sensitivity analysis is performed by changing the value of one parameter (perturbation) while keeping the remaining ones unchanged and running the model to analyze the variation in the response compared to the results of a base case. Normally, the parameter is not changed arbitrarily, but over a reasonable range. The results of the sensitivity analysis may be different for different base cases. To illustrate this, an excerpt taken from James (1992) mentions two cases where sensitivity analysis provides different results: “The sensitivity analysis produces different results for each application and for different weather conditions. An obvious example, snowmelt in the summer months, the response is insensitive to the snow parameters. A less obvious case is that of the infiltration parameters for light or heavy rainfall rates....”

"...For both cases they are not at all sensitive because: a) light rain only runs off impervious areas; the pervious areas contribute no runoff to the outflow, and b) in long-duration heavy rain, all the pervious areas have reached their final, low constant infiltration rates, and changing the initial infiltration capacity, or the infiltration capacity decay constant, does not affect the calculation; the whole area acts as though it is more or less impervious. So the infiltration parameters are sensitive only for intermediate rainfalls rates".

Understanding the sensitivity changes provides a better comprehension of the model and the results become more defensible and credible. Most of the discussion of sensitivity analysis is based on the assumption that the computed responses are smoothly varying (linear response). A common application involves changing the parameter values on both directions (increase and decrease a small percentage) of the base case and tracing the resulting response gradient. The normalized sensitivity coefficients and its ranking using average gradients are the methods chosen to perform the sensitivity analysis in the present work.

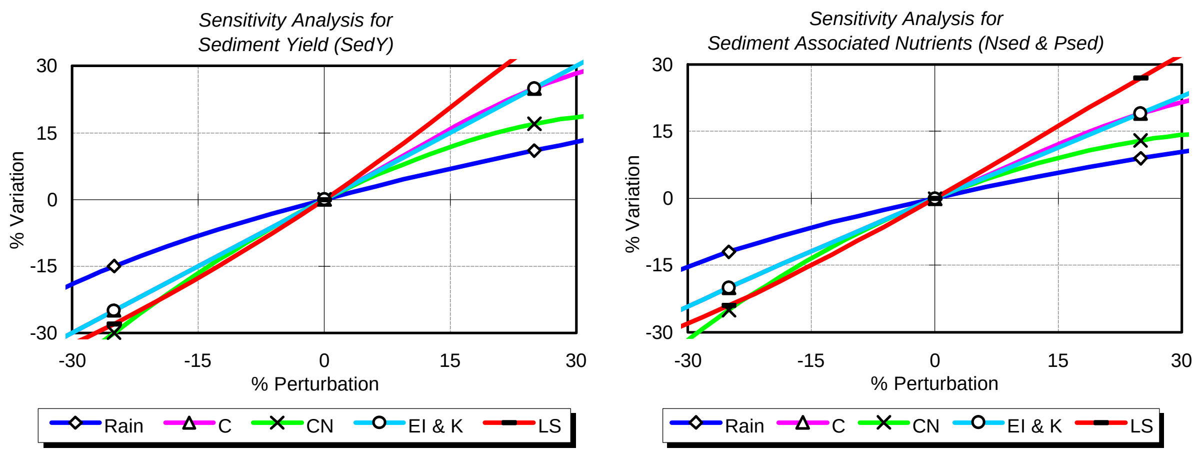
6.1.1 Normalized Sensitivity Gradients

The normalized sensitivity gradients indicates the percentage change in the result for a certain percentage change in a parameter, defined as (Sykes, 1994):

$$Sn_i = \left(\frac{dj}{da_i} \right) \frac{a_i}{j_i} \tag{6.1}$$

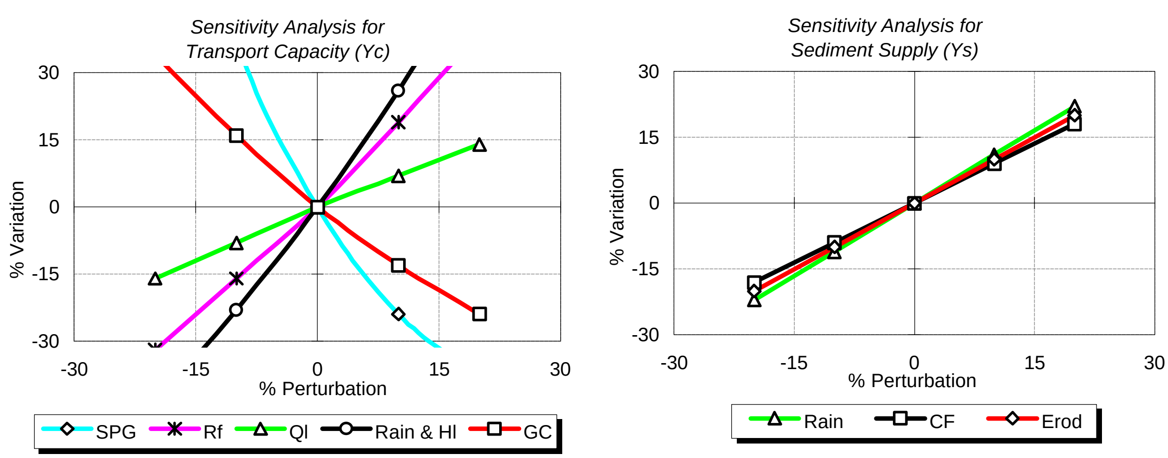
where Sn_i is the normalized sensitivity coefficient related to the base case (dimensionless), dj is the change in the result j, and da is the perturbation of the parameter a_i. If these coefficients are calculated for low and expected parameter values together with high and expected parameter values, a local derivative can be assessed for each case. This gives the slope or gradient for that specific range of percentage change. The greater the slope the greater the response to the parameter change.

As mentioned in Chapter 3, a preliminary sensitivity analysis was performed using the above concepts, for both AGNPS and the water quality component added to WATFLOOD. Complete set of results and calculations can be found in Tables F1 and F2 of Appendix F. To illustrate the results obtained, the gradient graphics are presented in Figures 6.1 and 6.2 for the analysis performed for AGNPS and for the sediment transport component of WATFLOOD respectively.



Variable description: LS-land slope, EI-storm energy-intensity, K-soil erodibility factor, CN-SCS curve number, C-cropping or cover factor, Rain-storm rainfall, P-practice factor, FSL-field slope length, CSS-channel side slope, N-Manning's roughness coefficient, CS-channel slope

Figure 6.1 Sensitivity analysis for sediment yield and sediment nutrients in AGNPS



Variable description: *Sediment Model:* SpG-specific weight, D_{50}-median particle size, Erod-soil erodibility, GC-ground cover, CF-cover factor, *WATFLOOD:* Rain-precipitation intensity, Slp2-overland slope, Rf-runoff amount, Ql-unit flow discharge, Hl-runoff depth

Figure 6.2 Sensitivity analysis for transport capacity and sediment supply in WATFLOOD

In the figures, the parameter perturbations are in the horizontal axis while the changes in the output are in the vertical axis. Figure 6.1 shows, for the AGNPS model, the normalized sensitivity gradients for the sediment yield and for the nutrients associated to the sediments and Figure 6.2 shows, for the sediment component for WATFLOOD, the normalized sensitivity gradients for the transport capacity and sediment supply.

6.1.2 Ranked Mean Normalized Gradients

Once the normalized gradients are calculated, a mean gradient provides a good ranking method to detect which parameters influence the output variable of interest. The mean normalized gradients close to zero indicate little sensitivity on the outcome of those parameters. For values greater than 0.5 but less than 1 a moderate variation can be defined. Finally, for values above 1, the output value is highly sensitive to the perturbation of the related parameters.

In general terms, the mean normalized gradient can be calculated through the use of the sensitivity coefficients or the percentages of variation for the output variables and parameter perturbations. The equation used in the calculation of the normalized gradients is:

$$Sm_i = \frac{1}{2}\left[\frac{Vl_i}{Pl_i} + \frac{Vh_i}{Ph_i}\right] \tag{6.2}$$

where Sm_i is the mean normalized gradient; Vl_i , Vh_i are the low and high variations for the output variable, and Pl_i , Ph_i are the low and high parameter perturbations. A numerical example follows to clarify the use of the above equations. Assuming that the base case value of an output variable is 0.17 and that a parameter *i* is perturbed $\pm$ 20% to get a low output value of 0.08 and a high output value of 0.28, then the low and high variations are:

Vl_i = (0.08/0.17) -1 = -0.53 = -53% and Vh_i = (0.28/0.17) -1 = +0.65 = +65%

The mean normalized gradient is:

$$Sm_i = \frac{1}{2}\left[\frac{-53}{-20} + \frac{65}{20}\right] = 2.94$$

meaning that, for a gradient of almost 3, an increase of 10% in parameter *i* produces an increment in the output value close to 30% higher. If the sign of the gradient is negative, then an increase in the parameter corresponds to a decrement in the output value.

Using the mean normalized gradients with the above equations, the graphs for the ranked mean normalized gradients in the preliminary sensitivity analysis for AGNPS and the water quality components of WATFLOOD were prepared and presented in Chapter 3. Table 6.1 presents a summary of the mean normalized gradients for the preliminary sensitivity analysis performed on both models.

Table 6.1 Summary of the Mean Normalized Gradients for Preliminary Sensitivity Analysis

	AGNPS Model			**WATFLOOD Model**	
Variable	**Sediment Yield**	**Nitrogen in Sediment**	**Variable**	**Transport Capacity**	**Sediment Yield**
LS	1.18	0.94	SPG	-3.50	0
EI	1.00	0.80	D50	-0.04	0
K	1.00	0.80	Erod	0	1.00
CN	0.91	0.79	GC	-1.45	-0.17
C	0.88	0.71	CF	0	0.90
Rain	0.58	0.46	Rain	2.48	1.10
P	0.50	0.42	Slp2	1.60	0.07
FSL	0.41	0.32	Rf	1.78	0.07
CSS	0.37	0.30	Ql	0.75	0.07
N	-0.25	-0.20	Hl	2.35	0
CS	0.17	0.14			

Variable description: LS-land slope, EI-storm energy-intensity, K-soil erodibility factor, CN-SCS curve number, C-cropping or cover factor, Rain-storm rainfall, P-practice factor, FSL-field slope length, CSS-channel side slope, N-Manning's roughness coefficient, CS-channel slope, SpG-specific weight, D_{50}-median particle size, Erod-soil erodibility, GC-ground cover, CF-cover factor, Rain-precipitation intensity, Slp2-overland slope, Rf-runoff amount, Ql-unit flow discharge, Hl-runoff depth

The analysis suggests that, for the AGNPS model, the variables most significantly affecting the sediment yield and the nutrient loadings associated with the sediments are the land slope, the storm energy intensity, the soil erodibility, the cover factor and the curve numbers. As stated in Chapter 3, the input data were extracted directly from digital information as accurately as possible. Although close estimates are desirable for all input parameters, greater justification can be made for rough estimation of the ones that least affect the major outputs of the model.

6.2 Implementation in the AGNPS Interface

As mentioned, the results of the sensitivity analysis may be different for each base case and the same change in parameters can affect other output variables in different ways. It was therefore considered desirable to provide the user with a set of tools so that the sensitivity analysis could be performed in a case by case basis. The AGNPS interface was selected to implement such tools. Because WATFLOOD has a parameter optimization method internally in its code, the following implementation was only developed for the AGNPS model.

6.2.1 Structure and Procedures

A brief description of the interface tools for the sensitivity analysis was presented in Chapter 4 and in Appendix C. A more detailed description is presented here. The selection of the output variables and input parameters to perturb was the first stage in the design of the sensitivity tools. This defines the number of runs and available results from the sensitivity analysis. The output variables are based on the resulting values at the outlet cell of the watershed. Among the input parameters, some are related to general watershed data while others are cell based values, either for general cell parameters, soil, fertilizer or channel data. This means that when perturbing the parameters, some of the variations have to be performed on a cell by cell basis.

A total of 8 output variables where selected together with 32 input parameters, implying that for a full analysis, a total of 64 runs are required for each base case. Table 6.2 shows the grouping and parameters for which a specific database table is created through the use of the interface to store the resulting values of the analysis. As a measure of both, the magnitude of the task involved and the usefulness of the implementation, the example that follows in this chapter involves the 64 runs. Each run will be made by modifying a total of 4 general input variables and 28 cell data values for every cell in the 57 elements in the grid. This activity that can require many hours with the manual edition of the AGNPS editor, is performed in minutes with the tools provided with the interface.

Table 6.2 Output Variables and Input Data Parameters by Group

Output Variables	***Initial Data***	***General Cell Data***
Total Runoff Volume Peak Runoff Rate Total Sediment Yield Nitrogen in Sediment Nitrogen in Runoff Soluble Nitrogen Concentration Phosphorus in Sediment Phosphorus in Runoff Soluble Phosphorus Concentration COD in Runoff COD Concentration	Precipitation Nitrogen in Rain Energy Intensity Factor K Coefficient/Percent Runoff	SCS Curve Number Land Slope Slope Length Overland Mannings_n K_Factor C_Factor P_Factor Surface Condition Constant COD_Factor
Soil Related Data	***Fertilizer Related Data***	***Channel Related Data***
Soil Nitrogen Soil Phosphorus Pore Water Nitrogen Pore Water Phosphorus Nitrogen Runoff Extraction Phosphorus Runoff Extraction Nitrogen Leakage Extraction Phosphorus Leakage Extraction Percent of Soil Organic Matter	Applied Nitrogen Applied Phosphorus Nitrogen Availability Factor Phosphorus Availability Factor	Channel Slope Channel Side Slope Channel Manning n Decay Percent for Nitrogen Decay Percent for Phosphorus Decay Percent for COD

The tools to implement the sensitivity analysis are divided in 3 sections: preparing input for the analysis, running the model in batch mode and intercepting the outputs to graphically display the sensitivity results. These procedures were attached as toolbars in the interface under the scenarios and sensitivity analysis section. Details of the interface windows are presented in the Appendix C. The input preparation for the sensitivity analysis will open the input data window and allows the selection of the parameter(s) to modify and the percentage of variation. The parameter selection can be made by group or individually. Also the variation can be set for each parameter for all selected parameters. Once selected and perturbed, these settings are saved in order to track the values to be modified during the export process of ASCII data.

The procedure to run the sensitivity analysis is programmed to export the required ASCII files with the modifications described in the input preparation. This means that for each parameter selected to be perturbed, two files must be created with a low and high value for that parameter. In the case of grid cell data, the program will modify the values for all the cells. Once all the data files are created, the process continues by running the model in batch mode and intercepting the relevant values for the output variables. The intercepted output is stored in memory arrays to be used later in the sensitivity coefficients and gradients calculations.

To calculate the sensitivity coefficients, the base case output is read from the grid database and using the equations presented in this chapter, the variations and gradients are calculated. These results are then stored in the grid database in the sensitivity table. This was done so that, once the analysis has been done, the results can be processed and visualized at any later time without running it again. The graphical display of the sensitivity analysis results is achieved by means of two types of displays. The first consists of the normalized sensitivity gradients that show the slope of the variations between the selected output variable and the selected parameters (see Figures 6.1 and 6.2 as examples of this display). The second type allows the display of the ranked normalized gradients. Both graphic windows have capabilities to display a legend, file and grid description together with the options for selecting/deselecting the parameters to be used in the graph.

Several windows can be open simultaneously to allow comparison of results between different sensitivity runs and even for results in different files. Some zoom capabilities are included in the display either by dragging a zoom box in the case of the normalized gradients or by a mouse click in the case of the ranked means. The numeric values are stored in the database file and can easily be extracted into a spreadsheet for further analysis. In what follows, examples of the use of the sensitivity analysis tools with numerical results display and graphical output will be presented.

6.2.2 Examples Using the Sensitivity Analysis Implementation

In order to test the sensitivity analysis module, several examples where performed by using the tools and procedures described above. The major test was to perform a full analysis by using the 2x2 km grid presented in Chapter 5. All of the 32 possible input parameters where selected to be perturbed by 10% for both low and high variations. After conducting the 64 model runs involved in the process by automatic batch mode, the numerical results where extracted from the database and tables were created accordingly. All the resulting tables are presented in Tables F3 to F13 in Appendix F. A summary of the normalized sensitivity gradients was created from these results and is shown in Table 6.3; a zero value means no response.

These results are compatible with the preliminary sensitivity analysis and show which of the parameters are more likely to produce important variations in the output variables. For the hydrology, represented by the total runoff volume and peak rate output variables, the values of precipitation and curve number are the most sensitive to the outcome. For sediment yield and the nitrogen associated with the sediments, the parameters that produce the largest variations in the output are the land slope, the rainfall intensity energy, the soil erodibility, the cover factor and the curve numbers. In order to verify that the sensitivity analysis is case dependent, a second test was performed using the 1x1 km grid. This increased by four the number of cells in the grid as a test of how sensitive is the model to cell size when compared with the 2x2 km grid. The main parameter changed in this test was the precipitation.

Table 6.3 Summary of the Normalized Sensitivity Gradients for the 2x2 km AGNPS Grid

Parameter	TRV	PRR	TSY	NS	NR	SNC	PS	PR	SPC	CODr	CODc
Initial Data											
Precipitation	3.16	2.90	0.93	0.50	0	-1.00	1.00	0	-5.00	2.19	-0.80
Nitrog_Rain	0	0	0	0	0	0.67	0	0	0	0	0
EI_Rfactor	0	0	0.74	0.50	0	0	1.00	0	0	0	0
KCoeff_PerRunoff	0	0	-1.31	-1.50	0	0	-2.00	0	0	0	0
General Cell Data											
SCS_No	8.16	7.92	2.53	2.00	5.00	0.33	2.00	0	5.00	7.19	-1.26
LandSlope	0	0	0.54	0.50	0	0	0	0	0	0	0
SlopeLength	0	0	0.22	0.50	0	0	0	0	0	0	0
Mannings_n	0	0	0	0	0	0	0	0	0	0	0
K_Factor	0	0	0.73	0.50	0	0	1.00	0	0	0	0
C_Factor	0	0	0.74	0.50	0	0	1.00	0	0	0	0
P_Factor	0	0	0.37	0	0	0	0	0	0	0	0
SurfCond	0	0	0	0	0	0	0	0	0	0	0
COD_Factor	0	0	0	0	0	0	0	0	0	0.94	0.99
Soil Related Data											
Soil_Nitro	0	0	0	1.00	0	0	0	0	0	0	0
Soil_Phos	0	0	0	0	0	0	1.00	0	0	0	0
PoreW_Nitro	0	0	0	0	0	0	0	0	0	0	0
PoreW_Phos	0	0	0	0	0	0	0	0	5.00	0	0
ExtR_Nitro	0	0	0	0	0	0.33	0	0	0	0	0
ExtR_Phos	0	0	0	0	0	0	0	0	5.00	0	0
ExtL_Nitro	0	0	0	0	0	-0.67	0	0	0	0	0
ExtL_Phos	0	0	0	0	0	0	0	0	-5.00	0	0
Per_OMS	0	0	0	0	0	0	0	0	0	0	0
Fertilizer Related Data											
Applied_Nitro	0	0	0	0	0	0.33	0	0	0	0	0
Applied_Phos	0	0	0	0	0	0	0	0	5.00	0	0
AvFac_Nitro	0	0	0	0	0	0.33	0	0	0	0	0
AvFac_Phos	0	0	0	0	0	0	0	0	5.00	0	0
Channel Related Data											
Chan_Slope	0	0.16	0.06	0	0	0	0	0	0	0	0
Chan_SideSlope	0	0	0.02	0	0	0	0	0	0	0	0
Chan_ManningN	0	0	-0.43	-0.50	0	0	0	0	0	0	0
Decay_Nitro	0	0	0	0	-5.00	-3.33	0	0	0	0	0
Decay_Phos	0	0	0	0	0	0	0	0	-5.00	0	0
Decay_COD	0	0	0	0	0	0	0	0	0	-2.50	-2.41

Variable description: TRV-Total Runoff Volume,PRF-Peak Runoff Rate, TSY-Total Sediment Yield, NS-Nitrogen in Sediment, NR-Nitrogen in Runoff, SNC-Soluble Nitrogen Concentration, PS-Phosphorus in Sediment, PR-Phosphorus in Runoff, SPC-Soluble Phosphorus Concentration, CODr-COD in Runoff, CODc-COD Concentration. For input data refer to the variables described in Table 6.2

In the 2x2 km grid the event was labeled as a long duration with medium intensity rainfall. For the 1x1 km grid, two different runs were performed. The first one with the same long duration/ medium intensity values for precipitation and the second one with a short duration/high intensity rainfall. Care was taken to ensure that the total volume of precipitation was the same for all cases. As can be seen, the grid size was not a dominant factor. The sensitivity values for the 1x1 and 2x2 km grids were almost the same for the long duration medium intensity event. This can be seen in the summary of the results for the effect of base case presented in Table 6.4.

Table 6.4 Normalized Sensitivity Gradients for the AGNPS Model. Effect of Grid Size, Storm Intensity and Duration.(1x1 km Grid)

	Long Duration/Medium Intensity			**Short Duration/High Intensity**		
Parameter	**TRV**	**TSY**	**NS**	**TRV**	**TSY**	**NS**
Precipitation	3.00	1.17	0.50	2.59	0.60	0.38
EI_factor	0	0.69	0.50	0	0.94	0.64
SCS_No	8.00	2.63	2.00	6.72	1.51	0.90
Land Slope	0	0.52	0.50	0	0.70	0.51
K_factor	0	0.70	0.50	0	0.94	0.77
C_factor	0	0.70	0.50	0	0.95	0.64

Variable description: TRV-Total Runoff Volume, TSY-Total Sediment Yield, NS-Nitrogen in Sediment

On the other hand, the effect of the precipitation compared with the short duration high intensity event is more important. For the total sediment yield, for example, the precipitation has a less impact for a short duration high intensity event while the energy, erodibility and cover factor are more important. Figure 6.3 shows a comparison of the mean sensitivity gradients for the total sediment yield displayed with the tools from the interface. With these tools in place, performing the sensitivity analysis is quite simple and straight forward, allowing the user to identify for each case the parameters that would mostly impact his results and making the modeling task more credible and its results more defensible.

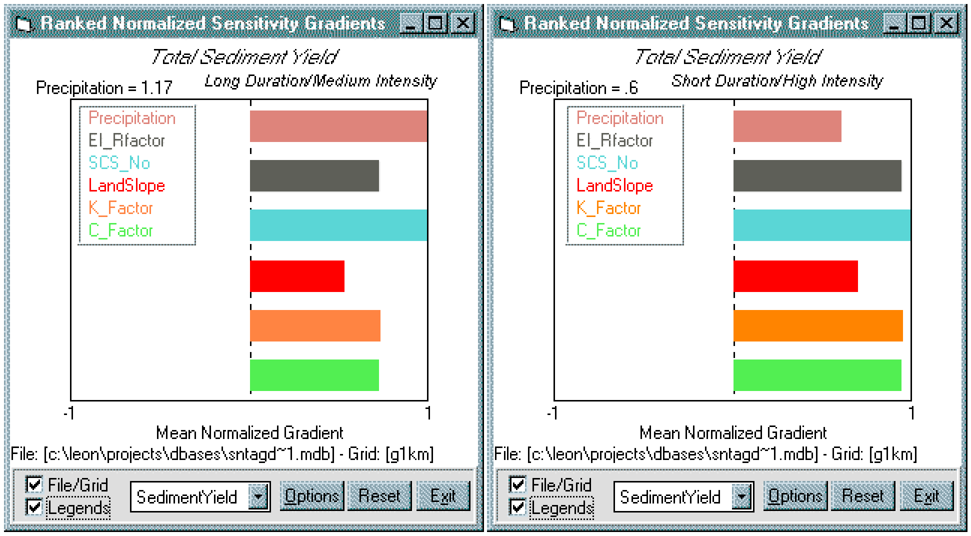


Figure 6.3 Ranked normalized sensitivity gradients for sediment yield and different events

6.3 Gaming Scenarios for Decision Support

This section was included to present additional tools that were developed during this research and designed to assist in the decision support area of non-point source modeling. It is fair to state that, from a management point of view, it is not enough just running a model to get some loading results. It will be a more useful tool if certain manipulating capabilities oriented to the decision making process are included. Some of the additional procedures were developed as a result of requests from pilot testing of the interface by MOE personnel and from the Lake Simcoe application.

Some descriptions of the tools for modifying scenarios with examples of the results that can be achieved were presented briefly in Chapters 4. A more complete discussion is presented here. The interface provides the means to easily set up, automatically extract data and simulate storm events on a given watershed, thus providing a major improvement in the modeling effort. It is also true that additional tools can provide a more useful system to help in the decision making process. In order to facilitate the decision support section, two aspects were taken into account, ease of use in modifying input data and availability of the most common features to create and analyze results for new scenarios.

Taking advantage of the system design and the use of relational databases, it was possible to implement the required options by storing in the same database, several grids for different scenarios in order to facilitate management and comparison. The first tool was designed for duplicating grids. Duplication was needed to avoid extracting the data from digital information over and over for the same landscape unless strictly required (i.e. landuse imagery for different years). The option is given during the duplication process to copy the existing data into the newly created grid. This is useful when creating different scenarios for the same landscape (ie. test BMPs, fertilizer reductions, etc.). A new set of tables for each duplicated grid is generated and stored in the same database. This allows further comparison of scenarios while keeping the integrity of the original data. If during the process, the user decides to copy the data for the grid that is being duplicated, then an indexed copy of the stored data in all the tables is triggered and the new grid is created as an exact duplicate of the selected grid. From this point, the new grid can be modified by changing any of the data.

Another tool was devised to support the decision making process to deal with landuse management issues. It accommodates changes in the landcover percentages. Several tools are available to select fields and amounts to change from one landuse to another. Once this change is complete, the model parameter values affected by the landuse change are recalculated. The program then reads the new landuse percentages and, using the same lookup table as in the extraction process, it calculates the new parameters and stores them in the general cell table of the new grid. This can be done for all the elements of the grid or only for those cells selected by the user through direct map clicking. This kind of flexibility has being found to be the most valuable aspect of the integration. It will give freedom of choice while maintaining the integrity and validity of the data. The newly created and modified grid can be viewed as a new scenario and while, it is still attached to the same file, the results can be compared quite easily. A spreadsheet type display was created to perform such comparisons by showing side to side summaries of results for as many grids as the database file contains. The detailed windows for the described procedures are presented in section C5 of Appendix C.

In order to show the flexibility of the integration, an application was created for Reesor Creek in the Stouffville area (AgStScen.mdb). A 1x1 km grid for the Reesor Creek watershed with 29 elements was created. This grid was considered as the base case with a long duration-medium intensity (1.5” of rain in 10 hr.) storm assigned for the event. The DEM, soil and landuse layers were used to extract the information from the digital maps. Figure 6.4 shows the grid for the simulation together with the flows direction.

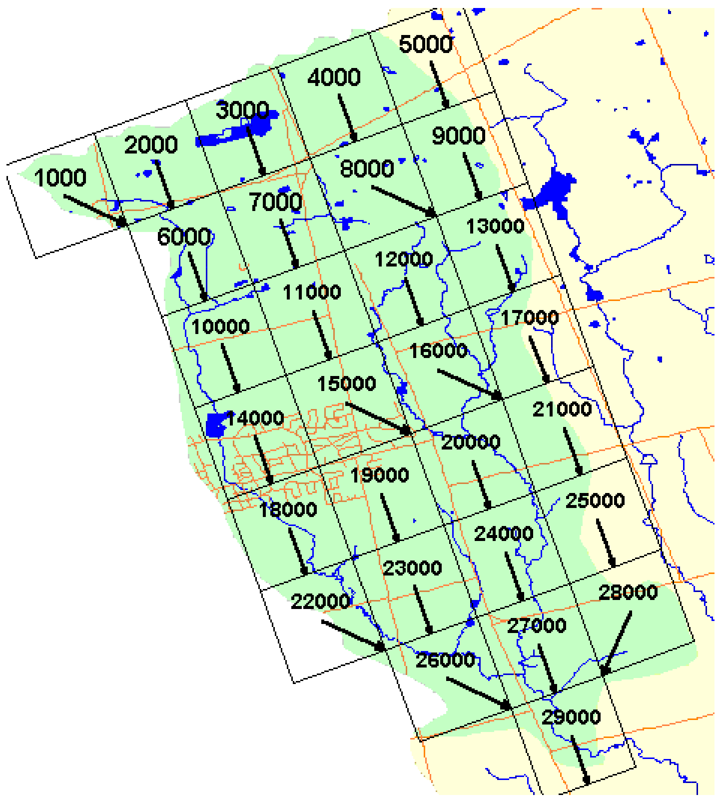


Figure 6.4 Grid at Reesor Creek with flow direction from DEM extraction

After the model is run and the results displayed for the base case, the next step is to show the gaming scenarios tools. The grid was duplicated three times, one for a sensitivity analysis comparison of the impact on the storm duration and intensity. The other two grid duplications were designed to demonstrate the effect on nutrients loads due to fertilizer application and reforestation practices.

For the first duplicate, the storm event was assigned a short duration-high intensity rainfall (2" of rain in 30 min). The second duplicate was subjected to a fertilizer application on areas with values above 25% of agricultural land according to the distribution described in chapter 5. The last duplicate, to simulate the effect of reforestation, was created from the fertilized grid to maintain the same rate of application but with the areas and model parameters automatically modified to change 20% of crop areas to forest.

The model was run for the three different scenarios and the comparisons made through the use of the spreadsheet view. Table 6.5 is a copy of the display showing the ease with which the user can compare results from different simulations. The sensitivity effect was already shown in the present chapter. The real time requirement for this example, including the extraction of data from digital maps, was less than an hour.

Table 6.5 Scenarios Summary Comparison for the AGNPS Model

Variable/Case	Units	Base	Base	Fertilizer	Reforest
Description		LDMI	SDHI	LDMI	LDMI
# Base Cells		29	29	29	29
# Total Cells		29	29	29	29
Area base cell	acre	351	351	351	351
Drainage area	acre	10179	10179	10179	10179
Precipitation	in	1.5	2	1.5	1.5
Energy intensity		16.6	112.55	16.6	16.6
Nitrogen in rain	ppm	1	1	1	1
Outlet Cell		29,000	29,000	29,000	29,000
Runoff Volume	in	0.17	0.37	0.17	0.07
Peak Rate	cfs	350.48	765.63	350.48	152.16
Sediment Yield	ton	207.21	1489.49	207.21	129.77
Nitrogen-Sediment	lb/acre	0.15	0.7	0.15	0.11
Nitrogen-Runoff	lb/acre	0	0.01	0.07	0.01
Phosphorus-Sediment	lb/acre	0.07	0.35	0.07	0.05
Phosphorus-Runoff	lb/acre	0	0	0.01	0
COD-Runoff	lb/acre	0.33	0.72	0.33	0.04
Nitrogen Conc	ppm	0.1	0.1	1.77	0.59
Phosphorus Conc	ppm	0	0	0.34	0.11
COD Conc	ppm	8.64	8.46	8.64	2.29

Variable description: LDMI=Long Duration/Medium Intensity, SDHI=Short Duration/High Intensity

6.4 Chapter Summary

This chapter deals with the sensitivity analysis methods and tools which were developed as a part of this research for inclusion in the interfaces. It shows the different equations used to calculate the normalized sensitivity gradients and its mean ranking. The implementation of the procedures is described and several examples on the use of the sensitivity analysis are presented. It also includes a more detailed description of the tools that where created to support the decision making process when dealing with nonpoint source pollution modeling. It describes the available options to create different scenarios and with a full example shows the ease of use and feasibility as a fully integrated decision support system.