Illinois State Water Survey

HYDROLOGY DIVISION

SWS Contract Report 504

SIMULATION OF URBAN RUNOFF AND POLLUTANT LOADING

SIMULATION OF URBAN RUNOFF AND POLLUTANT LOADING FROM THE GREATER LAKE CALUMET AREA

PART1. THEORY AND DEVELOPMENT
PART 2. AUTO_QI USER'S MANUAL

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EXECUTIVE SUMMARY

Features from the ILLUDAS model and the Q-ILLUDAS model were combined and modified to provide a new model known as AUTO_QI. The model provides for a continuous simulation of soil moisture based on a continuous hourly rainfall record, evapotranspiration, and soils parameters provided by the user. The soil moisture is used to determine the antecedent moisture condition for the simulation of runoff volumes for events exceeding a rainfall amount specified by the user.

The runoff volumes and buildup/washoff parameters for user-selected pollutants are then used to generate pollutant loadings and event mean concentrations (EMCs) for each event. The event results may be examined individually or combined to produce annual loadings. Event results may also be examined for one outfall or combined by receiving water. Critical events are also identified by the model.

Best management practices (BMPs) may be identified by the user and applied to any portion of the basin being simulated. Multiple BMPs may be specified and these may overlap on one or more subbasins. BMPs are applied by the model as a percent reduction for each of the water quality parameters requested. The user must provide this BMP "efficiency" for each parameter.

A sample data set is provided with the program and may be modified by the user through a menu system (QEMENU). QIMENU is used to enter or edit data, run the program, and generate output from the model. A complete user's manual is provided for QIMENU. When BMPs are employed, output is provided with and without BMP results. The program is designed to run on an IBM PC/AT or compatible.

An optional geographic information system (GIS) interface is provided to generate the necessary input files relating to land use, soils, and BMP distribution. The user must provide automated coverages of the entire basin for land use including percent impervious surface, soils, BMP distribution and effectiveness, and subbasin boundaries. The interface is provided as part of the AUTO_QI program and is designed to run on ARC/INFO on a PRIME computer. The interface produces two input files for the model that may be downloaded directly into QIMENU.

Observed rainfall, runoff, and water quality data were used to verify AUTO_QI on the Boneyard Creek basin in Champaign, Illinois, using literature values for the buildup and washoff of pollutants. The model was also applied to the Greater Lake Calumet area south of Chicago to determine annual pollutant loadings to the Calumet and Little Calumet Rivers.

Part 1 of this report describes the theory and development of the model as well as the results of verification and application. Part 2 is a detailed manual for users of the program.

PART 1. THEORY AND DEVELOPMENT

1.0 - INTRODUCTION

Models for simulation of urban runoff hydrographs such as the Illinois Urban Drainage Area Simulator, ILLUDAS (Terstriep and Stall, 1974), Stormwater Management Model, SWMM (Metcalf and Eddy, Inc., et al., 1971; Huber et al., 1975) and Storage, Treatment, Overflow, Runoff Model, STORM (Hydrologic Engineering Center, 1975) have been used for some time. They are considered reliable for stormwater drainage design and are widely used. Models that incorporate urban runoff water quality are available, but are less frequently used. The main reasons are: (1) the water quality component is less reliable; (2) the models require extensive input data; and (3) the models lack verification. This is unfortunate since urban water quality modeling is a convenient tool for assessing pollutant loadings. Considering the high cost of monitoring les the

3) Greate a GIS computer macro which can assist with Q-ILLUDAS input.
4) Apply the model to the Greater Lake Calumet Area near Chicago, Illinois.

This report is

Table 1.1.1. Urban Runoff Quality Model

schematic approach which assumes that the amount of accumulated pollutants on a surface can be described as a simple mass balance formula:

$$dP/dt = A - rP \quad (1)$$

where

A = the pollutant accumulation rate in pounds per day

r = the pollutant removal rate

P = the amount of street refuse or dust/dirt present on the street

t = time in days

Integrating Equation (1), then

$$P = A/r\,[1 - \exp(-rt)] + C \quad (2)$$

where

exp = exponential function

C = undefined constant

Using the empirical data from Shaheen (1975), the parameters were defined for the Washington, DC, area as follows:

A = (ATMFL + datf0.1a286 TL51 Tw (fo)Tj0 Tc (r900 T37 Tw (8w (=)4bzD/2w (fo)

where

p = particle transport per unit width

h

where

P = amount of solids remaining, pounds

t = time, in days

Ku = a constant depending on street surface characteristics (called urban washoff coefficient)

r = rainfall intensity, inches/hour

The constant Ku was found independent of particle size within the studied range of 10 to 1000 micrometers. The integrated form of the equation can be expressed as:

$$P_t = P_o [1-\exp(-Kurt)] \quad (6)$$

where:

P_o =

1.2.2 - Wet Periods

Runoff may only occur during a "wet period," a day during which rainfall occurs. During these potential runoff periods hourly rainfall amounts are required. The basin is assumed to have three types of area: directly connected paved area, supplemental paved area, and contributing grassed area. As the name implies, runoff from the directly connected paved area flows directly to the storm system. Runoff from the supplemental paved area flows first across the grassed area and is subjected to infiltration losses. The remainder of the basin is assumed to be grassed area and all rain falling on this surface is also subjected to infiltration losses. The runoff process is described below.

1.2.3 - Paved Area Runoff

The model distinguishes between directly connected paved area, and supplemental paved area. The losses from directly connected paved area consist of initial wetting and depression storage. These losses are combined and treated as an initial loss to be subtracted from the beginning of the rainfall pattern. After subtracting these losses from the rainfall pattern, the remainder of the rainfall wij1.612n.540 Tc(678 Tw0.33infal) T Tc(l) Tj5-pc(.) Tj9.984

where

R' = effective rainfall on the grassed area

R = actual rainfall

SPA = supplemental paved area

CGA = contributing grassed area

In an urban basin, the area that is not paved is most often covered with bluegrass turf. When rain falls on this turf, there are two principal losses, the first being the depression storage and the second being infiltration into the soil. In this model depression storage is filled and maintained and infiltration is satisfied before any runoff takes place. Depression storage is normally taken to be 0.20 inches, but provision is made in the model for this to be varied.

The dominant and far more complex loss of rainfall falling on grassed areas is that caused by infiltration. The theoretical approach to evaluating infiltration rates is based on using the physical properties of the soil to estimate the water storage available in the soil mantle and evaluating the role of this water storage as rain water infiltrates into and through the soil mantle. Details of water storage in soil and infiltration rates through soil are given in the original ILLUDAS manual. Onlyr

This equation is solved by the Newton-Raphson technique for given f_c and f_o values that depend on soil properties supplied by the user. A shape factor (k) of 2 was used to provide the shape best reflecting natural conditions.

The total amount of infiltration during a storm event depends upon the total amount of soil moisture (ET water and gravitational water) in storage. The higher the amount of available soil moisture, the lower the amount of infiltration and vice versa. In this model the total amount of infiltration is distributed among ET storage and gravitational storage in a preassigned 60/40 ratio. AUTO_QI continuously simulates soil moisture so that a reliable soil moisture is available at the beginning of any event.

1.2.5 - Dry Periods

During dry periods the model operates on two different time steps: daily if there is no rainfall on the current day and hourly if there is rainfall at some time during the current day. During dry periods depression storage and soil moisture depend on: 1) evaporation, at a user supplied rate from depression storage; 2) infiltration from depression storage, with the infiltration volume separated in a 60/40 ratio into ET water and gravitational water; 3) evapotranspiration, at a user specified rate, from ET water storage; and 4) percolation at a constant rate, f_c, from gravitational water storage.

1.2.6 - Spatial Distribution of Runoff Processes

All of the wet 20571 Tc>>BDCB3w (a)Tj0 Tc (d)Tj0.491 Tc725DCB3w67dry frTw 390.8

tfe onerv4of

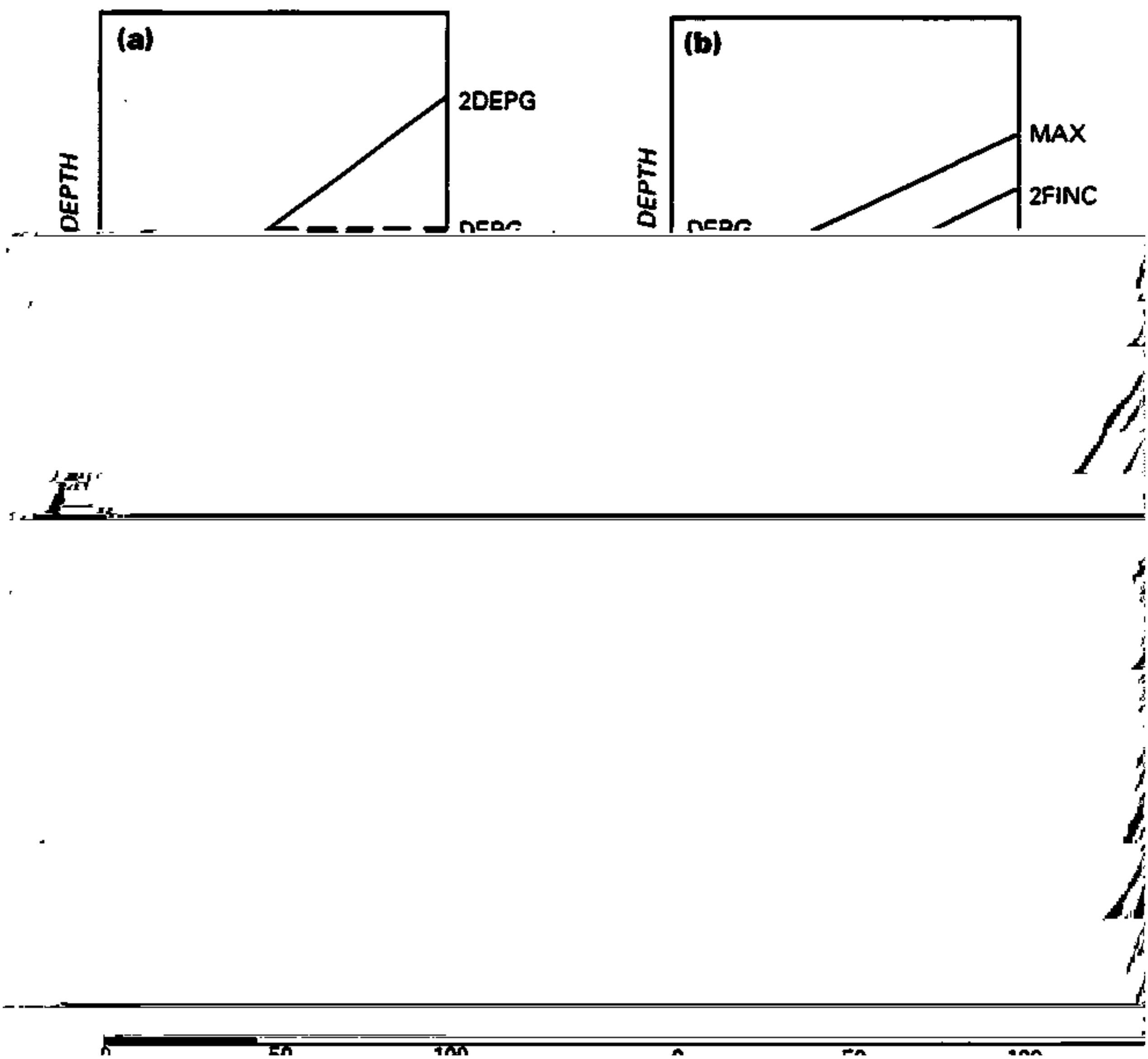


Figure 1.2.1. Triangular spatial distribution

zero to 2FINC, is satisfied for a particular level of supply, S, before considering depression storage. The supply rate, S, is defined as the sum of the rainfall and the uniformly distributed volume of depression storage at the start of the interval. The volume below S and between curves 2FINC and MAX represents the moisture supply to depression storage in the interval, D, and is processed according to the above discussion of Figures 1.2.1(a) and 1.2.1(b). The volume remaining below S and above the curve bounded by MAX is the surface runoff volume for the hour.

1.2.7 - Volume of Pollutant Generation

Once an effective hyra(t)Tj0.57 Tc 0.909 Tw (Genesurfo Tw (hyrah Tc (e)c (f)Tj18

$$- dP/dt = kP \quad (10)$$

which when integrated converts into the exponential washoff function for the removal of the surface loads as follows:

$$P_o - P = P_o(1\text{-}\exp(-kt)) \quad (11)$$

where:

P_o - P = washoff load, lb/acre

k = proportionality constant

t = storm duration, hours

In order to determine k, the model uses the same assumption as the SWMM model, that k varies in direct proportion to the rate of runoff such that:

$$k = iB$$

where:

i = runoff, in./hr

B = constant

To determine B it was assumed that a uniform runoff of 1/2 inch per hour would wash away 90 percent of the pollutant from paved areas and 50 percent of the pollutant from grassed areas in one hour. That leads to a value of B of 4.6 for paved areas and 1.4 for grassed areas. These are default values and can be modified by the user.

Washoff load is determined by applying each constituent's loading parameters to the buildup function to determine the initial load (by land use), and then applying the exponential washoff equation for impervious and pervious areas. The event mean concentration (EMC) is determined by dividing the total washoff loads by the runoff volume for each land use.

1.2.8 - Best Management Practices (BMP)

Best Management Practices (BMPs) are the measures implemented to reduce pollutants from source areas, or in streams and receiving waters. The mechanisms of pollutant removal by BMPs may be simple or complicated. There are many factors which govern their pollutant removal ability.

Schueler (1987) outlined three primary interrelated factors: 1) the removal mechanisms used, 2) the fraction of the annual runoff volume which is efficiently treated, and 3) the nature of urban pollutants being removed.

The AUTO_QI model does not model specific BMP processes, but represents the effectiveness of BMPs by a removal efficiency factor. The model can handle one or more BMPs in a catchment or portion of a catchment. A detailed description of preparing input data for the BMP component can be89.52 621.84 Tm(r232c 2.10 Tc 5.75 Tw (on)0 0 1 89.04 710.16 tn67ponen)T

1.3 - DATA PREPARATION

1.3.1 Interfacing the GIS Database and AUTO_QI

Urban runoff quantity and quality are highly dependent upon the land use and hydrologic soil type. To tabulate the land use/soil complex for a large basin is a time consuming process. To simplify the data collecting process, an optional ARC Macro Language (AML) program was developed to retrieve the land use/soil layers in a format suitable for model input.

The AML includes a menu driven data review feature with two windows on the screen. The right window shows an index map of the whole drainage basin and the subbasin boundaries. The user can select a subbasin and display the land use, soil layers, streets, and storm sewers. If the user wants the land use input file of a specific subbasin, the AML will retrieve the attribute data and generate an ASCII file for the model input.

1.3.2 - AML Programs

The AML programs provide the link and user interface between the GIS running on a PRIME and the AUTO_QI program running on a PC. These programs process the data for use by AUTO_QI and also enable the user to view the graphic data at the subbasin level via a menu. The programs are to be used with ESRI's ARC/INFO software on a PRIME computer and are grouped into two functions: the preprocessor programs and the menu system programs. PREPROCESSORLANDSOIL.AML, PREPROCESSORBMP.AML and RUNIT.AML are the names of the three main programs.

PREPROCESSORLANDSOIL.AML uses the soil, land use, and BMP coverages to create a soil-land use file that can be input to the AUTO_QI model. BMP.AML uses land use and BMP coverages to create BMP application files for the AUTO_QI model. RUNIT.AML is a program which accesses the ARC/INFO menu system to view the coverages and INFO data. This menu also allows the users to choose and view individual subbasins and their data layers. The detailed descriptions of these three programs can be found in Part 2 of this report.

1.4 - MODEL VERIFICATION

1.4.1 - Introduction

Due to the lack of observed data in the Lake Calumet area, the AUTO_QI model was verified by using the Boneyard Creek Basin in Champaign-Urbana, Illinois. This station has been continuously gaged by USGS since 1948.

The location of the Boneyard Creek streamgaging station is shown in Figure 1.4.1. The watershed area was reduced from 4.7 to 3.6 square miles in 1960 by a diversion. The basin contains a portion of Urbana, the commercial center of Champaign, and the University of Illinois campus. The central business district of Champaign makes up 7.5 percent of the drainage area, and is nearly 100 percent impervious. Other city properties, including predominantly residential, some commercial and light industrial, make up an additional 81.2 percent of the basin. The remaining 11.3 percent of the basin is in parks, open space and other land use classes. The basin has been measured to be approximately 44.1 percent total paved area, which includes 23.3 percent of direct connected paved area,. 13.1 percent of supplemental paved area and 6.7 percent of non-connected paved area. The soils of the basin are predominantly Flanigan silt loam of hydrologic class B (Terstriep and Stall, 1974).

1.4.2 - Runoff Simulation

The rainfall data for three years which represent low (25 percent), average (50 percent) and high (75 percent) annual exceedence of rainfall were chosen for runoff simulation. These years and total rainfall are shown in Table 1.4.1.

Table 1.4.1. Selected Years and Total Annual Rainfall

Year	*Total rainfall (inches)*	*Chance of exceedence (percent)*	*Comments*
1959	35.94	50	average year
1976	32.63	75	dry year
1977	42.44	25	wet year

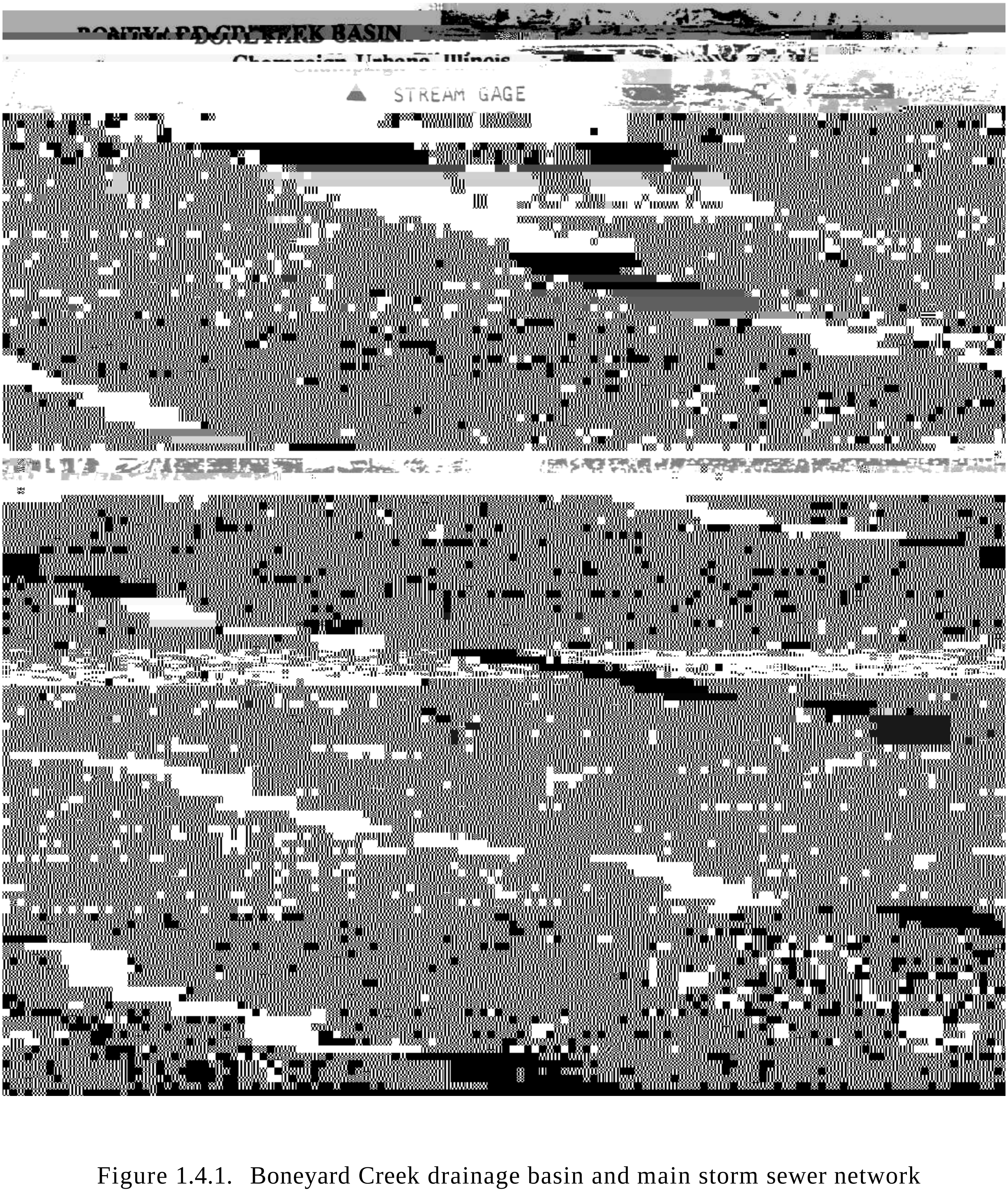


Figure 1.4.1. Boneyard Creek drainage basin and main storm sewer network

Land uses in the basin were simplified into two categories. The land use parameters for these categories that were used to verify the model are shown in Table 1.4.2.

Table 1.4.2. Land Use Parameters

Land use	*USGS land use Level 2 code*	*%PA*	*%SPA*	*DEPI (inch)*	*DEPG (inch)*
Residential	11	15	20	.1	.1
Commercial	12	90	5	.1	.1

Note: %PA= paved area in percent
%SPA= supplemental paved area in percent
DEPI= impervious depression storage depth
DEPG= pervious depression storage depth

1.4.3 - Results of Runoff Simulation

Events were selected for which the actual event runoff volume could be distinguished with reasonable confidence from the continuous runoff data. The events are tabulated in Tables 1.4.3,1.4.4 and 1.4.5 respectively.

Table 1.4.3. Summary of Runoff Simulation for Selected events in 1977

Date	*Dry days*	*Rain-fall (inches)*	*Event duration (hours)*	*Observed runoff (inches)*	*Simulated runoff (inches)*	*Simulated grass runoff (percent)*
1/13/77	3.04	.21	10.00	.006	.022	1
2/23/77	4.29	.33	4.00	.046	.05	2
8/28/77	5.13	1.43	11.00	.43	.32	1
9/24/77	2.13	.83	2.00	*26*	.18	5.4
10/05/77	.79	1.19	18.00	.31	.23	2
10/22/77	7.17	1.54	12.00	.40	.34	3.4

Table 1.4.4. Summary of Runoff Simulation for Selected Events in 1959

From Figure 1.4.2, it is seen that AUTO-QI does a reasonably good job in reproducing runoff runof

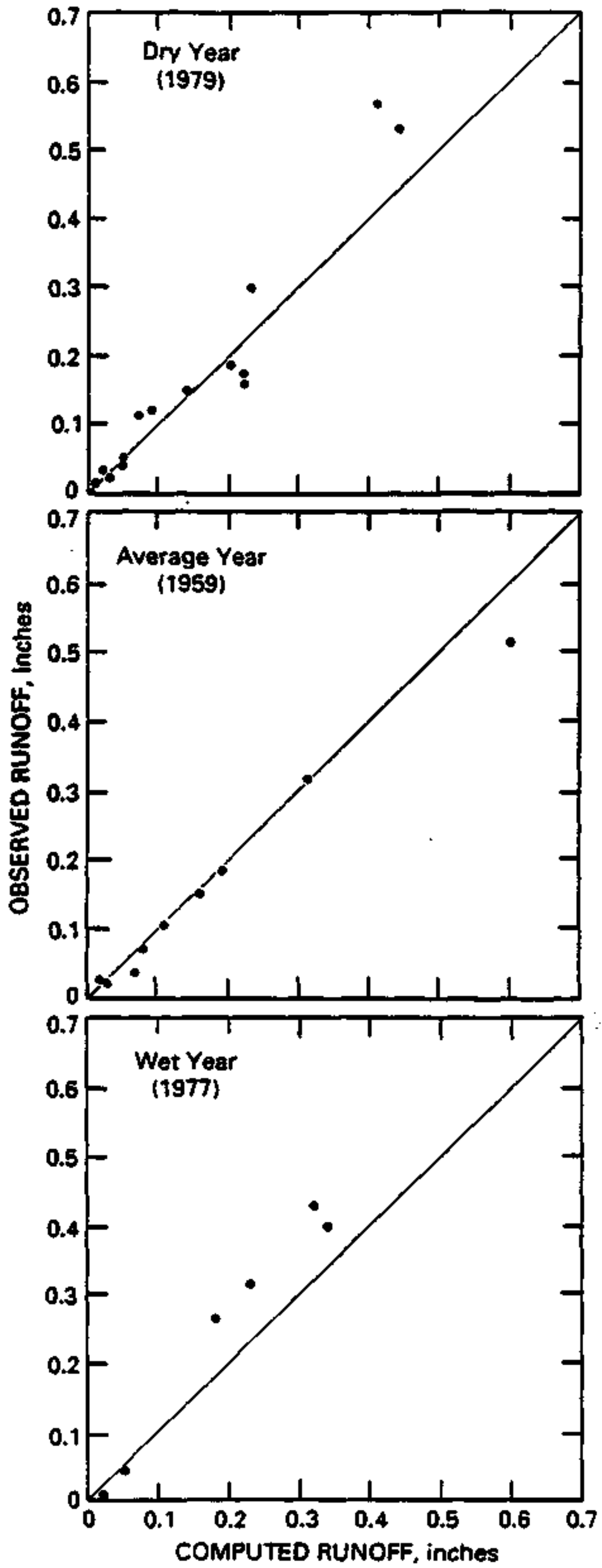


Figure 1.4.2. Comparison of observed and computed runoff volumes in Boneyard Creek basin, Champaign-Urbana, Illinois

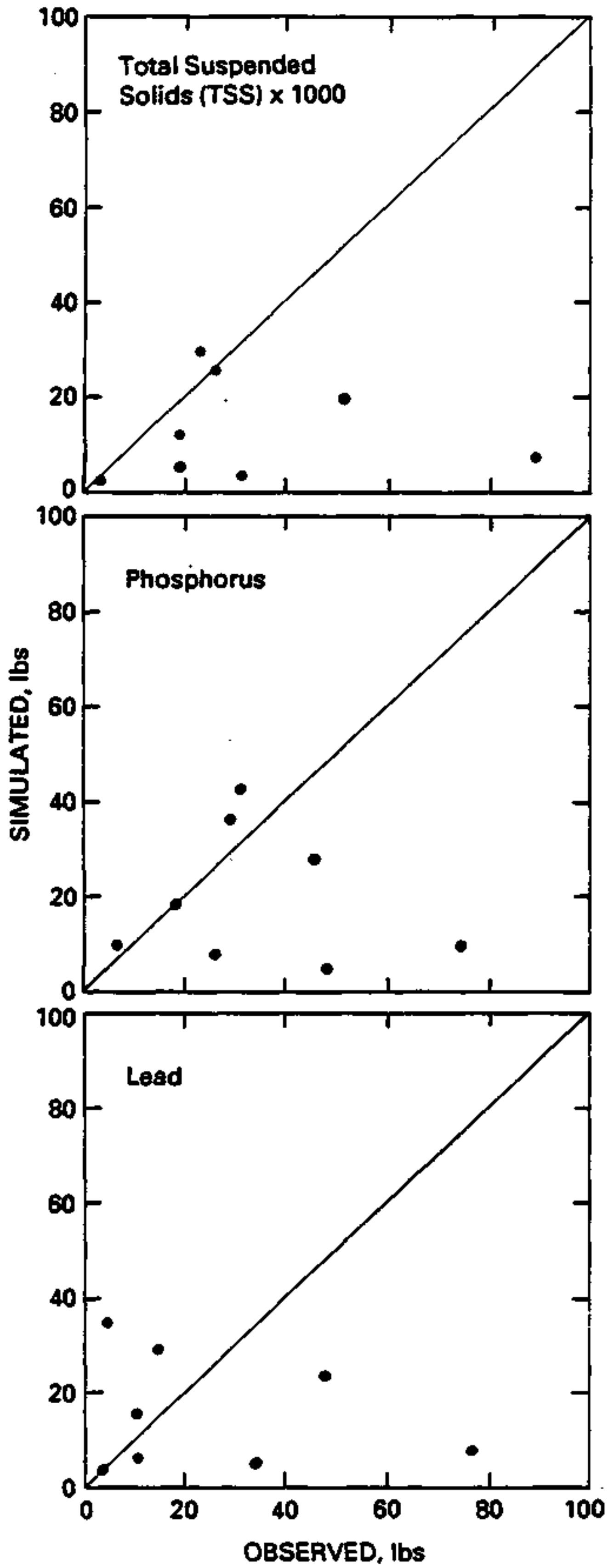


Figure 1.4.3. Comparison of observed and computed water quality loadings in Boneyard Creek basin, Champaign-Urbana, Illinois

The results of this verification are disappointing, but demonstrate the problems of water quality simulation without data for verification and calibration. The buildup and washoff factors in the model could be adjusted to "calibrate" the model to this data set and produce better results, but that was not the intent here.

Table 1.4.7. Washoff Load Simulation for Selected Events of 1982

			TSS		*Phosphorus*		*Lead*	
Date	*Rainfall (inches)*	*Runoff (inches)*	*Sim. (in*	*Obs. pounds)*	*Sim. (in*	*Obs. pounds)*	*Sim. (in pounds)*	*Obs.*
3/19/82	.52	.08	12,312	18,777	18	18	15	11
4/02/82	.66	.11	6,954	89,179	10	75	8	77
4/15/82	.12	.01	2,388	3,332	10	7	3	4
4/16/82	.60	.10	19,549	52,087	28	46	23	48
5/15/82	.43	.07	25,409	25,857	36	29	29	15
6/15/82	1.17	*21*	3,302	30,969	5	48	5	35
6/28/82	.98	.16	29,808	22,931	43	31	35	5
7/18/82	1.14	.30	5,070	19,001	8	26	6	11

1.5 - HYDROLOGIC AND POLLUTANT LOADINGS IN THE GREATER LAKE CALUMET AREA

1.5.1 - Introduction

Until the late nineteenth century, the Lake Calumet area southeast of Chicago was primarily a shallow marshy land abundant with wildlife. Rapid urbanization and industrialization since then, however, have left little of the original wetland as shown in Figure 1.5.1. Detailed descriptions of the study area can be found in numerous previous field reports (Colten, 1985; Ross et al., 1988; USHEW, 1965; USACE, 1983). The following sections describe the GIS databases which are needed for urban pollutant loadings.

1.5.2 - GIS Database Layers

1.5.2.1 - Soil Layer

The Statewide "General Soil Map of Illinois" was digitized for the Illinois GIS system in 1985 with funding from the Illinois Department of

Mines and Minerals (IDMM). This map contains 57 general soil associations in Illinois. The attribute data include the soil surface color, surface code and the hydrologic class (well drained, moderately well drained, somewhat well drained, and poorly drained). This hydrologic soil class is needed hydrologic modeling in the AUTO_QI model. The source map scale for the soil associations was 1:500,000.

1.5.2.2 - Land Use Layer

The statewide land use maps are available from the USGS LUDA digital data base (Anderson et al., 1976). The land uses are classified based on LUDA Level II containing 37 land use categories (Appendix D). Land use/cover information has been updated by using digital Landsat image data or by scanning aerial photographs (Hsu, 1978; King, Lee and Singh, 1989; Lee and Ke, 1990; Lee, Kao and Ke, 1990). The Illinois State Water Survey has developed image analysis capability using the ERDAS image processing package (ERDAS, 1989). The results of a classified land use can easily be transferred to the ARC/INFO system. Figure 1.5.2 shows the LUDA land use map of the study area.

1.5.2.3 - Street Layer (DIME file/Tiger LINE file)

The street coverage may be obtained from the 1980 DIME file or the 1990 TIGER/LINE files which were created by the U. S. Census Bureau. The DIME/TIGER files are composed of street segment records. A segment is defined as the length of a street feature between two distinct vertices or nodes. Other features are political boundaries and topologic features (rivers, shorelines, canals, railroads, airports). Additional demographic information is also available in the attribute data. This includes state, county and standard metropolitan statistical area codes, aggregate family income, aggregate rental cost for occupied dwelling units, and numerous other demographic statistics. The data can be plotted by census tract. The source map is 1:100,000. This layer is valuable for estimating the pollutant accumulation rate and the, of th ee

Figure 1.5.2. Land use coverage of the study area

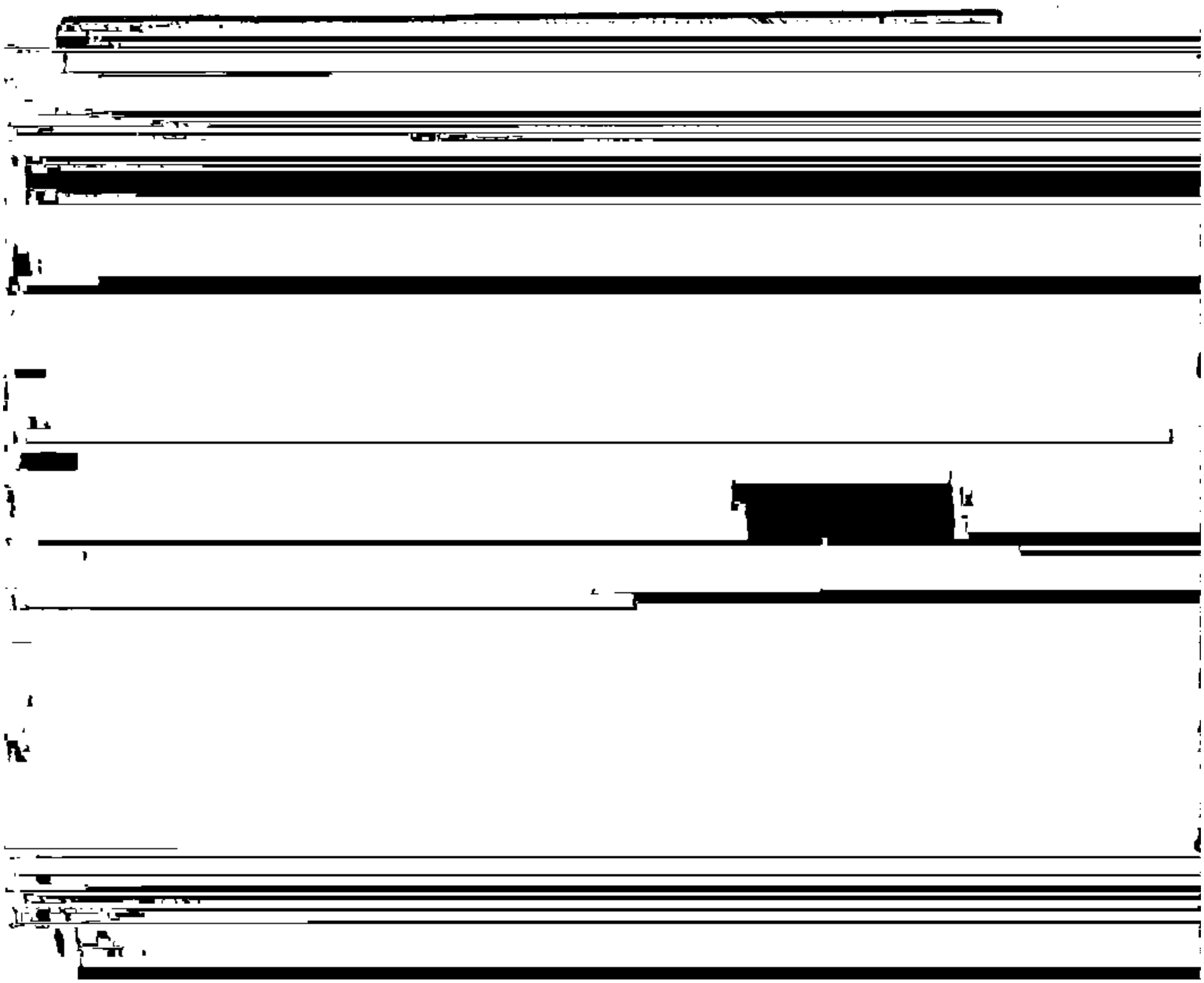


Figure 1.5.3. Street coverage of the study area

1.5.2.4 - Sewer Network

For the Greater Lake Calumet area, the sewer outfall points were identified from existin

Table 1.5.1. Breakdown of Land Uses in Each Subbasin

Land uses	*Land use code*	*Area in acres in subbasin #*			
		1	*2*	*3*	*4*
Residential	11	2,885.52	4,257.3	163.91	193.21
Commercial	12	213.15	1,361.15	111.72	6.37
Industrial	13	83.33	1,016.65	50.51	82.55
Transportation	14	131.80	439.39	0.00	0.00
Other urban or built-up area	17	93.54	53.59	0.00	0.00
Deciduous fores	41	11.84	29.00	0.00	0.00

The runoff was simulated for each subbasin for rainfall in years 1955, 1959 and 1971. Thirty-seven inches of rainfall in 1959 has approximately 25% chance of exceedence; 32.5 inches of rainfall in 1955 has approximately 50% chance of exceedence; and 29 inches of rainfall in 1971 has approximately 75% chance of exceedence (Neely and Heister, 1987).

A summary of the simulated rainfall/runoff ratios for various subbasins is shown in Table 1.5.3.

Table 1.5.3. Rainfall-Runoff Ratios for the Greater Lake Calumet Area

Year	*Total rainfall (inches)*	*Annual rainfall /runoff ratio for subbasin #*			
		#1	#2	#3	#4
1955 (Average)	32.5	.159	.30	.323	.27
1959 Wet year)	37	.15	.282	.308	.255
1971 (Dry year)	29	.146	.277	.30	.25

The annual average rainfall-runoff ratios range from 15 to 30 percent. The higher rainfall-runoff ratios are mainly due to larger percentages of land uses in commercial, industrial, and transportation categories which have a high percent of imperviousness. The majority of runoff was contributed from the paved areas.

1.5.5 - Water Quality Simulation

The water quality parameters for each land use were assumed to be the same as the parameters that were used for verification in the Boneyard Creek basin in Urbana. The parameters are presented in Table 1.5.4.

Table 1.5.4. Water Quality Parameters

Chemical const.	*ARi* *(lb / acre / day)*	*ARp* *(lb / acre / day)*	*RRi* *(percent)*	*RRp* *(percent)*
For residential land use:				
Suspended solids	7.6300	3.9900	4.50	4.50
Phosphorus	0.0100	0.0053	6.00	5.00
Lead	0.0106	0.0053	4.00	3.00
For commercial land use:				
Suspended solids	9.5500	5.5500	4.50	4.50
Phosphorus	0.0085	0.0040	6.00	5.00
Lead	0.0075	0.0025	4.00	3.00
For industrial land use:				
Suspended solids	8.3300	6.0000	4.50	4.50
Phosphorus	0.0100	0.0055	6.00	5.00
Lead	0.0125	0.0055	4.00	3.00
For transportation land use:				
Suspended solids	8.0000	4.7500	4.50	4.50
Phosphorus	0.0075	0.0040	6.00	5.00
Lead	0.0250	0.0150	4.00	3.00

ARi is the Accumulation Rate for impervious area
RRi is the Removal Rate for impervious area
ARp is the Accumulation Rate for pervious area
RRp is the Removal Rate for pervious area

The pollution accumulation rates for total suspended solids increase from residential areas to commercial and industrial areas. The lead accumulation rate for the transportation area was assigned about two-fold higher than that of the residential areas.

Subbasins 1 and 2 discharge to the Little Calumet River and subbasins 3 and 4 discharge to the Calumet River as shown in Figure 1.5.1. Table 1.5.5 shows the loadings discharging to the Little Calumet River (subbasins 1 and07nTw (1)Tj1.172 8

Table 1.5.5. Summary of Pollutant Loadings to the Little Calumet River (Subbasins 1 and 2)*

Year	*Yearly total load*	*Average*	*Max event* load*

annual total suspended solids loadings range from 352,000 to 437,000 pounds. This is equivalent to about 0.27 tons per acre, which is higher than that of the Calumet outfall points. This can be attributed to the higher percent of impervious areas in the commercial and industrial land-use areas. For comparative purposes, this amount is slightly lower than suspended sediment yields from a typical rural watershed.

The annual phosphorus loadings for the simulation for the selected three years range from 580 to 784 pounds at the Calumet River outfalls and 5,000 to 6,600 pounds at the Little Calumet River outfalls. The average EMCs range from 0.6 to 0.9 and 0.5 to 0.8 at the Calumet River outfalls and the Little Calumet outfalls, respectively.

The annual lead loadings for the simulation for the three years range from 5,300 to 6,400 pounds at the Little Calumet outfalls and 541 to 631 pounds at the Calumet River outfalls. The EMCs range from 0.5 to 0.7 mg/l at both the Little Calumet River and the Calumet River outfalls.

It is worthwhile to note that the variations of the event loadings and EMCs among the events are large. However, the variation of annual total loadings of the three-year simulation is relatively small. thl9t976.Tw (0 Tc 1.026 Twp946

generate loads and EMCs. BMP is the best management practices simulator which handles numerous separate or overlapping best management practices and produces the model output. The impacts of pollution reduction may be simulated at multiple stormwater outfall points. The results can be viewed at one outfall point or multiple outfall points.

QIMENU aids users with preparation of input files, selection of parameters, running the model, testing the BMPs and viewing the output.

The GIS interface uses the ARC macro language (AML) and automates the generation of the major input files for AUTO_QI. It also provides the user with a menu driven program to review GIS coverages on the screen.

The model was verified by using data from the Boneyard Creek drainage basin in Urbana, Illinoidsm1ec (.)Tj0.508c 4.674 (.)Tjr81 Tw (50 Tc (e)Tj0.552 v T pounds at the outfalls of the Calumet River and 5,300 to 6,400 pounds at the outfalls of the Little Calumet River.

1.6.2 - Conclusions

1) An urban model (AUTO_QI) has been produced that simulates volumes of storm runoff, pollutant loading, and event mean pollutant concentrations from a continuous rainfall record and basin parameters.

2) An optional geographic information system (GIS) interface has been developed that generates the required model input files relating to land use, soils, and BMP distribution.

3) Very limited verification of the model has shown good results for runoff simulation and poor results for pollutant simulation.

4) No calibration of the model was attempted and only literature values were used for the buildup and washoff of pollutants.

5) The model was applied to the Greater Lake Calumet area, Chicago, Illinois, and pollutant loadings were generated for the Calumet River and the Little Calumet River.

6) Creation of input files for the Lake Calumet area on the geographic information system did save significant office time. Additional office time was required to automate the subbasin boundaries in the area.

7) The model and interface have the potential for generating runoff volumes and pollutant loadings from a large urban area with multiple outfalls discharging to more than one receiving water. Both annual and event loadings including maximum event loadings are determined.

8) Output from the model can be used for subsequent frequency analysis to determine the probability of various event loads.

9) The model provides for the application of multiple and overlapping BMPs and all results are shown with and without BMPs in place.

10) Observed rainfall, runoff, and pollutant loadings should be used to verify the model before application.

PART 2. AUTO_QI USERS MANUAL

2.0 - INTRODUCTION

This user's manual is intended to provid from urbanized watersheds. Soil moisture simulation is continuous on a daily basis but only individual events above a user specified base rainfall are selected for runoff simulation. The simulation may include various Best Management Practices (BMPs). In this case, output will show pollutant levels with and without BMPs in place. Neither peak runoff values nor hydrograph shapes are simulated, only total runoff volume for each selected event.

The basin being simulated may be divided into a number of subcatchments, but the descriptive values such as land use and BMP areas are lumped within each subcatchment. The outputs for each subcatchment may be combined to simulate the total loadings to a given receiving water.

Pollutant loadings are simulated by using exponential accumulation and washoff functions on the impervious and pervious surfaces of the watershed. As such, the user may specify any pollutant for which accumulation and washoff rates are available. These factors are not provided by the model.

Any BMP may be specified by the user if removal efficiency is known by pollutant and land use. These removal efficiencies are not provided by the model.

2.2 - GENERAL CONCEPTS

Several files are required to run AUTO_QI. These may be considered in threSeveral

BASIN FILES - BASIN.DAT, BMPEFF.DAT, EVAP.DAT SOIL.DAT, WQLIST.DAT - These files, which will be described in detail below, include BASIN.DAT which selects the rainfall period and assigns a title to the run. The BMPEFF.DAT file describes BMP effectiveness. EVAP.DAT provides monthly evaporation and evapotranspiration values. Infiltration parameters for basic soil types are provided in EVAP.DAT, and WQLIST tells the model which pollutants will be simulated.

SUBCATCHMENT FILES - BMPAPP.nnn, LU.nnn, WQ.nnn One each of these files is required for each of the subcatchments. The value of "nnn" is the subbasin index or ID number. The BMPAPP.nnn file describes the extent of BMP application

MENU DISKETTE
The primary user interface and data editing programs:

QIMENU.EXE	LIST.COM
QIMENU.HLP	
QIMENU.INI	

SAMPLE DATA DISKETTE
The required data files for a small sample basin with 3 subcatchments:

BASIN.DAT	LU.001	BMPAPP.001	WQ.001
BMPEFF.DAT	LU.002	BMPAPP.002	WQ.002
DARAIN.DAT	LU.003	BMPAPP.003	WQ.003
HRRAIN.DAT			
EVAP.DAT			
SOIL.DAT			
WQLIST.DAT s			

1. Create the main directory (md\AUTO_QI) and move to it (cd\AUTO_QI).

2. Insert the MENU diskette into drive A: and copy all of the files to the main directory (copy a:*.* c:).

3. Create a sub-directory for the input data (md\AUTO_QI\QITEST) and move to that directory (cd\AUTO_QI\QITEST).

4. Insert the SYSTEM diskette into drive A: and copy all of the program files to the main directory (copy a:*.* c:).

5. Insert the SAMPLE DATA diskette into drive A: and copy all of the files to the data sub-directory (copy a:*.* c:).

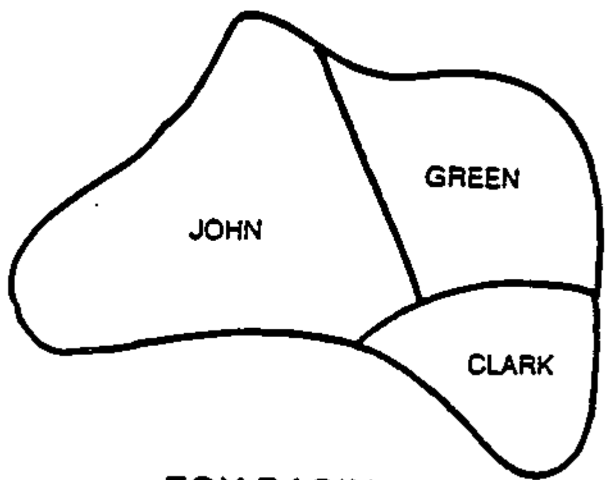
6. Run the program from AUTO_QI directory by typing QIMENU.

The ARC/INFO AML diskette will not be copied to the PC.

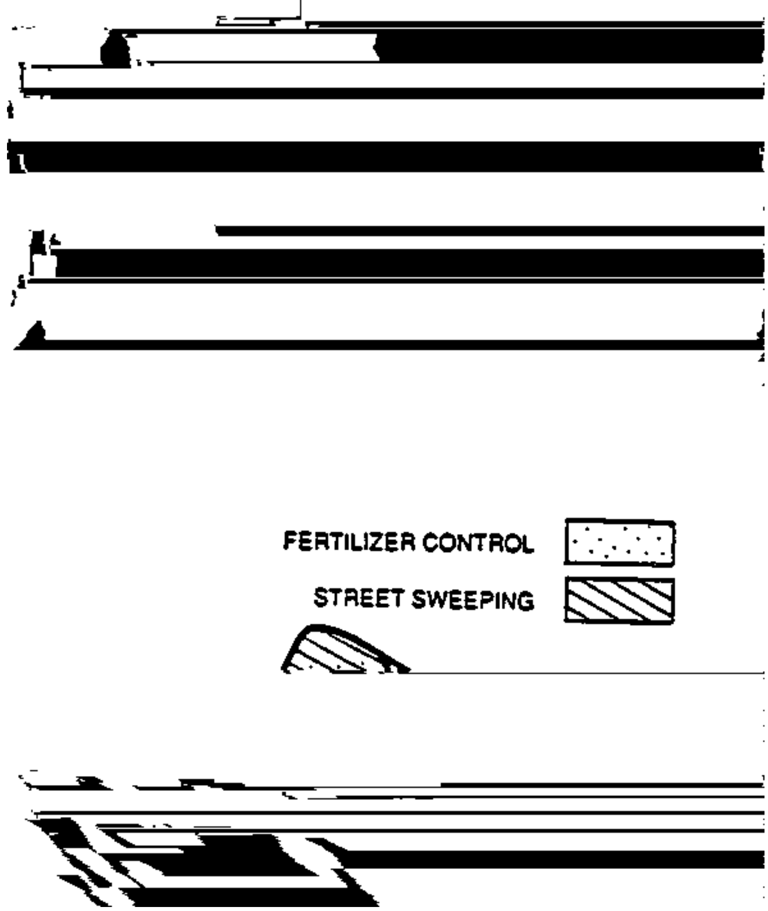
2.4 - DATA

2.4.1 - SAMPLE BASIN

The following figures show the FOX Basin for which data in this section and on the SAMPLE DATA diskette were prepared. The first figure shows the subbasin boundaries and names and the second figure shows the distribution of best management practices.



FOX BASIN



The following physical features were determined for the FOX Basin (363 total acres) and were used to compile the SAMPLE DATA.

Subbasin ID	1	2	3
Subbasin Name	CLARK	GREEN	JOHN
Residential (acres)	0	62	196
Commercial (acres)	40	42	0
Industrial (acres) Industri4Tj0 Tc (l)Tj0.253 Tc 24628.8(acres)Tj0 Tc ())Tj14.012	23	0	0
TOTAL (acres)	63	104	196

Land Use	Area	Imp acres	Supp %	Soil %
SUBBASIN #1 - CLARK STREET				
Commercial	40	80	10	5
Industrial	23	40	20	5

SUBBASINres1 5 0 Tc EMCET EMC /S

2.4.2 - BASIN-WIDE FILES

2.4.2.1 - GENERAL BASIN DATA - BASIN.DAT

This file is most easily created by modifying an existing file, such as the one provided in the SAMPLE DATA.

BASIN DESCRIPTION

The first line in this menu may contain any information the user wishes to identify the resulting output. The information will appear on all screen and printed output.

START DATE

This is the starting date of the simulation. It is imperative that this date fall within the range of data provided in the daily rainfall file DARAIN.DAT.

END DATE

This is the last date of the simulation period. This date must lie within the range of data provided in DARAIN.DAT.

MINIMUM RAINFALL

This value is the minimum rainfall in inches below which an event simulation will not occur. If you wish to simulate only those events for which the rainfall was at least one half inch, enter 0.5 here.

NUMBER AND NAME OF **SUBBASINS**

These values come from the BASIN menu described below.

FORMAT: **A80/2I7/F7.3/A15/I2**
A20 (for each subbasin)

SAMPLE DATA:

```
SAMPLE BASIN - CLARE, GREEN, & JOHN
060188 063088
  .20
EVAP.DAT
 3
CLARK STREET
GREEN STREET
JOHN STREET
```

2.4.2.2 - PRECIPITATION

.0	**.0**	**.0**	**.0**	**.0**	**.5**	**.8**	**.2**	**.0**	**.0**	**.0**	**.0**	**6/05**
.0	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	
.0	**.0**	**.0**	**.2**	**.3**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**6/10**
.0	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	
.0	**.0**	**.7**	**.8**	**.3**	**.3**	**.3**	**.1**	**.0**	**.0**	**.0**	**.0**	**6/13**
.0	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	**.0**	

2.4.2.3 - WATER QUALITY LIST - WQLIST.DAT

The user should determine and list here the chemical constituents that are required by the simulation. Any constituent may be used for which the user is able to specify the daily accumulation and washoff rate and the removal rate by any BMPs to be used. The model is most reliable for those constituents which are related to suspended solids. Those constituents which are to a large extent dissolved are most subject to question. In any case, it is always desirable to verify the model with real data.

The list of constituents provided here must be the same as that specified later in the BMP 1 154.5L2Tc 0.91554.56 52s.298 Tw (2j0.87200.149 Tc 0.9

2.4.2.4 - EVAPORATION - EVAP.DAT

Evaporation pertains to evaporation from free water surfaces such as standing water on impervious and pervious areas. Typical value for Illinois: 36 inches per year. Evapotranspiration is the combined process of evaporation and transpiration, where transpiration refers to the passage of soil water through the plant system and its vaporization into the atmosphere. Evapotranspiration depletes moisture from the soil. Typical growing season values for corn: 3-5 inches per month.

EVAP.DAT of the SAMPLE DATA provided with the AUTO_QI package and listed below shows typical values for central Illinois. The topic is also discussed in more detail in Appendix A.

For further information and formulas to calculate evaporation and evapotranspiration, see "Agricultural Engineers' Handbook," by C.B. Richey, editor-in-chief, m89 Tw (editor-in-chi32 Tc t4.88 484.3

Emax - The amount of storage available in the soil mantle for evapotranspiration water in inches.

Gmax - The amount of storage available in the soil mantle for gravitational water in inches.

Further information on these parameters is available in Appendix B. For a more detailed description of the above terms see also "The Illinois Urban Drainage Area Simulator, ILLUDAS," by Michael L. Terstriep and John B. Stall, Bulletin 58, Illinois State Water Survey, Urbana, 1974.

FORMAT: **20X/20X**
10X, 4F7.4 (for each soil type)

SAMPLE DATA: The first line of table headings and the following blank line are required.

SOIL TYPE	**FO**	**FC**	**EMAX**	**GMAX**
1	**10.000**	**1.000**	**2.700**	**12.600**
2	**9.000**	**0.750**	**3.410**	**11.050**
3	**8.000**	**0.500**	**4.120**	**10.500**
4	**6.500**	**0.375**	**5.000**	**7.650**
5	**5.000**	**0.250**	**5.100**	**4.800**
6	**4.000**	**0.175**	**4p31en315.6**	**Tm09 Tc 18.4919.85**

Environmental Programs, Metropolitan Washington Council of Governments, 1987.

The file contains the number of BMPs to be used followed by a line for each BMP and its anticipated removal rate in percent for each chemical constituent and in the same order as shown in the Water Quality Constituent file.

FORMAT: **I2**
A20,10F4.2 (for each BMP)

SAMPLE DATA:

2			
STREET SWEEPING	**.30**	**.15**	**.20**
FERTILIZER CONTROL	**.0**	**.25**	**.00**

2.4.3 - SUBBASIN FILES

The preceding files were applicable to the entire basin and must therefore also be appropriate for each subbasin. The following three files accessed from the lower portion of the MAIN - DATA portion of the menu describe specific aspects of each subbasin. There must be one of each of these 3 files for each subbasin.

2.4.3.1 - LAND USE - LU.nnn

The land use file contains the number of land uses in the specific subbasin and a line of data describing each land use. The legal land uses are limited to those included in the USGS LUDA Level II Land Use Codes. A list of these is provided in Appendix D. The list of land uses must also be compatible with those in the following Water Quality File and BMP Application File. Definitions of the variables on each line of the file follow.

CODE - The Level II Land Use Code as defined in the USGS LUDA data. These codes aree US7Tw (-01 Tw (th)Tj0j098I0fc (f)Tj0.8r3 Tc 1.354 Tw

DESCRIPTION - The description

2.4.3.2 - WATER QUALITY - WQ.nnn

The water quality file cond2.4.3.2

SAMPLE DATA: The land uses and water quality constituents must be compatible with their use in related files. Although not used by the program, it is advisable to add the land use at the end of the first line of each land use sector to aid in data editing.

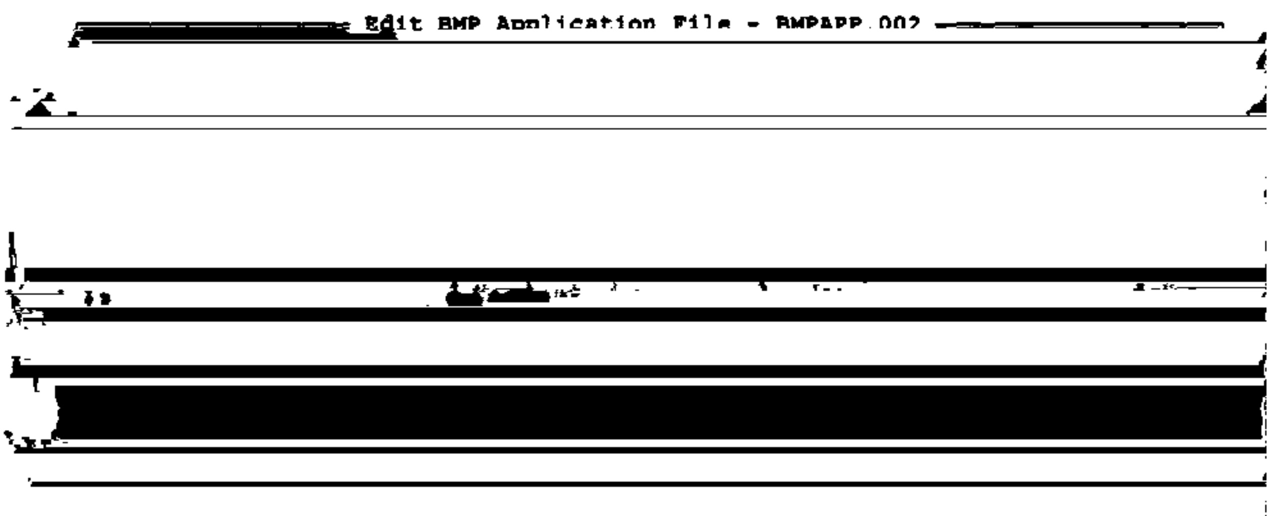
SAMPLE DATA:

AR_i	RR_i	AR_p	KR_p	P_i	P_p	EXP_i	EXP_p	
				(Headings not part of data)				
2.3100	.0500	1.1600	.0450	6.9300	3.4800	4.6000	1.4000	RESIDENTIAL
.0142	.0600	.0070	.0500	.0526	.0210	4.6000	1.4000	
.0030	.0300	.0015	.0300	.0090	.0045	4.6000	1.4000	
10.000	.0450	5.0000	.0450	30.000	15.000	4.6000	1.4000	COMMERCIAL
.0100	.0600	.0060	.0500	1.0000	1.0000	4.6000	1.4000	
.0100	.0300	.0050	.0300	.0300	.0150	4.6000	1.4000	

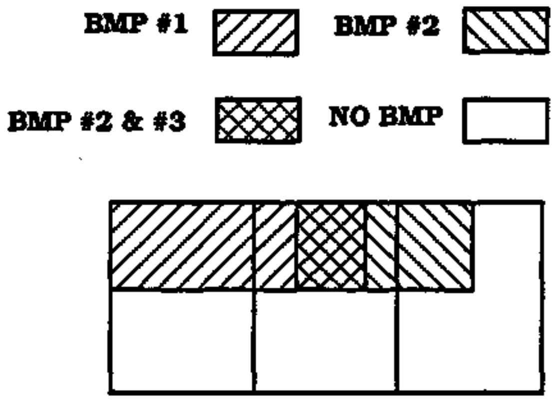
2.4.3.3 - BMP APPLICATION - BMPAPP.nnn

This file is most easily created by modifying an existing file using QIMENU. It provides information to the program about the distribution of BMPs in each of the subbasins. There may be no BMPs in a given subbasin or multiple BMPs that may or may not overlap. The SAMPLE PROBLEM has examples of both of these situations in a simple configuration of 3 subbasins and 2 BMPs.

Each subbasin is divided into regions with each region described by a distinct land use. An example subbasin is shown below:



Now consider the distribution of BMPs in the subbasin. Each BMP can be applied on any portion of the basin. A BMP may cover only part of Land Use #1 or it may cover parts of all three land uses. In addition, in cases when more than one BMP is being applied, the BMPs may overlap, as the following diagram illustrates:



BMP APPLICATION

Each line in the BMP Application File is a unique combination of one or more BMPs called a sector. In this example there are four sectors: one is the region covered by BMP #1; another is covered by BMP #2; the third is covered by BMPs 1 and 2; and the fourth has no BMPs. There must be a j0.496 Tc 2.013 Tw l3w (Thdb

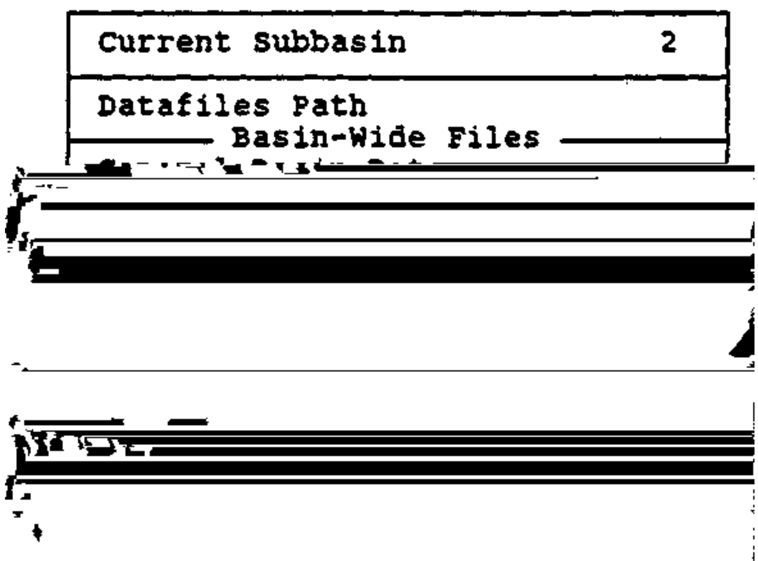
2.5

```
Edit Subbasin List - BASIN.DAT

Index  Description

  1    CLARK STREET
  2    GREEN STREET
```

ESC to discard it. Press DEL to delete the current subbasin. You will be asked to confirm your decision. The indexes associated with the descriptions are automatically renumbered after insertions and deletions.

To exit the subbasin list editing screen, press ESC. If you accepted changes to any of the lines or inserted or deleted any lines, the data will be written out to disk and a message notifying you of this will appear. This menu provides a list of subbasins on which the simulation may be run. It also determines the range of legal subbasin index values for the "Current Subbasin" in the *DATA* Menu.

2.5.3-DATAMENU



The *DATA* Menu provides access to all of the required *.DAT files and *.nnn files except the BASIN.DAT file described above and the rainfall files DARAIN.DAT and HRRAIN.DAT to be described later. Any of the files that can be accessed from within *DATA* may also be edited without leaving QIMENU.

2.5.3.1 - DATA, CURRENT SUBBASIN

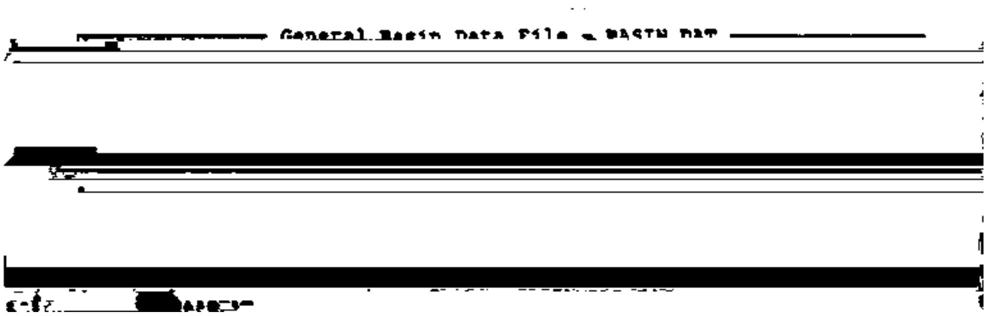
The value of the "Current Subbasin" is the current subbasin index and will determine which subbasin specific files are selected for editing. Press ENTER to change the value of the current subbasin and ENTER again to accept the value or ESC to reject. The "Current Subbasin" must be one of the subbasins listed in the BASIN.DAT file described above.

To choose from a list of available subbasins and their associated descriptions, enter a value of zero. You will be told that the value is illegal. Press Enter and a scrollable list of subbasins will appear. Use the arrow keys to move to the one you wish to select, then press ENTER. The number will appear in the edit box automatically. Selecting from this list insures a legal value.

2.5.3.2 - DATA, DATAFILES PATH

DATAPATH FILES identifies the drive and directory in which the input data files for QIMENU can be found. Scroll to this option and press ENTER or press "D". A new line will be displayed showing the current path. Make sure that this line may be edited if necessary to identify the correct path name.

2.5.3.3 - DATA, GENERAL BASIN DATA - BASIN.DAT



The *GENERAL BASIN DATA* menu containsmt tpicesTj0 Tc (s)Tj0.320 Tc 3.434

CTRL-ENTER on any of the fields or ENTER on the last field (Minimum Rainfall). To discard any changes, press ESC.

2.5.3.4 - DATA, DAILY RAIN - DARAIN.DAT

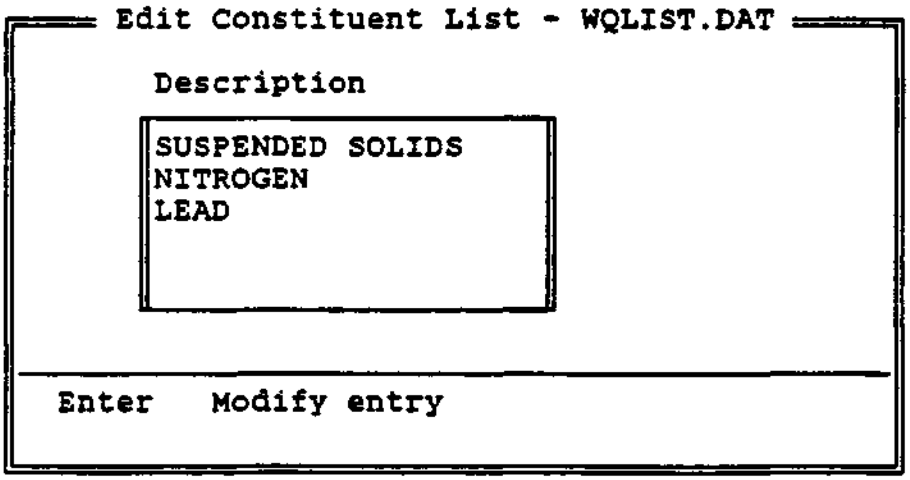
This file, DARAIN.DAT is not accessible from the menu. An external editor is required to create and edit the file. This must be a continuous sequential file of daily rainfall in inches for the longest simulation period desired.

2.5.3.5 - DATA, HOURLY RAIN - HRRAIN.DAT

This file, HRRAIN.DAT is not accessible from the menu. An external editor is required to create and edit the file. See "Data Preparation" above for details.

Having created this file, the user may select any simulation period between the first and last day of DARAIN.DAT. This is done in the *DATA* Menu under "General Basin Data".

2.5.3.6 - DATA, WATER QUALITY CONSTITUENTS - WQLIST.DAT



Each line in the "Water Quality Constituents" file is the name of a chemical constituent. To modify the name of the current constituent, press the Enter key. Type in the new name and press ENTER to accept it or ESC to discard it.

To exit the constituent list editing screen, press ESC. If you accepted changes to any of the lines, the data will be written out to disk and a message notifying you of this will appear.

CTj0 Tc(l) Tj0.138 Tw1nwil

2.5.3.7 - DATA, EVAPORATION - EVAP.DAT

Evaporation Data File - EVAP.DAT

Evapotranspiration Rates (inches)

Jan:	1.10	Apr:	5.10	Jul:	8.06	Oct:	3.72
Feb:	1.38	May:	6.82	Aug:	6.82	Nov:	2.10
Mar:	3.10	Jun:	7.80	Sep:	5.40	Dec:	1.16

Evaporation Rates (inches)

Jan:	.94	Apr:	5.06	Jul:	6.78	Oct:	2.74
Feb:	1.17	May:	6.19	Aug:	6.02	Nov:	1.80
Mar:	2.34	Jun:	7.30	Sep:	4.47	Dec:	.99

F2 List editing keys

Evaporation and evapotranspiration values must be provided for all twelve months. To accept any changes you've made to the data, press CTRL-ENTER on any of the fields or ENTER on the last field. To discard the changes, press ESC. See "Data Preparation" above and Appendix A for details.

EDIT EVAPORATION FILENAME

Using this option in QIMENU the user may specify a secondary EVAP.DAT file. This is the only one of the data files for which the filename is not fixed. The user may apply different evaporation values for different simulations and compare the results.

Enter the name of the new file containing the evaporation and evapotranspiration data. Enter only the filename's extension and base (e.g. URBANA.DAT). The full filename is assumed to be [datapath]\evapfname. For example, if you specified the "Datafiles Path" as C:\QIMENU and the evaporation filename as URBANA.DAT, you are describing
C:\QIMENU\URBANA.DAT.

2.5.3.8 - **DATA, SOIL - SOIL.DAT**

Edit Soil Data File - SOIL.DAT

SOIL GROUP	FO (in/hr)	FC (in/hr)	Emax (in)	Gmax (in)
A	10.000	1.000	2.700	12.600
AB	9.000	0.750	3.410	11.050
B	8.000	0.500	4.120	10.500
BC	6.500	0.375	5.000	7.650
C	5.000	0.250	5.100	4.800
CD	4.000	0.175	4.650	4.650
D	3.000	0.100	4.200	4.500

Each line in the Soil File contains information for one of the seven hydrologic soil groups as defined by the U.S. Soil Conservation Service. There are four parameters per soil group as described above under "Data Preparation." To accept any changes you've made to the data, press CTRL-ENTER on any of the fields or ENTER on the last field. To discard the changes, press ESC.

2.5.3.9 - DATA, BMP REMOVAL EFFICIENCY - BMPEFF.DAT

Edit Removal Efficiency File - BMPEFF.DAT

BMP Description	Percent Removal Rate for Constituent: A	B	C
STREET SWEEPING	30	15	20
FERTILIZER CONTROL	0	25	0

A SUSPENDED SOLIDS
B NITROGEN
C LEAD

Enter	Modify entry	Ins	Insert entry
		Del	Delete entry

The BMP Removal Efficiency File BMPEFF.DAT provides a list of BMPs to be applied to the basin and their removal efficiencies for each constituent being simulated. Each line of the file contains a name describing a BMP (e.g. "Street Sweeping") followed by the removal rate as % of total pollutant removed for each constituent.

The list is presented as a scrollable list of lines, each line containing the name of the BMP and the removal rates for each of the constituents. To modify an existing BMP, press ENTER. The BMP name and the removal rates will turn into editing fields. At the current field, you can type in a new value or, if the value is OK, press TAB to move on to the next field. To accept your changes, press CTRL-ENTER on any of the fields or ENTER on the last field.

To insert a new BMP, press the Insert key. A new entry will appear with the same values as the entry below. Change any of the values using the methods described above to modify an entry. To delete a BMP, press DEL. You will be asked to confirm the deletion. Press ENTER to delete it or ESC to retain it. To exit the removal efficiency editing screen, press ESC. If you accepted changes to any of the lines or inserted or deleted any lines, the data will be written out to disk and a message notifying you of this will appear.

CAUTION

THIS FILE MUST CONTAIN THE SAME LIST OF BMPs AND CONSTITUENTS AS THOSE IN WQLIST.DAT, AND BMP.001. THIS IS THE USERS RESPONSIBILITY, AND DIFFERENCES WILL CAUSE AN ERROR IN QIMENU.

2.5.3.10 - DATA, LAND USE **- LU.nnn**

Each line of the Land Use File describes a segment of the current subbasin. Each record must have a distinct land use code and soil group combination.

Edit Land Use File - LU.002

CODE	DESCRIPTION	%IMP	%SUPP	DS1	DSp	AREA	SOIL	%MOIST
11	Residential	30	10	0.10	0.20	82.00	4	50
12	Commercial	60	20	0.10	0.20	22.00	3	50

Enter Modify entry

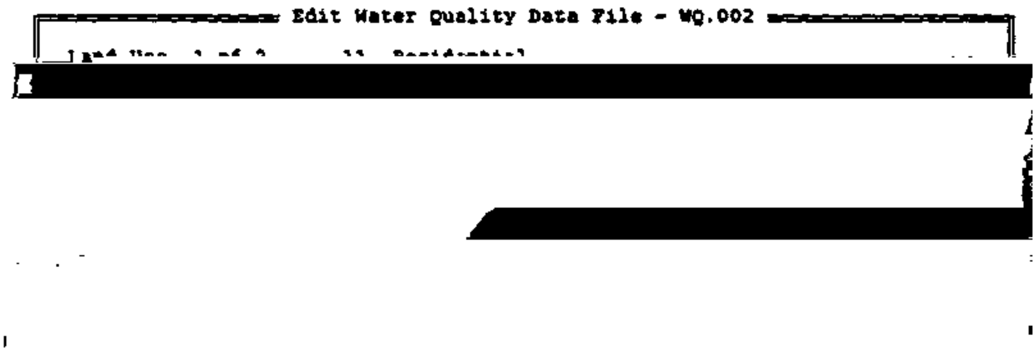
The input is arranged as a scrollable list of land use lines. You can move among the lines by using the arrow keys, the PgUp and PgDn keys, and the HOME and END keys.

Each line contains both a land use and a soil type. The land use code and its description cannot be edited within QIMENU. This must be done externally from DOS or an editor. QIMENU will not allow two lines with the same land use and soil. You may have two lines with the same land use if they have different soils.

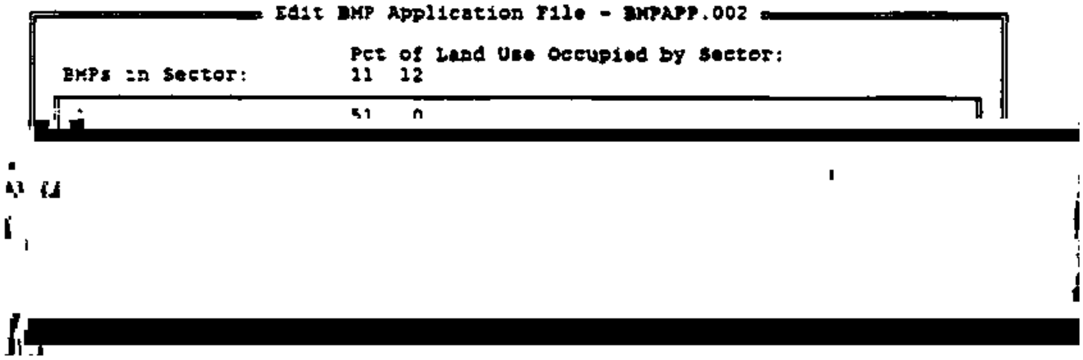
CAUTION

THE LU.nnn, WQ.nnn, AND BMPAPP.nnn FILES ARE CLOSELY RELATED. THE LAND USE AND SOIL AND COMBINATIONS AND THE PARAMETERS ASSIGNED TO THEM MUST BE COMPATIBLE IN ALL THREE FILES. ERROR MESSAGES WILL GENERALLY IDENTIFY THESE INCONSISTENCIES.

To modify other parameters in the current land use entry, press ENTER. You can move among these fields by using TAB and SHIFT-TAB (press F2 for a complete list of editing keys). Make a change to a field and then press ENTER. The cursor will move to the next field. If the value



For a particular page of data, use the Tab key and arrow keys to move from parameter to parameter and from constituent to constituent. To change a field, simply



below. Use the methods described above for modifying an entry. Press ENTER or ESC to accept or discard your changes. To delete a sector, press the Delete key. You will be asked to

```
          Index  Description
            1    CLARK STREET
         √  2    GREEN STREET
            3    JOHN STREET

Number of subbasins selected: 1

   Enter   Toggle subbasin
       A   Select all        C   Clear all
  ^Enter   Run model on selected subbasins
```

that it has indeed been selected.) Pressing ENTER on a selected subbasin will deselect it, and the checkmark will disappear. Typing the letter A will select all of the subbasins. Typing the letter C will deselect all of the subbasins.

Move through the list, selecting the set of subbasins for which you wish to see output. When the set is complete, press CTRL-ENTER to begin the simulation. You will be asked from which program you wish to begin processing. If you select Hydro, then the Hydro, Load, and BMP programs will be run, in that order. If you select Load, then the Load and BMP programs will be run, in that order. If you select BMP, then only the BMP program will be run.

You cannot begin the simulation with Load unless the Hydro program has already been run and the output files exist in your Datapath file space. Similarly, you cannot begin with BMP unless Hydro and Load have been run.

2.5.5 - OUTPUT MENU

Select an Event or Summary

Date	Rainfall	Runoff (ac-ft)	(in)	R/R	Dry	Dur
*** SUMMARY ***						
06/05/88	1.50	4.39	0.51	0.34	4.21	3.00
06/10/88	0.50	1.23	0.14	0.28	4.79	2.00
06/13/88	2.50	7.47	0.86	0.34	2.88	6.00

If you elected to run one subbasin, output will be created for all of the rainfall events for which the rainfall was at least the minimum specified in the "General Basin File". In addition, a summary will be created which computes totals, maxima, and averages for the entire run. If more than one subbasin was selected, output will be combined as if they were one subbasin. This option can be used to show multiple subbasin impact on one receiving water. The user also has the option of printing event or summary output.

After each "Run" of the program, several output files will appear in the Datapath file space. These only exist until the next "Run" of the program, at which point they are replaced by the new output. If the user wishes to save these output files they should be moved to a new directory or a new path established for the next "Run."

Most of these files contain information already presented in the "Output" portion of QIMENU. The user will find additional information in HYDRDOUT.nnn and HYDLUOUT.nnn, however. The LIST utility described earlier is an excellent way to view these files.

2.5.5.1 - SINGLE SUBBASIN OUTPUT

After AUTO_QI has completed the simulation, you will be presented with a scrollable list containing one entry for a summary and one entry for each event. Scroll to the entry you wish to view and pres f Tcw (entr601 Tc 4d1 Tw (ne)Tj0 Tc (w)Tj04f Tcw (entr

2.5.6.3 - DELAY

Sets the time in seconds that certain messages appear on the screen.

2.5.7 - ON-LINE HELP

Help is available at any time in QIMENU by pressing the Fl key. QIMENU's help is said to be context-sensitive. This means that the help information displayed depends on where you are in the program. If you are editing an input file and press Fl, help appropriate to the editing of that file will be shown.

Information for some topics is listed on more than one page. You can use the PgUp and PgDn keys to move among the different pages. If there are multiple pages, the lower right border of the help window will tell you which of the PgUp and PgDn keys are applicable. QIMENU's help was developed using a method called hypertext. Hypertext help, besides providing information for a topic, can also contain links to related topics. For example, if you call up help for the Miscellaneous menu, a description of the menu will appear. In addition, you will see the words "Shell" and "About" and "Delay" which stand out from the rest of the text. These are hypertext links to those topics. You use the arrow keys to move among the links. The current link will be displayed in reverse text (red on white on color monitors), while all other links will be displayed in highlighted text (yellow on color monitors). If you press Enter on a selected link, information for that topic will be displayed. This makes it easy to move from topic to topic.

There is also an "Index" of all help topics if you wish to view information for a topic which is not a link in the current help screen.

When you are through viewing the help information, press the Escape key and you will return to the point in the program where you were when the Fl key was pressed.

2.5.8 - EXIT MENU

The EXIT Menu is used to exit QIMENU. You will be asked to confirm your intention.

2.5.9 - GIS INTERFACE

Introduction

A Geographic Information System (GIS) consists of computer hardware, software, and a database. A computer-oriented GIS performs sophisticated manipulations and analyses which include map overlay, buffer generation, boundary dissolve (regroup and reclassify), tabular data analyses and network analyses. A complete GIS system contains computer mapping and display capabilities for generating high quality cartographic products. The user can specify size and scale to produce the desired map outputs.

Urban runoff quantity and quality are highly dependent upon the land use and hydrologic soil class. To tabulate the land use/soil complex is a time consuming process. To simplify the data collection and management process, an ARC Macro Language (AML) program was developed to retrieve the land use and soil layers in a final format suitable for model input.

The following GIS layers were created to support the simulation of urban runoff quantity/quality.

2.5.9.1- GIS Layers

Soil Layer

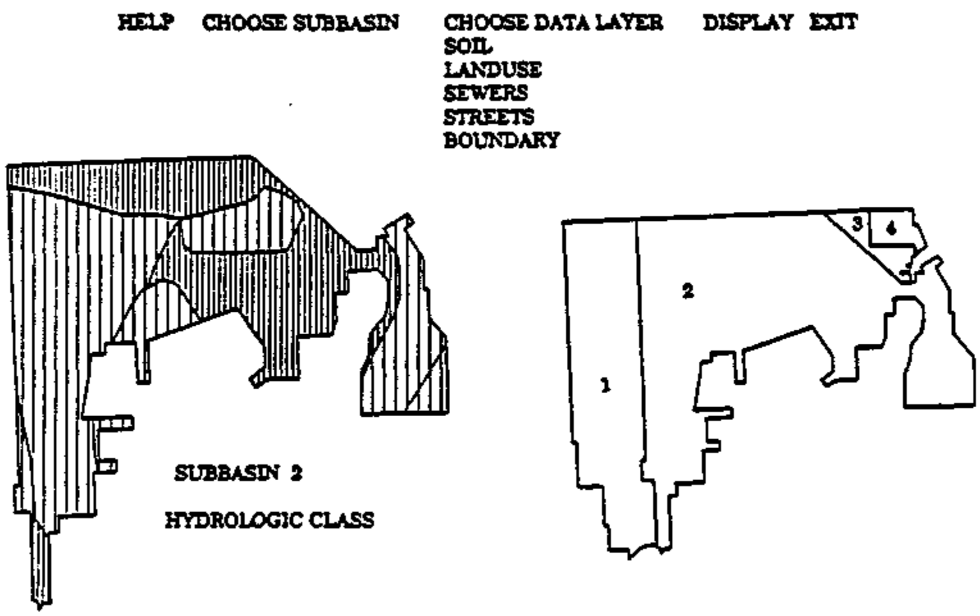
The Statewide "General Soil Map of Illinois" was digitized for the Illinois GIS system in 1985 with funding from the Illinois Department of Mines and Minerals (IDMM). This map contains 57 generals image analysis capability using the ERDAS image processing package (ERDAS, 1989). The results of the classified land use can easily

2.5.9.2 - PRIME Installation

The AML programs provide the link and user interface between the GIS running on a PRIME and the AUTO_QI program running on a PC. These programs process the data for use by AUTO_QI and also enable the user to view the graphic data at the subbasin level via a menu. The programs are to be used with ESRI's ARC/INFO software on a PRIME computer and are grouped into two functions: the preprocessor programs and the menu system programs. PREPROCESSORLANDTiUIL.AMLTj0 Tc (.G4o

This program needs to be run only one time. It requires a few hours or a lot longer, depending on the number of subbasins. This program will check topology and CLEAN the coverages if necessary: split the SOIL, LANDUSE, and BASINBND coverages along subbasin boundaries: create a new intersected coverage LANDSOIL and split it along subbasin boundaries: and then create the files LS#.OUT (one for each subbasin) from the LANDSOIL coverages for use by Q-ILLUDAS as LU.nnn on the PC. The STREET and SEWER coverages will also be processed if they5 Tw (PC)TN7stPC.l be reviewed. The BMP coverages can be viewed over the entire basin.

The AML was designed to have two windows on the screen. The right window shows an index map of the whole drainage basin with the subbasin boundaries. The user can select a subbasin and display the land use, soil, and other layers for the subbasin in the left window.



2.5.9.4 - Export Files to the Personal Computer

Since all files to be moved contain the extension .OUT, use file transfer software with a wildcard to move the files easily. The following files should be moved:

LS#.OUT	one for each subbasin
MATRIX#.OUT	one for each subbasin
BMP#.OUT	one for each subbasin
SIZE.OUT	

2.5.9.5 - List of Programs on Distribution Diskette
Preprocessor Programs

PREPROCESSORLANDSOIL.AML
PREPROCESSORBMP.AML re

Sample GIS Coverages

- SOIL
- LANDUSE
- BASINBND
- STREET
- SEWER
- BMP1
- BMP2
- BMP3

Transfer Programs

- EXPORTALL.AML
- IMPORTALL.AML

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APPENDIX A: EVAPORATION AND EVAPOTRANSPERATTON DATA

Evaporation

Available data for evaporation and evapotranspiration are limited compared with rainfall, temperature and runoff data. The available evaporation data in Illinois were obtained from the Illinois State Water Survey (Personal communication with Wendland, 1990). Table A-1 shows the 1983-89 average monthly evaporation in Illinois. The data for January through March and November and December which were not observed are estimated based on the percent of annual evaporation by month (Neely and Heister, 1987).

Evapotranspiration

The direct measurement of evapotranspiration is difficult and the data are not readily available. The potential evapotranspiration is commonly estimated by using the Penman equation (Russell, 1961). The Soil Conservation Service (1981) has provided estimates of Penman's ET monthly values for the months of March through October for the 12 Midwest states. Using the SCS values and the percent monthly distribution of the evaporation, the missing monthly values were estimated for three Illinois regions. The results are shown in Table A-2.

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Table A-1. Monthly Evaporation Values for Illinois in Inches

	Month											
Location	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Hennepin (N)	.90	1.20	2.60	4.60	7.23	7.51	7.36	7.05	5.08	3.88	1.80	.95
Urbana(C)	.94	1.17	2.34	5.06	6.19	7.30	6.78	6.02	4.47	2.74	1.80	.99
Spr'gfld(C)	1.26	1.56	3.12	6.04	8.20	8.91	9.03	7.82	6.19	4.49	2.40	1.32
Belleville (S)9s					*7*				.			*8*

where N = northern region of

APPENDIX B: SOIL PARAMETERS

Four soil parameters for each hydrologic class are needed. They are: initial potentialee

Table B-1. Selected Soil parameters

Hydrologic soil group	*Description*	F_0	F_C	*Emax*	*Gmax*
1. A	Low runoff potential, deep sand, deep loess, aggregated silts	10	1.00	2.7	12.6
3. B	Shallow loess, sandy loam	8	0.50	3.9	10.5
5. C	Clay loams, shallow sandy loam, soils low in organic content	5	.25	5.1	4.8
7. D	Soils that swell significantly when wet, heavy plastic clays and certain saline soils	3	.10	4.2	4.5

Note: For the suggested Emax and Gmax values, 36 inches of soil depth is assumed.

Table C-1. Street Refuse Accumulation

Land use	Solids Accumulation: Chicago[1] dust and dirt (g/curb m/day)		Eight American cities[2] total solids (g/curb m/day)	
	(g/curb m/day)	(lb/ac/day)[3]	(g/curb m/day)	(16/ac/day)[3]
Single family	10.4	2.1	48	9.5
Multi-family	34.2	6.8	66	13.1
Commercial	49.1	9.7	69	13.7
Industrial	68.4	13.5	127	25.1

Note:
1. American Public Works Association, 1969.
2. Sartor et al., 1972, 1974.
3. The curb length per acre in Chicago was assumed to be 90 meter/ac.

Table C-2. Pollutants Associated with Street Refuse[1] (µg/g of solids)

Constituents	Land Use: Residential	Industrial	Commercial	Transportation
BOD_5	9,166	7,500	8,333	2,300
COD	20,822	35,714	19,444	54,000
Volatile	71,666	53,571	77,000	51,000
KjeldahalN	1,666	1,392	1,111	156
$P0_4$ P	916	1,214	833	610
$N0_3$ N	50	64	500	79
Pb	1,468	1,339	3,924	12,000
Cr	186	208	241	80
Cu	95	55	126	120
Ni	22	59	59	190
Zn	397	283	506	1,500
Total Coliform (no./g)	160,000	82,000	110,000	NR[2]
Fecal Coliform (no./g)	16,000	4,000	5,900	925

Note:
1. Novotny, V. and G. Chesters, 1981.
2. NR = not reported

Table C-3. Ratio of Various Constituents to Total Solids in Eight Illinois Metropolitan Areas[1]

Constituents	*Eight Metropolitan Areas[2] in Illinois*							
	KKK	***C-U***	***RKF***	***SPG***	***B-N***	***DCT***	***Q-C***	***PIA***
Susp. Solids	0.60	0.79	0.60	0.72	0.50	0.79	0.79	0.70
BOD_5	0.03	0.03	0.05	0.05	0.027	0.024	0.031	0.04
Lead	0.0009	0.0010	0.0015	0.0007	0.0007	0.0005	0.0005	0.0010
Copper	0.00015	0.00018	0.0001	0.00012	0.00012	0.00012	0.00012	0.00015
Iron	0.010	0.013	0.012	0.013	0.013	0.010	0.013	0.014
Zinc	0.0006	0.0007	0.0011	0.0006	0.0007	0.0004	0.0004	0.0005
Phosphorus	0.0020	0.0013	0.0013	0.0024	0.0013	0.0006	0.0013	0.0010
COD	0.170	0.215	0.570	0.366	0.098	0.103	0.215	0.200
NO2 + NO3	0.0040	0.0023	0.0032	0.0019	0.0012	0.0015	0.0023	0.0024
Mercury ($x10^{-6}$)	0.7	1.5	0.88	0.0	0.26	0.4	0.2	0.7

Note:

1. Illinois Environmental Protection Agency. 1979.
2. KKK = Kankakee, C-U = Champaign-Urbana, RKF = Rockford, SPG = Springfield, B-N = Bloomington-Normal, DCT = Decatur, Q-C = Quad cities, and PIA = Peoria.

APPENDIX D - LUDA DATA

USGS LAND USE AND LAND COVER CLASSIFICATION SYSTEM
FOR USE WITH REMOTE SENSOR DATA

Level 1	*Level 2*
1 urban or built-up land	11 residential
	12 commercial and services
	13 industrial
	14 transportation, communications and services
	15 industrial and commercial complexes
	16 mixed urban or built-up land
	17 other urban or built-up land
2 agricultural land	21 cropland and pasture
	22 orchards, groves, vineyards, nurseries, and ornamental horticultural areas
	23 confined feeding operations
	24 other agricultural land
3 rangeland	31 herbaceous rangeland
	32 shrub-brushland rangeland
	33 mixed rangeland
4 forest land	41 deciduous forest land
	42 evergreen forest land
	43 mixed forest land
5 water	51 streams and canals
	52 lakes
	53 reservoirs
	54 bays and estuaries
6 wetland	61 forest wetland
	62 nonforested wetland

concluded on next page

Level 1	*Level 2*
7 barren land	71 dry salt flats
	72 beaches
	73 sandy areas other than beaches
	74 bare exposed rock
	75 strip mine, quarries, and gravel pits
	76 transitional areas
	77 mixed barren land
8 tundra	81 shrub and brush tundra
	82 herbaceous tundra
	83 bare ground
	84 wet tundra
	85 mixed tundra
9 perennial snow or ice	91 perennial snowfields
	92 glaciers

No output has been created.

Location: Output menu

The Output menu displays the output created by the last run. If no run has been completed yet, there is no output to view.

Create a run by using the Run menu.

Land Use *x* is not in the set of distinct land uses.

Location: Edit Land Use

You may only change a land use code in such a way that the set of distinct land use codes remains constant.

Enter a land use which already exists.

The percentage must lie in the range 0-100.

Location: Edit Land Use

The value entered for a percentage must be an integer from zero to 100 inclusive.

Soil type *x* is not defined.

Location: Edit Land Use

The soil type must be an integer from one to seven inclusive.

The Load program requires an input file created by Hydro which does not exist.

Location: Run menu

The Load program cannot find a file which should have been created by the Hydro program.

The most probable cause is running the Load program without first running the Hydro program.

Run the Hydro program before running the Load program.

The BMP program requires an input file created by Load which does not exist.

Location: Run menu

The BMP program cannot find a file which should have been created by the Load program.

The most probable cause is running the BMP program without first running the Load program.

Run the Load program before running the BMP program.

You must select at least one subbasin for output.

Location: Run menu

In order to make a run, at least one subbasin must be selected.

Select the subbasins of interest and then make the run.

Cannot find the program directory: *path*

Location: Run menu

The QILLUDAS programs (HYDRO.EXE, LOAD.EXE, and BMP.EXE) could not be found.

They must be located in the same directory as the datafiles.

Exit QIMENU and make sure all three programs are in the datafiles directory.

Cannot find *the prog-type* program.

Location: Run

Cannot find soil ID *x*.

Location: Edit Soil

There must be an entry for all seven hydrological classes.

Exit QIMEN

Cannot find the number of constituents.

Location: Edit Constituent List

The first line of the Constituent List file must contain the number of constituents.

Exit QIMENU and check the Constituent List file.

Warning Messages

Cannot open defaults file for writing...

When QIMENU terminates it attempts to update the defaults to QIMENU.INI.

This file could not be opened for output so any changes to the defaults will be lost.