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Simulation of Streamflow and Selected Water-Quality Constituents through a model of the Onondaga Lake Basin, Onondaga County, New York— A Guide to Model Application

Open-File Report 2008–1188

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Conversion Factors, Datum, and Chemical Abbreviations

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	megagram (Mg)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F-32)/1.8$$

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Chemical Abbreviations

BOD	Biochemical oxygen demand
DO	Dissolved oxygen
NH_3	Ammonia nitrogen
NO_2	Nitrite nitrogen
NO_3	Nitrate nitrogen
NO_x	Nitrate-plus-nitrite nitrogen
OP	Orthophosphate
OrgN	Organic nitrogen
OrgP	Organic phosphorus
SED	Sediment
SRP	Soluble reactive phosphorus
TDP	Total dissolved phosphorus
TKN	Ammonia-plus-organic nitrogen (total Kjeldahl nitrogen)
TP	Total phosphorus
TSS	Total suspended solids

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Simulation of Streamflow and Selected Water-Quality Constituents through a Model of the Onondaga Lake Basin, Onondaga County, New York—A Guide to Model Application

By William F. Coon

Abstract

A computer model of hydrologic and water-quality processes of the Onondaga Lake basin in Onondaga County, N.Y., was developed during 2003–07 to assist water-resources managers in making basin-wide management decisions that could affect peak flows and the water quality of tributaries to Onondaga Lake. The model was developed with the Hydrological Simulation Program-Fortran (HSPF) and was designed to allow simulation of proposed or hypothetical land-use changes, best-management practices (BMPs), and instream stormwater-detention basins such that their effects on flows and loads of suspended sediment, orthophosphate, total phosphorus, ammonia, organic nitrogen, and nitrate could be analyzed. Extreme weather conditions, such as intense storms and prolonged droughts, can be simulated through manipulation of the precipitation record. Model results obtained from different scenarios can then be compared and analyzed through an interactive computer program known as Generation and Analysis of Model Simulation Scenarios for Watersheds (GenScn). Background information on HSPF and GenScn is presented to familiarize the user with these two programs. Step-by-step examples are provided on (1) the creation of land-use, BMP, and stormflow-detention scenarios for simulation by the HSPF model, and (2) the analysis of simulation results through GenScn.

Introduction

In the past, Onondaga Lake has been the recipient of large loads of chemicals from point and nonpoint sources. Point sources have been decreased or eliminated, but agricultural and urban nonpoint sources continue to thwart efforts to reach water-quality targets for the lake. During 2003–07, the U.S. Geological Survey (USGS), in cooperation with the Onondaga Lake Partnership (OLP), developed a computer model of the hydrologic and water-quality processes within the Onondaga Lake basin in Onondaga County, N.Y. (fig. 1) (Coon and Reddy, 2008). The model was developed with the Hydrological Simulation Program-Fortran (HSPF), version 12 (Bicknell and others, 2001) to allow simulation of proposed or hypothetical land-use changes, best-management practices (BMPs), and instream stormwater-detention basins, and analysis of their effects on flows and water quality through an interactive computer program known as Generation and Analysis of Model Simulation Scenarios for Watersheds (GenScn), version 2.3 (Kittle and others, 1998). Streamflow and (or) water-quality data from 13 sites within the lake basin were available for model development and calibration (fig. 1). The identification number, location, and drainage area of each site are listed in table 1.

This report is a guide that provides background information on the two computer programs on which the model is based—HSPF and GenScn. The report outlines the steps for creating scenarios of land-use changes, BMPs, stormflow-detention basins, and extreme weather conditions (storms and droughts) in the Onondaga Lake basin and for simulating these scenarios with the HSPF model. The report describes the use of GenScn to analyze the model outputs from these scenarios, the results of which can, in turn, aid the user in making basin-wide water-resources-management decisions.

Overview

Three classes of data—meteorological, hydrologic, and water quality—are stored as time-series datasets in a watershed-data-management (WDM) file. The input to HSPF is a user's-control-input file (UCI) that contains instructions and parameter values that HSPF requires for simulation of the hydrologic and water-quality processes of the basin. This UCI file also identifies the datasets in the WDM that are required for a given simulation, as well as the datasets in which output generated by HSPF will be stored. The output stored in the WDM can then be viewed, compared, and analyzed through GenScn. A diagram of this process is shown in figure 2.

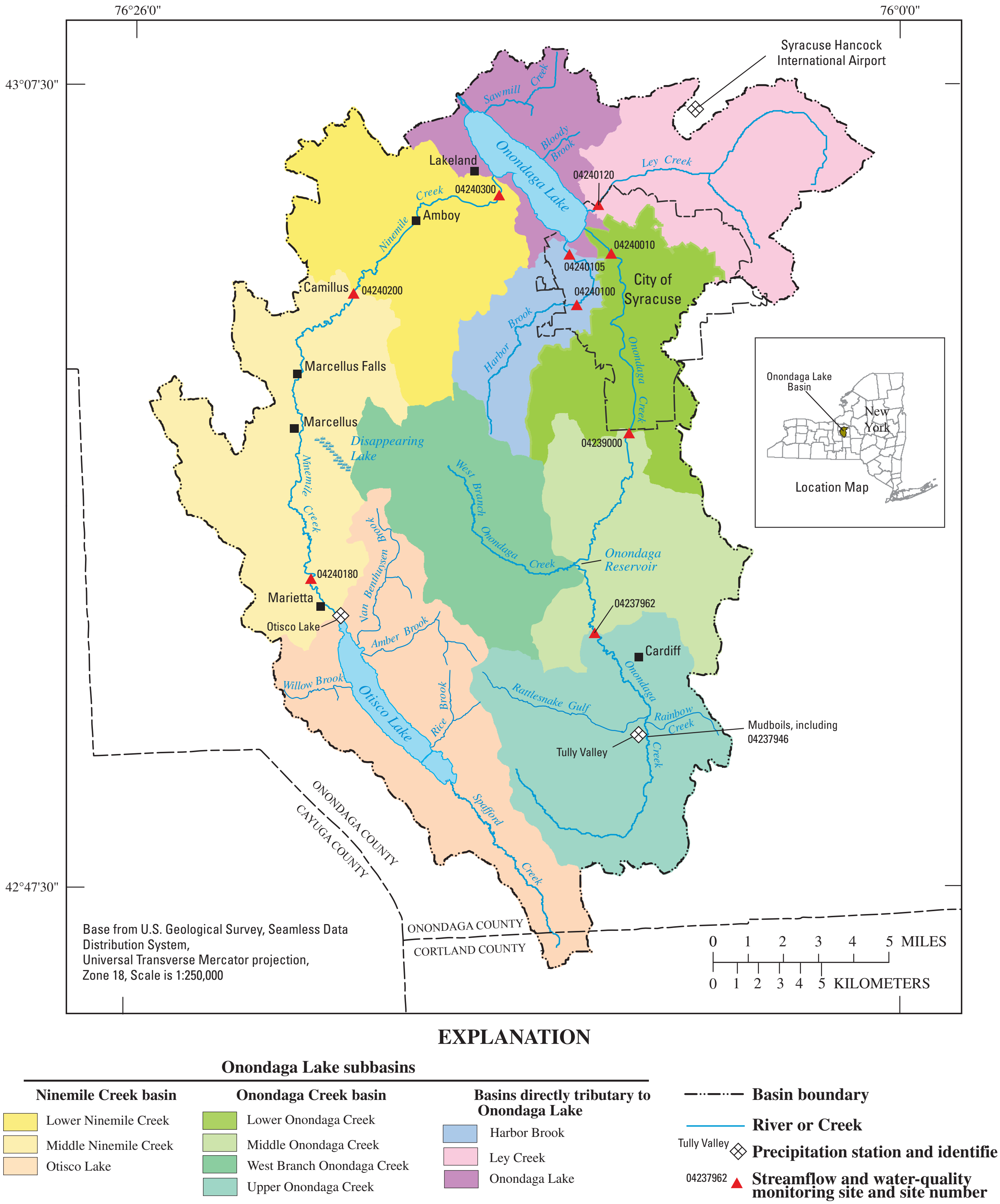
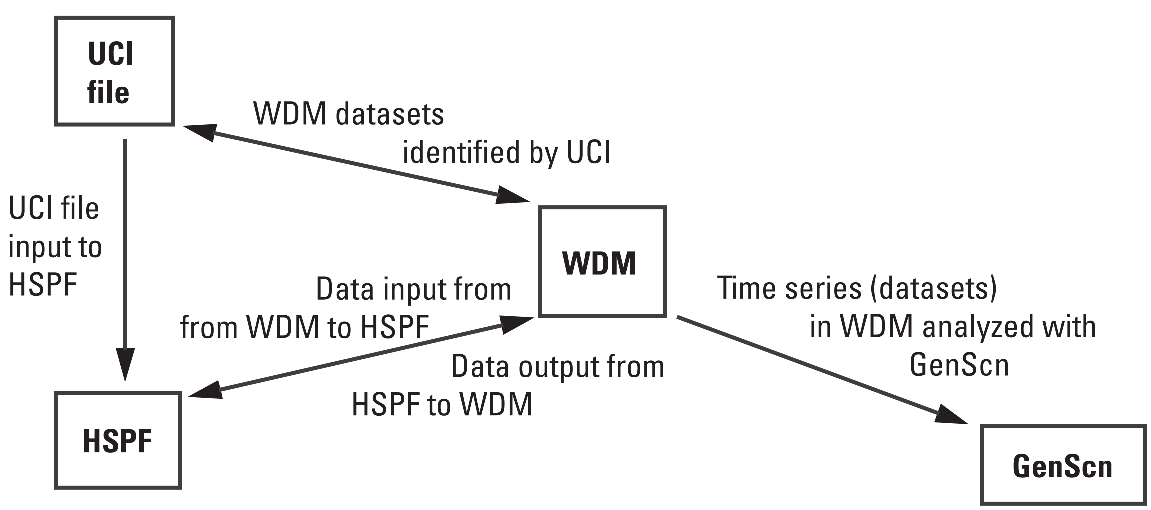


Figure 1. Locations of precipitation, streamflow, and water-quality monitoring sites in the Onondaga Lake basin, Onondaga County, N.Y.

Table 1. Selected data-collection sites for which observed data are stored in the Onondaga Lake basin model's watershed-data-management (WDM) file.

[USGS, U.S. Geological Survey; mi^2, square miles; GenScn, Generation and Analysis of Model Simulation Scenarios for Watersheds (Kittle and others, 1998); –, no site number; na, not applicable; e, estimated. Locations are shown in fig. 1.]

USGS site number	Site location description	Drainage area (mi^2)	GenScn location identification (IDLOCN)	Subbasin number
04237946	Onondaga Creek Tributary (No. 6) below main mudboil depression area near Otisco Road, Tully Valley	0.32	MUDBOIL	na
04237962	Onondaga Creek at U.S. Highway 20 near Cardiff	33.9	CARDIFF	111
04239000	Onondaga Creek at Dorwin Avenue, Syracuse	88.5	DORWIN	128
04240010	Onondaga Creek at Spencer or Kirkpatrick Streets, Syracuse	110	SPENCER	137
04240100	Harbor Brook at Holden Street or Velasko Road, Syracuse	10.0	HOLDEN	205
04240105	Harbor Brook at Hiawatha Boulevard, Syracuse	12.1	HIAWATHA	206
04240120	Ley Creek at Park Street, Syracuse	29.9	LEY	312
–	Otisco Lake outlet at Otisco Valley Road near Marietta	42.3	OTISCOLK	409
04240180	Ninemile Creek at Schuyler Road near Marietta	45.1	MARIETTA	410
04240200	Ninemile Creek at Main Street, Camillus	84.3	CAMILLUS	430
04240300	Ninemile Creek at State Highway 48, Lakeland	115	LAKELAND	443
–	Bloody Brook at mouth near Liverpool	e 3.9	BLOODY	501
–	Sawmill Creek at mouth near Liverpool	2.34	SAWMILL	502



EXPLANATION

UCI	User-Control Input file
HSPF	Hydrological Simulation Program-Fortran
WDM	Watershed Data-Management file
GenScn	Generation and Analysis of Model Simulation Scenarios for Watersheds

Figure 2. Data flow and connections between file system and computer programs to simulate and analyze output from model scenarios.

Hydrological Simulation Program-Fortran User's-Control-Input (UCI) File

The UCI file is the text file of the user-developed model and is required by HSPF to simulate the hydrology and water-quality processes of the basin. The UCI file contains modules that control the simulation of specific processes within the model. These modules and their associated purposes are listed in table 2 and described in the following paragraphs.

Table 2. Selected modules of Hydrological Simulation Program–Fortran (HSPF) used in model of Onondaga Lake basin, Onondaga County, N.Y.

[WDM, watershed-data-management file.]

Abbreviation	Name	Purpose
PERLND	Pervious land segment	Simulates hydrologic and water-quality processes of a pervious land area.
IMPLND	Impervious land segment	Simulates hydrologic and water-quality processes of an impervious land area.
RCHRES	Stream reach or reservoir	Simulates hydrologic and water-quality processes of a free-flowing reach or a mixed reservoir (lake).
EXT SOURCES	External sources	Identifies the input data and dataset numbers from the WDM file that are required by HSPF.
EXT TARGETS	External targets	Identifies the dataset numbers in the WDM file that will receive output from HSPF.
SCHEMATIC	Schematic	Lists the connections between land segments (PERLNDs and IMPLNDs) and RCHRESs, and between RCHRESs.
MASS-LINK	Mass link	Identifies the specific constituent(s) to be transferred from one operation to another.
BMPRAC	Best management practice	Simulates the removal of a water-quality constituent(s) by a best-management practice.
FTABLE	Function table	Relates stream-surface elevation (or depth), channel surface area and volume, and discharge for a given RCHRES.

Pervious (PERLND) and Impervious (IMPLND) Land Segments Modules

The Onondaga Lake basin was divided into land segments, each of which was assumed to show uniform hydrologic and water-quality responses to precipitation, potential evapotranspiration, and other meteorological factors. Each of these segments, also called hydrologic response units (HRUs), is simulated by HSPF as either a PERLND (pervious land area) or an IMPLND (impervious land area).

PERLNDs

PERLNDs were defined primarily by type of land cover and principal land use as classified by the National Land Cover Data (NLCD; U.S. Geological Survey, 1999). The initial set of eight PERLNDs included forest, pasture-hay, row crops, urban and (or) recreational grass (primarily golf courses and parks), wetland and water, low-intensity residential, high-intensity residential, and the combined land uses of commercial, industrial, and transportation (CIT). A ninth PERLND—farmsteads (livestock and dairy farms)—was added to each subbasin in which farmsteads were found by converting an equal number of pasture-hay acres to this new land-use type. A tenth PERLND was created to simulate large sediment loads that are derived from lacustrine silt-and-clay in which crops are planted. The utility of this added PERLND (a subset of row crops) was inferred from a study of sediment loads to Otisco Lake (Paschal and Sherwood, 1986) that documented the generation of disproportionately larger sediment loads through cultivation of lacustrine silt-and-clay soils than through cultivation of till soils.

Two PERLNDs—forested and pasture-hay areas—cover nearly 64 percent of the basin and, therefore, were further divided according to hydrologic soil group (HSG) and aspect (north- or south-facing slope); this was done with the expectation that an improvement in simulation of the hydrologic and water-quality processes in the basin would be realized. HSG is a soil classification based on the soil properties that control the minimum rate of infiltration for a bare, unfrozen soil after prolonged wetting and, therefore, determine runoff potential. HSG types A and B soils were combined and simulated as soils with low runoff potential and HSG types C and D soils were combined and simulated as soils with high runoff potential. The aspect of the hill slopes was included because it affects the timing and magnitude of snow melt. North-facing slopes receive less solar radiation than south-facing slopes and, therefore, undergo a more gradual snowmelt than snow on south-facing slopes.

The above segmentation of the basin produced a set of 16 PERLNDs (table 3), the first 4 of which represented forested areas, and the next 4 represented pasture-hay areas. Both of these land-cover types were subdivided by two HSG classes and two aspect classes. The remaining eight PERLNDs represented land-use categories that were not further divided by HSG type or aspect.

IMPLNDs

The impervious areas of the basin were divided into three similar categories as were the developed pervious HRUs, that is, by low-intensity residential, high-intensity residential, and commercial-industrial-transportation areas. A distinction is made between "effective" impervious areas—those that are hydraulically connected to the natural drainage system by ditches, culverts, and (or) a storm-sewer system, and "ineffective" impervious areas—those that are not hydraulically connected to the natural drainage system but instead drain to adjacent pervious areas. The percentages of basin area designated as effective impervious areas in the model were calibrated to improve the fit between observed and simulated peak flows (Coon and Reddy, 2008). The average percentages of effective impervious areas, by land use, were 5 percent for low-intensity residential, 40 percent for high-intensity residential, and 66 percent for commercial-industrial-transportation uses, respectively. The corresponding percentages of pervious areas for each land use were 95, 60, and 34 percent, respectively (the complements of the impervious-area values). These percentages were included in the multiplication factors used in the MASS-LINK module of the model described farther on (see table 2). Therefore, the acreages that were associated with a given developed HRU—that is, both the PERLND and IMPLND components of that HRU—in the SCHEMATIC module of the model were the total acreages designated for that particular land use. In other words, the total developed acreage that applied to a given land use was input to the SCHEMATIC module for the PERLND and the IMPLND associated with that land use. Then in the appropriate MASS-LINK blocks, the percentages for pervious or impervious areas were incorporated into the multiplication factors, and the acreages for each land use were computed during each model run. For example, if 100 acres had been classified as low-intensity residential in a given subbasin, then 100 acres was assigned to both the pervious and impervious components of this land use in the SCHEMATIC module. Then, in the MASS-LINK block, the appropriate multiplication factors—0.05 for the IMPLND and its complement, 0.95, for the PERLND—were used to compute the correct acreages—5 and 95 acres, respectively.

Impervious areas within the combined storm-and-sanitary sewer overflow (CSO) areas of the basin were estimated from the documentation for a hydraulic model of the Syracuse, N.Y., area (D.P. Davis, Brown and Caldwell Consultants, written commun., 2003). A weighted percentage for impervious area was computed from the impervious-area percentage and the drainage area of the CSOs that were found in each modelled subbasin. This percentage was applied to the total areas of each of the three "developed" land-use categories—low-intensity residential, high-intensity residential, and commercial-industrial-transportation—and the result was then entered into the model as the effective impervious area. The pervious-area component of each land-use category was then computed as the difference between the total and the impervious areas. Therefore, the impervious area estimated for the CSO areas through this procedure was assumed to be more precise than if the basin-wide percentages for these three land uses—5, 40, and 66—had been used.

This method of impervious-area estimation resulted in a paired relation between PERLNDs and IMPLNDs for the three "developed" land uses; for example, if a subbasin was found to contain PERLND 13 (pervious low-intensity residential), then IMPLND 1 (impervious low-intensity residential) should also be present because these HRUs represent the pervious and impervious components of the same land use. Similarly, if PERLNDs 14 and 15 were present, then IMPLNDs 2 and 3, respectively, should also be present (see table 3). This paired relation is shown in the scenario example in a later section, "Scenario 1—Simulation of Land-Use Changes."

Distinctions Among Hydrologic-Response-Unit Groups

The segmentation of the Onondaga Lake basin produced a basic set of 19 HRUs, which included 16 PERLNDs and 3 IMPLNDs (table 3). This set was replicated for each of three "precipitation areas" whose boundaries were approximately defined by Thiessen (1911) polygons according to proximity to one of three precipitation stations whose data were used in the model (fig. 3). The three stations included a USGS station near Tully Valley, a National Weather Service (NWS) station at the Syracuse Hancock International Airport, and an Onondaga County Water Authority (OCWA) station at Otisco Lake. The HRUs in each precipitation area were numbered as follows: those in the Tully Valley precipitation area were numbered PERLNDs 1–16 and IMPLNDS 1–3; those in the Hancock Airport precipitation area were numbered PERLNDs 101–116 and IMPLNDS 101–103; and those in the Otisco Lake precipitation area were numbered PERLNDs 301–316 and

Table 3. Hydrologic-response units (HRUs) used in the precipitation-runoff model of the Onondaga Lake basin, Onondaga County, N.Y.

[HRU, hydrologic response unit; na, not applicable; CSO, combined storm-and-sanitary sewer overflow. Dash indicates hydrologic response unit was not divided according to this basin characteristic]

HRU number for given precipitation area					Land use or land cover	Hydrologic-soil-group runoff potential	Aspect (north- or south-facing slope)	Mass-Link
Tully Valley (or Mudboil)	Hancock Airport		Otisco Lake					
	Excluding Harbor Brook	Harbor Brook	Otisco Lake	Upper Ninemile Creek				
Undeveloped Pervious Land Segments (PERLNDs)								
1	101	121	201	301	Forest	Low	South	1
2	102	122	202	302	Forest	High	South	1
3	103	123	203	303	Forest	Low	North	1
4	104	124	204	304	Forest	High	North	1
5	105	125	205	305	Pasture-hay	Low	South	1
6	106	126	206	306	Pasture-hay	High	South	1
7	107	127	207	307	Pasture-hay	Low	North	1
8	108	128	208	308	Pasture-hay	High	North	1
9	109	129	209	309	Row crops	–	–	1
10	110	130	210	310	Farmstead	–	–	1
11	111	131	211	311	Urban or recreational grass	–	–	1
12	112	132	212	312	Wetland-water	–	–	1
16	116	na	216	316	Row crops in lacustrine silt-and-clay soils	–	–	1
Developed Pervious Land Segments (PERLNDs)								
13	113	133	213	313	Low-intensity residential	–	–	2
14	114	134	214	314	High-intensity residential	–	–	3
15	115	135	215	315	Commercial, industrial, and transportation	–	–	4
Impervious Land Segments (IMPLNDs)								
1	101	101	201	201	Low-intensity residential	–	–	5
2	102	102	202	202	High-intensity residential	–	–	6
3	103	103	203	203	Commercial, industrial, and transportation	–	–	7
na	111	111	na	na	Sewered (CSO) low-intensity residential	–	–	11
na	112	112	na	na	Sewered (CSO) high-intensity residential	–	–	11
na	113	113	na	na	Sewered (CSO) commercial, industrial, and transportation	–	–	11

IMPLNDS 201–203 (table 3). The CSO impervious areas described previously were within the Hancock Airport precipitation area of three subbasins—Onondaga Creek, Harbor Brook, and Ley Creek—and were uniquely simulated and assigned IMPLND numbers 111–113. Therefore, subbasins in these CSO areas could have an additional three IMPLNDs and a total of 22 HRUs. Two areas of the Onondaga Lake basin—the Harbor Brook basin and the Otisco Lake basin—were deemed to have distinct hydrologic characteristics that could not be calibrated with the same parameter values that were used elsewhere in their respective precipitation areas and thus required separate sets of HRUs (table 3).

Stream Reach and Reservoir (RCHRES) Module

The overland and subsurface flows from the PERLNDs, and the overland flow from the IMPLNDs, are routed to the main surface-water channel (RCHRES) within a given subbasin. Subbasins and their associated RCHRESs share the same identification number (fig. 3), which increases in a downstream order. The subbasin identifiers are for the benefit of the user and are not used in the model, whereas the RCHRES numbers are used in the model to route water through the basin.

External Sources (EXT SOURCES) and External Targets (EXT TARGETS) of Data Modules

The dataset numbers used in the EXT SOURCES and EXT TARGETS modules of the UCI file refer to the datasets contained in the WDM file (fig. 2). The time-series datasets required by HSPF are input to the model through the EXT SOURCES module, and output is directed to desired storage datasets through the EXT TARGETS module. No user modifications to EXT SOURCES are required. Modifications to EXT TARGETS permit storage of output from user-defined simulations (scenarios) and subsequent comparison of simulated results. An example of an EXT TARGETS command line is:

```
RCHRES  312  HYDR      RO           1 1       1.0         WDM1        3122  SIMQ        1  ENGL          REPL
```

Here the number 3122 between the terms WDM1 and SIMQ is the dataset number (DSN) for the streamflow output by HSPF (HYDR – RO) at the downstream end of RCHRES 312 (Ley Creek at Park Street, Syracuse). The remaining terms and numbers are inconsequential in making revisions to the UCI file for creation of scenarios.

Connections and Linkages–SCHEMATIC and MASS-LINK Modules

The SCHEMATIC and MASS-LINK modules work together to map the paths that constituents follow through the conceptual basin defined by the model. The SCHEMATIC module contains instructions that define the connections between land segments (PERLNDs and IMPLNDs) and RCHRESs, and among RCHRESs, as well as the acreages for the PERLNDs and IMPLNDs in a given subbasin. The MASS-LINK module identifies the specific constituent(s) to be transferred from one model operation to another. The user, if simulating land-use changes in the basin, need not be concerned with modifying these connections because land-use changes are simulated by switching the types and quantities of pervious and impervious acreages that are specified in the SCHEMATIC module for a given subbasin. An example of four command lines in the SCHEMATIC module that pertain to a given subbasin (312, in this example) is

PERLND 101	1.480	RCHRES 312	1
PERLND 102	16.510	RCHRES 312	1
PERLND 113	149.150	RCHRES 312	2
PERLND 114	193.620	RCHRES 312	3

The numbers with decimal points represent the numbers of acres of associated PERLNDs (1.480 acres for PERLND 101) in this subbasin. The flows and chemical loads from these PERLNDs are routed to RCHRES 312 through the instructions contained in MASS-LINK numbers 1, 2, or 3, as specified by the last number in each line.

Best-Management Practices (BMPRAC) Module

Best-management practices (BMPs) are assumed to decrease constituent loads and, therefore, are simulated through inclusion of percent-removal values, which are applied to the pertinent processes simulated by HSPF. The removal fractions can be estimated, taken from scientific literature, or calibrated (if data are available). BMPs can be simulated for movement of constituent loads from PERLNDs and IMPLNDs to RCHRESs, or from one RCHRES to another. Two examples of BMPRAC instructions pertaining to RCHRES 121 are given below.

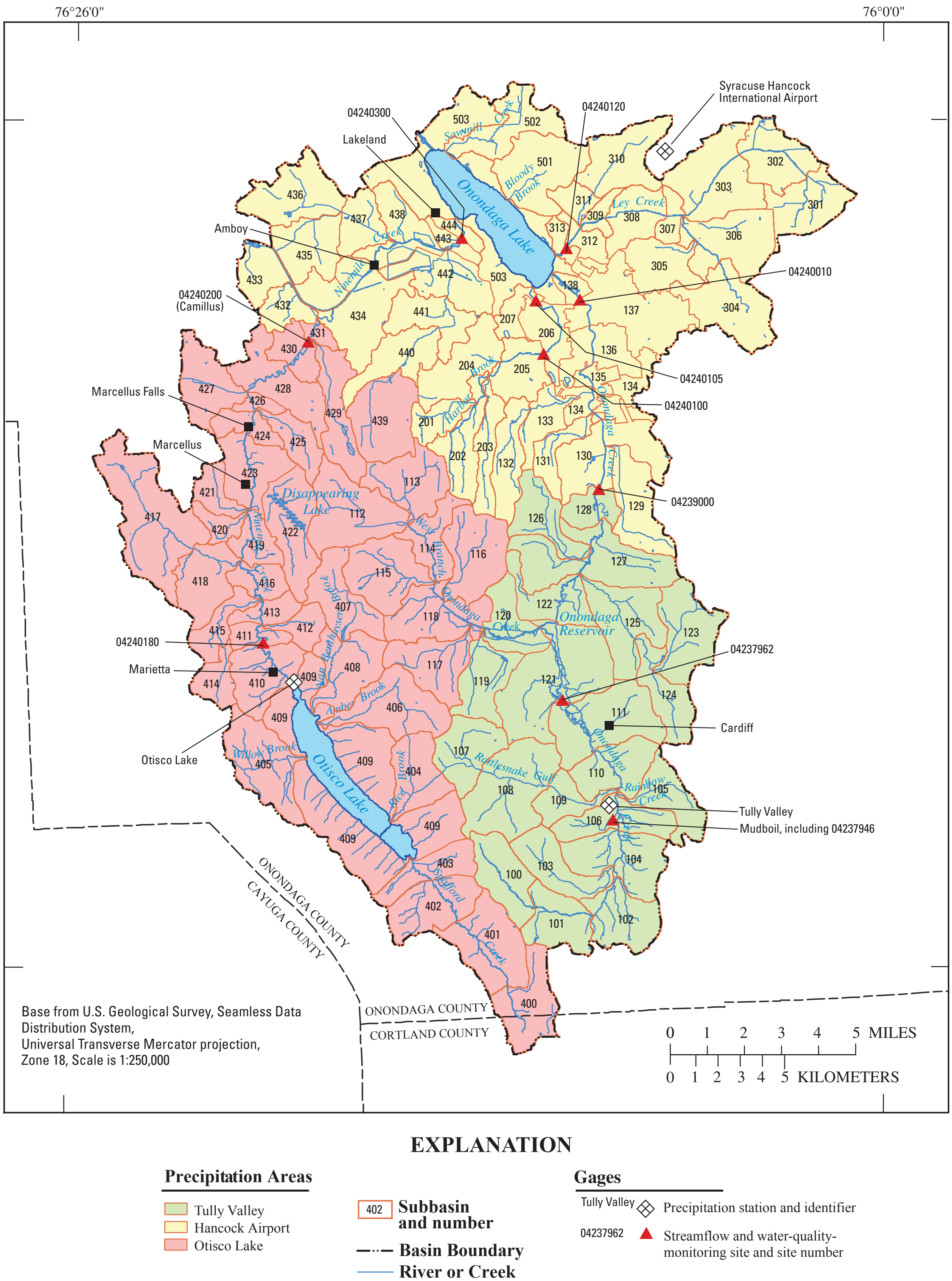


Figure 3. Locations of subbasins and precipitation areas used in precipitation-runoff model of the Onondaga Lake basin, Onondaga County, N.Y.

(1)	#	#	SANDFRAC	SILTFRAC	CLAYFRAC	***
	121		1.00	0.85	0.30	

In the above example, 100, 85, and 30 percent of the sand, silt, and clay fractions of sediment carried into RCHRES 121 are to be removed; thus, only 15 and 70 percent of the incoming silt and clay loads will be passed to the downstream RCHRES. The three asterisks at the end of the first line denote a comment line, which is included in the UCI file for the user's benefit and is ignored by HSPF.

(2)	#	#	NO3	TAM	NO2	PO4	***
	121		0.40	0.00	0.40	0.00	

The second example (above) simulates the effects of a BMP that will remove 40 percent of the incoming nitrate (NO_3) and 40 percent of the nitrite (NO_2) loads before flows are passed downstream but will have no effect on total ammonia (TAM) or phosphate (PO_4) loads.

Function Table (FTABLE) Module for Hydraulic Properties of a Reach

The FTABLE module, which contains a function table for each RCHRES, relates surface-water elevation or depth in a RCHRES to water-surface area and volume in the channel and to discharge at the downstream end of the RCHRES. An Ftable shares the same identification number as the RCHRES with which it is associated. Flow detention can be simulated by increasing the storage volume or decreasing the discharge that is associated with a given depth (Donigian and others, 1997). The modifications can be hypothetical or based on a hydraulic analysis of an existing or proposed flow-control structure. Discharges from a RCHRES are dependent on the volume of water in storage; that is, HSPF calculates a discharge from the volume of water that has entered the RCHRES from an upstream RCHRES and from adjacent PERLNDs and IMPLNDs during a given time step. HSPF is not a hydraulic model and, therefore, does not compute water-surface elevations or associated discharges; rather, the relation between these two parameters is defined by the user in the Ftables. An example of several lines of an Ftable is:

DEPTH	AREA	VOLUME	DISCH ***
(FT)	(ACRES)	(AC-FT)	(CFS) ***
0.000	0.000	0.000	0.00
0.500	1.095	0.261	13.00
1.000	2.211	1.095	50.00
1.500	2.923	2.481	120.00
2.000	3.093	3.968	227.00

The column headings define the values in the table. As in previous examples, the first two lines are "commented out" by the addition of three asterisks (***) and will be ignored by HSPF.

Watershed Data-Management (WDM) System

The HSPF input and output time series of data (data recorded or stored at a regular time step) are stored in a WDM file (named *onmod.wdm*). The input time series include hourly precipitation, air temperature, wind speed, and other meteorological data. Point inflows and chemical or sediment loads entering the Onondaga Lake tributaries from the mudboils in the Tully Valley and the Marcellus wastewater-treatment plant, as well as from carbonate-bedrock springs and Otisco Lake are also stored in the WDM file. The output time series include hourly flows and daily chemical and sediment loads at the downstream end of subbasins or channel reaches (RCHRESs), as well as loads generated from specific land-use areas such as forested or low-intensity residential areas. [**CAUTION**: Never open a WDM file in a text editor because this could corrupt the file; always use GenScn to view datasets stored in the WDM file.]

Each dataset in the WDM file is identified by a unique combination of three identifiers—a location (IDLOCN), a scenario (IDSCEN), and a constituent (IDCONS). IDLOCN could be either a nondescript label, such as RCH310, which refers to the unique RCHRES number specified in the UCI file, or it could be an informative label, such as DORWIN, which refers to the downstream end of a reach on Onondaga Creek at Dorwin Avenue, Syracuse. Additional examples are given in table 1. IDSCEN identifies a scenario that was simulated by HSPF. The calibrated-model scenario is identified as BASE. Another scenario might be labeled LUC1 for land-use change number 1, or DBASIN, for simulation of a detention basin. IDCONS identifies the constituent(s), such as streamflow (FLOW), orthophosphate concentration (OP), or sediment load (SEDLD), that is associated with the time series. Additional examples are given in table 4. Selection of a specific dataset for analysis in GenScn requires that the three identifiers that uniquely identify the dataset be chosen.

Data stored in the WDM file will be overwritten with data generated by simulation of a new scenario. A user who wishes to compare the output from two scenarios must run the first scenario, then create new datasets and input these dataset numbers in the EXT TARGETS module of the UCI file before running the second scenario. The specific steps to perform these tasks are discussed farther on.

The storage and comparison of data from differing scenarios is facilitated through the use of four blocks of datasets that have been created in the WDM file and included in the EXT TARGETS module of the UCI file. A user would first find this module in the UCI file and locate the target blocks for the generic reaches, RCH1 through RCH4. Each block has lines that will target output from a scenario for the 20 constituents listed in table 4. The user simply identifies the subbasin or RCHRES for which data are desired and substitutes that RCHRES' identification number for the one that currently is listed in columns 8–10 on each line of the dataset block. In this manner, the user can obtain output for four different RCHRESs and need only keep track of which RCHRES applies to RCH1, RCH2, and so forth when the output are analyzed in GenScn. The following is an example of an EXT TARGET command line:

```
RCHRES    312    HYDR        RO        1 1        1.0        WDM1      401   SIMQ        1 ENGL            REPL
```

Table 4. Constituents simulated by Onondaga Lake basin model, Onondaga County, N.Y., with GenScn and HSPF abbreviations.

[GenScn, Generation and Analysis of Model Simulation Scenarios for Watersheds (Kittle and others, 1998); HSPF, Hydrological Simulation Program–Fortran (Bicknell and others, 2001)]

GenScn constituent identification (IDCONS)	HSPF time-series type (TSTYPE)	Description	Time step	Units
DO	DO	Dissolved oxygen concentration	Hourly	Milligrams per Liter
BOD	BOD	Biochemical oxygen demand	Hourly	Milligrams per Liter
FLOW	FLOW	Streamflow	Hourly	Cubic feet per second
NH3	NH3	Ammonia concentration	Hourly	Milligrams per Liter
NH3LD	NH3M	Ammonia load	Daily	Tons
NO3	NO3	Nitrate concentration	Hourly	Milligrams per Liter
NO3LD	NO3M	Nitrate load	Daily	Tons
ORGN	ORGN	Organic nitrogen concentration	Hourly	Milligrams per Liter
ORGNLD	ORNM	Organic nitrogen load	Daily	Tons
ORGP	ORGP	Organic phosphorus concentration	Hourly	Milligrams per Liter
ORGPLD	ORPM	Organic phosphorus load	Daily	Tons
OP	OP	Orthophosphate concentration	Hourly	Milligrams per Liter
OPLD	OPM	Orthophosphate load	Daily	Tons
SSED	SSED	Suspended sediment concentration	Hourly	Milligrams per Liter
SEDLD	SEDM	Suspended sediment load	Daily	Tons
TP	TP	Total phosphorus concentration	Hourly	Milligrams per Liter
TPLD	TPM	Total phosphorus load	Daily	Tons
TN	TN	Total nitrogen concentration	Hourly	Milligrams per Liter
TNLD	TNM	Total nitrogen load	Daily	Tons
WTMP	WTMP	Water temperature	Hourly	Degrees, Fahrenheit

If the user wishes to save streamflows (HYDR – RO) for RCHRES 121, simply replace the RCHRES number "312" with "121." The data will be stored in the WDM in DSN 401 (the number between the terms WDM1 and SIMQ). Repeat this step for every line in a given target block for which output is desired.

Generation and Analysis of Model Scenarios

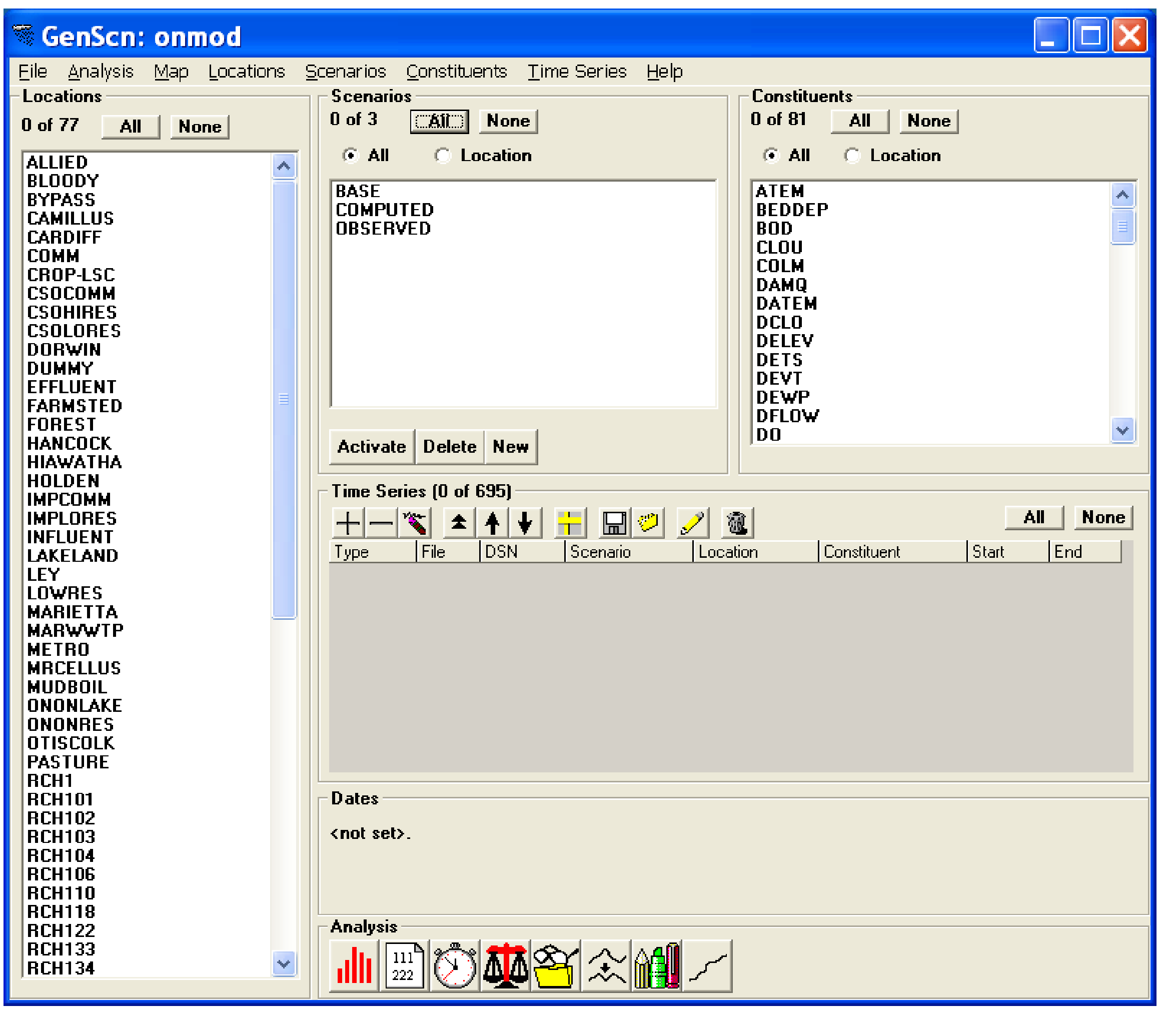
GenScn is a component of the software system BASINS, which stands for Better Assessment Science Integrating Point and Nonpoint Sources. BASINS was developed by the U.S. Environmental Protection Agency (2007) as "a multipurpose environmental analysis system designed for use by regional, state, and local agencies in performing watershed and water quality-based studies." BASINS can be downloaded from the world-wide web at the address given in Appendix A.

GenScn comprises six frames—Locations, Scenarios, Constituents, Time Series, Dates, and Analysis—that permit a user to identify and select desired times series (or records) of data, define a desired date range for the selected data, and choose an analytical tool. The function of each of these frames can be explored through the following steps. (Instructions on how to view and compare the records stored in a WDM file are given in a later section, "Analysis of Model Simulation Results.")

1. First, click on "File" and "Open Project," and select *onmod.sta*. This file contains the instructions for GenScn to process the Onondaga Lake basin model data. A GenScn window will appear as shown below.

2. "Locations" frame: select "Locations/Change to list" and select the desired location identification (RCH1, RCH2, RCH3, or RCH4). To identify the LOCATIONS stored in the WDM, click on "Locations" in the tool bar and select "Properties."

3. "Scenarios" frame: select the scenario with data to be analyzed (such as, BASE or OBSERVED). To see a brief description of a scenario stored in the WDM, point the mouse cursor at a scenario name and a pop-up window that identifies the scenario will appear.



4. “Constituents” frame: select “FLOW” or some other constituent to view and analyze. To see a definition of a constituent stored in the WDM, point the mouse cursor at a constituent name and a pop-up window that identifies the constituent will appear.

5. “Time Series” frame: add the selected time series (or records) to the list by using the “plus-sign” icon. Scan the DSN numbers to confirm that the selection process picked the desired records. Extraneous records can, but need not, be removed by highlighting them and then clicking the “minus-sign” icon. Highlight the records to be compared. Several can be selected at a time by holding down the Control-key and clicking on each record in turn.

6. “Dates” frame: Note the start and end dates that appear in the frame. GenScn will automatically select the longest time period that is common to all records in the “Time Series” frame, but the user can manually change this time range if desired. The earliest valid simulation date is October 1, 1997. The 1-year period prior to this date, which is shown for all the data records, was included in the model to allow HSPF to approximate realistic water-storage volumes in the RCHRESs and soil and ground-water compartments before the actual simulation period from October 1997 through September 2003. Therefore, the data from October 1996 through September 1997 should not be included in any analysis.

7. “Analysis” frame: select any of the following: a. the “red-bar” icon to generate graphs of the time series; b. the “111–222” icon to list the values in the time series; c. the “stopwatch” icon to perform flow-duration analysis; or d. the “balance-scale” icon to perform statistical comparisons of the time series.

8. When closing a GenScn project, the user may be prompted to save a “Changed status file.”
CAUTION: Always respond negatively to this prompt.

Generation of Scenarios

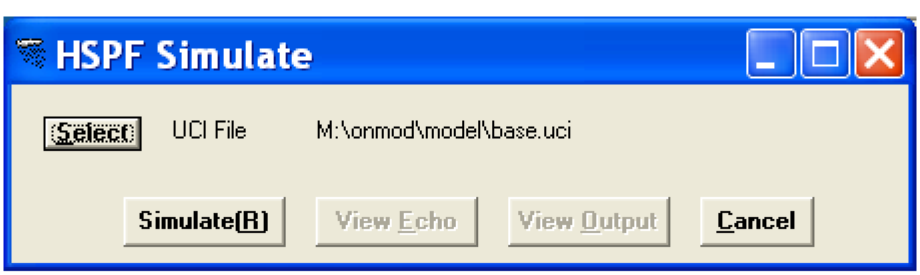
The first step in the generation of a new scenario is to decide whether a comparison with output from the calibrated model (Coon and Reddy, 2008) is desired. If so, then run the BASE UCI in HSPF by the following steps to ensure that valid data have been stored.

1. Make a copy of the file, *base.uci*, and save as *Copy of base.uci*. This file should never be edited, but should be retained as a backup should the working version of *base.uci* become corrupted and unusable.

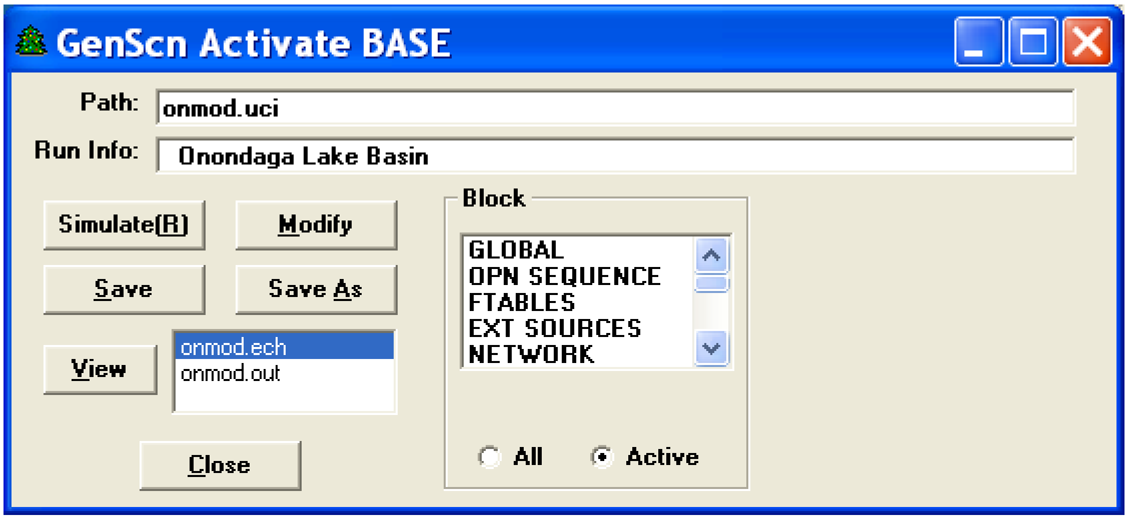
2. Open *base.uci* in a text editor. Find the EXT TARGETS module and locate the target blocks for RCH1 through RCH4. Decide which reach in the basin is to be analyzed by a new scenario. Obtain the RCHRES number from the subbasin figure (fig. 3) and substitute this new subbasin number for the number currently in the RCH1 block, as explained earlier in this report. If more than one reach is to be analyzed, repeat this step for the RCH2 block of datasets, and so on. As many as four reaches can be analyzed simultaneously. (**CAUTION**: Do not use the tab key while editing a UCI file; it creates a hidden character that HSPF cannot interpret, and the job will not run. Instead, either position the cursor with the mouse, or move it along lines or columns in the file using the arrow keys or the space bar. Also remember to maintain column alignment as changes are made.)

3. “Comment out” any lines in EXT TARGETS for which data output will not be required for the new scenario by adding three asterisks (***) anywhere in each command line. This will decrease the time required for HSPF to simulate the scenario.

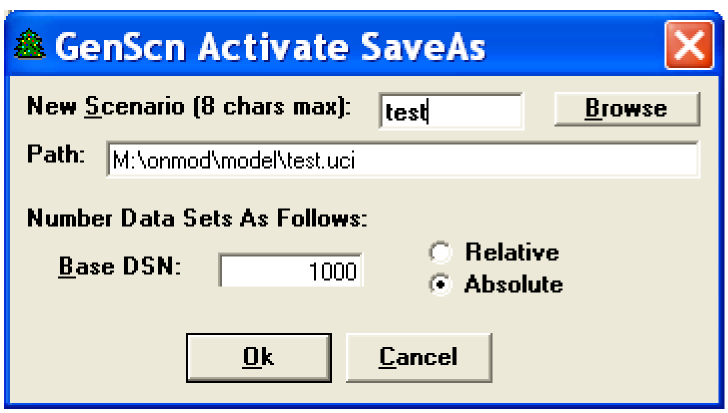
4. Open a GenScn window to run the *base.uci* file. Click on “File” and “Open Project,” and select *onmod.sta*. Then in the GenScn menu bar, click on “Analysis,” then “HSPF.” Select *base.uci* from the model directory, and then click “Simulate.”



5. After the BASE scenario has run to completion, the user is ready to (1) create new datasets in the WDM file where output from a new scenario will be stored, and (2) modify the *base.uci* file to create the new scenario. In the GenScn “Scenarios” frame, click on “BASE” in the list of scenarios. Then click on “Activate” at the bottom of the frame.



When the “Activate” frame appears, describe the scenario to be created by inserting descriptive information in the “Run Info” box, then select “Save As.”



In the “Save As” frame, identify a new scenario name (up to 8-characters long) that is descriptive of the scenario that will be created and subsequently simulated. Accept the default entries for the remaining options, and click “OK.” When this new scenario (which will be called TEST for instruction purposes) is created, a duplicate dataset for each dataset identified in EXT TARGETS will automatically be created in the WDM file. This duplication will apply to every dataset in EXT TARGETS regardless of whether the line is “active” or has been “commented out” by the addition of three asterisks (***). This process can take 10 to15 minutes to complete. The new datasets will have the same IDLOCN and IDCONS as the original file, but the IDSCEN will be changed to the new scenario identification (TEST). In addition, a new UCI file will be created that uses the new scenario name (*test.uci*). This file will be identical to *base.uci* except that (1) the third line of the file will contain the descriptive phrase inserted in the “Run Info” box, and (2) all targeted output datasets will have been assigned new and unique dataset numbers in EXT TARGETS. In the “Activate” frame, click “Close.”

6. Outside of GenScn, in a text editor, modify *test.uci* to simulate the new scenario. Follow the instructions presented in the section “Scenario Examples” to simulate a land-use change, a BMP, an instream stormwater-detention basin, or a revised precipitation record. Save the UCI file.

7. Go back to the GenScn window, and run the new scenario (click “Analysis,” “HSPF,” Select *test.uci*, and click “Simulate”), then select the datasets from the BASE and TEST scenarios for analysis as described in the section, “Analysis of Model Simulation Results.”

Scenario Examples

The main objective in the development of the Onondaga Lake basin model was to provide a tool that would enable water-resources managers to assess the effects that future development, instream stormwater-detention basins, and BMPs might have on the flows and chemical loads of the lake's tributaries. The model can also be used to assess the effects of extreme weather conditions by fabricating a precipitation record. The steps required to simulate these scenarios are given below.

Scenario 1—Simulation of Land-Use Changes

The Onondaga Lake basin is undergoing continuous changes in land use, whereby development is spreading southward from the already heavily developed areas that surround Onondaga Lake. Rural areas that were dominated by forests, farms, and pasture land are being converted to residential developments, sprawling technology parks, and large shopping malls. The question of what effects continued development will have on flooding and stream-water quality in the basin can be addressed through simulation of these land-use changes by the following steps.

1. In a text editor, open the file, *test.uci*, which was created with the Activate option in GenScn. The UCI file is a fixed-format file that requires data input in specific columns; therefore, a text editor that maintains column alignment is required. As mentioned previously, do not use the tab key when editing a UCI file.
2. Search for the SCHEMATIC module of the UCI file, and locate the desired subbasin by its number. The subbasin identification line is followed by a list of that subbasin's HRUs and associated acreages. Consult table 3 herein to identify the lines that need to be revised, and copy and paste these lines directly below the original entries. Then "comment out" the original lines by inserting three asterisks (***) anywhere in each of the lines. These changes might affect only PERLNDs if, for example, a scenario is intended to evaluate the effects of permitting a pasture-hay area to revert to forest; or the changes might affect PERLNDs and IMPLNDs as would result if a forested area were to be converted to a residential or commercial development. In either case, the acreages associated with the current PERLNDs would be decreased, and the acreages associated with changed land uses would be increased by an equal amount. Remember that if developed land uses are involved, the PERLND and IMPLND components of those lands are treated as a paired set, and the total number of acres associated with the simulated change is added to both components of the developed HRUs as described in the earlier section "Hydrological Simulation Program-Fortran User's-Control-Input (UCI) File." A subbasin that did not previously contain developed land uses would have no lines for developed PERLNDs and IMPLNDs 1–3 in its SCHEMATIC block; therefore, these lines, including the appropriate MASS-LINK number in the last column (which would be selected according to values listed in table 3 herein) would need to be inserted.

An example of the procedure to simulate land-use changes is given below.

Example: Assume that a 320-acre residential-commercial development is proposed for subbasin 103, a tributary to Onondaga Creek. (NOTE: This is a completely hypothetical development; no private or public entity is currently known to have plans to develop this subbasin for residential or commercial uses.) The proposed development is in an area classified as forest with a mix of north- and south-facing slopes and soils with both high and low runoff potentials (PERLNDs 1–4, from table 3). Assume that 160 and 120 acres will be converted to low- and high-intensity residential uses, respectively, and the remaining 40 acres will be converted to commercial, industrial, or transportation (CIT) uses. The pertinent HRUs, from table 3, are as follows: low-intensity residential uses are PERLND 13 and IMPLND 1; high-intensity residential uses are PERLND 14 and IMPLND 2; and CIT uses are PERLND 15 and IMPLND 3. The SCHEMATIC block for Subbasin 103 appears as follows:

```
*** Subbasin 103
PERLND    1              392.720     RCHRES    103          1
PERLND    2              152.930     RCHRES    103          1
PERLND    3              368.600     RCHRES    103          1
PERLND    4              110.180     RCHRES    103          1
PERLND    5              229.280     RCHRES    103          1
PERLND    6               78.900     RCHRES    103          1
PERLND    7               96.320     RCHRES    103          1
PERLND    8               34.200     RCHRES    103          1
PERLND    9               38.200     RCHRES    103          1
PERLND   12               34.830     RCHRES    103          1
```

Copy and paste the lines for the four forested PERLNDs (1–4); comment out the original set of lines, and decrease the acreages in the copied lines by 80 acres each (total of 320 acres). Create the lines for PERLNDs 13–15 and IMPLNDs 1–3. Increase the acreages for PERLND 13 and IMPLND 1 by 160; for PERLND 14 and IMPLND 2 by 120; and for PERLND 15 and IMPLND 3 by 40. The resultant SCHEMATIC block will appear as follows (changes are in bold face):

`*** Subbasin 103`

PERLND	1	***	392.720	RCHRES	103	1
PERLND	2	***	152.930	RCHRES	103	1
PERLND	3	***	368.600	RCHRES	103	1
PERLND	4	***	110.180	RCHRES	103	1
PERLND	1		**312.720**	RCHRES	103	1
PERLND	2		**72.930**	RCHRES	103	1
PERLND	3		**288.600**	RCHRES	103	1
PERLND	4		**30.180**	RCHRES	103	1
PERLND	5		229.280	RCHRES	103	1
PERLND	6		78.900	RCHRES	103	1
PERLND	7		96.320	RCHRES	103	1
PERLND	8		34.200	RCHRES	103	1
PERLND	9		38.200	RCHRES	103	1
PERLND	12		34.830	RCHRES	103	1
PERLND	**13**		**160.00**	**RCHRES**	**103**	**2**
PERLND	**14**		**120.00**	**RCHRES**	**103**	**3**
PERLND	**15**		**40.00**	**RCHRES**	**103**	**4**
IMPLND	**1**		**160.00**	**RCHRES**	**103**	**5**
IMPLND	**2**		**120.00**	**RCHRES**	**103**	**6**
IMPLND	**3**		**40.00**	**RCHRES**	**103**	**7**

3. Locate the EXT TARGETS module in the UCI file and revise the subbasin numbers in the targeted blocks for RCH1, RCH2, RCH3, or RCH4, if necessary and as desired. For the above scenario, a user might identify RCHRES 103 as RCH1 and its receiving water body, RCHRES 104, as RCH2.

4. Save this edited UCI file and simulate the scenario in GenScn. NOTE: The HSPF-parameter values that simulate the processes that generate the chemical-constituent loads are associated with overland- and subsurface-flow processes of the PERLND module, the overland-flow processes of the IMPLND module, and the channel-flow processes of the RCHRES module. When PERLND and IMPLND acreages are modified as instructed in Scenario 1, HSPF automatically simulates chemical loads resulting from these changes, and no adjustment of parameter values is required.

5. Compare and analyze the output from the BASE and TEST scenarios.

Scenario 2—Simulation of Stormflow-Detention Basins

Mitigation of the adverse effects of urbanization on flooding has become a major objective in the planning and development of heavily populated watersheds. The optimal design objective for any flood-control measure would be to maintain post-development discharges at or below predevelopment rates for storms of specified magnitudes. Many methods of minimizing the effects of increased runoff, such as infiltration trenches and pits, porous pavement, rooftop storage, and cisterns, can be expensive or constrained by site-specific limitations (Natural Resources Conservation Service, 1986). An alternative method—use of instream stormwater-detention basins—has been widely used to control peak flows because such basins (1) are relatively inexpensive to design and build, (2) can be designed to fit a wide variety of sites and outflow requirements, (3) can be incorporated into a proposed development plan, and (4) can be constructed in areas where the development potential is limited by susceptibility to flooding. HSPF allows simulation of a detention basin as an instream basin or as a basin adjacent to a stream into which stormflows can be routed; it also permits simulation of a single detention basin to represent the cumulative effects of several small basins. Simulation of an instream detention basin is done through the steps listed below.

1. Use a text editor to open the file, *test.uci*, which was created with the “Activate” option in GenScn.

2. Locate the FTABLES module near the end of the file, then locate the desired Ftable by subbasin or RCHRES number. Each Ftable lists four parameters—a reference depth (usually at the downstream end of the reach), water-surface area along the reach, volume of water stored in the channel along the reach, and the estimated discharge at the downstream end of the reach.

3. Detention basins can be simulated by (1) decreasing the outflow rates (in cubic feet per second) associated with the given storage volumes to mimic the effect of a flow-control structure across the channel, or (2) increasing the channel-storage volumes (in acre-feet) associated with the given discharges to mimic the effects of one or more storage pools adjacent to the channel or upstream from the discharge point. These modifications can be hypothetical or based on computed outflows and storages from a field survey and design calculations for a proposed basin. To simulate a detention basin, copy and paste the current Ftable in the UCI file directly below itself to preserve the original version of the table, then comment out each line of the original table. Make revisions only to the copied lines of the Ftable, leaving the original unaltered. An Ftable revised to simulate a detention basin might appear as follows:

```
FTABLE    103                                         ***
 ROWS  COLS     Tributary to Onondaga Creek           ***
    6    4                                            ***
      DEPTH       AREA     VOLUME     DISCH           ***
       (FT)    (ACRES)    (AC-FT)     (CFS)           ***
      0.000      0.000      0.000      0.00           ***
      1.000      4.138      1.661     23.00           ***
      2.000     11.199      6.147     90.00           ***
      3.000     16.144     17.821    162.00           ***
      4.000     19.752     37.405    358.00           ***
      5.000     23.082     52.759    505.00           ***
END FTABLE103                                         ***
```

```
  FTABLE    103
***  Outflow rates were decreased to simulate an instream detention basin.
   ROWS  COLS     Tributary to Onondaga Creek  ***
      6     4
        DEPTH       AREA    VOLUME     DISCH   ***
         (FT)    (ACRES)   (AC-FT)     (CFS)   ***
        0.000      0.000     0.000      0.00
        1.000      4.138     1.661      0.00
        2.000     11.199     6.147     10.00
        3.000     16.144    17.821     50.00
        4.000     19.752    37.405    100.00
        5.000     23.082    52.759    200.00
  END FTABLE103
```

If storage-volume changes are made, the outflow rates of the Ftable (column 4) would be left "as is," and the storage volumes (column 3) would be increased by an appropriate amount. If a flow-control structure is added, only the discharges (column 4) would be revised, as shown in the above example. An Ftable can be modified to reflect the combined storage of several detention basins within the area drained by a particular RCHRES. Column alignment of the values for each of the four parameters in an Ftable must be maintained when revisions are made; each field is 10 characters wide, and the values are right justified in their respective columns. Also, the third line of an Ftable (between the lines that begin with the words "ROW" and "DEPTH") contains two numbers that refer to the number of data lines and columns in the Ftable (6 and 4, respectively, in the above example). If the number of data lines in an Ftable is changed, the first number must be corrected to agree with this change; these numbers are right justified in their respective locations. The maximum permissible number of data lines in an Ftable is 25.

4. Locate the EXT TARGETS module in the UCI file and revise the subbasin numbers in the targeted blocks for RCH1, RCH2, RCH3, or RCH4, if necessary and as desired.

5. Save this edited UCI file and run the scenario in GenScn. NOTE: When RCHRES storage volumes or discharge rates from a stormwater-detention basin are modified as instructed in Scenario 2, HSPF will automatically simulate the changes in chemical loads that result from increased detention time and removal of particulate constituents. If the user, after reviewing the output from these simulations, decides that more precise simulation of constituent removals is required, the BMPRAC module can be used as described below in Scenario 3.

6. Compare and analyze the output from the BASE and TEST scenarios.

Scenario 3—Simulation of Best-Management Practices (BMPs)

Four revisions to the UCI file are required for simulation of BMPs through HSPF: (1) two MASS-LINKs must be created to identify the constituents to be routed from a PERLND, IMPLND, or RCHRES to a BMP and then from the BMP to a receiving RCHRES; (2) new lines must be entered in the SCHEMATIC module to route constituents to the BMP and to identify the numbers of the MASS-LINKs created in step 1; (3) appropriate removal fractions for each of the constituents to be mitigated by the simulated BMP must be entered in the BMPRAC module; and (4) the BMPRAC operations must be added to the OPN SEQUENCE (operations sequence) module. These steps are briefly described below, but the user is advised to consult HSPF documentation (included in electronic form with the GenScn software) and become familiar with HSPF constituent names and how to code data in the MASS-LINK, SCHEMATIC, and BMPRAC modules to successfully modify the UCI file and simulate BMPs.

A demonstration of the steps for simulation of a BMP to decrease sediment loads carried in the outflow from a PERLND and through a RCHRES is given below. Constituents other than sediment can be removed in a similar manner after (1) the appropriate outflow and inflow constituent names are identified from the HSPF documentation, and (2) an appropriate removal fraction to be input in the BMPRAC module is selected. Examples of BMPRAC entries in a UCI file can be viewed by searching for the term "BMPRAC" in the *base.uci* file. Expanded examples of (1) MASS-LINKs that might be used to control constituent transfers into and out of a BMP, and (2) a BMPRAC module are given in Appendix B. The steps for simulation of a BMP are listed below.

1. In a text editor, open the file, *test.uci*, which was created with the Activate option in GenScn.
2. Create the MASS-LINKs to identify the constituents to be mitigated by the BMP. Examples are shown for routing constituents from a PERLND or a RCHRES to a BMP, as well as from a BMP to a receiving RCHRES.

Example A. *Routing constituents from a PERLND to a BMP.* The total sediment load (SEDMNT-SOSED) from a PERLND is apportioned among the three particle-size components—sand, silt, and clay—by the percentages 10, 55, and 35, respectively, before being routed to the BMP. These percentages were derived from particle-size analyses of suspended-sediment samples that were collected in tributaries to Otisco Lake (Paschal and Sherwood, 1987). NOTE: All other simulated constituents from this PERLND, including flow, heat, and loads of chemical constituents, must be included in the MASS LINK, even if the BMP is likely to have no effect on them. (See Appendix B.) These other constituents are omitted in the following examples for simplicity.

```
  MASS-LINK        20
<Srce>      <-Grp>  <-Member-> <—Mult—>    <Targ>    ***    <-Grp>   <-Member->
<Name>      <Name>  <Name># #<-factor->    <Name>    ***    <Name>   <Name>  # #
PERLND      SEDMNT  SOSED          0.10    BMPRAC           INFLOW   ISED    1
PERLND      SEDMNT  SOSED          0.55    BMPRAC           INFLOW   ISED    2
PERLND      SEDMNT  SOSED          0.35    BMPRAC           INFLOW   ISED    3
  END MASS-LINK    20
```

Example B. *Routing constituents from a RCHRES to a BMP.* The sediment load from a RCHRES is routed to the BMP. No apportionment of the particle-size components—sand, silt, and clay—is required because this was done when the sediment load entered the RCHRES.

```
  MASS-LINK        21
RCHRES      ROFLOW  ROSED  1               BMPRAC           INFLOW   ISED    1
RCHRES      ROFLOW  ROSED  2               BMPRAC           INFLOW   ISED    2
RCHRES      ROFLOW  ROSED  3               BMPRAC           INFLOW   ISED    3
  END MASS-LINK    21
```

Alternatively, the following line alone would perform the same function as the three lines above.

```
  MASS-LINK        21
RCHRES      ROFLOW  ROSED                  BMPRAC           INFLOW   ISED
  END MASS-LINK    21
```

Example C. *Routing constituents from a BMP to a receiving RCHRES.*

```
  MASS-LINK        22
BMPRAC      ROFLOW  ROSED  1               RCHRES           INFLOW   ISED    1
BMPRAC      ROFLOW  ROSED  2               RCHRES           INFLOW   ISED    2
BMPRAC      ROFLOW  ROSED  3               RCHRES           INFLOW   ISED    3
  END MASS-LINK    22
```

Alternatively, the following line alone will perform the same function as the three lines above.

```
  MASS-LINK        22
BMPRAC     ROFLOW  ROSED                       RCHRES          INFLOW   ISED
  END MASS-LINK    22
```

3. Modify the SCHEMATIC module to route constituents to the BMP and to identify the numbers of the MASS-LINKs created above.

Example A. *Routing constituents from a PERLND to a BMP, and then to a receiving RCHRES.*

```
<-Source->                     <—Area—>      <-Target->   <ML->  ***
<Name>####                    <-acres—>      <Name>####       #  ***
PERLND   9                      108.320      BMPRAC   1      20
PERLND  10                        3.000      BMPRAC   1      20
BMPRAC   1                        1.000      RCHRES 121      22
```

Example B. *Routing constituents from a RCHRES to a BMP, and then to a receiving RCHRES.*

```
RCHRES 121                         1.00      BMPRAC 121      21
BMPRAC 121                         1.00      RCHRES 122      22
```

4. Set up the BMPRAC module and input appropriate removal fractions for each of the constituents to be mitigated by the simulated BMP. In this example, the removal fractions are entered under SED-FRAC below; 100, 85, and 30 percent of the input loads of sand, silt, and clay, respectively, will be removed, and only 15 and 70 percent of the input loads of silt and clay, respectively, will be passed to the receiving RCHRES.

Example A. *Routing constituents from a PERLND to BMPRAC.*

```
GEN-INFO
121     Onondaga Reservoir      1    0    0          1    1    50    0
END GEN-INFO
SED-FLAG
   #    #  SAND  SILT  CLAY   0 = constant removal fraction ***
121          0     0     0
END SED-FLAG
SED-FRAC
   #    #    SANDFRC   SILTFRAC   CLAYFRAC     ***
121             1.00       0.85       0.30
END SED-FRAC
```

5. Locate the EXT TARGETS module in the UCI file and revise the subbasin numbers in the targeted blocks for RCH1, RCH2, RCH3, or RCH4, if necessary and as desired.
6. Search for “OPN SEQUENCE” and insert the BMPRAC operation at an appropriate spot. In the above example, the required entry would be “BMPRAC 121”.
7. Save this edited UCI file and simulate the scenario in GenScn.
8. Compare and analyze the output from the BASE and TEST scenarios.

Scenario 4—Simulation of Extreme Weather Conditions

The precipitation records (from one or more of the three precipitation stations) that are input to the model can be revised to simulate extreme weather conditions–either high-intensity rainfall or droughts–and to assess the probable effects of these conditions on the hydrology of the Onondaga Lake basin. The dataset numbers of the original precipitation records in the WDM file are 32 for the Hancock Airport record, 62 for the Tully Valley (MUDBOIL) record, and 96 for the Otisco Lake record.

1. Open a GenScn window and load the project file (*onmod.sta*).
2. Identify the precipitation record to be revised by selecting the desired location (HANCOCK, MUDBOIL, or OTISCOLK), scenario (OBSERVED), and constituent (PREC), and adding it to the "Time Series" frame.
3. Create a copy of this dataset by clicking "Analysis," then "Generate." Select the "Math" tab and the "Mult" or Multiplication button. Double-click in the white space to the right of "arg1" and select the desired time series. Click in the space to the right of "arg2" and insert the number "1." Under "New Properties," identify a unique "ID" or dataset number (any number between 800 and 900 will do) and save in *onmod.wdm*. When OK is clicked, the two arguments will be multiplied, thus producing a new record identical to the first. (The same result can be achieved by selecting the "Add" button and inserting zero for "arg2".)
4. Highlight the new dataset in the "Time Series" frame. Confirm that the dates in the "Dates" frame agree with those in the "Time Series" frame; in other words, make sure that the entire record will be selected. Click on the "111–222" icon in the "Analysis" frame. Edit the new dataset as desired within the calibration period of the model (October 1, 1997 to September 30, 2003) and save.
5. Activate the BASE scenario and save with a new scenario name (up to 8 charaters long), such as PRECIP.
6. Open the new UCI file, *precip.uci*, in a text editor and replace the dataset number of the original precipitation record with the new number of the revised record in EXT SOURCES. Each precipitation record is targeted to a range of PERLNDs and IMPLNDs and to many RCHRESs. Be certain to make the dataset-number (DSN) revision to all appropriate lines. Locate the EXT TARGETS module and revise the subbasin numbers in the targeted blocks for RCH1, RCH2, RCH3, or RCH4, as desired.
7. An alternative method of manipulating the precipitation record is to simulate a long-term, regional increase or decrease in total precipitation. This can be done by changing the multiplication factor in each line of the EXT SOURCES module that pertains to precipitation directed to the PERLNDs, IMPLNDs, and RCHRESs in the model from its default value of 1.00 to a different value. In the following example, the number "1.00" to the left of the word "SAME" is the multiplication factor. A new factor can be inserted anywhere in the space between "ZERO" and "SAME", as long as column alignment is maintained for the other variables on the line. This adjustment to the precipitation multiplication factor would be made in a text editor.

```
WDM    62   PREC     0   ENGLZERO        1.00SAME     PERLND  1  16  EXTNL    PREC   1 1.
```

8. Save the edited *precip.uci* file and simulate the scenario in GenScn.
9. Compare and analyze the output from the BASE and PRECIP scenarios.

Analysis of Model Simulation Results

This section explains how to view and compare the records generated by the BASE and TEST scenarios. Open GenScn and the project file, then specify the desired parameters in the six GenScn frames as described in the section, "Generation and Analysis of Model Scenarios."

1. Select the correct combinations of Location, Scenario, and Constituent that uniquely identify the desired time series (or records) for comparison and analysis.
2. Add the selected records to the "Times Series" frame (click on the "plus-sign" icon). Scan the DSN numbers to confirm that the selection process picked the desired records. Extraneous records can, but need not, be removed by highlighting, and then using the "minus-sign" icon. Highlight the records to be compared. Several can be selected at a time by holding down the Control key and clicking on each record in turn.

3. Note the start and end dates that appear in the “Dates” frame. GenScn will automatically select the longest time period that is common to all records in the “Time Series” frame, but the user can manually change this time range if desired. Alternatively, if extraneous records are removed, the user can click “Reset” in the “Dates” frame, and a new date range will be shown. The earliest valid simulation date is October 1, 1997.

4. Data will be presented and analyzed in the form and time step in which they are output by HSPF and stored in the WDM file (that is, “Native” data); however, the stored data can be averaged or summed, or the maximum or minimum values can be computed, over longer time steps. For example, daily mean flows or maximum temperatures can be computed from stored hourly values, and monthly or annual loads can be summed from stored daily loads.

5. Select the “red-bar” icon or click “Analysis,” then “Graph” in the tool bar to plot the data. Graphical options include standard time-series plot, residual plot, cumulative-difference plot, flow duration and exceedence probability, and scatter plot with regression line.

6. Select the “111–222” icon or click “Analysis,” then “List” to tabulate the data, edit stored values, or output data to a text file.

7. Select the “stopwatch” icon or click “Analysis,” then “Duration” to analyze the duration of events above and below specified levels or thresholds.

8. Select the “balance-scale” icon or click “Analysis,” then “Compare” to perform statistical comparisons of the records. Be aware that the order of the records listed in the “Times Series” frame will have no effect on the computation of GenScn statistics, except for the coefficient of model-fit efficiency. For the correct computation of this statistic, the observed record must follow the simulated record. Selected records can be reordered in the list by using the arrow icons at the top of the “Time Series” frame.

9. Select the “double-line” icon or click “Analysis,” then “Generate” to create new records from stored data. The time step of the record can be changed. The start and end times can be changed, and missing data can be copied, interpolated, or cloned. Mathematical operations can be performed on records.

10. Documentation for GenScn and explanation of these analytical tools can be obtained by clicking “Help,” then “Contents” or from the Internet at http://water.usgs.gov/software/genscn.html.

11. Delete obsolete scenarios by highlighting the scenario name in the “Scenarios” frame, then click “Delete” at the bottom of the frame.

Troubleshooting

During the initial step of the simulation, HSPF checks the UCI file for any coding errors and automatically creates an echo file, *onmod.ech*, each time a simulation is run. If the simulation fails to run, open this file in a text editor and search for lines of asterisks, which will bracket an error message. The message should identify the problem and lead the user to its correction. The echo file is overwritten each time a simulation is run.

References Cited

Bicknell, B.R., Imhoff, J.C., Kittle, J.L., Jr., Jobes, T.H., and Donigian, A.S., Jr., 2001, Hydrological Simulation Program-Fortran, user’s manual for version 12: Athens, Ga., U.S. Environmental Protection Agency, 873 p., accessed April 15, 2005, at http://www.epa.gov/docs/ostwater/BASINS/bsnsdocs.html#hspf

Coon, W.F., and Reddy, J.E., 2008, Hydrologic and water-quality characterization and modeling of the Onondaga Lake basin, Onondaga County, New York: U.S. Geological Survey Scientific Investigations Report 2008–5013, 85 p.

Donigian, A.S., Jr., Chinnaswamy, R.V., and Jobes, T.H., 1997, Conceptual design of multipurpose detention facilities for flood protection and nonpoint source pollution control: Mountain View, Calif., Aqua Terra Consultants, 151 p.

Kittle, J.L., Jr., Lumb, A.M., Hummel, P.R., Duda, P.B., and Gray, M.H., 1998, A tool for the generation and analysis of model simulation scenarios for watersheds (GenScn): U.S. Geological Survey Water-Resources Investigations Report 98–4134, 152 p., accessed April 2002, at http://water.usgs.gov/software/genscn.html

Natural Resources Conservation Service, 1986, Urban hydrology for small watersheds: U.S. Department of Agriculture, Natural Resources Conservation Service Technical Release 55 (paginated by section).

Paschal, J.E., Jr., and Sherwood, D.A., 1987, Relation of sediment and nutrient loads to watershed characteristics and land use in the Otisco Lake basin, Onondaga County, New York: U.S. Geological Survey Water-Resources Investigations Report 86–4036, 62 p.

Thiessen, A.H., 1911, Precipitation for large areas: Monthly Weather Review, v. 39, no. 7, p. 1082–1084.

U.S. Environmental Protection Agency, 2007, Better assessment science integrating point and nonpoint sources: U.S. Environmental Protection Agency, accessed November 8, 2007, at www.epa.gov/waterscience/basins/

U.S. Geological Survey, 1999, National land cover data, New York: U.S. Geological Survey, accessed April 2003, at New York S tate GIS Clearinghouse at http://www.nysgis.state.ny.us

Appendix A. Onondaga Lake Basin Model Software and Associated Files

GenScn is a component of the software system, BASINS, which stands for Better Assessment Science Integrating Point and Nonpoint Sources. BASINS was developed by the U.S. Environmental Protection Agency (2007) as “a multipurpose environmental analysis system designed for use by regional, state, and local agencies in performing watershed and water quality-based studies.” HSPF and GenScn can be obtained by downloading BASINS from the website, www.epa.gov/waterscience/basins/. Documentation for GenScn and HSPF can be viewed in GenScn by clicking “Help,” then “Contents” or “Help,” then “HSPF Manual,” respectively. GenScn version 2.3 was used independently of BASINS version 3.1 for running HSPF and analyzing the output from the Onondaga Lake basin model. HSPF version 12 was run from within GenScn or through WinHspfLt, another program, which is also included in the BASINS’ system.

BASINS has the following minimum computer-system requirements: (1) Windows 95, 98, Windows NT, ME, 2000, or XP operating system, (2) 166-megahertz Pentium processor, (3) 64 megabytes of random-access memory, (4) 300 megabytes of free disk space, and (5) a color monitor configured for 16 colors (800 x 600). The following system requirements are preferred: (1) Pentium processor, running at 400 megahertz or faster, (2) 128 megabytes of random-access memory, (3) 2 gigabytes of free disk space, and (4) a color monitor configured for 256 colors (1024 x 768).

The system requirements for GenScn are less rigorous than those for BASINS and include (1) Windows 95, 98, or Windows NT 4.0 or higher; (2) 486 or greater processor, running at 50 megahertz or faster; (3) 16 megabytes of memory; (4) 60 megabytes of free disk space; and (5) a monitor with display resolution of 1024 × 768. For optimal performance, the following are recommended: (1) Pentium processor, running at 200 megahertz or faster; (2) 64 megabytes of memory; (3) 100 megabytes of free disk space; (4) a monitor with display resolution of 1280 × 1024; and (5) a color printer.

A project CD (compact disk), which contains the BASINS executable files (version 3.1), program support files, and WDM, UCI, and GenScn project files, was distributed to Onondaga Lake Partnership members to use with this report and is referred to in the following steps, which outline the GenScn installation procedures.

1. Download the files, BASINS3.1.exe and BASINS3.1update4.exe, from the project CD and install them in the main directory of the computer’s hard drive (C:\); this will establish the complete directory network for proper functioning of the programs. GenScn, version 3, is stored within this executable file and automatically will be installed at C:\BASINS\models\HSPF\bin\GenScn.exe if the installation is successfully completed. A shortcut to this executable file can be placed on your desktop for easy access. NOTE: If BASINS is not stored on the C: drive or if the directory structure is changed in any way, the first line in the files *onmod.sta* and *onmod2.sta* must be revised to identify the location of the *hspfmsg.wdm* file.

2. Copy the master folder, “onmod”, which contains the folder “model” and its subfolders and files, from the project CD to a directory of the user’s choice. The “model” folder contains the WDM, UCI, and GenScn project files.

3. In an Explore window, right-click the “onmod” folder and remove “Read-Only” access to it, its subfolders, and all subfolder files at one time. Double-check the Properties of the files in the “model” subfolder to confirm that this step was successfully completed.

In addition to the BASINS executable files, the following files are stored on the project CD and include the Onondaga Lake basin model and any associated files required to successfully run the model. The user is strongly urged to make backup copies of *base.uci*, *onmod.wdm*, *onmod.map*, and *onmod.sta* in case the original files become corrupted.

base.uci is the calibrated version of the user’s control input (UCI) file for the Onondaga Lake basin model.

test.uci is a modified *base.uci* that was used to simulate a test scenario for training purposes.

onmod.wdm is the watershed data management (WDM) file that contains the data time series that are required to run the model. These input datasets include meteorological data, flows, and computed loads. The WDM file is also the repository of data time series that are output during a model run.

onmod.sta is the GenScn project status file, which defines the locations, scenarios, and constituents of the datasets stored in *onmod.wdm*, identifies the MAP file that contains links to the shapefiles that appear when the Locations / Map option is selected in GenScn, and identifies the database files that contain the discrete water-quality data that have been collected at the water-quality monitoring sites by WEP.

onmod2.sta is a modified version of *onmod.sta* that excludes references to the MAP file and the water-quality database files. If these files are not required for the current GenScn session, then the project will load more quickly using *onmod2.sta* than using *onmod.sta*.

onmod.map is the file in *onmod.sta* that identifies the shapefiles that appear when the Locations / Map option is selected in GenScn.

Shapefiles is a directory that contains the shapefiles identified in *onmod.sta*.

DBFfiles is a directory that contains the relational database files with the discrete water-quality data from each of the seven water-quality monitoring sites that are maintained by WEP.

Appendix B. Sample Coding of Mass-Link and BMPRAC Modules for Simulation of a BMP

The following lines in a UCI file show the proper way to code a pair of MASS-LINKs to simulate the effects of a land-management BMP. MASS-LINK 20 identifies the transfer of constituents from a PERLND to a BMP, and MASS-LINK 21 shows the transfer of constituents from the BMP to a receiving RCHRES. The multiplication factors included in MASS-LINK 20 are identical to those used in other PERLND MASS-LINKs in the Onondaga Lake basin model. The constituent that pertains to a given MASS-LINK command line is identified on the line preceding each command.

```
  MASS-LINK       20
<Srce>     <-Grp> <-Member-><--Mult-->     <Targ>   ***   <-Grp> <-Member->
<Name>     <Name> <Name> # #<-factor->     <Name>   ***   <Name> <Name> # #
*** Flow
PERLND     PWATER PERO      0.08333333     BMPRAC         INFLOW IVOL
*** Heat
PERLND     PWTGAS POHT                     BMPRAC         INFLOW IHEAT
*** Dissolved oxygen
PERLND     PWTGAS PODOXM                   BMPRAC         INFLOW IOX    1
*** Three sediment particle sizes: sand, silt, and clay
PERLND     SEDMNT SOSED           0.10     BMPRAC         INFLOW ISED   1
PERLND     SEDMNT SOSED           0.55     BMPRAC         INFLOW ISED   2
PERLND     SEDMNT SOSED           0.35     BMPRAC         INFLOW ISED   3
*** Orthophosphate
PERLND     PQUAL  POQUAL 1        1.00     BMPRAC         INFLOW IDNUT  4
*** Organic phosphorus
PERLND     PQUAL  POQUAL 2         .84     BMPRAC         INFLOW IPLK   4
*** Nitrate nitrogen
PERLND     PQUAL  POQUAL 3        1.00     BMPRAC         INFLOW IDNUT  1
*** Ammonia nitrogen
PERLND     PQUAL  POQUAL 4        0.05     BMPRAC         INFLOW IDNUT  2
*** Organic nitrogen
PERLND     PQUAL  POQUAL 4        1.00     BMPRAC         INFLOW IPLK   3
*** Organic carbon
PERLND     PQUAL  POQUAL 4        5.00     BMPRAC         INFLOW IPLK   5
*** Biochemical oxygen demand
PERLND     PQUAL  POQUAL 4   *** 10.00     BMPRAC         INFLOW IOX    2
  END MASS-LINK   20
```

```
*** Additional sample lines that were NOT used in the Onondaga Lake basin model
*** illustrate how constituent loads from the total outflow from a PERLND
*** (POQUAL, as shown above) might be identified by their specific flow paths,
*** including surface overland flow (SOQUAL), interflow (IOQUAL), and active
*** ground-water flow (AOQUAL), and directed to specific constituent forms.

*** Orthophosphate carried in surface runoff and apportioned to the
*** following forms:  dissolved (IDNUT 4), particulate associated with
*** silt (ISNUT 2 2), and particulate associated with clay (ISNUT 3 2).

PERLND     PQUAL  SOQUAL 1       0.100     BMPRAC         INFLOW IDNUT  4

PERLND     PQUAL  SOQUAL 1       0.580     BMPRAC         INFLOW ISNUT  2 2

PERLND     PQUAL  SOQUAL 1        0.32     BMPRAC         INFLOW ISNUT  3 2

*** Dissolved orthophosphate carried in interflow and ground water.

PERLND     PQUAL  IOQUAL 1        0.67     BMPRAC         INFLOW IDNUT  4

PERLND     PQUAL  AOQUAL 1        0.50     BMPRAC         INFLOW IDNUT  4

*** Organic phosphorus

PERLND     PQUAL  SOQUAL 2      0.0051     BMPRAC         INFLOW IPLK   4

PERLND     PQUAL  IOQUAL 2      0.0051     BMPRAC         INFLOW IPLK   4

PERLND     PQUAL  AOQUAL 2      0.0040     BMPRAC         INFLOW IPLK   4

*** Organic nitrogen

PERLND     PQUAL  SOQUAL 4      0.0407     BMPRAC         INFLOW IPLK   3

PERLND     PQUAL  IOQUAL 4      0.0407     BMPRAC         INFLOW IPLK   3

PERLND     PQUAL  AOQUAL 4      0.0488     BMPRAC         INFLOW IPLK   3

*** Biochemical oxygen demand

PERLND     PQUAL  SOQUAL 4        0.40     BMPRAC         INFLOW IOX    2

PERLND     PQUAL  IOQUAL 4        0.32     BMPRAC         INFLOW IOX    2

PERLND     PQUAL  AOQUAL 4        0.40     BMPRAC         INFLOW IOX    2


  MASS-LINK       21

*** All outflow components (ROFLOW) from a BMPRAC can be directed to a
*** receiving RCHRES by a single command.

BMPRAC     ROFLOW                          RCHRES         INFLOW

  END MASS-LINK   21


*** OR individual components can be specified with or without multiplication
*** factors.

*** Flow

BMPRAC     ROFLOW ROVOL                    RCHRES         INFLOW IVOL

*** Heat

BMPRAC     ROFLOW ROHEAT                   RCHRES         INFLOW IHEAT

*** Dissolved oxygen

BMPRAC     ROFLOW ROOX   1                 RCHRES         INFLOW OXIF   1

*** Three sediment particle sizes: sand, silt, and clay

BMPRAC     ROFLOW ROSED  1                 RCHRES         INFLOW ISED   1

BMPRAC     ROFLOW ROSED  2                 RCHRES         INFLOW ISED   2

BMPRAC     ROFLOW ROSED  3                 RCHRES         INFLOW ISED   3
```

```
*** Nitrate nitrogen
BMPRAC     ROFLOW RODNUT 1                  RCHRES        INFLOW NUIF1  1
*** Ammonia nitrogen
BMPRAC     ROFLOW RODNUT 2                  RCHRES        INFLOW NUIF1  2
*** Orthophosphate: dissolved (RODNUT 4), particulate associated with
*** silt (ROSNUT 2 2), and particulate associated with clay (ROSNUT 3 2).
BMPRAC     ROFLOW RODNUT 4                  RCHRES        INFLOW NUIF1  4
BMPRAC     ROFLOW ROSNUT 2 2     ***        RCHRES        INFLOW NUIF2  2 2
BMPRAC     ROFLOW ROSNUT 3 2     ***        RCHRES        INFLOW NUIF2  3 2
*** Organic nitrogen
BMPRAC     ROFLOW ROPLK  3                  RCHRES        INFLOW PKIF   3
*** Organic phosphorus
BMPRAC     ROFLOW ROPLK  4                  RCHRES        INFLOW PKIF   4
*** Organic carbon
BMPRAC     ROFLOW ROPLK  5                  RCHRES        INFLOW PKIF   5
*** Biochemical oxygen demand
BMPRAC     ROFLOW ROOX   2       ***        RCHRES        INFLOW OXIF   2
```

The following lines in a UCI file show how the BMPRAC module might be coded to simulate the effects of the Onondaga Reservoir (RCHRES 121) and Otisco Lake (RCHRES 409).

```
  SED-FLAG
    #    # SAND SILT CLAY   0 = constant removal fraction ***
  100  503    0    0    0
  END SED-FLAG
  SED-FRAC
*** SWCD report states 75% retention by Onondaga Reservoir and 90%
*** retention by Otisco Lake. Assume 75% retention is achieved by removal
*** of all sand; 85% of silt and 30% of clay. Assume 90% retention is
*** achieved by removal of all sand; all silt and 60% of clay.
    #    #   SANDFRC   SILTFRAC  CLAYFRAC             ***
  121           1.00       0.85      0.30
  409           1.00       1.00      0.60
  NUT-FLAG
    BMPRAC<-----Dissolved---><---Ads-NH3---><---Ads-PO4--->***
    #    #  NO3  TAM  NO2  PO4 Sand Silt Clay Sand Silt Clay***
  100  503
  END NUT-FLAG
  DNUT-FRAC
    BMPRAC             Removal fractions           ***
    #    #       NO3        TAM        NO2        PO4 ***
  121           0.50       0.00       0.50       0.00
  409           0.50       0.00       0.50       0.00
  END DNUT-FRAC
```

```
  ADSNUT-FRAC
*** Values same as sediment fractions
    BMPRAC <-----------Ammonia--------->< -----Phosphate------------->***
    #    #      Sand      Silt      Clay      Sand      Silt      Clay***
  121           1.00      0.85      0.30      1.00      0.85      0.30
  409           1.00      1.00      0.60      1.00      1.00      0.60
  END ADSNUT-FRAC
  PLANK-FLAG
    #    # Phyt  Zoo  ORN  ORP  ORC  ***
  100  503
  END PLANK-FLAG
  PLANK-FRAC
    BMPRAC            Removal fractions                    ***
    #    #      Phyt        Zoo       ORN       ORP       ORC ***
  121           0.00      0.00      0.30      0.50      0.50
  409           0.00      0.00      0.60      0.90      0.90
  END PLANK-FRAC
```

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Coon—Simulation of Streamflow and Selected Water-Quality Constituents through a Model of the Onondaga Lake Basin,—Open-File Report 2008–1188
Onondaga County, New York—A Guide to Model Application—