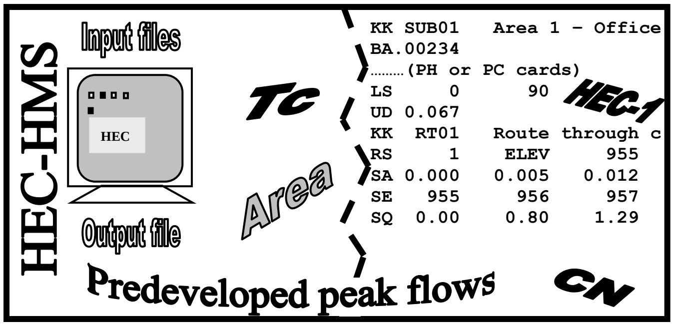
ACTIVITY: Detention Example for HEC-1 & HEC-HMS	ST – 12



CITY OF KNOXVILLE

Description

The purpose of this stormwater treatment BMP is to give a basic example of how to use the HEC-1 and HEC-HMS hydrograph programs in detention basin routing and design. The potential user of this BMP is expected to be thoroughly familiar with the TR-55 publication "Urban Hydrology for Small Watersheds" (reference 175) and also the theory and practical application of detention routing. The detention example for this BMP is the same one as used in ST-11 (Detention Example for Spreadsheet).

Approach

A brief description of detention requirements and NRCS methods are given in ST-10, Detention Computations. All hydrologic and hydraulic computations for stormwater detention facilities must be prepared and stamped by a registered engineer (licensed in the state of Tennessee) who is proficient in this field. Plans must show sufficient information to allow the builder to construct the detention structure correctly, and to verify that the detention facility operates as required.

In Section 22.5-33 of the Knoxville Stormwater and Street Ordinance, hydrologic and hydraulic computations are required to be in accordance with National Resources Conservation Service (NRCS) methods. The NRCS Unit Hydrograph shall be used with average antecedent moisture conditions (AMC II) and Type II rainfall distribution, as specified by Technical Release 55 (TR-55) publication from June 1986. The TR-55 publication ("Urban Hydrology for Small Watersheds", reference 175) can be downloaded at:

http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html

NRCS Computational Software

A brief description of common hydrograph and detention routing software is given in ST-10, Detention Computations. This BMP represents one option available to the stormwater designer. Both HEC-1 and HEC-HMS are freely available software programs that can be downloaded from the U.S. Army Corps of Engineers website. These programs can generate hydrographs using several methods and also perform detention storage routing. The program user generates the elevation-discharge-volume (E-Q-V) curves by manually computing and analyzing each type of outlet device (by hand or with a spreadsheet) separately prior to combining the results as input data for the hydrograph routing program.

Software computations submitted for review to the City of Knoxville must include all of the necessary input data to reproduce the detention design, including details as needed to illustrate the outlet structure. Computations should be organized and neatly printed on standard 8.5" x 11" paper so that the results are easily referenced and located. The Knoxville Engineering Department may require verification of software programs that are unproved or not well-known in the Knoxville area.

Overview of HEC-1 Software

Introduction

HEC-1 is a commonly-used hydrograph program originally developed by the U.S. Army Corps of Engineers (USACE) over 30 years ago, and adapted to personal computers in the mid-1980s. The HEC-1 program and the associated HEC-1 user's manual can be downloaded from the USACE website at:

http://www.hec.usace.army.mil/software/legacysoftware/hec1/hec1.htm

HEC-1 is a DOS-based program for which the user prepares an input data file prior to running the program. Each line of the HEC-1 input file is called a "card" (from days when computers used punched cards). See the example input file on page ST-12-8. The first two letters of each line (columns 1-2) designate the type of data shown on that line. The example input file on page ST-12-6 uses the following 16 types of cards:

HEC-1 input "cards"

ID = project identification, * = comments, IT = time specification
IN = input data interval, IO = output control, KK = location identifier,
BA = basin area, PB = basin total precipitation,
PC = cumulative precipitation, RS = storage routing, LS = loss rate,
UD = unit dimensionless hydrograph, SQ = discharge data,
SV = storage volume data, SE = elevation data, ZZ = end of run

Appendix A of the *HEC-1 User's Manual* provides a complete description for the data fields. It is recommended that the HEC-1 user should print the input card description for each type of input card used. Each line contains up to 10 data fields with a maximum line length of 80 spaces or columns. The data fields are in a "fixed-format" unless otherwise specified by a *FREE card. The data fields each contain 8 spaces, except for the first data field which only has 6 spaces (columns 3-8). Numbers should be right-justified within each 8-space field and/or contain a decimal point.

The NRCS Type II rainfall distribution is entered on PC or PI cards; the example on page ST-12-8 is shown using cumulative rainfall fractions (PC cards) at intervals of 0.1 hours. Do not use PH cards to specify the intensity-duration-frequency curve, as this rainfall pattern does not match the NRCS Type II rainfall distribution.

Postdeveloped watershed input parameters (area, curve number, time of concentration) are entered on the BA, LS and UD cards. The basin area is entered as square miles on the first field of the BA card. The curve number is entered on the second field of LS card. Instead of the time of concentration, the lag time (in hours) is entered on the first field of the UD card, with the lag time equal to 2/3 of Tc.

The overall elevation-discharge-volume (E-Q-V) relationship is entered on matching fields of the cards labeled SE, SQ, and SV. The units for the E-Q-V curve are: feet elevation (SE), cubic feet per second (SQ), and acre-feet (SV). The following pages show an example of HEC-1 input file (for iteration #1 of the detention basin design *****) and HEC-1 output file (for iteration #2 of the detention basin design ******):

Worksheet #2 from ST-11 is highly recommended as a starting point for storage volume estimates

Pages		Contents of HEC-1 file	File name
ST-12-8	*	Initial detention estimate	HEC1-ex1.dat
ST-12-9 to ST-12-11	**	Final detention computation output	HEC1-ex2.out

***** Initial detention estimate corresponds to the example spreadsheet in ST-11.
****** Final detention computation using the revised outlet configuration in ST-11.

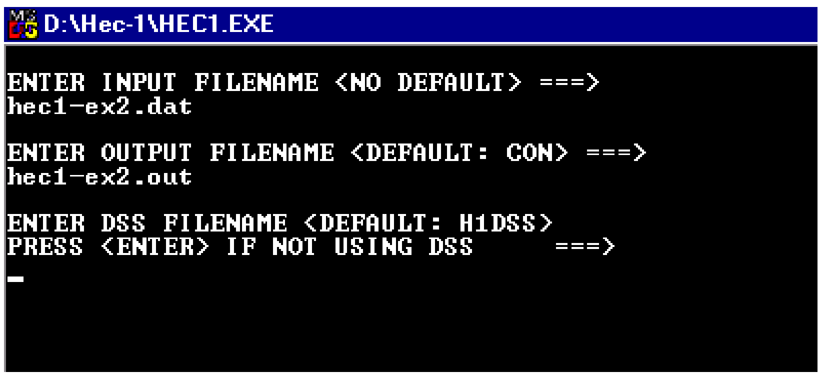
To improve the output precision of a HEC-1 run by a decimal point, perform these simple modifications:

- Multiply the basin area (BA card) by a factor of 10.
- Multiply either the pond areas or pond volumes (SA or SV cards) by a factor of 10.
- Multiply the pond outflows (SQ cards) by a factor of 10.

The example HEC-1 input file on page ST-12-8 includes the three modifications listed above (shown in bold print), using SV cards rather than SA cards. After running the HEC-1 file, the peak inflow and outflow values should be divided by 10 to determine the actual output values.

Hints for Using HEC-1 Example File

- After downloading and installing the HEC-1 program, it will run by clicking on the file HEC-1.EXE. As part of the HEC-1 program, a screen will pop up to ask for the input filename, the output filename, and an optional DSS filename (which is not needed). The input file needs to be in the same subdirectory as the HEC-1 program.



- The input data files for the initial design configuration (hec1-ex1.dat) and for the final outlet structure configuration (hec1-ex2.dat) are included in this BMP. The input data file can be easily edited using any type of ASCII text editor (such as Notepad). Align input data into the correct columns.
- The following cards each only need one value changed: BA, PB, LS, UD, RS. BA is the basin area in square miles, PB is the 24-hour rainfall in inches, LS is the postdeveloped curve number, UD is the time of concentration multiplied by 0.67, and RS is the starting water surface elevation of the analysis.
- The following cards need to be recomputed and revised whenever the detention basin volumes and/or outlet structure configuration are changed: SE, SQ, SV. A new E-Q-V curve can be computed by hand or by spreadsheet. Provide a sufficient number of values to accurately reflect the storage and discharge curves.
- The HEC-1 output data is formatted by the program for the wide green computer paper commonly used 30 years ago. To print onto 8.5” x 11” paper, shrink all of the output text to Courier New, font size 8, with 0.25” margins all around the page. Or print the results using paper with a landscape orientation.

Overview of HEC-HMS Software

Introduction

The HEC-HMS is a windows-based hydrograph program developed by the U.S. Army Corps of Engineers (USACE) to succeed HEC-1. The HEC-HMS software program and associated manuals can be downloaded from the USACE website at:

http://www.hec.usace.army.mil/software/software.html

Within the HEC-HMS program, the user creates three different types of components for each modeling run:

HEC-HMS components

- Basin: size, precipitation loss functions, routing parameters, routing lengths and channels, baseflow, reservoirs.
- Meteorological: precipitation gages, rainfall distributions, storm events.
- Control: duration of analysis, time intervals, computational increment.

Different basin configurations and outlet structures can be tested by mixing and matching different components for a modeling run. After each modeling run, the routing results can be displayed by selecting each element from the basin schematic and choosing "View Results" from the menu. Graphical output and/or a global summary sheet can also be viewed. The HEC-HMS program can import HEC-1 input files, which can be helpful in preparing reports and graphs.

The current version of HEC-HMS will only allow the user to directly input one orifice and one weir. For structures with more than one orifice, the user will have to compute the elevation-storage-discharge data separately (by hand or by spreadsheet) prior to entering the input data.

The HEC-HMS data interface can be confusing. For instance, sometimes it is not obvious how to edit existing data files for the various components. For most screens, select the file with the cursor and then choose "Edit" from the pulldown menu.

The HEC-HMS program is much more complicated than the HEC-1 program and will require a longer learning curve to use effectively. For most engineers, it will take some patience to learn how to use the HEC-HMS model. Read and review the available training documents (Users Manual, Technical Reference Manual) while practicing with the data sets provided by the U.S. Army Corps of Engineers.

The NRCS Type II rainfall distribution can be typed into the precipitation gage data fields once, and then used over and over again for different projects by transfering gage data into new project files as needed. The rainfall distribution can be adjusted on each model run by choosing "Run Options" and then selecting a precipitation ratio.

Other Hints for Using HEC-HMS Software

- The program user must save each component as it is being edited, and also must save the project file prior to exiting the HEC-HMS program.
- The component with meteorological data, once it has been edited correctly, can be used and reused for all project files. The total rainfall amount can be adjusted on each model run by selecting "Run Options" from the Run Manager screen.
- Each iteration (predeveloped & postdeveloped) can be run within the same basin model (shown on page ST-12-12) by placing the design elements in parallel alignment, reducing the number of basin files and components needed.

Detention Example

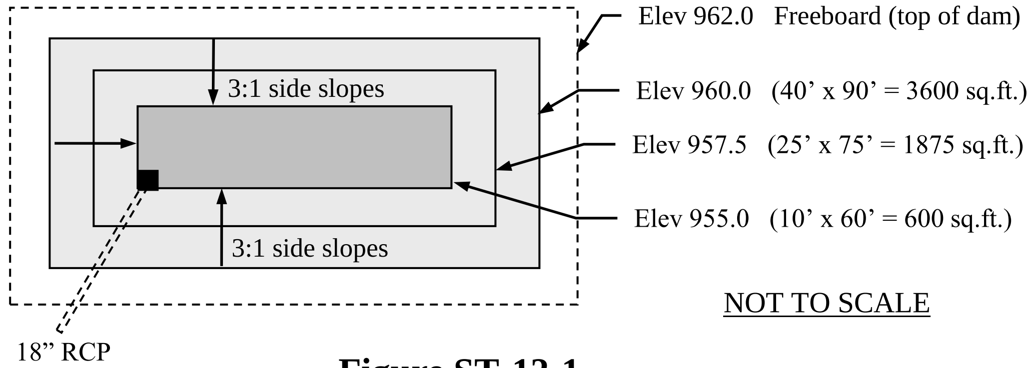


Figure ST-12-1
Example Detention Basin Geometry

Input Data Needed

The initial volume estimate was made using Worksheet #2 (page ST-11-11), which is based on NRCS methods outlined in the TR-55 publication. To summarize the watershed parameters from ST-11:

Predeveloped CN = 75	Postdeveloped CN = 90
Predeveloped Tc = 0.4 hours	Postdeveloped Tc = 0.1 hours
Predeveloped area = 1.5 acres	Postdeveloped area = 1.5 acres

Volumes are computed from a rectangular detention basin with 3:1 slopes:

10’ x 60’ at elevation 955	First flush volume = 4500 cubic feet
25’ x 75’ at elevation 957.5	(from elevation 958.20 and below)
40’ x 90’ at elevation 960	
52’ x 102’ at elevation 962	

The initial outlet structure configuration was selected as a square concrete riser with four circular orifices to limit postdevelopment flow rates to predevelopment flow rates:

Initial outlet structure configuration

- 4” orifice at invert 955.00
- 8” orifice at invert 957.85
- 6” orifice at invert 958.40
- 4” orifice at invert 959.20
- top of square concrete riser at 959.90 (total weir length of 8’)

This iteration was computed in the HEC-1 input data file on page ST-12-6, and similar data was used within the HEC-HMS program. However, this outlet structure configuration did not account for the first flush volume to be detained for a minimum of 24 hours, so a second iteration was required. The bottommost orifice is sized as 1.25” diameter (page ST-10-9) to release the first flush volume (4500 cubic feet at the required flow rate. A second outlet structure configuration (determined by trial and error) is:

Final outlet structure configuration

- 1.25” orifice at invert 955.00
- 8” orifice at invert 958.20
- 6” orifice at invert 958.50
- 4” orifice at invert 959.20
- top of square concrete riser at 960.65 (total weir length of 8’)

The second iteration was computed in the HEC-1 output file shown on pages ST-12-9 through ST-12-11. Both HEC-1 and HEC-HMS will require the user to first compute the overall elevation-discharge-volume (E-Q-V) curve. The E-Q-V curve for this example was taken from spreadsheets shown on pages ST-11-13 to ST-11-16 in the previous BMP.

After the stormwater detention computations are completed, an additional 15% storage volume is provided. Multiply the 100-year peak flow storage volume by 115% to determine an elevation adjustment value. Raise the top of the concrete riser (or other principal outlet control) by this value to provide 15% additional storage volume. An example of this computation is shown on page ST-10-8.

HEC-1 Results

Predevelopment Flows (HEC-1 Version 4.1, June 1998)

HEC-1 input file without detention for: A = 1.5 acres, CN = 75, Tc = 0.4 hours

Return period	*Peak flow*	*Time of peak inflow*
1-year	*0.8 cfs*	*11.93 hours*
2-year	*1.6 cfs*	*“ “*
5-year	*2.4 cfs*	*“ “*
10-year	*3.2 cfs*	*“ “*
25-year	*4.0 cfs*	*“ “*
100-year	*5.2 cfs*	*“ “*

Iteration #1: HEC-1 Results (Version 4.1, June 1998)

(Results from the HEC-1 input data file on page ST-12-8.)

Return period	*Peak inflow*	*Peak outflow*	*Target*	*Peak WSE*	*Time of peak outflow*
1-year	*3.3 cfs*	*0.6 cfs*	*0.8 cfs ✓*	*957.53*	*12.20 hours*
2-year	*4.9 cfs*	*1.2 cfs*	*1.6 cfs ✓*	*958.24*	*12.17 “*
5-year	*6.4 cfs*	*2.3 cfs*	*2.4 cfs ✓*	*958.73*	*12.10 “*
10-year	*7.8 cfs*	*3.1 cfs*	*3.2 cfs ✓*	*959.11*	*12.10 “*
25-year	*9.2 cfs*	*3.8 cfs*	*4.0 cfs ✓*	*959.47*	*12.10 “*
100-year	*11.1 cfs*	*5.1 cfs*	*5.2 cfs ✓*	*959.90*	*12.10 “*

Iteration #2: HEC-1 Results (Version 4.1, June 1998)

(Results from the HEC-1 output data file on pages ST-12-9 through ST-12-11.)

Return period	*Peak inflow*	*Peak outflow*	*Target*	*Peak WSE*	*Time of peak outflow*
1-year	*3.3 cfs*	*0.2 cfs*	*0.8 cfs ✓*	*958.30*	*12.97 hours*
2-year	*4.9 cfs*	*1.2 cfs*	*1.6 cfs ✓*	*958.81*	*12.17 “*
5-year	*6.4 cfs*	*2.3 cfs*	*2.4 cfs ✓*	*959.31*	*12.10 “*
10-year	*7.8 cfs*	*3.1 cfs*	*3.2 cfs ✓*	*959.72*	*12.10 “*
25-year	*9.2 cfs*	*3.7 cfs*	*4.0 cfs ✓*	*960.11*	*12.10 “*
100-year	*11.1 cfs*	*5.4 cfs*	*5.2 cfs ✓*	*960.58*	*12.10 “*

HEC-HMS Results

Predevelopment Flows (HEC-HMS Version 2.2.1, October 2002)

HEC-HMS input file without detention for: A = 1.5 acres, CN = 75, Tc = 0.4 hours

Return period	*Peak flow*	*Time of peak inflow*
1-year	*0.83 cfs*	*11:58 hours*
2-year	*1.60 cfs*	*“ “*
5-year	*2.46 cfs*	*“ “*
10-year	*3.27 cfs*	*“ “*
25-year	*4.10 cfs*	*“ “*
100-year	*5.34 cfs*	*“ “*

Iteration #1: HEC-HMS Results (Version 2.2.1, October 2002)

(Using a HEC-HMS project file similar to input file on page ST-12-8, but with an embedded Type II NRCS rainfall.)

Return period	*Peak inflow*	*Peak outflow*	*Target*	*Peak WSE*	*Time of peak outflow*
1-year	*3.7 cfs*	*0.7 cfs*	*0.8 cfs* ✓	*957.68*	*12:10 hours*
2-year	*5.3 cfs*	*1.4 cfs*	*1.6 cfs* ✓	*958.34*	*12:08 "*
5-year	*6.9 cfs*	*2.5 cfs*	*2.5 cfs* ✓	*958.82*	*12:06 "*
10-year	*8.3 cfs*	*3.3 cfs*	*3.3 cfs* ✓	*959.19*	*12:06 "*
25-year	*9.7 cfs*	*4.0 cfs*	*4.1 cfs* ✓	*959.54*	*12:06 "*
100-year	*11.6 cfs*	*5.3 cfs*	*5.3 cfs* ✓	*959.96*	*12:06 "*

Iteration #2: HEC-HMS Results (Version 2.2.1, October 2002)

(Using a HEC-HMS project file similar to pages ST-12-9 to ST-12-11 with an embedded Type II NRCS rainfall.)

Return period	*Peak inflow*	*Peak outflow*	*Target*	*Peak WSE*	*Time of peak*
1-year	*3.7 cfs*	*0.3 cfs*	*0.8 cfs* ✓	*958.48*	*12:36 hours*
2-year	*5.3 cfs*	*1.6 cfs*	*1.6 cfs* ✓	*958.97*	*12:08 "*
5-year	*6.9 cfs*	*2.6 cfs*	*2.5 cfs* ✓	*959.47*	*12:06 "*
10-year	*8.3 cfs*	*3.3 cfs*	*3.3 cfs* ✓	*959.87*	*12:06 "*
25-year	*9.7 cfs*	*3.8 cfs*	*4.1 cfs* ✓	*960.24*	*12:06 "*
100-year	*11.6 cfs*	***6.3** cfs*	*5.3 cfs* ***X***	*960.64*	*12:04 "*

Adding more points increases accuracy of routing computation.

By adding extra E-Q-V points at elevations 960.60, 960.70 and 960.80, the detention routing computations for the 100-year storm (for iteration #2) become more accurate:

100-year	*11.6 cfs*	***5.5** cfs*	*5.3 cfs* ✓	*960.68*	*12:04 hours*

Conclusions

The example software programs used in this BMP (HEC-1 and HEC-HMS hydrograph routing) are able to generate inflow hydrographs and route them with a designed detention basin. Many commercially available programs can also accomplish these same tasks. Detention routing is necessary to verify that design estimates are adequate, particularly since the initial volume estimate method within the TR-55 document does not take into account the first flush volume requirements. Available detention space and configuration must be included into a project site very early in the design process.

Comparison of HEC-1 and HEC-HMS Programs

HEC-HMS has a few advantages over HEC-1 for detention routing analysis:

- The NRCS Type II storm can be easily selected as a menu option, instead of requiring to be input as a rainfall distribution with PC or PI cards.
- Basin areas can be entered with more precision; therefore, the user does not have to use the "multiply & divide by 10" procedure as per HEC-1 in order to add a decimal point to the final answers.
- U.S. Army Corps of Engineers is making adjustments/improvements to the HEC-HMS program each year. Therefore, HEC-HMS will be state-of-the-art for many years, while HEC-1 is no longer actively supported. Printing and checking graphical displays is easier to accomplish using HEC-HMS.

The advantages of HEC-1 include:

- The HEC-1 input data file (and/or output file) is easy to edit and contains all input information in one location. A single data file is easier to archive, share and print when compared to the multiple files used by HEC-HMS.
- HEC-1 is not as complicated as HEC-HMS and is easier for occasional users to learn and master.

References

153, 154, 158, 175, 180, 181, 186, 187, 200 (see BMP Manual Chapter 10 for list)
Knoxville Stormwater and Street Ordinance

```
ID  HEC-1 run for BMP Manual   ---   Initial volume estimate with the
ID  ST-12, Detention Examples        initial outlet structure configuration.
ID  10-YEAR  24-HOUR STORM
*
*      This example problem has 1.5 acres, CN = 90, Tc = 0.1 hour.
*      The basin area (BA), pond volumes (SV) and pond outflows (SQ) are
*      multiplied by a factor of 10 to increase the precision of analysis.
*      In other words, the basin area is input as 0.02344 square miles (15 acres).
*      Detention basin is initially sized with spreadsheet ST-11 (Worksheet #2).
*      City of Knoxville - Engineering Department - Ken Oliver
*      May 1, 2003
*      File:  Hec1-ex1.dat
*
IT     2 01MAY03    0000    1500                    2000
IN     6
IO     5       0
*
KK AREA1     Runoff into detention basin
BA.02344              * Basin area must be entered as square miles.
PB   4.8              * Total precipitation must be entered as inches.
PC 0.000   0.001   0.002   0.003   0.004   0.005   0.006   0.007   0.008   0.009
PC 0.010   0.012   0.013   0.014   0.015   0.016   0.017   0.018   0.020   0.021
PC 0.022   0.023   0.024   0.026   0.027   0.028   0.029   0.031   0.032   0.033
PC 0.034   0.036   0.037   0.038   0.040   0.041   0.042   0.044   0.045   0.047
PC 0.048   0.049   0.051   0.052   0.054   0.055   0.057   0.058   0.060   0.061
PC 0.063   0.065   0.066   0.068   0.070   0.071   0.073   0.075   0.076   0.078
PC 0.080   0.082   0.084   0.085   0.087   0.089   0.091   0.093   0.095   0.097
PC 0.099   0.101   0.103   0.105   0.107   0.109   0.111   0.113   0.116   0.118
PC 0.120   0.122   0.125   0.127   0.130   0.132   0.135   0.138   0.141   0.144
PC 0.147   0.150   0.153   0.157   0.160   0.163   0.166   0.170   0.173   0.177
PC 0.181   0.185   0.189   0.194   0.199   0.204   0.209   0.215   0.221   0.228
PC 0.235   0.243   0.251   0.261   0.271   0.283   0.307   0.354   0.431   0.568
PC 0.663   0.682   0.699   0.713   0.725   0.735   0.743   0.751   0.759   0.766
PC 0.772   0.778   0.784   0.789   0.794   0.799   0.804   0.808   0.812   0.816
PC 0.820   0.824   0.827   0.831   0.834   0.838   0.841   0.844   0.847   0.850
PC 0.854   0.856   0.859   0.862   0.865   0.868   0.870   0.873   0.875   0.878
PC 0.880   0.882   0.885   0.887   0.889   0.891   0.893   0.895   0.898   0.900
PC 0.902   0.904   0.906   0.908   0.910   0.912   0.914   0.915   0.917   0.919
PC 0.921   0.923   0.925   0.926   0.928   0.930   0.931   0.933   0.935   0.936
PC 0.938   0.939   0.941   0.942   0.944   0.945   0.947   0.948   0.949   0.951
PC 0.952   0.953   0.955   0.956   0.957   0.958   0.960   0.961   0.962   0.964
PC 0.965   0.966   0.967   0.968   0.970   0.971   0.972   0.973   0.975   0.976
PC 0.977   0.978   0.979   0.981   0.982   0.983   0.984   0.985   0.986   0.988
PC 0.989   0.990   0.991   0.992   0.993   0.994   0.996   0.997   0.998   0.999
PC 1.000
LS     0      90      *  This is the postdeveloped curve number (CN=90).
UD  .067              *  This is the SCS lag time in hours (equal to 2/3 of Tc).
*
KK PONDA     Route the hydrograph from Area 1 through Pond A
RS     1    ELEV   955.0       0
SV     0  0.0807  0.1876  0.3230  0.4886  0.6869  0.9196  1.1887  1.4964  1.8448
SV2.2358  2.6717  3.1543  3.6859  4.2685
SQ  0.00     2.4     3.8     4.9     5.7     6.4     7.7    17.2    29.0    38.2
SQ  53.8   164.2   198.0   208.0   218.0
SE 955.0   955.5   956.0   956.5   957.0   957.5   958.0   958.5   959.0   959.5
SE 960.0   960.5   961.0   961.5   962.0
ZZ
```

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*    U.S. ARMY CORPS OF ENGINEERS       *
*               JUN   1998              *
*    HYDROLOGIC ENGINEERING CENTER      *
*            VERSION 4.1                *
*          609 SECOND STREET            *
*                                       *
*       DAVIS, CALIFORNIA 95616         *
*  RUN DATE    1MAY03  TIME  11:20:31   *
*           (916) 756-1104              *
*                                       *
*****************************************

  X     X  XXXXXXX   XXXXX          X
  X     X  X        X     X        XX
  X     X  X        X               X
  XXXXXXX  XXXX     X        XXXXX  X
  X     X  X        X               X
  X     X  X        X     X         X
  X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES –RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.

THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION

NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION,
DSS:WRITE STAGE FREQUENCY
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL
LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

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                            HEC-1 INPUT
LINE
ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1  ID   HEC-1 run for BMP Manual     ---   Detention rating computations with the
2  ID   ST-12, Detention Examples          final outlet structure configuration
3  ID   10-YEAR  24-HOUR STORM             Only the SQ cards have been changed.
*
*      This example problem has 1.5 acres, CN = 90, Tc = 0.1 hour.
*      The basin (BA), pond volumes (SV) and pond outflows (SQ) are
*      multiplied by a factor of 10 to increase the precision of analysis.
*      In other words, the basin area is input as 0.02344 square miles (15 acre
*
*      Detention basin was initially sized using NRCS TR-55 methodology.
*      City of Knoxville - Engineering Department - Ken Oliver
*      May 1, 2003
*      File:  Hec1-ex2.dat
*
*DIAGRAM
4  IT        2 01MAY03    0000    1500                 2000
5  IN        6
6  IO        5       0
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*
*      1-year storm   2.5"
*      2-year storm   3.3"
*      5-year storm   4.1"
*     10-year storm   4.8"
*     25-year storm   5.5"
*     50-year storm   6.1"
*    100-year storm   6.5"
*
7  KK   AREA1     Runoff into detention basin
8  BA  .02344     (= 15.0 acres, which is ten times the actual area of 1.5 acres)
9  PB     4.8
10 PC 0.000   0.001   0.002   0.003   0.004   0.005   0.006   0.007   0.008  0.009
11 PC 0.010   0.012   0.013   0.014   0.015   0.016   0.017   0.018   0.020  0.021
12 PC 0.022   0.023   0.024   0.026   0.027   0.028   0.029   0.031   0.032  0.033
13 PC 0.034   0.036   0.037   0.038   0.040   0.041   0.042   0.044   0.045  0.047
14 PC 0.048   0.049   0.051   0.052   0.054   0.055   0.057   0.058   0.060  0.061
15 PC 0.063   0.065   0.066   0.068   0.070   0.071   0.073   0.075   0.076  0.078
16 PC 0.080   0.082   0.084   0.085   0.087   0.089   0.091   0.093   0.095  0.097
17 PC 0.099   0.101   0.103   0.105   0.107   0.109   0.111   0.113   0.116  0.118
18 PC 0.120   0.122   0.125   0.127   0.130   0.132   0.135   0.138   0.141  0.144
19 PC 0.147   0.150   0.153   0.157   0.160   0.163   0.166   0.170   0.173  0.177
20 PC 0.181   0.185   0.189   0.194   0.199   0.204   0.209   0.215   0.221  0.228
21 PC 0.235   0.243   0.251   0.261   0.271   0.283   0.307   0.354   0.431  0.568
22 PC 0.663   0.682   0.699   0.713   0.725   0.735   0.743   0.751   0.759  0.766
23 PC 0.772   0.778   0.784   0.789   0.794   0.799   0.804   0.808   0.812  0.816
24 PC 0.820   0.824   0.827   0.831   0.834   0.838   0.841   0.844   0.847  0.850
25 PC 0.854   0.856   0.859   0.862   0.865   0.868   0.870   0.873   0.875  0.878
26 PC 0.880   0.882   0.885   0.887   0.889   0.891   0.893   0.895   0.898  0.900
27 PC 0.902   0.904   0.906   0.908   0.910   0.912   0.914   0.915   0.917  0.919
28 PC 0.921   0.923   0.925   0.926   0.928   0.930   0.931   0.933   0.935  0.936
29 PC 0.938   0.939   0.941   0.942   0.944   0.945   0.947   0.948   0.949  0.951
30 PC 0.952   0.953   0.955   0.956   0.957   0.958   0.960   0.961   0.962  0.964
31 PC 0.965   0.966   0.967   0.968   0.970   0.971   0.972   0.973   0.975  0.976
32 PC 0.977   0.978   0.979   0.981   0.982   0.983   0.984   0.985   0.986  0.988
33 PC 0.989   0.990   0.991   0.992   0.993   0.994   0.996   0.997   0.998  0.999
34 PC 1.000
35 LS     0      90
36 UD  .067
*
37 KK PONDA
38 KM           ROUTE HYDROGRAPH FROM AREA A THROUGH POND A
39 RS     1    ELEV   955.0      0
40 SV     0  0.0807  0.1876  0.3230  0.4886  0.6869  0.9196  1.1887  1.4964 1.8448
41 SV2.2358  2.6717  3.1543  3.6859  4.2685
42 SQ  0.0     0.3     0.4     0.5     0.6     0.6     0.7     3.0    17.0   27.0
43 SQ  35.2    41.5   119.4   208.0   218.0
44 SE 955.0   955.5   956.0   956.5   957.0   957.5   958.0   958.5   959.0  959.5
45 SE 960.0   960.5   961.0   961.5   962.0
46 ZZ

                 SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
   NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

    7       AREA1
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                 V
                 V
   37       PONDA

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*    U.S. ARMY CORPS OF ENGINEERS      *
*              JUN   1998              *
*    HYDROLOGIC ENGINEERING CENTER     *
*           VERSION 4.1                *
*         609 SECOND STREET            *
*                                      *
*       DAVIS, CALIFORNIA 95616        *
*  RUN DATE    1MAY03  TIME  11:20:31  *
*           (916) 756-1104             *
*                                      *
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HEC-1 run for BMP Manual     ---   Detention rating computations with the
ST-12, Detention Examples          final outlet structure configuration
10-YEAR  24-HOUR STORM             Only the SQ cards have been changed.

    6 IO          OUTPUT CONTROL VARIABLES
                        IPRNT           5  PRINT CONTROL
                        IPLOT           0  PLOT CONTROL
                        QSCAL          0.  HYDROGRAPH PLOT SCALE

      IT          HYDROGRAPH TIME DATA
                         NMIN           2  MINUTES IN COMPUTATION INTERVAL
                        IDATE      1MAY 3  STARTING DATE
                        ITIME        0000  STARTING TIME
                           NQ        1500  NUMBER OF HYDROGRAPH ORDINATES
                       NDDATE      3MAY 3  ENDING DATE
                       NDTIME        0158  ENDING TIME
                        ICENT          20  CENTURY MARK

                    COMPUTATION INTERVAL     .03 HOURS
                         TOTAL TIME BASE   49.97 HOURS

           ENGLISH UNITS
                DRAINAGE AREA         SQUARE MILES
                PRECIPITATION DEPTH   INCHES
                LENGTH, ELEVATION     FEET
                FLOW                  CUBIC FEET PER SECOND
                STORAGE VOLUME        ACRE-FEET
                SURFACE AREA          ACRES
                TEMPERATURE           DEGREES FAHRENHEIT

                                        RUNOFF SUMMARY
                                  FLOW IN CUBIC FEET PER SECOND
                               TIME IN HOURS,  AREA IN SQUARE MILES

                         PEAK  TIME OF AVERAGE FLOW FOR MAXIMUM PERIOD BASIN MAXIMUM  TIME OF
OPERATION    STATION    FLOW   PEAK     6-HOUR  24-HOUR  72-HOUR      AREA  STAGE   MAX STAGE

HYDROGRAPH AT  AREA1    78.    11.93      7.       2.       1.         .02
ROUTED TO      PONDA    31.    12.10      6.       2.       1.         .02   959.72    12.10

 *** NORMAL END OF HEC-1 ***
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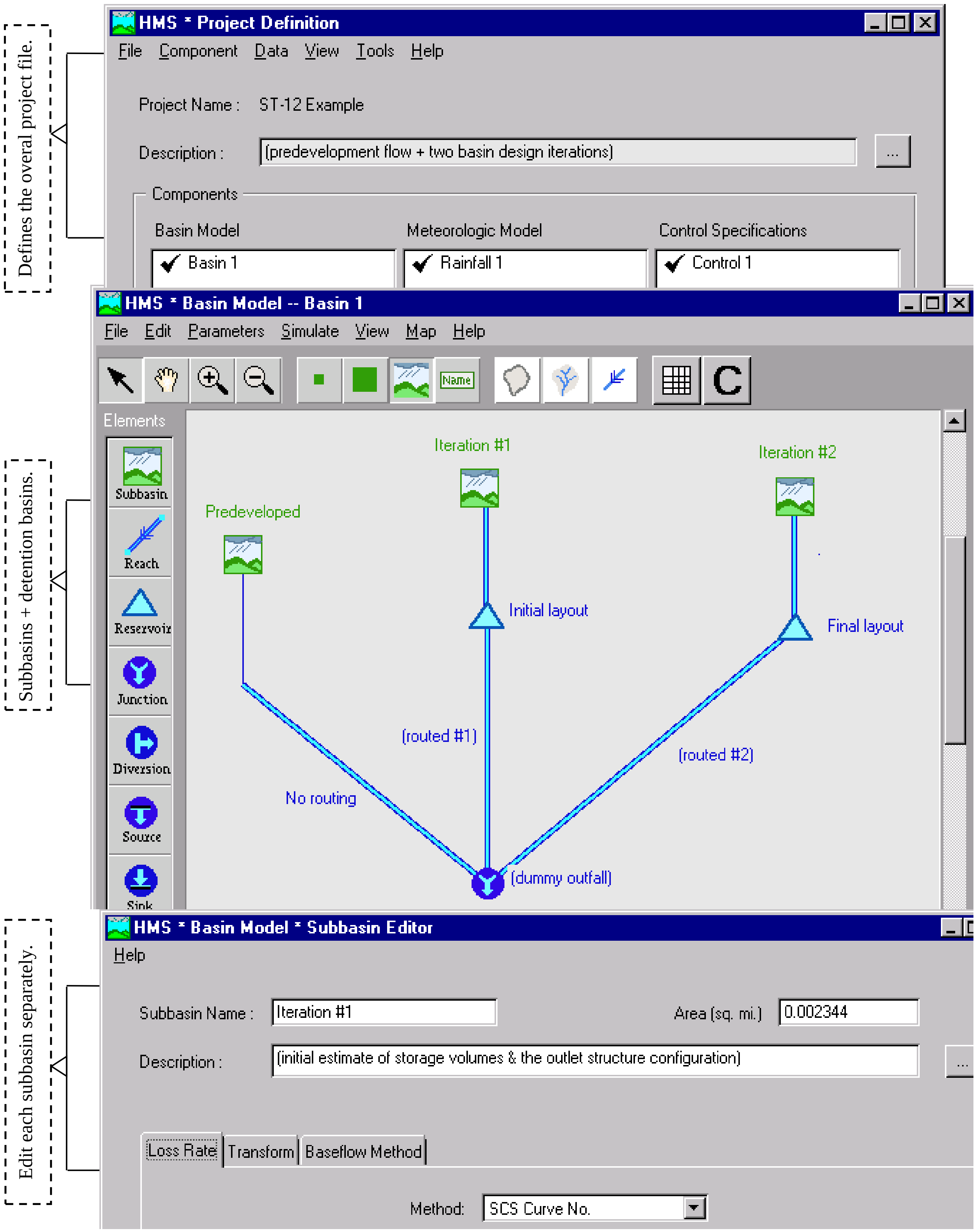
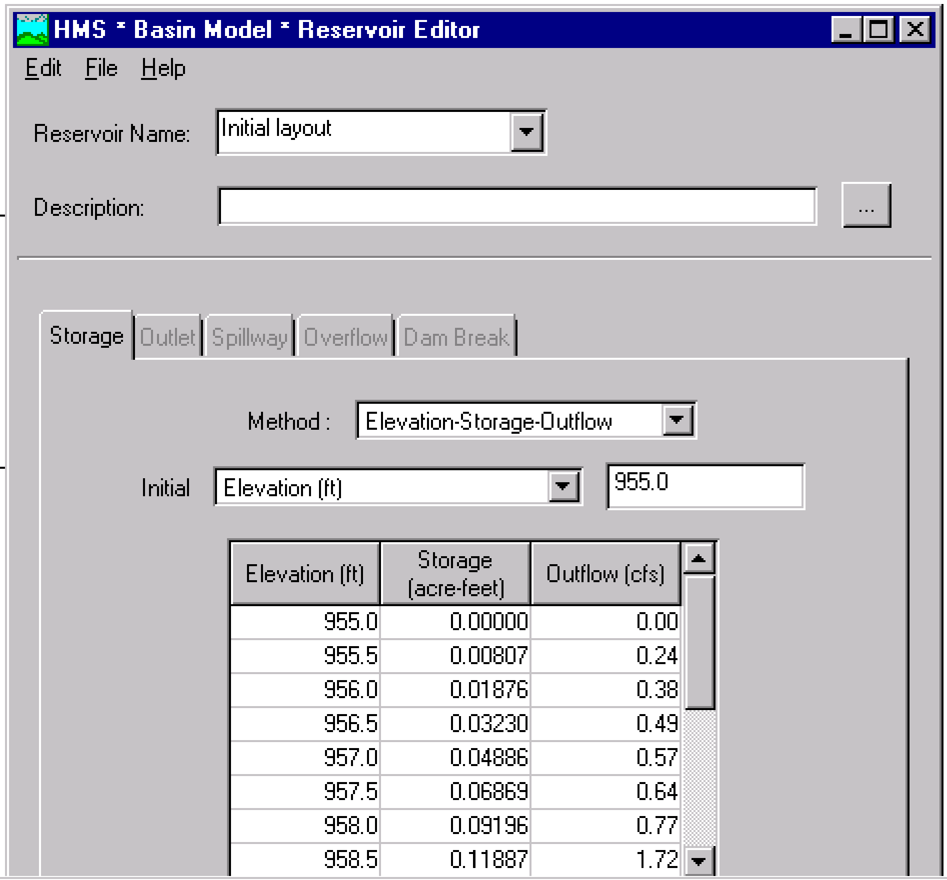
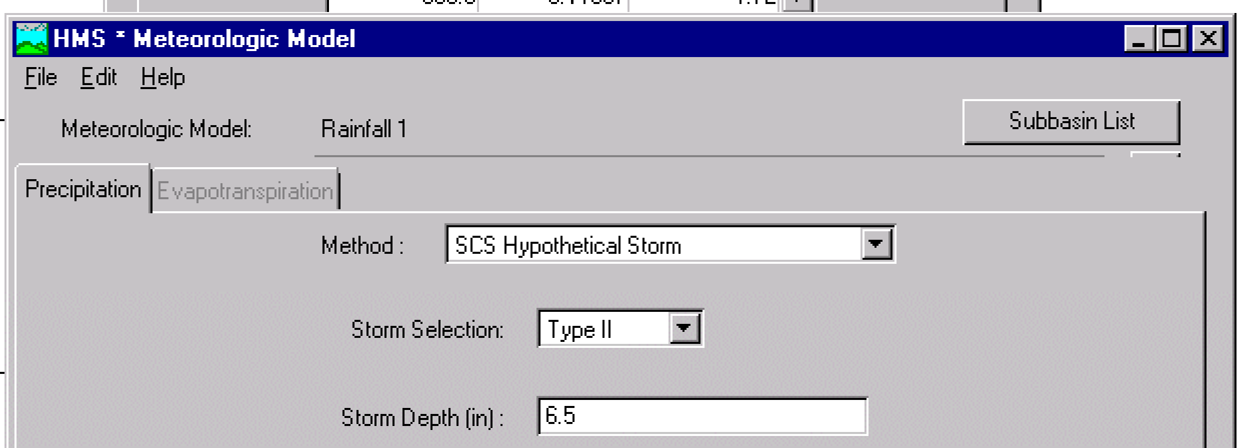
Portions of input data and output summary from HEC-HMS:



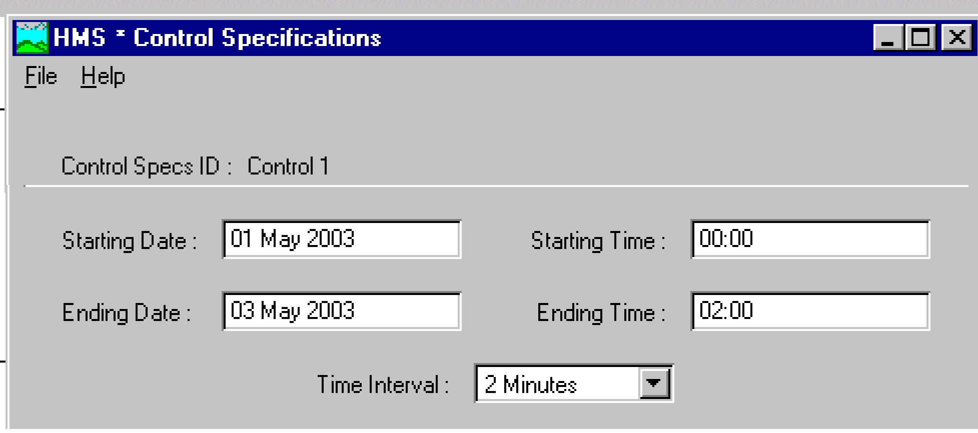
Compute storage and outflow data at regular intervals for input.



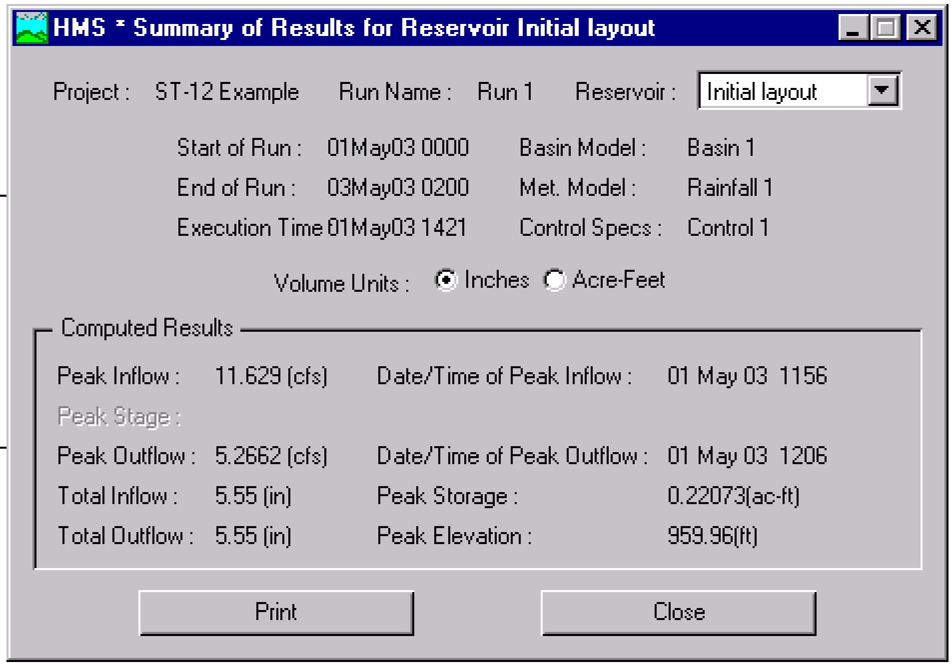
Defines the rainfall distribution.

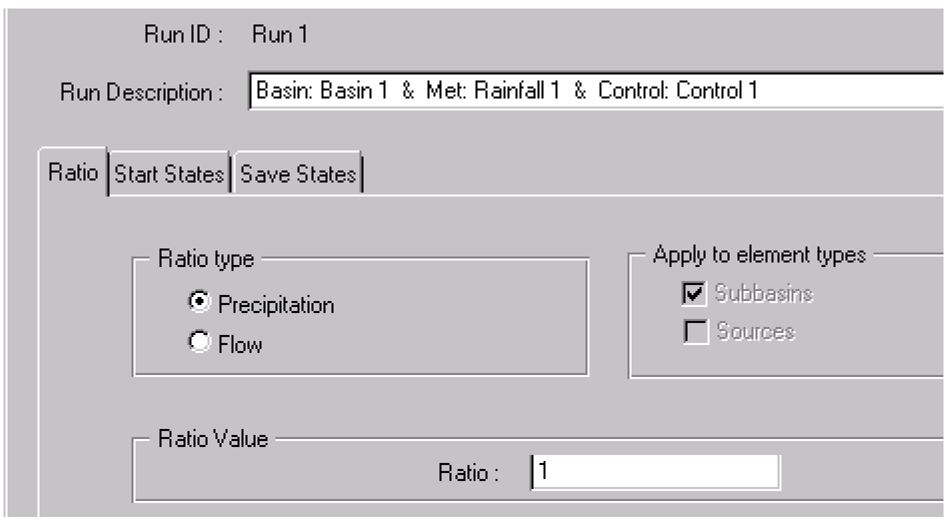


Computational time interval.



Summary routing results for 1 storm.





Example of graphical output for initial layout