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Glossary

AMC, antecedent moisture condition – A quantitative description of watershed soil moisture. The variable in the SCS CN method that accounts for storm to storm variation of hydrologic response to rainfall. AMC II is the median condition, AMC I is a dry condition meaning little previous rainfall, and AMC III is the wet condition meaning soils are relatively saturated.

AML – Arc Macro Language. A scripting language used in ARC/INFO.

ASCII – American standard for code and information exchange.

Basin model – A HEC-HMS input file that describes the elements of a hydrologic system.

Bilinear interpolation – A raster resampling technique in which the value of the new cell center is computed as a weighted average from the values of the four nearest original cell centers.

CASC2D, Cascade, Two Dimensional – A grid based distributed hydrologic runoff model.

CN, curve number – A hydrologic variable determined from soil characteristics and land cover. Also used to refer to the SCS Curve Number method of calculating precipitation excess.

Computer model – A computer algorithm used in the solution of a mathematical model or models when the equations of a mathematical model become too numerous or complex to be solved by hand.

Control specifications – A HEC-HMS input that describes the start time, end time, and time step of a HEC-HMS model run.

CRWR – Center for Research in Water Resources at the University of Texas at Austin.

D8 – Deterministic 8 node algorithm. Used in calculating flow direction from a raster DEM.

DEM burning – The process of selectively imposing a vector stream network on a raster DEM to improve the accuracy of watershed and stream channel delineation. Elevations of raster cells containing an existing stream channel are decreased through raster algebra.

DEM, digital elevation model – A digital model of terrain or topographic data in either a raster or TIN format.

Distributed – A model that accounts for the spatial distribution of model parameters or model inputs.

Downscaling – The process of converting a dataset (typically raster) to a finer resolution.

DPA – Digital precipitation array.

DSS – The data storage system used by HEC-HMS. It is a database structure designed for use with hydrologic data.

DSSTS – DSS time series. A program used to import time series data, either regularly or irregularly spaced, into the HEC DSS database.

ESRI – Environmental Systems Research Institute

EST – Eastern Standard Time.

EDT – Eastern Daylight Time.

Flow accumulation – The number of cells in a raster DEM which drain through a specific DEM cell.

Flow direction – The steepest gradient from each cell in a raster DEM.

GCM – Global Circulation Model

GIS, geographic information system – Computer technology that allows management, analysis, and display of spatial data, which has attached attribute data.

GRID – The raster based processing environment in ARC/INFO.

Grid cell parameter file – A HEC-HMS input file that describes the hydrologic parameters relevant to each grid cell in a watershed.

Grid cell size, grid scale – The spacing of elements in a raster dataset. Equal to the length of the side of a square grid cell.

HEC-GeoHMS – The geographic extrension for HEC-HMS. An ArcView extension requiring ArcView 3.x and Spatial Analyst 1.x.

HEC-GeoRAS – The geographic extension for HEC-RAS. An ArcView extension requiring ArcView 3.x and 3D analyst.

HEC-HMS – Hydrologic Modeling System of the Hydrologic Engineering Center of the U.S. Army Corps of Engineers (USACE).

HEC-RAS – HEC River Analysis System.

Hillshade – A raster dataset typically calculated from a raster DEM showing aspect and shading relative to a specified light source. Used to enhance graphical display.

HRAP – Hydrologic rainfall analysis project. Most often used to refer to the HRAP grid, a polar stereographic projection used to specifiy location of NEXRAD products.

HSG – Hydrologic soil group classification. A measure of soil infiltrative potential.

IFLOWS – Interactive flood level observation and warning system.

KFCX – The identifier for the Blacksburg, VA WSR-88D radar unit.

LFM – Limited Fine Mesh

Lumped – Spatially averaged. A model that does not account for spatial variability in hydrologic processes or model inputs.

Mathematical model – An equation or set of equations that represents the behavior of a system or process.

Mean field bias – The average of radar to gage precipitation ratios taken at a number of points over a geographic area.

Meteorlogic model – A HEC-HMS input that quantifies the precipitation inputs to the hydrologic system.

MIKE-SHE, The microcomputer version of the European Hydrologic System (System Hydrologic European) – A grid based distributed hydrologic runoff model.

ModClark – The Modified version of the Clark Unit Hydrograph utilized in the HEC-HMS distributed runoff model.

Model – A simplified representation of reality used to gain insight into the behavior of a real system.

NAD27 – North American Datum of 1927.

NAD83 – North American Datum of 1983.

Nearest neighbor reassignment – A raster resampling technique in which the value of the nearest new cell center is equivalent to the value of the nearest original cell center.

NED – National elevation dataset of the USGS.

NLCD – National land cover dataset of the USGS.

NRCS – Natural Resources Conservation Service, formerly SCS, of the United States Department of Agriculture (USDA).

NWS – National Weather Service of the National Oceanic and Atmospheric Administration of the US Department of Commerce.

Parameter – A constant or variable form in a mathematical function that describes the specific form of the function but not the general nature. Used in hydrologic modeling to quantify a portion of the hydrologic cycle. Numerical measures of the properties of a real world system.

POI – Point of Inflection.

Raster, grid data structure – A geographic data structure that quantizes space into a series of regularly shaped and spaced (usually square) elements.

Resolution – The level of detail contained in a raster dataset. Not synonymous with cell size.

RFC – River forecast center of the NWS.

RS, remote sensing – the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects.

SCS – Soil Conservation Service, now NRCS, of the United States Department of Agriculture (USDA).

SHG – Standard hydrologic grid. An Albers equal area conical projection proposed by HEC for use in hydrologic modeling with GIS.
Sink – A relative minima in a raster elevation dataset that prevents overland flow from traveling downgradient and reaching the DEM boundary.
SMA – Soil Moisture Accounting.

Smoothing – The downscaling of a raster dataset in which a continuous rate of change is assumed between the original raster cells.
SSURGO – Soil survey geographic database of the NRCS.

Stage I – The first level of processing of NEXRAD rainfall products. Includes quality control with corrections for reflectivity outliers, beam blockages, and isolated reflectivity echoes (DeBarry, et al., 1999).

Stage II – The second level of processing of NEXRAD rainfall products. Stage II processing consists of mean field bias adjustment based on satellite data or ground based gages.

Stage III – The third level of processing of NEXRAD rainfall products. Stage III processing includes mosaicing and overlaying data from adjacent radar units and interactive quality control.

Storm smearing – In a gridded precipitation dataset, reduction in rainfall rates or gradients resulting from the rainfall resolution being coarser that rainfall correlation length.

STATSGO – State soil survey geographic database of the NRCS.

TIN, triangulated irregular network – A vector data structure which represents a continuous based on two basic elements: points with (x, y, z) values, and edges joining these points to form triangles. This triangular mosaic forms a continuous faceted surface.

TR-55 – Technical release 55 of the NRCS, "Urban Hydrology for Small Watersheds."

Upscaling – The process of converting a dataset (typically raster) to a coarser resolution. Also known as degradation or aggregation.

USGS – United States Geological Survey of the Department of the Interior.

UTC – Universal Coordinated Time also known as Greenwich Mean Time (GMT).

Vector data structure – A geographic data structure which represents objects as points, lines, or polygons each with inherent geometric attributes and descriptive attributes.

Watershed – The land area draining through a specific point, separated from other watersheds by a divide.

Watershed smearing – In a gridded precipitation dataset, uncertainty in the location of precipitation due to the precipitation resolution becoming large relative to the watershed size.

WFO – Weather forecast office of the NWS.

WSR-88D NEXRAD – Weather Service Radar, 1988 Doppler, NEXt generation RADar. A network of 10cm wavelength (S band) Doppler radars used by the National Weather Service.

XMRG – "x-merge" a proprietary NWS binary file format used in the storage and transfer of NEXRAD precipitation products.

Z-R – The relationship between reflectivity and rainfall rate in radar estimation of precipitation.

Appendix C ARC/INFO Projection *.prj files

Projection Parameters for HRAP

```
/*--------------------------------------------------------------------
/* hrap.prj
/* Brian C. McCormick 7/1/02
projection polar
units meters
spheroid sphere
parameters
-105 0 0               /* longtitude of the projection center d m s
60 0 24.5304792        /* true latitude d m s.ss
0                      /* false easting
0                      /* false northing
end
/*--------------------------------------------------------------------
```

Projection Parameters for SHG

```
/*--------------------------------------------------------------------
/* shg.prj
/* Brian C. McCormick 7/1/02
projection albers
units meters
spheroid grs80
parameters
29 30 0                /* 1st standard parallel
45 30 0                /* 2nd standard parallel
-96 0 0                /* central meridian
23 0 0                 /* latitude of origin
0.0                    /* false easting
0.0                    /* false northing
end
/*--------------------------------------------------------------------
```

This projection file projects data from HRAP to SHG. A datum shift is required as the data is being projected from a spherical datum to an ellipsoidal datum (NAD83 using the GRS 80 ellipsoid). The projection file used is as follows:

```
/*--------------------------------------------------------------------
/* hrap2shg.prj
/*  projection from HRAP to SHG
/*  Brian McCormick 7/1/02
input                 /*defines the projection of the input data
projection polar
units meters
spheroid sphere
parameters
-105 0 0               /* longtitude of the projection center d m s
60 0 24.5304792        /* true latitude d m s.ss
0                      /* false easting
0                      /* false northing
output                 /* desired projection of the output data set
projection albers
```

```
units meters
spheroid grs80
parameters
29 30 0                 /* 1st standard parallel
45 30 0                 /* 2nd standard parallel
-96 0 0                 /* central meridian
23 0 0                  /* latitude of origin
0.0                     /* false easting
0.0                     /* false northing
end
/*-------------------------------------------------------------------
```

Appendix D: CN grid creation with ARC/INFO GRID

This appendix contains the AML script and selected reclassification tables used in the raster based reclassification of SSURGO and NLCD data to SCS CN.

```
/* ---------------------------------------------------------------
/*
/* CN Grid creation in ARC) GRID) *.aml script.
/* Brian McCormick
/* 7/24/02
/*
/* Requirements prior to running
/* Ensure that classification tables exist for each soil type
encountered in the soil grid
/*
/* ---------------------------------------------------------------
/*
&type Creation of a Curve Number grid from gridded HSG and Land Cover
&type Brian C. McCormick
&type 7/24/02
&type Soil grid, LC grid, and buffered watershed boundary must be in
same workspace
&type Grids must have same registration and resolution

/* set the workspace
&workspace [response 'select workspace where soil and landcover data is
stored']
lg

/* Query user for Soil grid.
&s soil = [response 'enter the name of the soil grid (string)']

/* Query user for CN grid
&s lc = [response 'enter the name of the land cover grid (string)']

/* query user for buffered watershed
&s wshd = [response 'enter the name of the buffered watershed grid
(string)']

grid

/* reclass soil grids to 1 (yes soil) 0 (no soil)
&type splitting soil grid to individual soil types
h:\temp\soila   = Reclass(%soil% , soila.cls   , NODATA)
h:\temp\soilb   = Reclass(%soil% , soilb.cls   , NODATA)
h:\temp\soilbd  = Reclass(%soil% , soilbd.cls  , NODATA)
h:\temp\soilc   = Reclass(%soil% , soilc.cls   , NODATA)
h:\temp\soild   = Reclass(%soil% , soild.cls   , NODATA)
h:\temp\soilurb = Reclass(%soil% , soilurb.cls , NODATA)

/* multiply soil grids by LC grid (outgrid = ingrid1 * ingrid2)
&type multiplying soil types by landcover
h:\temp\lca   = h:\temp\soila   * %lc%
h:\temp\lcb   = h:\temp\soilb   * %lc%
h:\temp\lcbd  = h:\temp\soilbd  * %lc%
h:\temp\lcc   = h:\temp\soilc   * %lc%
```

```
h:\temp\lcd   = h:\temp\soild   * %lc%
h:\temp\lcurb = h:\temp\soilurb * %lc%

/* Reclass LC grids to CNs
&type reclassifying landcover and soil as curve number
h:\temp\cna   = reclass(h:\temp\lca   , lca.cls   , nodata)
h:\temp\cnb   = reclass(h:\temp\lcb   , lcb.cls   , nodata)
h:\temp\cnbd  = reclass(h:\temp\lcbd  , lcbd.cls  , nodata)
h:\temp\cnc   = reclass(h:\temp\lcc   , lcc.cls   , nodata)
h:\temp\cnd   = reclass(h:\temp\lcd   , lcd.cls   , nodata)
h:\temp\cnurb = reclass(h:\temp\lcurb , lcurb.cls , nodata)

/*  Add up CN grids to produce final CN grid
&type summing cn grids to produce overall curve number
h:\temp\cn_unclip = sum(h:\temp\cna , h:\temp\cnb , h:\temp\cnbd ,
h:\temp\cnc ,  h:\temp\cnd , h:\temp\cnurb)

/* "clip" grid using watershed bounding box

gridclip h:\temp\cn_unclip h:\temp\cn_clip Box 1350000 1650000 1430000
1730000

/* "clip" grid using buffered watershed grid

h:\temp\cn = h:\temp\cn_clip * %wshd%

/* reclassify to produce varied AMC estiamtes

cnamc2 = int(h:\temp\cn)
cnamc1 = reclass(cnamc2,amc1.cls,nodata)
cnamc3 = reclass(cnamc2,amc3.cls,nodata)
cnamc15 = reclass(cnamc2,amc15.cls,nodata)
cnamc25 = reclass(cnamc2,amc25.cls,nodata)

/* exit grid
quit
```

Sample soil reclassification table

```
#soila.cls
#reclassifies soila (value = 1) to 1 and else to 0
1 : 1
2 : 0
3 : 0
4 : 0
5 : 0
6 : 0
```

Sample reclassification from NLCD to CN for HSG A

```
/*---------------------------------------------------------------------

# reclassification file used to reclass lc to cn for areas with HSG = A
# lc grid number, description, curve number (first as comments, then as
reclass commands)
#
# 0 No Data 0
0 : 0
# 11 Open Water 100
11 : 100
# 21 Low Intensity Res 54
21 : 54
# 22 High Intensity Res 77
22 : 77
# 23 Commercial / Industrial 85
23 : 85
# 32 Quarries / stripmines / gravel pits 76
32 : 76
# 33 transitional 49
33 : 49
# 41 deciduous forest 30
41 : 30
# 42 evergreen forest 30
42 : 30
# 43 mixed forest 30
43 : 30
# 81 pasture/hay 39
81 : 39
# 82 row crops 68
82 : 68
# 85 urban/recreational grasses 39
85 : 39
# 91 woody wetlands 45
91 : 45
# 92 emergent herbaceous wetlands 45
92 : 45
```

Sample reclassification table to change AMC

```
# AMC II : AMC III
0 : 0
5 : 13
10 : 22
15 : 30
20 : 37
25 : 43
30 : 50
31 : 51
32 : 52
33 : 53
34 : 54
35 : 55
36 : 56
37 : 57
38 : 58
39 : 59
40 : 60
41 : 61
42 : 62
43 : 63
44 : 64
45 : 65
46 : 66
47 : 67
48 : 68
49 : 69
50 : 70
51 : 70
52 : 71
53 : 72
54 : 73
55 : 74
56 : 75
57 : 75
58 : 76
59 : 77
60 : 78
61 : 78
62 : 79
63 : 80
64 : 81
65 : 82
66 : 82
67 : 83
68 : 84
69 : 84
… many lines omitted …
100 : 100
```

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

---

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

---

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

[3] *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2]	A [3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1] Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.

[2] Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.

[3] Curve numbers for group A have been developed only for desert shrub.

Appendix E: Radar Processing

Decoding archived NEXRAD stage III precipitation data. From archived stage III NEXRAD precipitation data to the HEC data storage system database, with coordinate reprojection.

Summary:

The source of spatially distributed precipitation information used in this modeling scale study is an archive of stage III hourly precipitation depths made available by the Hydrology Research Lab (HRL) of the National Weather Service (NWS). This archive contains is in the proprietary NWS XMRG file format, a binary storage format designed for a UNIX platform. These archives are available as far back as 1993 with at least a few years of data available for each NWS river forecast center (RFC). Data, and documentation is available at: http://weather.gov/oh/hrl/dmip/nexrad.html. This information is stored in reference to Universal Coordinated Time (UTC). Monthly archives are available for download and may be decompressed to daily files and then to hourly files using the UNIX tar and uncompress utilities or equivalent. The hourly files have a filename convention of:

xmrgMMDDYYYYHHz

The HH shown in the filename is the time at the end of the hour of interest. Grids therefore show the precipitation depth accumulated in the previous hour. For example, rainfall occurring between 0000UTC and 0100UTC is shown in the 0100UTC grid.

Hourly records are referenced to the Hydrologic Resource Analysis Program (HRAP) map projection, a polar stereographic map projection with parameters described adequately by Fulton (1998) and Reed and Maidment (1999). The NWS xmrg files may be decoded and converted to ASCII grid files on a UNIX platform with a c program provided by the HRL (xmrgtoasc.c). Code must be compiled on a machine with big Endian architecture. The VTAIX machine at the computing center on the Virginia Tech campus was found to be adequate for this purpose. A batch script was written for the UNIX Bourne Shell (xmrgbatch.sh) which runs the tar utilities, uncompress utilities and xmrg to ASCII conversion for all hours of specified days of interest. The decoded ASCII grids, in the HRAP projection, are then available for use in modeling or may be processed further.

To match the map projection and spatial resolution requirements of the HEC-HMS model proposed for the Upper Roanoke Watershed, ASCII grids referenced to the HRAP map projection were reprojected using ARC/INFO projection utilities to the Albers equal area projection known as the Standard Hydrologic Grid (SHG). To accomplish this reprojection in an efficient and reproducible manner, an Arc Macro Language (AML) script was written to perform the necessary conversions in the ARC/INFO GRID environment. The aml script (hrap2shg.aml) utilizes a projection file (hrap2shg.prj) which describes the parameters of the input, HRAP, projection and output, SHG, projection. The script converts the input ASCII text files to ESRI grids, projects them to the desired coordinate system, upscales, downscales or interpolates if requested, clips the grids to a user specified boundary, and rewrites to another ASCII text file for use in modeling.

For this study, the ASCII text files are imported into the HEC Data Storage System (DSS) database utilizing a DOS program provided by the HEC (ai2dssgrid.exe). The use of this program for multiple time steps may be simplified with the use of DOS batch files such as shg2dss.bat which repeatedly run the ai2dssgrid program for the time periods of interest.

The conversion process may be summed up into three steps:

1) Convert NWS archives to ASCII text files using xmrgtoasc.c and xmrgbatch.sh.
   Required inputs: xmrgtoasc.c, xmrgbatch.sh, and monthly *.tar archive.
   Platform: UNIX Workstation such as VTAIX.
2) Process hourly grids in ARC/INFO including reprojection, clipping, resampling, scaling, and unit conversion as necessary using hrap2shg.aml.
   Required inputs: hrap2shg.aml, hrap2shg.prj, hourly ASCII files produced by step 1.
3) Populate the HEC DSS database using the ai2dssgrid.exe program.
   Required inputs: ai2dssgrid.exe, shg2dss.bat, hourly ASCII files produced by step 2.

Filename conventions used in the code and the remainder of this document are as follows:

MM:	2digit month
Mon:	3 character text string of month (ex 01 = jan, 02 = feb…)
DD:	2digit day
YY:	2digit year
YYYY:	4digit year
HHz:	2digit hour in UTC
xmrg:	file stored in xmrg format
asch:	ASCII grid in HRAP projection
hrap:	ARC/INFO grid in HRAP format
s1k:	ARC/INFO grid in SHG format at 1k resolution
ascs:	ASCII grid in SHG projection
*.asc:	ASCII grid file

no extension on ARC/INFO grid files
there is a 13 character limit on the names of ARC/INFO grids. Filenames are limited to 13 characters. No spaces are permitted in grid paths.

The commands for each step in the conversion are summarized below. This specific series of commands will bilinearly interpolate a precipitation grid from the HRAP projection to the SHG Projection at 1000m resolution and clip it to fit a rectangle surrounding the upper Roanoke watershed.

1) Convert NWS Archives to ASCII grids

```
UNIX)             xmrgtoasc xmrgMMDDYYHHz aschMMDDYYHHz.asc ster
```

2) Reproject and resample ASCII grids

```
------- Convert ASCII to ESRI grid ---------
ARC/INFO GRID)     hrapMMDDYYHHz = asciigrid (aschMMDDYYHHz.asc , float)

------- Reproject from HRAP to SHG ---------
ARC/INFO GRID)     S1kMMDDYYHHz = project (hrapMMDDYYHHz  , hrap2shg.prj
                            , bilinear , 1000 , 0 , 0)

------- Clip ESRI Grid to watershed boundary -------
ARC/INFO GRID)     gridclip s1kMMDDYYHHz s1kMMDDYYHHc box 1350000
                            1650000 1430000 1730000

------- Convert precipitation depths in cm to mm -----------
ARC/INFO GRID)     s1kMMDDYYHHm = (s1kMMDDYYHHc * 10)

------- Convert ERSI grid to ASCII --------
ARC/INFO GRID)     ascsMMDDYYHHz.asc = gridascii s1kMMDDYYHHm
```

3) Populate the HEC DSS database

```
DOS)              ai2dssgrid gr=SHG in=ascsMMDDYYHHz.asc ds=prcp_grd.dss
                        pa=/uproa/radar/precip/DDmonYYYY/1hour/1k_bilin
                        sd=DDmonYY st=HH00
```

Step (1) Details -- UNIX conversion of NWS archives to ASCII grids.

Radar data is archived in an encoded UNIX file format (XMRG) from the weather service and registered to the HRAP 4km x 4km polar stereographic grid.

Decode using xmrgtoasc.c program in Unix. This program will decode xmrg files containing gridded precipitation in the HRAP coordinate system to ASCII grid format (readable by ARC/INFO).

Example syntax to compile xmrgtoasc.c on HP workstations: `cc –Aa –o xmrgtoasc xmrgtoasc.c`.

Example execution syntax: `xmrgtoasc <infilename> <outfilename> ster`. The “ster” keyword specifies output as polar stereographic coordinates. Creation of the grid in polar stereographic coordinates allows the dataset to be reprojected by ARC/INFO.

```
xmrgtoasc xmrgMMDDYYHHz aschMMDDYYHHz.asc ster
```

This process is scripted in the Bourne shell on the VTAIX machine to go from monthly archives *.tar files to hourly ascii files for days of interest.

C program from NWS: xmrgtoasc.c
Compile: `cc -g -Aa -o xmrgtoasc xmrgtoasc.c`
Run: `xmrgtoasc xmrgMMDDYYHHz aschMMDDYYHHz.asc ster`

Batch file: xmrgbatch.sh
Make executable: `chmod 755 xmrgbatch.sh`
Run: `xmrgbatch.sh MM YY ‘DD DD DD … DD’`

--xmrgbatch.sh---------------------------------------

```
#!/bin/sh
# script to automate decoding of archived xmrg radar data to ascii grids
# designed for use in the Bourne shell on VTAIX
# Brian McCormick
# 8/1/02
# !!!Use caution as this script contains the rm command with wildcards!!!
# ----------------------------------------
# command should be entered as:
# xmrgbatch.sh MM YY 'DD DD DD ... DD'
# MM = month (two digit),
# YY = year (two digit), and
# DD = days of interest (2 digit) list each day.
# ----------------------------------------
# xmrgtoasc.c should be compiled and the binary placed in the same directory as
# the tarred monthly archive and the batch script xmrgbatch.sh
# use a convention of MM_YYYY for the folder you are working in
# set variables
mm=$1                                           #Set month from user input
yy=$2                                           #Set year from user input
cp Siii${mm}*${yy}SE.tar Siii${mm}${yy}SE.bak   #Creates backup of original archive
tar -xvf Siii${mm}*${yy}SE.tar                  #untars monthly to dailys
    for dd in $3                                #for days specified by user
    do
    tar -xvf Siii${mm}${dd}*${yy}SE.tar         #untars daily to hourly
    uncompress xmrg*.Z                          #decos compressed hourly records
        for hh in 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
        do
            xmrgtoasc xmrg${mm}${dd}${yy}${hh}z asch${mm}${dd}${yy}${hh}z ster
            echo xmrg${mm}${dd}${yy}${hh}z      # type the filename to track progress
        done
    rm xmrg${mm}${dd}*                          #removes hourly xmrg binary files
    done
rm *.tar                   #removes temporary tar files (the original remains as *.bak)
```

xmrgtoasc.c from NWS HRL
http://www.nws.noaa.gov/oh/hrl/gis/hrap/xmrgtoasc.c

```
/*
Name: xmrgtoasc.c

Description: Read an XMRG file and write to an ASCII file that
can be read directly read by ArcView as an Arc/Info grid. Output
coordinates are either HRAP or polar stereographic depending on the
third command line argument provided by the user.

This program will recognize two types of XMRG headers
-- pre and post AWIPS Bld 4.2
Also modified in Jan. 2000 to recognize pre-1997 headers which don't
have a second record in the header.
Successfully compiled and run on NHDRS using the following syntax:
cc -g -Aa -o xmrgtoasc xmrgtoasc.c
Syntax to run the program is then:
xmrgtoasc <infilename> <outfilename> <hrap|ster>
Third argument is either the string "hrap" or the string "ster",
depending on the desired coordinates for the output grid.
-- Note1:  Do not include an extension in the output file name.
-- Note2:  This will not decode an XMRG file properly on a Little
Endian
machine (e.g. Linux running on an Intel chip) see
http://www.nws.noaa.gov/oh/hrl/dmip/nexrad.html for mor info
*/

#include <stdio.h>
#include <math.h>
#include <stdlib.h>

main(int argc,char *argv[])

{

        FILE     *in_file_ptr, *out_file_ptr;

        char    binfile[18], outfile[18];
        char     tempstr[256], user_id[10], date[10], time[10],
process_flag[8];
        char date2[10],time2[10];
        char dummy[10],asc_name[18];

        int     rfchd[4];
        int     ddd[2];
        int numsuccess,*numbytes;

   short *itest;
        long     MAXX, MAXY, XOR, YOR;
        long     nrows, ncols;
        long     i, j, temp;
        /*short     precip[1000];*/
        short  *onerow;
        /*int     rainfall[1000][1000];*/
        float **matrix;
```

```
        float outval;
        float xstereo,ystereo;

        /* end variable declaration */

   if (argc != 4)
        {
           (void)printf("Incorrect number of arguments. Should be
3.\n");
      exit(0);
   }

   in_file_ptr=fopen(argv[1],"rb");
   if (in_file_ptr == NULL)
      {
      (void)printf("Can not open file %s for input.\n",argv[1]);
                return(1);
      }
   (void)strcpy(asc_name,argv[2]);
   (void)strcat(asc_name,".asc");
   out_file_ptr=fopen(asc_name,"w");
   if (out_file_ptr == NULL)
      {
      (void)printf("Can not open file %s for output.\n",argv[2]);
      return(1);
      }

   /* start reading the XMRG file*/
        /*SEEK_SET specifies the position offset from the beginning of
the file*/
        fseek(in_file_ptr, 4, SEEK_SET);
        for(i=0;i<4;i++)
        {
                fread(&rfchd[i], sizeof(int), 1, in_file_ptr);
        }

        XOR=rfchd[0];
        YOR=rfchd[1];
        xstereo=XOR*4762.5-401.0*4762.5;
        ystereo=YOR*4762.5-1601.0*4762.5;
        MAXX=rfchd[2];
        MAXY=rfchd[3];
        nrows = MAXY;
        ncols = MAXX;

        /*print to header file*/
        (void)fprintf(out_file_ptr,"ncols %d\n",MAXX);
        (void)fprintf(out_file_ptr,"nrows %d\n",MAXY);
        /*echo to screen*/
        (void)printf("ncols %d\n",MAXX);
        (void)printf("nrows %d\n",MAXY);
        if (strcmp(argv[3],"hrap")==0)
        {
           (void)fprintf(out_file_ptr,"xllcorner %d\n",XOR);
           (void)fprintf(out_file_ptr,"yllcorner %d\n",YOR);
           (void)fprintf(out_file_ptr,"cellsize 1\n");
                (void)printf("xllcorner %d\n",XOR);
```

```
           (void)printf("yllcorner %d\n",YOR);
           (void)printf("cellsize 1\n");
        }
   else if (strcmp(argv[3],"ster")==0)
        {
           (void)fprintf(out_file_ptr,"xllcorner %f\n",xstereo);
           (void)fprintf(out_file_ptr,"yllcorner %f\n",ystereo);
           (void)fprintf(out_file_ptr,"cellsize 4762.5\n");
           (void)fprintf(out_file_ptr,"nodata_value -9999.0\n");
           (void)printf("xllcorner %f\n",xstereo);
           (void)printf("yllcorner %f\n",ystereo);
           (void)printf("cellsize 4762.5\n");
           /*nodata_value and byteorder are optional*/
           /*echo to screen*/
    }
         else
         {
            (void)printf("Specify either hrap or ster as the third
argument.\n");
         }

   /*each record is preceded and followed by 4 bytes*/
        /*first record is 4+16+4 bytes*/
        fseek(in_file_ptr, 24, SEEK_SET);
        /*read second FORTRAN record*/
        fread(&numbytes,4,1,in_file_ptr);
        fseek(in_file_ptr, 4, SEEK_CUR);

        numsuccess=fscanf(in_file_ptr, "%10s %10s %10s %8s %10s %10s",
user_id, date, time, process_flag,date2,time2);
        /*numsuccess=fscanf*/


        /*first record (24) plus second record(46) is 70*/
        /*if (strlen(date2)>0)*/
        if ((int) numbytes == 66)
        {
                fseek(in_file_ptr, 98, SEEK_SET);
                (void)printf("user_id %10s\n",user_id);
           (void)printf("date %10s\n",date);
           (void)printf("time %10s\n",time);
           (void)printf("process_flag %8s\n",process_flag);
           (void)printf("datelen %d\n",strlen(date));
           (void)printf("timelen %d\n",strlen(time));
           (void)printf("user_id %d\n",strlen(user_id));
           (void)printf("date2 %s\n",date2);
           (void)printf("time2 %s\n",time2);
           (void)printf("numbytes %d\n",numbytes);
        }
        else if ((int) numbytes==38)
        {
                fseek(in_file_ptr, 70, SEEK_SET);
                /*(void)printf("gothere\n");*/
                (void)printf("user_id %10s\n",user_id);
           (void)printf("date %10s\n",date);
           (void)printf("time %10s\n",time);
           (void)printf("process_flag %8s\n",process_flag);
```

```
           (void)printf("numbytes %d\n",numbytes);
   }
        else if ((int) numbytes==37)
        {
           /* read first header line */
                fseek(in_file_ptr, 4, SEEK_SET);
           for(i=0;i<4;i++)
           {
                   fread(&rfchd[i], sizeof(int), 1, in_file_ptr);
           }
                /* read second header line */
           (void)printf("Reading June 1997 - Summer 1999 AWIPS
format.\n");
                /*first record (24) plus second record(45) is 70*/
                fseek(in_file_ptr, 69, SEEK_SET);

                /*(void)printf("gothere\n");*/
                (void)printf("WARNING: SECOND RECORD ONLY HAS 37
BYTES\n");
                (void)printf("SHOULD HAVE 38 BYTES\n");
                (void)printf("Assuming data is still valid. . . \n");
                (void)printf("user_id %10s\n",user_id);
           (void)printf("date %10s\n",date);
           (void)printf("time %10s\n",time);
           (void)printf("process_flag %8s\n",process_flag);
           (void)printf("numbytes %d\n",numbytes);
   }
        else if ((int) numbytes == (ncols*2))
        /* the second record of the files was nonexistent in pre-June
1997 files.*/
        {
           /* read first header line */
                fseek(in_file_ptr, 4, SEEK_SET);
           for(i=0;i<4;i++)
           {
                   fread(&rfchd[i], sizeof(int), 1, in_file_ptr);
           }
                (void)printf("Reading pre-1997 format.\n");
                fseek(in_file_ptr,24, SEEK_SET);
        }
        else
        {
                (void)printf("numbytes %d\n",numbytes);
           (void)printf("Header file is in a nonstandard format. Data
NOT READ!\n");
                exit(1);
        }

        /* allocate memory for arrays */
        onerow = (short int*) malloc(sizeof(short int*)*ncols);
        matrix = (float**) malloc(sizeof(float*)*nrows);
   for (i=0;i<nrows;i++)
      matrix[i]=(float*) malloc(sizeof(float)*ncols);

        for(i=nrows-1;i>-1;i--)
        {
        fseek(in_file_ptr, 4, SEEK_CUR);
```

```
        /* read one row */
        fread(onerow,sizeof(short),ncols,in_file_ptr);
        fseek(in_file_ptr, 4, SEEK_CUR);
                for(j=0;j<ncols;j++)
                {
                matrix[i][j] = (float) onerow[j];

                } /* close j */
        } /* close i  */


        for(i=0; i<nrows; i++)
        {
                for(j=0; j<ncols; j++)
                {
                        /*fwrite(&rainfall[i][j], 4, 1, out_file_ptr);*/
                        outval=matrix[i][j];
                        if (matrix[i][j] < 0)
                        {
                                outval=-9999.0;
                        }
                        else
                        {
                           outval = outval/1000.0;
                                /*  convert from hundredths of mm to cm*/
                   }
         /*fwrite(&outval,4,1,out_file_ptr);*/
                        fprintf(out_file_ptr,"%f ",outval);
                        }
                        fprintf(out_file_ptr,"\n");
        }

/*free allocated memory*/
free(onerow);
for (i=0;i<nrows;i++)
                { free(matrix[i]);free(matrix); }
fclose(in_file_ptr);
fclose(out_file_ptr);
/*fclose(hdr_file_ptr);*/

}  /**  END OF MAIN  **/
```

Details on XMRG File Format

Xmrg file format – from http://www.nws.noaa.gov/oh/hrl/pps/pps.htm Precipitation Processing System Documentation 11/15/2002

xmrg files contain the hourly precip amounts on an HRAP grid for an RFC area. They are output from the StageIII, Auto_StageIII and RFCWide MPE processes. At an RFC, the xmrg files are input to the OFS MAPX preprocessor.

The StageIII process mosaics the multisensor field grids generated by the StageII process to produce the xmrg file grids. The multisensor field combines gage values with gridded radar values with a multiplicative bias applied to produce what is considered to be the "best" estimate of the precip across an RFC's area.

File Format

xmrg files are written row by row from within a "do-loop" using a FORTRAN unformatted write statement (see section below entitled "Format of FORTRAN Unformatted Records"). The loop is from 1 to MAXY which places the southernmost row as the first row of the file. Each file consists of a two record header followed by the data. The first record of the header contains the following values:

FIELD #	DESCRIPTION
1	HRAP-X coordinate of southwest corner of grid (also referred to as XOR)
2	HRAP-Y coordinate of southwest corner of grid (also referred to as YOR)
3	Number of HRAP grid boxes in X direction (also referred to as MAXX)
4	Number of HRAP grid boxes in Y direction (also referred to as MAXY)

These values appear in the file /.../geo_data/ascii/coord_XXXXX.dat where XXXXX is the RFC name. These four values are written as I*4. The second record of the header was added in June 1997 and contains the following information:

FIELD #	DESCRIPTION	TYPE	EXPLANATION
1	user id	char*10	LOGNAME of user that saved the file
2	saved date/time	char*20	ccyy-mm-dd hh:mm:ss (Z time)
3	process flag	char*8	see below
4	valid date/time	char*20	ccyy-mm-dd hh:mm:ss (Z time)
5	maximum value	integer*4	units = mm
6	version number	float	AWIPS Build number

Fields 4,5,6 were added as part of the AWIPS Bld 4.2 upgrade which was implemented during the summer of 1999. For gridded FFG data, field 5 is not used and is set to -999 and field 6 is the file version number.

The precip data values are written to the file as I*2 values in units of hundredths of mm. Data values for bins which have no radar coverage are set to -1. There are MAXY rows of data each with MAXX values.

Because the I*2 data type can hold values only up to approximately 32,000, the xmrg format is not appropriate for large data values. Data values greater than approximately 12 inches cannot be currently stored in this format. A future enhancement to the xmrg file format will allow larger values to be stored.

Process Flag

For AWIPS Bld5.0, the process flag will be defined as follows:

XXyHH

where XX = process code
y = A (automatic) or M (manual)
HH = duration in hours

Examples are

auto_stageiii	S3A01
manual stageiii	S3M01
rfcwide (auto)	MPA01
rfcwide GUI	MPM01

This new process flag will be used by the xmrg to grib encoder process for defining grib parameters.

Format of FORTRAN Unformatted Records

FORTRAN unformatted records have a 4 byte integer at the beginning and end of each record that is equal to the number of 4 byte words contained in the record. When reading xmrg files through C using the fread function, the user must account for these extra bytes in each record.

Details on ASCII Grid File Format

ASCII Grid File Format – from ACRDOC (2002).
The ASCII file must consist of header information containing a set of keywords, followed by cell values in row-major order. The file format is

```
<ncols xxx>
<nrows xxx>
<xllcenter xxx | xllcorner xxx>
<yllcenter xxx | yllcorner xxx>
<cellsize xxx>
{nodata_value xxx}
row 1
row 2
.
.
.
row n
```

where xxx is a number, and the keyword nodata_value is optional and defaults to -9999. Row 1 of the data is at the top of the grid, row 2 is just under row 1 and so on.

For example,

```
ncols 480
nrows 450
xllcorner 378923
YLLCORNER 4072345
cellsize 30
nodata_value -32768
43 2 45 7 3 56 2 5 23 65 34 6 32 54 57 34 2 2 54 6
35 45 65 34 2 6 78 4 2 6 89 3 2 7 45 23 5 8 4 1 62  ...
```

The nodata_value is the value in the ASCII file to be assigned to those cells whose true value is unknown. In the grid they will be assigned the keyword NODATA.

Cell values should be delimited by spaces. No carriage returns are necessary at the end of each row in the grid. The number of columns in the header is used to determine when a new row begins.

The number of cell values must be equal to the number of rows times the number of columns, or an error will be returned.

Step 2: Details – Reprojection and Resampling with ARC/INFO

To reproject the ASCII grid to the SHG coordinate system, use the ASCIIGRID and PROJECTGRID functions in ARC/INFO. This step is scripted in Arc Macro Language (AML) to work within the ARC/INFO GRID environment.

ASCIIGRID converts an ASCII file to a ESRI grid.
PROJECTGRID is used to transform grids from the HRAP (more precisely polar stereographic) projection to the SHG (Albers Conical) projection.
GRIDCLIP is used to make the data set more manageable in size.
* 10 is used to convert from cm to mm.
GRIDASCII converts back to an ASCII file that can be imported into the HEC-DSS.

The float option is necessary as rainfall will be in cm in the grids created by the xmrgtoasc command. Precipitation depths are stored as hundredths of mm as an integer in the xmrg format. The output grids will be in units of cm and will be floating point grids.

The hrap2shg.aml file is an AML script used to reproject and resample the radar data. Many versions of this script were written to create gridded precipitation records with varied resolutions and cell sizes. The version below bilinearly interpolates to a 1kilometer grid cell size from the 4km HRAP grid.

The hrap2shg.prj file is a text file used in projection from HRAP to SHG. It is included below.

```
/* ----------------------- hrap2shg.aml -------------------------------------
/*
/* This file is an aml script to speed the process of converting hourly ascii
/* hrap precipitation grids to HEC's SHG format.
/*
/* This version Bilinearly interpolates to 1k resolution in the SHG projection from 4kHRAP.
/*
/* required inputs:
/*  (1) hourly precipitation ASCII grids:
/*           named aschMMDDYYHHz.asc
/*           in polar stereographic coordinates
/*      the xmrgtoasc.c program with the ster option
/*      within the xmrgbatch.sh batch file produces these inputs
/*  (2) projection file specified below hrap2shg.prj
/*  (3) appropriate directory structure
/*        h:\radar\ascii for the ascii inputs
/*        h:\radar\ascii\OUTPUT for the outputs you want to keep
/*        h:\radar\ascii\TEMP for the temporary grids created during processing
/*
/* All input ASCII grids must be in the same workspace --
/* use a convention of h:/radar/ascii/
/*
/* the projection file hrap2shg.prj should be placed in the workspace as well
/*
/* run with ARC: &run h:\......hrap2shg.aml  FULL path should be given
/*
/* Run for one storm event at a time.  If a storm event crosses the boundaries
/* of a month (as storms often do in total disrespect of the roman calendar)
/* run separately for each month.
/*
/* All input ASCII grids must be in the same workspace --
/* use a convention of h:/radar/ascii/
/*
/* the projection file hrap2shg.prj must be placed in the workspace as well
/*
/* if an area other than the upper Roanoke watershed is desired,
/* bounding box coordinates must be revised in the GRIDCLIP command.
/* upper Roanoke watershed bounding box in SHG (meters) is as follows:
```

```
/* x1: 1350000
/* y1: 1650000
/* x2: 1430000
/* y2: 1730000
/*
/* Upper roanoke bounding box (extended to avoid rounding errors in scale study)
/* in polar stereographic coordinates is as follows
/* x1: 2300000
/* y1: -5500000
/* x2: 2700000
/* y2: -5200000
/*
/* Revised 8/7/02
/* -----------------------------------------------------------------------------
&type CONVERSION OF ASCII GRIDS FROM HRAP TO SHG
&type Brian C. McCormick
&type revised 8/7/02

&workspace [response 'select workspace where ASCII radar data is stored']

/*  Query the month day and year of interest
/* "s" is a shortcut for the "setvar" or set variable command
/* if statements are used to place zeros in front of 1 digit hours, days and years

&type Do not precede single digit months and days with zeros.
&s mm = [response 'month M']
&if %mm% < 10 &then &s mm = 0%mm%
&s dd = [response 'start day D']
&s ed = [response 'end day D']
&s yy = [response 'year YY']

/* set up nested loops perform the necessary conversions for each hour within each day of records.  Runs
for days from start day to and including end day from 00 to 23 hours for each day.

Grid

&do &while %dd% <= %ed%
&if %dd% < 10 &then &s dd = 0%dd%
```

```
   &s hh = 0
   &do &while 0 <= %hh% and %hh% <= 23
      &if %hh% < 10 &then &s hh = 0%hh%

/* convert ascii to grids (this section may be commented out if grids already exist in the ./TEMP
directory)
h:\radar\ascii\TEMP\hrap%mm%%dd%%yy%%hh%z = asciigrid(h:\radar\ascii\asch%mm%%dd%%yy%%hh%z.asc , float)

/* clip the HRAP grid to reduce projection time
gridclip h:\radar\ascii\TEMP\hrap%mm%%dd%%yy%%hh%z h:\radar\ascii\TEMP\hrap%mm%%dd%%yy%%hh%c box 2300000 -
5500000 2700000 -5200000

/* resampling is possible here for data degradation (ex: in a scale study)
/* note this command is presently commented out (/*)
/* h:\radar\ascii\TEMP\resample_grid_name = resample (h:\radar\ascii\TEMP\hrap%mm%%dd%%yy%%hh%c, 10000,
bilinear)

/* Project from HRAP to SHG -- desired grid resolution and interpolation option are specified here.
/* nearest, bilinear, cubic are the interpolation options, 1000 (in this example) is the cell size
h:\radar\ascii\TEMP\s1k%mm%%dd%%yy%%hh%z = project (h:\radar\ascii\TEMP\hrap%mm%%dd%%yy%%hh%c  ,
hrap2shg.prj , bilinear , 1000 , 0 , 0)

/* clip the SHG to the bounds of the watershed
gridclip h:\radar\ascii\TEMP\s1k%mm%%dd%%yy%%hh%z h:\radar\ascii\TEMP\s1k%mm%%dd%%yy%%hh%c box 1350000
1650000 1430000 1730000

/* convert cm to mm
h:\radar\ascii\OUTPUT\s1k%mm%%dd%%yy%%hh%m = (h:\radar\ascii\TEMP\s1k%mm%%dd%%yy%%hh%c * 10)

/* write the reprojected ascii file (used for importation into the HEC *.dss or another database)
h:\radar\ascii\OUTPUT\ascs%mm%%dd%%yy%%hh%z.asc = gridascii (h:\radar\ascii\OUTPUT\s1k%mm%%dd%%yy%%hh%m)

      &type %mm%%dd%%yy%%hh%
      &s hh = %hh% + 1
   &end
   &s dd = %dd% + 1
&end
quit
```

```
/*-------------------hrap2shg.prj----------------------
/* projection from HRAP
/* (product of xmrg to ascii with ster option) to SHG
/* Brian McCormick 7/1/02
input                   /*defines the projection of data being input
projection polar
units meters
spheroid sphere
parameters
-105 0 0                /* longtitude of the center of the projection d m s
60 0 24.5304792         /* true latitude d m s.ss
0                       /* false easting
0                       /* false northing
output                  /* describes the desired projection of the output data set (SHG)
projection albers
units meters
spheroid grs80
parameters
29 30 0                 /* 1st standard parallel
45 30 0                 /* 2nd standard parallel
-96 0 0                 /* central meridian
23 0 0                  /* latitude of origin
0.0                     /* false easting
0.0                     /* false northing
end
/*-------------------end of hrap2shg.prj----------------
```

Step 3: Details -- Importing into the HEC-DSS file format

This is accomplished using the ai2dssgrid.exe program in DOS provided by HEC
The ai2dssgrid.exe command runs for one hour at a time Ai2dssgrid.exe must be in the same folder as the ASCII grids. The DSS file can be anywhere as long as the appropriate path is specified.

This command has been streamlined with the use of DOS batch files such as shg2dss.bat created using a text editor.

Ai2dssgrid.exe parameters are as follows

Gr = HRAP, SHG, or LOCAL
in = the input ASCII grid (in arc info format)
ds = name of the dss file in which the grid is to be stored
pa = the path to the dss file (by convention in 6 parts /apart/bpart/…/fpart)
sd = start date in DDmonYY convention
st = start time in hours (UTC) USE (HH-1)00 to enter a number of hours. Ex: 1200
!!As the start time is one hour before the time stamp of the radar grid or archive, (HH-1) is used as the start time for the ai2dss command!!
ed = end date
et = end time
The default ending time is 1 hour after the start time meaning that for 1 hour rainfall records, ending times and dates do not need to be specified in the command.

Sample Usage:

```
ai2dssgrid gr=SHG in=ascsMMDDYYHHz.asc ds=h:\radar\stageiii.dss
        pa=/uproa/radar/precip/DDmonYYYY/1hour/1k_bilin/
        sd=DDmonYY  st=(HH-1)00
```

Batch file format is shown in the shg2dss.bat file.

To run place the batch files, copy all ASCII grids, the batch script, and the ai2dssgrid.exe program into the appropriate directory.
Replace the name of the *.dss, the dss path description and the path in the cd command with the variables if interest.

```
---------------------------------------shg2dss.bat-----------------------------------------
@echo off
rem shg2dss.bat
rem
rem THIS IS A TEMPLATE -- CREATION OF THIS FILE MAY BE AUTOMATED IN THE FUTURE
rem
rem ai2dssgrid.exe must be in the same folder as the ASCII precipitation grids and
rem this batch file.
rem Run from the command prompt with h:\... \shg2dss.bat or
rem by double clicking the batch file in WINNT or equivalent.
rem
rem Conversion of ASCII precipitation grids to HEC-DSS database
rem Brian McCormick
rem revised 8/13/02
rem
CLS
echo.
echo      THIS BATCH FILE AUTOMATES THE PROCESS OF IMPORTING
echo      ASCII PRECIPITATION GRIDS INTO THE HEC-DSS
echo.
echo      BRIAN C. McCORMICK
echo      revised 8/13/02
echo.
pause
rem
cd h:\radar\ascii\OUTPUT
rem ai2dssgrid gr=SHG in=ascsmmddyyhhz.asc ds=OUTPUT.dss pa=/////// sd=ddmonyy  st=(hh-1)00
rem 10 24 97
ai2dssgrid gr=SHG in=ascs10249700z.asc ds=OUTPUT.dss pa=/////// sd=23oct97  st=2300
ai2dssgrid gr=SHG in=ascs10249701z.asc ds=OUTPUT.dss pa=/////// sd=24oct97  st=0000
ai2dssgrid gr=SHG in=ascs10249702z.asc ds=OUTPUT.dss pa=/////// sd=24oct97  st=0100
ai2dssgrid gr=SHG in=ascs10249703z.asc ds=OUTPUT.dss pa=/////// sd=24oct97  st=0200
…many lines omitted…
ai2dssgrid gr=SHG in=ascs10249723z.asc ds=OUTPUT.dss pa=/////// sd=24oct97  st=2200
rem 10 25 97
ai2dssgrid gr=SHG in=ascs10259700z.asc ds=OUTPUT.dss pa=/////// sd=24oct97  st=2300
ai2dssgrid gr=SHG in=ascs10259701z.asc ds=OUTPUT.dss pa=/////// sd=25oct97  st=0000
… many lines omitted …
```

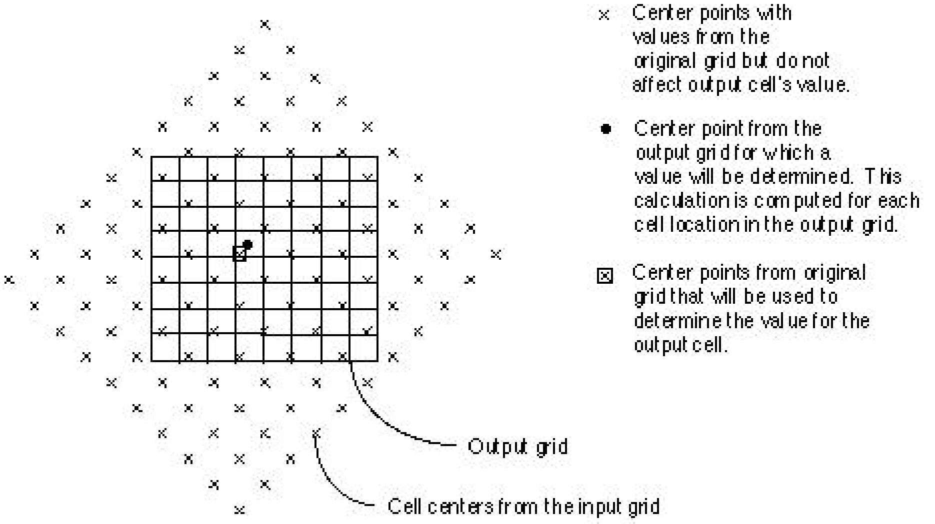
```
/* ----------------------- grid2point.aml -------------------------------------
/*
/* This script is designed to use a series of input grids
/* in ARC/INFO grid format to generate a series of values for each
/* point in a user specified point coverage.
/*
/* It is intended to be used with hourly NEXRAD derived precipitation grids
/* and a point coverage of rain gages for which time series of gage estimated precipitation
/* is available.  This can be used as a check on the radar precipitation grids registration
/* and processing.
/*
/* ----------------------------------------------------------------------------
/*  establish the workspace

&type CREATION OF PRECIP TIME SERIES AT POINTS FROM PRECIP GRIDS
&type requires a time series of precip grids and a point coverage
&type check registration of each dataset prior to running script
&type Brian C. McCormick
&type 8/6/02

&workspace [response 'select workspace where gridded precip data is stored']

/*  Query the month day and year of interest
/* if statements are used to place zeros in front of 1 digit hours, days and years

lg
&s head = [response 'input head of precip grid names']
/* &s tail = [response 'input tail of precip grid names (press spacebar and enter if none)']
lc
&s point = [response 'input rain gage point coverage']
&type -------------------------------------------------------
&type Do not precede single digit months and days with zeros.
&type -------------------------------------------------------
&s mm = [response 'month M']
&if %mm% < 10 &then &s mm = 0%mm%
&s dd = [response 'start day D']
&s ed = [response 'end day D']
&s yy = [response 'year YY']
```

```
/* set up nested loops perform the necessary conversions for each hour within each day of records.  Runs
for days from start day to and including end day from 00 to 23 hours for each day.

&do &while %dd% <= %ed%
&if %dd% < 10 &then &s dd = 0%dd%
   &s hh = 0
   &do &while 0 <= %hh% and %hh% <= 23
      &if %hh% < 10 &then &s hh = 0%hh%

         latticespot %head%%mm%%dd%%yy%%hh% %point% p%mm%%dd%%hh% .03937 /* gives units of in
/* change .03937 (z factor on above line to 1 to output time series in mm)
/* input grids are assumed to be depths in mm -- METRIC FOR EXCELLENCE!

      &type %mm%%dd%%yy%%hh%
      &s hh = %hh% + 1
   &end
   &s dd = %dd% + 1
&end
```

Appendix F: Grid Resampling Techniques (ESRI, 2002)

Nearest neighbor assignment

Nearest neighbor is the resampling technique of choice for categorical data since it does not alter the value of the input cells. Once the location of the cell's center on the output grid is located on the input grid, the nearest neighbor assignment will determine the location of the closest cell center on the input grid, identify the value that is associated with the cell, and assign that value to the cell that the output cell center is associated with.

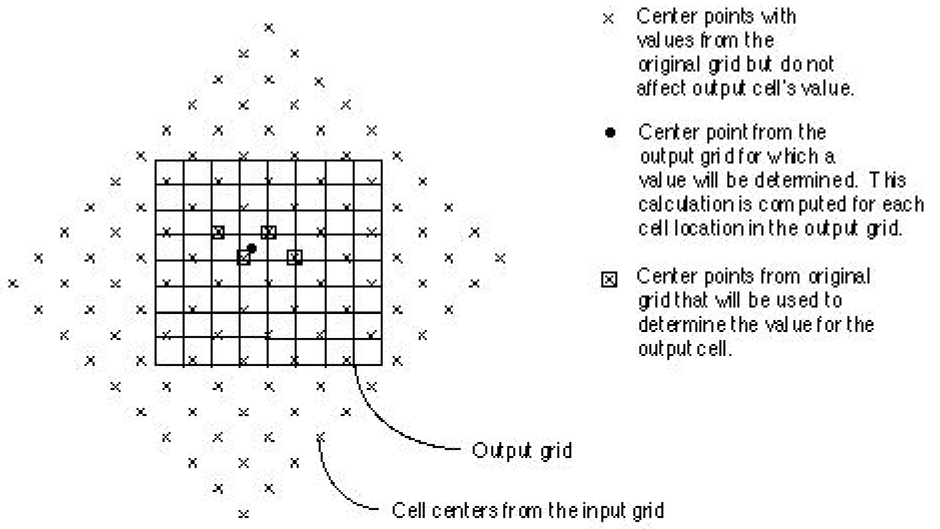


The output value in the nearest neighbor resampling technique is taken from the nearest input cell center. A value is determined for each cell in the grid output.

The nearest neighbor assignment does not change any of the values of cells from the input grid. A value '2' in the input grid, will always be the value '2' in the output grid; it will never be '2.2' or '2.3'. Since the output cell values remain the same, the nearest neighbor assignment should be used for nominal or ordinal data, where each value represents a class, member, or classification; categorical or integer data (i.e., a landuse, or a soil or forest type).

Bilinear interpolation

Bilinear interpolation identifies the four nearest input cell centers to the location of the center of an output cell on the input grid. The new value for the output cell is a weighted average determined by the value of the four nearest input cell centers and their relative position or weighted distance from the location of the center of the output cell in the input grid.



The output value in the bilinear interpolation technique is influenced by the value of the four nearest input cell centers. A value is determined for each cell in the grid output.

Since the values for the output cells are calculated according to the relative position and the value of the input cells, the bilinear interpolation is preferred for data where the location from a known point or phenomenon determines the value assigned to the cell (i.e., continuous surfaces). Elevation, slope, intensity of noise from an airport, and salinity of the groundwater near an estuary are all phenomenon represented as continuous surfaces and are most appropriately resampled using bilinear interpolation.

Appendix G: HEC-HMS Input Files

```
*/-------------------------Basin Model--------------------------------
Basin: roanoke_3
     Description: Upper Roanoke Watershed with CN from AMC3 optimized
using March98 and Apr98 Storm Events
     Last Modified Date: 10 December 2002
     Last Modified Time: 11:00:51
     Version: 2.1.3
     Default DSS File Name: H:\HEC\roanoke\roanoke.dss
     Unit System: SI
     Map File: H:\geo_run2\to_hms\roa_10.map
     Grid Cell File: H:\HEC\GridParm\roa1kam3.mod
End:

Junction: Outlet
     Description: Pour Point after confluence of Back Creek and the
Upper Roanoke River.
     Canvas X: 1412979.651
     Canvas Y: 1695895.004
     Label X: 21
     Label Y: -17
End:

Gridded Subbasin: ROA_NIAGARA
     Canvas X: 1407398.736
     Canvas Y: 1708581.705
     Label X: 16
     Label Y: 0
     Area: 263.791000
     Downstream: Niagara_gage

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 12
     Storage Coefficient: 8.35

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 4.321
     Monthly rate: 4.272
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.646
     Monthly rate:
     Monthly rate:
End:
```

```
Gridded Subbasin: ROA_WALNUT
     Canvas X: 1391809.553
     Canvas Y: 1701726.635
     Label X: 16
     Label Y: 0
     Area: 269.124000
     Downstream: Walnut_gage

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 5.1
     Storage Coefficient: 6.4

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 1.699
     Monthly rate: 2.549
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.425
     Monthly rate:
     Monthly rate:
End:

Gridded Subbasin: confluence
     Canvas X: 1411761.285
     Canvas Y: 1698366.518
     Label X: 16
     Label Y: 0
     Area: 15.691000
     Downstream: Junction-1

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 6
     Storage Coefficient: 1

     Baseflow: None
End:

Gridded Subbasin: NF_IRONTO
     Description: North Fork of the Roanoke River above the Ironto, VA
IFLOWS stream (stage only) gage.
     Canvas X: 1372388.235
     Canvas Y: 1691674.239
```

```
     Label X: 16
     Label Y: 0
     Area: 288.804000
     Downstream: Ironto_Lafayette

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 4.5
     Storage Coefficient: 26

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 3.65
     Monthly rate: 5.37
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.30
     Monthly rate:
     Monthly rate:
End:

Gridded Subbasin: ROA_LAFAYETTE
     Canvas X: 1381934.389
     Canvas Y: 1685617.403
     Label X: 16
     Label Y: 0
     Area: 95.093000
     Downstream: Lafayette

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 8
     Storage Coefficient: 1.6

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 1.19
     Monthly rate: 1.76
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.10
```

```
     Monthly rate:
     Monthly rate:
End:

Gridded Subbasin: SF_SHAWSVILLE
     Canvas X: 1379765.537
     Canvas Y: 1677447.798
     Label X: 16
     Label Y: 0
     Area: 279.808000
     Observed Hydrograph Gage: Shawsville
     Downstream: Shawsville_Lafayette

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 4
     Storage Coefficient: 25

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 3.115
     Monthly rate: 2.832
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.878
     Monthly rate:
     Monthly rate:
End:

Gridded Subbasin: ROA_GLENVAR
     Description: Local watershed above the Glenvar gage.
     Canvas X: 1385450.270
     Canvas Y: 1692509.373
     Label X: 16
     Label Y: 0
     Area: 58.046000
     Downstream: Glenvar

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 6
     Storage Coefficient: 2.41

     Baseflow: Monthly Constant
     Monthly rate:
```

```
     Monthly rate:
     Monthly rate: 0.283
     Monthly rate: 0.283
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.142
     Monthly rate:
     Monthly rate:
End:

Gridded Subbasin: TINKER
     Description: Tinker creek above Daleville, VA.  USS gage number
....
     Canvas X: 1401662.879
     Canvas Y: 1718658.995
     Label X: 16
     Label Y: 0
     Area: 30.123000
     Observed Hydrograph Gage: Daleville
     Downstream: R150

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 3.0
     Storage Coefficient: 0.2

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.736
     Monthly rate: 0.510
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.085
     Monthly rate:
     Monthly rate:
End:

Gridded Subbasin: BACK_CRK
     Description: Back Creek above Dundee, VA stream gage
     Canvas X: 1400085.000
     Canvas Y: 1690125.000
     Label X: 16
     Label Y: 0
     Area: 144.964000
     Observed Hydrograph Gage: Dundee
     Downstream: Dundee_Confluence
```

```
     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 2.6
     Storage Coefficient: 20

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 2.379
     Monthly rate: 2.322
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.283
     Monthly rate:
     Monthly rate:
End:

Gridded Subbasin: CARVIN
     Canvas X: 1398664.634
     Canvas Y: 1713638.420
     Label X: 16
     Label Y: 0
     Area: 37.039000
     Downstream: R300

     LossRate: Gridded SCS
     Percent Impervious Area: 0.0
     Potential Retention Scale Factor: 1.0
     Initial Abstraction Ratio: 0.2

     Transform: Modified Clark
     Time of Concentration: 2
     Storage Coefficient: 0.2

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.606
     Monthly rate: 0.599
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.091
     Monthly rate:
     Monthly rate:
End:
```

```
Junction: JR330
     Canvas X: 1403942.420
     Canvas Y: 1705395.502
     Label X: 12
     Label Y: 0
     Downstream: R330
End:

Junction: Lafayette
     Description: Junction of the NF and SF Roanoke Rivers at
Lafayette, VA
     Canvas X: 1381843.901
     Canvas Y: 1691995.911
     Label X: -21
     Label Y: 29
     Observed Hydrograph Gage: Lafayette
     Downstream: Lafayette_Glenvar
End:

Reach: R300
     Canvas X: 1403942.420
     Canvas Y: 1705395.502
     From Canvas X: 1400685.000
     From Canvas Y: 1710495.000
     Label X: -42
     Label Y: -7
     Downstream: JR330

     Route: Muskingum
     Muskingum K: 2
     Muskingum X: 0.2
     Muskingum Steps: 2
End:

Reach: R150
     Canvas X: 1403942.420
     Canvas Y: 1705395.502
     From Canvas X: 1401727.165
     From Canvas Y: 1716093.563
     Label X: 16
     Label Y: 0
     Downstream: JR330

     Route: Muskingum
     Muskingum K: 3
     Muskingum X: 0.2
     Muskingum Steps: 3
End:

Reach: R330
     Canvas X: 1410568.502
     Canvas Y: 1699078.757
     From Canvas X: 1403942.420
     From Canvas Y: 1705395.502
     Label X: 16
     Label Y: 0
     Downstream: Niagara_gage
```

```
     Route: Muskingum
     Muskingum K: 3
     Muskingum X: 0.2
     Muskingum Steps: 3
End:

Reach: Walnut_Niagara
     Description: Walnut street stream gage to Niagara stream gage
     Canvas X: 1410568.502
     Canvas Y: 1699078.757
     From Canvas X: 1404322.715
     From Canvas Y: 1698380.953
     Label X: -56
     Label Y: 19
     Downstream: Niagara_gage

     Route: Muskingum
     Muskingum K: 2
     Muskingum X: 0.2
     Muskingum Steps: 2
End:

Reach: R390
     Canvas X: 1412901.684
     Canvas Y: 1695977.025
     From Canvas X: 1410568.502
     From Canvas Y: 1699078.757
     Label X: 16
     Label Y: 0
     Downstream: Junction-1

     Route: Lag
     Lag: 20
End:

Reach: Glenvar_Walnut
     Description: Reach between Glenvar, vA and Walnut Street Gage --
Roanoke, VA
     Canvas X: 1404322.715
     Canvas Y: 1698380.953
     From Canvas X: 1387074.881
     From Canvas Y: 1696672.771
     Label X: 16
     Label Y: 0
     Downstream: Walnut_gage

     Route: Muskingum
     Muskingum K: 4
     Muskingum X: 0.2
     Muskingum Steps: 5
End:

Reach: Ironto_Lafayette
     Description: Ironto to Lafayette
     Canvas X: 1381843.901
     Canvas Y: 1691995.911
```

```
     From Canvas X: 1378695.000
     From Canvas Y: 1691475.000
     Label X: -77
     Label Y: 18
     Downstream: Lafayette

     Route: Muskingum
     Muskingum K: 0.8
     Muskingum X: 0.3
     Muskingum Steps: 1
End:

Reach: Dundee_Confluence
     Description: Channel section from Dundee to Confluence of Back
Creek and Roanoke River.
     Canvas X: 1412901.684
     Canvas Y: 1695977.025
     From Canvas X: 1411130.257
     From Canvas Y: 1696109.302
     Label X: -57
     Label Y: -44
     Downstream: Junction-1

     Route: Lag
     Lag: 20
End:

Reach: Shawsville_Lafayette
     Description: Shawsville SG to Lafayette SG
     Canvas X: 1381843.901
     Canvas Y: 1691995.911
     From Canvas X: 1378169.820
     From Canvas Y: 1680649.483
     Label X: -36
     Label Y: 1
     Downstream: Lafayette

     Route: Muskingum
     Muskingum K: 0.8
     Muskingum X: 0.3
     Muskingum Steps: 1
End:

Reach: Lafayette_Glenvar
     Description: Lafayette to Glenvar on the main stem of the Roanoke
River
     Canvas X: 1387074.881
     Canvas Y: 1696672.771
     From Canvas X: 1381843.901
     From Canvas Y: 1691995.911
     Label X: -80
     Label Y: 21
     Downstream: Glenvar

     Route: Muskingum
     Muskingum K: 2
     Muskingum X: 0.2
```

```
     Muskingum Steps: 2
End:

Junction: Junction-1
     Description: Connection point for Back Creek, Roanoke River, and
Local Subarea contribution.
     Canvas X: 1412901.684
     Canvas Y: 1695977.025
     Label X: 20
     Label Y: 11
     Downstream: Reach-1
End:

Reach: Reach-1
     Description: "Dummy" channel from confluence of Back Crk and Upper
Roanoke to outlet.  Necessary to model confluence as outlet point.
     Canvas X: 1412979.651
     Canvas Y: 1695895.004
     From Canvas X: 1412901.684
     From Canvas Y: 1695977.025
     Label X: 25
     Label Y: -2
     Downstream: Outlet

     Route: Lag
     Lag: 0
End:

Junction: Glenvar
     Description: Stream gage on Roanoke River at Glenvar, VA
     Canvas X: 1387074.881
     Canvas Y: 1696672.771
     Label X: 16
     Label Y: 0
     Observed Hydrograph Gage: Glenvar
     Downstream: Glenvar_Walnut
End:

Junction: Walnut_gage
     Description: Walnut Street Gage, Roanoke River, Roanoke, VA
     Canvas X: 1404322.715
     Canvas Y: 1698380.953
     Label X: -28
     Label Y: -27
     Observed Hydrograph Gage: Walnut
     Downstream: Walnut_Niagara
End:

Junction: Niagara_gage
     Description: Stream gage, Roanoke River at Niagara, VA
     Canvas X: 1410568.502
     Canvas Y: 1699078.757
     Label X: 23
     Label Y: 18
     Observed Hydrograph Gage: Niagara
     Downstream: R390
End:
```

```
Default Attributes:
     Default Basin Unit System: SI
     Default Meteorology Unit System: SI
     Default Loss Rate: Gridded SCS
     Default Transform: Modified Clark
     Default Baseflow: Recession
     Default Route: Muskingum
     Enable Flow Ratio: No
     Enable Evapotranspiration: No
     Compute Local Flow At Junctions: Yes
     Warning On Delete Component: Yes
     Warning On Change Method: Yes
End:

*/---------------------End Basin Model-------------------------------
```

```
*/-----------------Control Specifications---------------------------

Control: OCT97_Event
     Description: Oct 24 to 28 1997 Storm Event:  10/24/97 0000UTC to
10/29/97 0000UTC
     Last Modified Date: 31 October 2002
     Last Modified Time: 11:22:54
     Start Date: 24 October 1997
     Start Time: 12:00
     End Date: 28 October 1997
     End Time: 23:00
     Time Interval: 60
End:

Control: MAR98_Event
     Description: March 17 to 22 1998 Storm Event:  03/17/1998 0000UTC
to 03/22/1998 0000UTC
     Last Modified Date: 31 October 2002
     Last Modified Time: 11:23:00
     Start Date: 17 March 1998
     Start Time: 12:00
     End Date: 22 March 1998
     End Time: 23:00
     Time Interval: 60
End:

Control: APR98_Event
     Description: April 16 to 21 1998 Storm Event:  4/16/1998 0000UTC
to 4/22/1998 0000UTC
     Last Modified Date: 31 October 2002
     Last Modified Time: 11:23:06
     Start Date: 16 April 1998
     Start Time: 12:00
     End Date: 21 April 1998
     End Time: 23:00
     Time Interval: 60
End:

*/-----------------End Control Specifications-------------------------
```

```
*/----------------------Meteorlogic Models--------------------------

*/ 4km resolution
Precip: 1k_near
     Description: NWS hourly stage III reassigned to 1k nearest
neighbor on SHG for Upper Roanoke watershed.
     Last Modified Date: 1 October 2002
     Last Modified Time: 12:19:19
     Version: 2.1.3
     Default DSS File Name: H:\HEC\roanoke\roanoke.dss
     Unit System: Metric
     Enable Evapotranspiration: No
     Precipitation Method: Gridded Precipitation
End:
Method Parameters: Gridded Precipitation
     Gridded Precip File Name: H:\HEC\DSS\stageiii.dss
     Gridded Precip Path: A=uproa B=radar C=PRECIP F=1k_near
     MissingRecordAction: Set data to zero
End:

*/1k resolution
Precip: 1k_bilin
     Description: NWS hourly stage III "smoothed" by 1k bilinear
reassignment to SHG for Upper Roanoke watershed.
     Last Modified Date: 2 October 2002
     Last Modified Time: 11:37:00
     Version: 2.1.3
     Default DSS File Name: H:\HEC\roanoke\roanoke.dss
     Unit System: Metric
     Enable Evapotranspiration: No
     Precipitation Method: Gridded Precipitation
End:
Method Parameters: Gridded Precipitation
     Gridded Precip File Name: H:\HEC\DSS\stageiii.dss
     Gridded Precip Path: A=uproa B=radar C=PRECIP F=1k_bilin
     MissingRecordAction: Set data to zero
End:

*/8k resolution
Precip: 8kbh1ksn
     Description: NWS hourly stage III "degraded" by bilinear
interpolation to 8k HRAP and reassigned by nearest neighbor to 1kSHG
for Upper Roanoke watershed.
     Last Modified Date: 2 October 2002
     Last Modified Time: 11:38:00
     Version: 2.1.3
     Default DSS File Name: H:\HEC\roanoke\roanoke.dss
     Unit System: Metric
     Enable Evapotranspiration: No
     Precipitation Method: Gridded Precipitation
End:
Method Parameters: Gridded Precipitation
     Gridded Precip File Name: H:\HEC\DSS\stageiii.dss
     Gridded Precip Path: A=uproa B=radar C=PRECIP F=8kbh1ksn
     MissingRecordAction: Set data to zero
End:
*/----------------------End Meteorlogic Models----------------------
```

```
/*----------Grid cell parameter file (1k)---------------------------

Parameter Order: xcoord ycoord area travellength scscn
end:
subbasin: ROA_NIAGARA
gridcell: 1395 1707 0.05890000000 21.80409179687 85.00
gridcell: 1395 1708 0.23290000000 22.55257617188 78.22
gridcell: 1396 1706 0.01710000000 20.24180664063 83.00
gridcell: 1396 1707 0.64810100000 20.86902539063 85.07
gridcell: 1396 1708 1.00000000000 22.16295117188 84.00
gridcell: 1396 1709 0.59379900000 24.33781250000 83.91
...many lines omitted...
end:
subbasin: ROA_WALNUT
gridcell: 1381 1697 0.00480000000 12.19821777344 82.00
gridcell: 1381 1698 0.06690000000 28.81354296875 71.66
gridcell: 1382 1696 0.22710000000 28.01381054688 80.58
gridcell: 1382 1697 0.64650000000 28.44164062500 61.18
gridcell: 1382 1698 0.98280000000 28.23877734375 58.85
gridcell: 1382 1699 0.59009900000 28.70683593750 60.78
...many lines omitted...
end:
subbasin: confluence
gridcell: 1407 1696 0.00150000000 6.97778515625 74.00
gridcell: 1408 1696 0.45330000000 6.31245214844 78.86
gridcell: 1409 1695 0.09240100000 5.07037109375 81.34
gridcell: 1409 1696 0.98760000000 5.29803613281 77.48
gridcell: 1409 1697 0.42989900000 5.18860302734 76.28
...many lines omitted...
end:
subbasin: NF_IRONTO
gridcell: 1363 1681 0.00730000000 24.74208007812 77.70
gridcell: 1363 1682 0.07700000000 24.74209960938 87.29
gridcell: 1363 1690 0.17680000000 27.72343164063 86.95
gridcell: 1363 1691 0.04880000000 27.66401171875 81.89
gridcell: 1363 1695 0.17270000000 33.30331640625 79.54
...many lines omitted...
end:
subbasin: ROA_LAFAYETTE
gridcell: 1373 1679 0.02430000000 22.87436328125 88.26
gridcell: 1373 1680 0.39480000000 22.13813281250 85.88
gridcell: 1373 1681 0.36480000000 21.02345703125 82.87
gridcell: 1373 1682 0.37800000000 20.62686718750 85.02
gridcell: 1373 1683 0.06840000000 21.00713476563 86.03
gridcell: 1374 1679 0.16650100000 22.74285937500 85.16
...many lines omitted...
end:
subbasin: SF_SHAWSVILLE
gridcell: 1362 1672 0.06660000000 22.78418554688 84.52
gridcell: 1363 1670 0.05220100000 22.51232031250 86.36
gridcell: 1363 1671 0.93440000000 22.18508789062 86.07
gridcell: 1363 1672 0.92330000000 22.18086328125 87.99
gridcell: 1363 1673 0.33289900000 22.05516601563 88.58
gridcell: 1363 1674 0.13680000000 22.66666015625 87.40
...many lines omitted...
end:
subbasin: ROA_GLENVAR
```

```
gridcell: 1380 1694 0.08430000000 11.12903320312 82.33
gridcell: 1380 1695 0.61300000000 11.48715527344 77.99
gridcell: 1380 1696 0.10490000000 11.93341894531 82.53
gridcell: 1381 1691 0.09840000000 11.17512402344 85.09
gridcell: 1381 1692 0.03210000000 11.06379785156 78.30
gridcell: 1381 1692 0.05780000000 11.72133496094 78.17
gridcell: 1381 1693 0.36950000000 10.66493847656 84.58
...many lines omitted...
end:
subbasin: TINKER
gridcell: 1396 1717 0.00210000000 7.36097802734 50.00
gridcell: 1397 1717 0.47280100000 6.00606835937 56.80
gridcell: 1397 1718 0.74549900000 6.09161083984 78.54
gridcell: 1397 1719 0.00540000000 5.86382373047 85.83
gridcell: 1397 1719 0.00540000000 5.61119140625 78.00
gridcell: 1398 1716 0.01450000000 4.59005615234 50.00
...many lines omitted...
end:
subbasin: BACK_CRK
gridcell: 1387 1688 0.01620000000 28.38740429688 55.57
gridcell: 1387 1689 0.06600000000 35.54660156250 80.14
gridcell: 1388 1687 0.03060000000 34.33901171875 50.00
gridcell: 1388 1688 0.66330100000 34.87408593750 51.24
gridcell: 1388 1689 0.70439900000 34.70931640625 58.53
gridcell: 1388 1690 0.03780000000 34.41469140625 89.00
...many lines omitted...
end:
subbasin: CARVIN
gridcell: 1393 1711 0.00090000000 13.17688867188 85.00
gridcell: 1393 1711 0.06270000000 12.83965527344 83.60
gridcell: 1394 1711 0.59670000000 11.99751757813 57.29
gridcell: 1394 1712 0.00480000000 11.58125683594 85.00
gridcell: 1395 1710 0.49420100000 11.01386132813 84.02
gridcell: 1395 1711 0.99220000000 10.79673144531 71.75
gridcell: 1395 1712 0.61749900000 10.08555371094 56.64
...many lines omitted...
end:

/*----------End Grid cell parameter file (1k)------------------------
```

```
/*-------------------------Lumped Basin Model---------------------------
Basin: roanoke_lump
     Description: Upper Roanoke Watershed with CN from AMC3 optimized
using March98 and Apr98 Storm Events
     Last Modified Date: 16 December 2002
     Last Modified Time: 14:56:06
     Version: 2.1.3
     Default DSS File Name: H:\roanoke_lumped\roanoke_lumped.dss
     Unit System: SI
     Map File: H:\geo_run2\to_hms\roa_10.map
     Grid Cell File: H:\HEC\GridParm\roa1kam3.mod
End:
Junction: Outlet
     Description: Pour Point after confluence of Back Creek and the
Upper Roanoke River.
     Canvas X: 1412979.651
     Canvas Y: 1695895.004
     Label X: 21
     Label Y: -17
End:

Subbasin: ROA_NIAGARA
     Canvas X: 1407398.736
     Canvas Y: 1708581.705
     Label X: 16
     Label Y: 0
     Area: 263.791000
     Downstream: Niagara_gage

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 82.9

     Transform: Clark
     Time of Concentration: 12
     Storage Coefficient: 8.35

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 4.321
     Monthly rate: 4.272
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.646
     Monthly rate:
     Monthly rate:
End:

Subbasin: ROA_WALNUT
     Canvas X: 1391809.553
     Canvas Y: 1701726.635
     Label X: 16
     Label Y: 0
```

```
     Area: 269.124000
     Downstream: Walnut_gage

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 82.17

     Transform: Clark
     Time of Concentration: 5.1
     Storage Coefficient: 6.4

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 1.699
     Monthly rate: 2.549
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.425
     Monthly rate:
     Monthly rate:
End:

Subbasin: confluence
     Canvas X: 1411761.285
     Canvas Y: 1698366.518
     Label X: 16
     Label Y: 0
     Area: 15.691000
     Downstream: Junction-1

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80.96

     Transform: Clark
     Time of Concentration: 6
     Storage Coefficient: 1

     Baseflow: None
End:

Subbasin: ROA_LAFAYETTE
     Canvas X: 1381913.888
     Canvas Y: 1685761.155
     Label X: 16
     Label Y: 0
     Area: 95.093000
     Downstream: Lafayette

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 83.73
```

```
     Transform: Clark
     Time of Concentration: 8
     Storage Coefficient: 1.6

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 1.19
     Monthly rate: 1.76
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.10
     Monthly rate:
     Monthly rate:
End:

Subbasin: SF_SHAWSVILLE
     Canvas X: 1379765.537
     Canvas Y: 1677447.798
     Label X: 16
     Label Y: 0
     Area: 279.808000
     Observed Hydrograph Gage: Shawsville
     Downstream: Shawsville_Lafayette

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 79.75

     Transform: Clark
     Time of Concentration: 4
     Storage Coefficient: 25

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 3.115
     Monthly rate: 2.832
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.878
     Monthly rate:
     Monthly rate:
End:

Subbasin: ROA_GLENVAR
     Description: Local watershed above the Glenvar gage.
     Canvas X: 1385450.270
     Canvas Y: 1692509.373
     Label X: 16
     Label Y: 0
```

```
     Area: 58.046000
     Downstream: Glenvar

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 82.14

     Transform: Clark
     Time of Concentration: 6
     Storage Coefficient: 2.41

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.283
     Monthly rate: 0.283
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.142
     Monthly rate:
     Monthly rate:
End:

Subbasin: TINKER
     Description: Tinker creek above Daleville, VA.  USS gage number
....
     Canvas X: 1401662.879
     Canvas Y: 1718658.995
     Label X: 16
     Label Y: 0
     Area: 30.123000
     Observed Hydrograph Gage: Tinker
     Downstream: R150

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 81.79

     Transform: Clark
     Time of Concentration: 3.0
     Storage Coefficient: 0.2

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.736
     Monthly rate: 0.510
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.085
     Monthly rate:
```

```
     Monthly rate:
End:

Subbasin: BACK_CRK
     Description: Back Creek above Dundee, VA stream gage
     Canvas X: 1400085.000
     Canvas Y: 1690125.000
     Label X: 16
     Label Y: 0
     Area: 144.964000
     Observed Hydrograph Gage: Back_Cr
     Downstream: Dundee_Confluence

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 79.13

     Transform: Clark
     Time of Concentration: 2.6
     Storage Coefficient: 20

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 2.379
     Monthly rate: 2.322
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.283
     Monthly rate:
     Monthly rate:
End:

Subbasin: CARVIN
     Canvas X: 1398664.634
     Canvas Y: 1713638.420
     Label X: 16
     Label Y: 0
     Area: 37.039000
     Downstream: R300

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 75.61

     Transform: Clark
     Time of Concentration: 2
     Storage Coefficient: 0.2

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.606
     Monthly rate: 0.599
```

```
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.091
     Monthly rate:
     Monthly rate:
End:

Junction: JR330
     Canvas X: 1403942.420
     Canvas Y: 1705395.502
     Label X: 12
     Label Y: 0
     Downstream: R330
End:

Junction: Lafayette
     Description: Junction of the NF and SF Roanoke Rivers at
Lafayette, VA
     Canvas X: 1381843.901
     Canvas Y: 1691995.911
     Label X: -21
     Label Y: 29
     Observed Hydrograph Gage: Lafayette
     Downstream: Lafayette_Glenvar
End:

Reach: R300
     Canvas X: 1403942.420
     Canvas Y: 1705395.502
     From Canvas X: 1400685.000
     From Canvas Y: 1710495.000
     Label X: -42
     Label Y: -7
     Downstream: JR330

     Route: Muskingum
     Muskingum K: 2
     Muskingum X: 0.2
     Muskingum Steps: 2
End:

Reach: R150
     Canvas X: 1403942.420
     Canvas Y: 1705395.502
     From Canvas X: 1401727.165
     From Canvas Y: 1716093.563
     Label X: 16
     Label Y: 0
     Downstream: JR330

     Route: Muskingum
     Muskingum K: 3
     Muskingum X: 0.2
     Muskingum Steps: 3
```

```
End:

Reach: R330
     Canvas X: 1410568.502
     Canvas Y: 1699078.757
     From Canvas X: 1403942.420
     From Canvas Y: 1705395.502
     Label X: 16
     Label Y: 0
     Downstream: Niagara_gage

     Route: Muskingum
     Muskingum K: 3
     Muskingum X: 0.2
     Muskingum Steps: 3
End:

Reach: Walnut_Niagara
     Description: Walnut street stream gage to Niagara stream gage
     Canvas X: 1410568.502
     Canvas Y: 1699078.757
     From Canvas X: 1404440.262
     From Canvas Y: 1698369.044
     Label X: -56
     Label Y: 19
     Downstream: Niagara_gage

     Route: Muskingum
     Muskingum K: 2
     Muskingum X: 0.2
     Muskingum Steps: 2
End:

Reach: R390
     Canvas X: 1412901.684
     Canvas Y: 1695977.025
     From Canvas X: 1410568.502
     From Canvas Y: 1699078.757
     Label X: 16
     Label Y: 0
     Downstream: Junction-1

     Route: Lag
     Lag: 20
End:

Reach: Glenvar_Walnut
     Description: Reach between Glenvar, vA and Walnut Street Gage --
Roanoke, VA
     Canvas X: 1404440.262
     Canvas Y: 1698369.044
     From Canvas X: 1387074.881
     From Canvas Y: 1696672.771
     Label X: 16
     Label Y: 0
     Downstream: Walnut_gage
```

```
     Route: Muskingum
     Muskingum K: 4
     Muskingum X: 0.2
     Muskingum Steps: 5
End:

Reach: Ironto_Lafayette
     Description: Ironto to Lafayette
     Canvas X: 1381843.901
     Canvas Y: 1691995.911
     From Canvas X: 1378695.000
     From Canvas Y: 1691475.000
     Label X: -77
     Label Y: 18
     Downstream: Lafayette

     Route: Muskingum
     Muskingum K: 0.8
     Muskingum X: 0.3
     Muskingum Steps: 1
End:

Reach: Dundee_Confluence
     Description: Channel section from Dundee to Confluence of Back
Creek and Roanoke River.
     Canvas X: 1412901.684
     Canvas Y: 1695977.025
     From Canvas X: 1411130.257
     From Canvas Y: 1696109.302
     Label X: -57
     Label Y: -44
     Downstream: Junction-1

     Route: Lag
     Lag: 20
End:

Reach: Shawsville_Lafayette
     Description: Shawsville SG to Lafayette SG
     Canvas X: 1381843.901
     Canvas Y: 1691995.911
     From Canvas X: 1378169.820
     From Canvas Y: 1680649.483
     Label X: -36
     Label Y: 1
     Downstream: Lafayette

     Route: Muskingum
     Muskingum K: 0.8
     Muskingum X: 0.3
     Muskingum Steps: 1
End:

Reach: Lafayette_Glenvar
     Description: Lafayette to Glenvar on the main stem of the Roanoke
River
     Canvas X: 1387074.881
```

```
     Canvas Y: 1696672.771
     From Canvas X: 1381843.901
     From Canvas Y: 1691995.911
     Label X: -80
     Label Y: 21
     Downstream: Glenvar

     Route: Muskingum
     Muskingum K: 2
     Muskingum X: 0.2
     Muskingum Steps: 2
End:

Junction: Junction-1
     Description: Connection point for Back Creek, Roanoke River, and
Local Subarea contribution.
     Canvas X: 1412901.684
     Canvas Y: 1695977.025
     Label X: 20
     Label Y: 11
     Downstream: Reach-1
End:

Reach: Reach-1
     Description: "Dummy" channel from confluence of Back Crk and Upper
Roanoke to outlet.  Necessary to model confluence as outlet point.
     Canvas X: 1412979.651
     Canvas Y: 1695895.004
     From Canvas X: 1412901.684
     From Canvas Y: 1695977.025
     Label X: 25
     Label Y: -2
     Downstream: Outlet

     Route: Lag
     Lag: 0
End:

Junction: Glenvar
     Description: Stream gage on Roanoke River at Glenvar, VA
     Canvas X: 1387074.881
     Canvas Y: 1696672.771
     Label X: 16
     Label Y: 0
     Observed Hydrograph Gage: Glenvar
     Downstream: Glenvar_Walnut
End:

Junction: Walnut_gage
     Description: Walnut Street Gage, Roanoke River, Roanoke, VA
     Canvas X: 1404440.262
     Canvas Y: 1698369.044
     Label X: -28
     Label Y: -27
     Observed Hydrograph Gage: Walnut
     Downstream: Walnut_Niagara
End:
```

```
Junction: Niagara_gage
     Description: Stream gage, Roanoke River at Niagara, VA
     Canvas X: 1410568.502
     Canvas Y: 1699078.757
     Label X: 23
     Label Y: 18
     Observed Hydrograph Gage: Niagara
     Downstream: R390
End:

Subbasin: NF_IRONTO
     Description: North Fork of the Roanoke River above the Ironto, VA
IFLOWS stream (stage only) gage.
     Canvas X: 1372525.034
     Canvas Y: 1691662.720
     Label X: 16
     Label Y: 0
     Area: 288.804000
     Downstream: Ironto_Lafayette

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 82.43

     Transform: Clark
     Time of Concentration: 4.5
     Storage Coefficient: 26

     Baseflow: Monthly Constant
     Monthly rate:
     Monthly rate:
     Monthly rate: 3.65
     Monthly rate: 5.37
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate:
     Monthly rate: 0.30
     Monthly rate:
     Monthly rate:
End:
Default Attributes:
     Default Basin Unit System: SI
     Default Meteorology Unit System: SI
     Default Loss Rate: SCS
     Default Transform: Clark
     Default Baseflow: Monthly Constant
     Default Route: Muskingum
     Enable Flow Ratio: No
     Enable Evapotranspiration: No
     Compute Local Flow At Junctions: Yes
     Warning On Delete Component: Yes
     Warning On Change Method: Yes
End:
/*------------------End Lumped Basin Model-----------------------------
```

Appendix H: HEC-HMS Model Results

OCT_97

All basin models are distributed with 1k cell size, excepting "lumped" uses the lumped basin model.

Precipitation model

			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Oct_1997_1k	OCT_1997_2k	OCT_1997_4k	OCT_1997_6k	OCT_1997_8k	OCT_1997_10k	OCT97_Lumped
			AMC2	AMC2	AMC2	AMC2	AMC2	AMC2	AMC2
Subbasin	Output	Units							
IRONTO	Mod_Peak_flow	m^3/s	2.519	2.523	2.7103	2.34	2.21	2.979	2.58
Area(km^2	Mod_Time_Peak	hr	10/27 600	10/27 600	10/27 600	10/27 600	10/27 600	10/27 600	10/27 500
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	35.2	35.2	35.5	34.7	34.6	36.6	37.3
	Mod_Precip_Loss	mm	34.2	34.2	34.3	33.8	33.8	35.4	36.3
	Mod_Precip_Excess	mm	1	1	1.1	0.9	0.9	1.2	1
	Mod_Direct_RO	km^3	244.5	244.6	269.5	221.7	207.7	296.9	246
	Mod_Baseflow	km^3	115.6	115.6	115.6	115.6	115.6	115.6	115.6
	Mod_Discharge	km^3	360	360.21	385.1	337.22	323.28	412.42	361.5
	Obs_Discharge	km^3							
Subbasin	Output	Units							
SHAWSVI	Mod_Peak_flow	m^3/s	1.188	1.181	1.268	1.165	1.283	1.42	0.878
Area(km^2	Mod_Time_Peak	hr	10/27 1000	10/27 1000	10/27 1000	10/27 1000	10/27 1100	10/27 600	
	Obs_Peak Flow	m^3/s	1.442	1.442	1.442	1.442	1.442	1.442	1.442
Num.Cells	Obs_Time_Peak	hr	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830
	Mod_Total_Precip	mm	25	25	25.2	24.8	25.4	25.7	25.7
	Mod_Precip_Loss	mm	24.9	24.9	25	24.6	24.3	25.3	25.7
	Mod_Precip_Excess	mm	0.1	0.1	0.2	0.1	0.2	0.2	0
	Mod_Direct_RO	km^3	30.45	29.78	39.39	28.16	39.8	54.5	0
	Mod_Baseflow	km^3	338.2	338.2	338.2	338.2	338.2	338.2	338.2
	Mod_Discharge	km^3	368.7	367.99	377.6	366.4	378	392.7	338.2
	Obs_Discharge	km^3	439.5	439.5	439.5	439.5	439.5	439.5	439.5

OCT_97

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Oct_1997_1k	OCT_1997_2k	OCT_1997_4k	OCT_1997_6k	OCT_1997_8k	OCT_1997_10k	OCT97_Lumped
Subbasin	Output	Units							
LAFAYETT	Mod_Peak_flow	m^3/s	3.117	3.08	3.42	2.77	2.35	2.07	3.05
Area(km^2	Mod_Time_Peak	hr	10/27 500	10/27 500	10/27 500	10/27 600	10/27 700	10/27 600	10/27 700
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	36.2	36.2	36.7	35.8	34.4	33.2	36.8
	Mod_Precip_Loss	mm	34.5	34.5	34.7	34.3	33.2	32.2	35.4
	Mod_Precip_Excess	mm	1.7	1.7	2	1.5	1.2	1	1.4
	Mod_Direct_RO	km^3	160	159.2	191.2	146.4	109.6	94.89	132.4
	Mod_Baseflow	km^3	38.5	38.5	38.5	38.5	38.5	38.5	38.5
	Mod_Discharge	km^3	198.5	197.7	229.7	184.9	148.1	133.41	170.95
	Obs_Discharge	km^3							
Subbasin	Output	Units							
GLENVAR	Mod_Peak_flow	m^3/s	1.141	1.138	1.227	1.306	1.524	1.569	0.845
Area(km^2	Mod_Time_Peak	hr	10/27 500	10/27 500	10/27 500	10/27 500	10/27 500	10/27 500	10/27 600
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	29.9	29.9	30.1	30.3	31.5	31.1	32.5
	Mod_Precip_Loss	mm	29.3	29.4	29.5	29.6	30.6	30.2	32.1
	Mod_Precip_Excess	mm	0.6	0.6	0.6	0.8	0.9	0.9	0.4
	Mod_Direct_RO	km^3	32.62	32.5	36.4	43.8	50.5	50.6	23.48
	Mod_Baseflow	km^3	54.7	54.7	54.7	54.7	54.7	54.7	54.7
	Mod_Discharge	km^3	87.32	87.2	91.06	98.55	105.2	105.3	78.18
	Obs_Discharge	km^3							

OCT_97

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Oct_1997_1k	OCT_1997_2k	OCT_1997_4k	OCT_1997_6k	OCT_1997_8k	OCT_1997_10k	OCT97_Lumped
Subbasin	Output	Units							
WALNUT	Mod_Peak_flow	m^3/s	2.96	2.97	3.21	2.96	2.84	2.89	0.63
Area(km^2	Mod_Time_Peak	hr	10/27 500	10/27 500	10/27 500	10/27 500	10/27 500	10/27 500	10/27 1200
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	26.9	26.8	27	26.6	26.2	26	26.9
	Mod_Precip_Loss	mm	26.3	26.3	26.4	26.1	25.7	25.5	26.9
	Mod_Precip_Excess	mm	0.5	0.6	0.6	0.5	0.5	0.5	0
	Mod_Direct_RO	km^3	147.6	148.6	167.2	147.1	138.9	144	9.7
	Mod_Baseflow	km^3	163.7	163.7	163.7	163.7	163.7	163.7	163.7
	Mod_Discharge	km^3	311.4	312.3	330.87	310.76	302.6	307.75	173.5
	Obs_Discharge	km^3							
Subbasin	Output	Units							
CARVIN	Mod_Peak_flow	m^3/s	0.1	0.1	0.1	0.12	0.18	0.149	0.1
Area(km^2	Mod_Time_Peak	hr	10/26 1400	10/26 1500	10/27 600	10/26 1800	10/26 1500	10/26 1500	
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	13.7	13.7	13.5	15	16.2	14.2	17.4
	Mod_Precip_Loss	mm	13.7	13.7	13.5	14.9	16.1	14.2	17.4
	Mod_Precip_Excess	mm	0	0	0	0	0.1	0	0
	Mod_Direct_RO	km^3	0.276	0.22	0.22	1.64	3.35	1.17	0
	Mod_Baseflow	km^3	35.1	35.1	35.1	35.1	35.1	35.1	35.1
	Mod_Discharge	km^3	35.3	35.3	35.3	36.7	38.4	36.23	35.05
	Obs_Discharge	km^3							

OCT_97

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Oct_1997_1k	OCT_1997_2k	OCT_1997_4k	OCT_1997_6k	OCT_1997_8k	OCT_1997_10k	OCT97_Lumped
Subbasin	Output	Units							
TINKER	Mod_Peak_flow	m^3/s	0.085	0.085	0.085	0.085	0.085	0.085	0.085
Area(km^2	Mod_Time_Peak	hr	10/24 1200	10/24 1200	10/24 1200	10/24 1200	10/24 1200	10/24 1200	
	Obs_Peak Flow	m^3/s	1.44	1.44	1.44	1.44	1.44	1.44	1.44
Num.Cells	Obs_Time_Peak	hr	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830
	Mod_Total_Precip	mm	9.9	9.9	9.7	9.6	10.3	10.8	10
	Mod_Precip_Loss	mm	9.9	9.9	9.7	9.6	10.3	10.8	10
	Mod_Precip_Excess	mm	0	0	0	0	0	0	0
	Mod_Direct_RO	km^3	0	0	0	0	0	0	0
	Mod_Baseflow	km^3	32.7	32.7	32.7	32.7	32.7	32.7	32.7
	Mod_Discharge	km^3	32.7	32.7	32.7	32.7	32.7	32.7	32.7
	Obs_Discharge	km^3	439.5	439.5	439.5	439.5	439.5	439.5	439.5
Subbasin	Output	Units							
NIAGARA	Mod_Peak_flow	m^3/s	2.38	2.38	2.6	2.08	2.09	2.25	0.646
Area(km^2	Mod_Time_Peak	hr	10/27 700	10/27 700	10/27 700	10/27 800	10/27 800	10/27 800	
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	21.9	21.9	22.1	21.6	20.9	20.5	21.8
	Mod_Precip_Loss	mm	21.4	21.4	21.5	21.1	20.4	20	21.8
	Mod_Precip_Excess	mm	0.5	0.5	0.6	0.4	0.4	0.5	0
	Mod_Direct_RO	km^3	140	139	160.9	113	109	123.4	0
	Mod_Baseflow	km^3	248.8	248.8	248.8	248.8	248.8	248.8	248.8
	Mod_Discharge	km^3	388.8	387.6	409.71	361.87	357.8	372.27	248.8
	Obs_Discharge	km^3							

OCT_97

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Oct_1997_1k	OCT_1997_2k	OCT_1997_4k	OCT_1997_6k	OCT_1997_8k	OCT_1997_10k	OCT97_Lumped
Subbasin	Output	Units							
BACK_CR	Mod_Peak_flow	m^3/s	0.586	0.59	0.597	0.621	0.536	0.91	0.3
Area(km^2	Mod_Time_Peak	hr	10/27 700	10/27 700	10/27 700	10/27 700	10/27 1000	10/27 1000	
	Obs_Peak Flow	m^3/s	1.44	1.44	1.44	1.44	1.44	1.44	1.44
Num.Cells	Obs_Time_Peak	hr	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830	10/27 830
	Mod_Total_Precip	mm	30.8	30.8	30.6	31	31	32.1	32.2
	Mod_Precip_Loss	mm	30.6	30.6	30.4	30.8	30.9	31.6	32.2
	Mod_Precip_Excess	mm	0.2	0.2	0.2	0.2	0.2	0.4	0
	Mod_Direct_RO	km^3	27.1	27.6	28.45	30.58	22.36	58.1	1.303
	Mod_Baseflow	km^3	109	109	109	109	109	109	109
	Mod_Discharge	km^3	136.2	136.57	137.46	139.59	131.37	167.1	110.3
	Obs_Discharge	km^3	439.5	439.5	439.5	439.5	439.5	439.5	439.5
Subbasin	Output	Units							
OUTLET	Mod_Peak_flow	m^3/s	0	0	0	0	0	0	0
Area(km^2	Mod_Time_Peak	hr	-	-	-	-	-	-	-
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	21.5	21.5	21.7	22	21.3	20.7	23.3
	Mod_Precip_Loss	mm	21.5	21.5	21.7	22	21.3	20.7	23.3
	Mod_Precip_Excess	mm	0	0	0	0	0	0	0
	Mod_Direct_RO	km^3	0	0	0	0	0	0	0
	Mod_Baseflow	km^3	0	0	0	0	0	0	0
	Mod_Discharge	km^3	0	0	0	0	0	0	0
	Obs_Discharge	km^3							

OCT_97

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Oct_1997_1k	OCT_1997_2k	OCT_1997_4k	OCT_1997_6k	OCT_1997_8k	OCT_1997_10k	OCT97_Lumped
Gage	Output	Units							
LAFAYETT	Mod_Peak_Flow	m^3/s	6.58	6.54	7.02	6.14	5.81	6.3	6.48
Tot_area(k	Mod_Time_Peak	hr	10/27 600	10/27 600	10/27 600	10/27 600	10/27 700	10/27 600	10/27 700
	Mod_Volume	km^3	925.42	924.14	990.4	886.9	847.77	936.29	675.8
Total_Cells	Obs_Peak_Flow	m^3/s	2.24	2.24	2.24	2.24	2.24	2.24	2.24
	Obs_Time_Peak	hr	10/27 1745	10/27 1745	10/27 1745	10/27 1745	10/27 1745	10/27 1745	10/27 1745
	Obs_Volume	km^3	675.8	675.8	675.8	675.8	675.8	675.8	675.8
Gage	Output	Units							
GLENVAR	Mod_Peak_Flow	m^3/s	6.85	6.82	7.36	6.56	6.16	6.72	6.92
Tot_area(k	Mod_Time_Peak	hr	10/27 800	10/27 800	10/27 700	10/27 800	10/27 900	10/27 800	10/27 900
	Mod_Volume	km^3	1008	1006	1076.2	981	948.54	1035.5	675.8
Total_Cells	Obs_Peak_Flow	m^3/s	2.577	2.577	2.577	2.577	2.577	2.577	2.577
	Obs_Time_Peak	hr	10/28 0015	10/28 0015	10/28 0015	10/28 0015	10/28 0015	10/28 0015	10/28 0015
	Obs_Volume	km^3	790.4	790.4	790.4	790.4	790.4	790.4	790.4
Gage	Output	Units							
NIAGARA	Mod_Peak_Flow	m^3/s	10.59	10.57	11.72	10.07	9.49	10.25	8.05
Tot_area(k	Mod_Time_Peak	hr	10/27 700	10/27 700	10/27 700	10/27 800	10/27 1200	10/27 1200	10/27 1500
	Mod_Volume	km^3	1759.5	1757.9	1866.5	1707.7	1664.6	1763.2	1417.6
Total_Cells	Obs_Peak_Flow	m^3/s	-	-	-	-	-	-	-
	Obs_Time_Peak	hr	-	-	-	-	-	-	-
	Obs_Volume	km^3	-	-	-	-	-	-	-

OCT_97

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Oct_1997_1k	OCT_1997_2k	OCT_1997_4k	OCT_1997_6k	OCT_1997_8k	OCT_1997_10k	OCT97_Lumped
Gage	Output	Units							
WALNUT	Mod_Peak_Flow	m^3/s	8.46	8.45	9.19	8.13	7.69	8.29	7.34
Tot_area(k	Mod_Time_Peak	hr	10/27 1100	10/27 1100	10/27 500	10/27 1100	10/27 1000	10/27 1100	10/27 1300
	Mod_Volume	km^3	1308.7	1308.3	1395.4	1282	1241.3	1329.7	1106.5
Total_Cells	Obs_Peak_Flow	m^3/s	5.57	5.57	5.57	5.57	5.57	5.57	5.57
	Obs_Time_Peak	hr	10/26 2200	10/26 2200	10/26 2200	10/26 2200	10/26 2200	10/26 2200	10/26 2200
	Obs_Volume	km^3	1186	1186	1186	1186	1186	1186	1186
Gage	Output	Units							
OUTLET	Mod_Peak_Flow	m^3/s	11.17	11.15	12.25	10.68	10.05	11.08	8.34
Tot_area(k	Mod_Time_Peak	hr	10/27 800	10/27 800	10/27 800	10/27 800	10/27 1200	10/27 1200	10/27 1500
	Mod_Volume	km^3	1895	1893.4	2002.7	1846.3	1795	1928.8	1526.9
Total_Cells	Obs_Peak_Flow	m^3/s							
	Obs_Time_Peak	hr							
	Obs_Volume	km^3							

All basin models are distributed with 1k cell size, excepting "lumped" uses the lumped basin model.

Precipitation model.

			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Mar_1998_1k	Mar_1998_2k	Mar_1998_4k	Mar_1998_6k	Mar_1998_8k	Mar_1998_10k	MAR98_Lumped
			AMC3	AMC3	AMC3	AMC3	AMC3	AMC3	AMC3
Subbasin	Output	Units							
IRONTO	Mod_Peak_flow	m^3/s	94.86	94.83	95.05	95.29	95.81	93.47	95.03
Area(km^2	Mod_Time_Peak	hr	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 900
288.8	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	97.1	97.1	97.4	97.2	97.9	97.4	97.3
	Mod_Precip_Loss	mm	43.8	43.8	43.8	43.8	43.9	43.8	44.1
	Mod_Precip_Excess	mm	53.3	53.3	53.6	53.4	54	53.6	53.1
	Mod_Direct_RO	km^3	13062	13059	13126	13073	13234	13157	13072
	Mod_Baseflow	km^3	1721	1721	1721	1721	1721	1721	1721
	Mod_Discharge	km^3	14783	14781	14848	14794	14955	14880	14793
	Obs_Discharge	km^3							
Subbasin	Output	Units							
SHAWSVI	Mod_Peak_flow	m^3/s	76.41	76.38	76.79	76.32	77.06	74.42	76.8
Area(km^2	Mod_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800
279.8	Obs_Peak Flow	m^3/s	114.1	114.1	114.1	114.1	114.1	114.1	114.1
Num.Cells	Obs_Time_Peak	hr	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330
	Mod_Total_Precip	mm	85.1	85	85	85	85.5	84.1	85.9
	Mod_Precip_Loss	mm	45.9	45.9	45.9	45.9	45.8	45.8	47.1
	Mod_Precip_Excess	mm	39.2	39.2	39.4	39.1	39.7	38.3	38.8
	Mod_Direct_RO	km^3	9236	9234	9303	9217	9363	9035	9158
	Mod_Baseflow	km^3	1469	1469	1469	1469	1469	1469	1469
	Mod_Discharge	km^3	10705	10703	10772	10686	10832	10504	10627
	Obs_Discharge	km^3	10521	10521	10521	10521	10521	10521	10521

MAR_98

			Precipitation model.						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Mar_1998_1k	Mar_1998_2k	Mar_1998_4k	Mar_1998_6k	Mar_1998_8k	Mar_1998_10k	MAR98_Lumped
Subbasin	Output	Units							
LAFAYETT	Mod_Peak_flow	m^3/s	85.44	85.33	86.58	84.93	86.131	85.49	73.09
Area(km^2	Mod_Time_Peak	hr	3/21 200	3/21 200	3/21 200	3/21 300	3/21 200	3/21 200	3/21 100
95.09	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	83.6	83.6	83.6	84.1	85.3	82.3	83.5
	Mod_Precip_Loss	mm	39.2	39.2	39.2	39.3	39.6	39	39.4
	Mod_Precip_Excess	mm	44.3	44.3	44.4	44.7	45.8	43.3	44.1
	Mod_Direct_RO	km^3	4215	4216	4220	4255	4353	4115	4194
	Mod_Baseflow	km^3	561.2	561.2	561.2	561.2	561.2	561.2	561.2
	Mod_Discharge	km^3	4776.6	4777.5	4781.6	4815.9	4914.3	4675.7	4755.3
	Obs_Discharge	km^3							
Subbasin	Output	Units							
GLENVAR	Mod_Peak_flow	m^3/s	54.4	54.5	54.6	53.8	51.8	57.77	40.78
Area(km^2	Mod_Time_Peak	hr	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/21 100
58.05	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	79.2	79.4	78.8	80.1	78.9	82	78.9
	Mod_Precip_Loss	mm	41	41	40.8	41.2	41	41.4	41.5
	Mod_Precip_Excess	mm	38.2	38.3	38	38.9	37.9	40.6	37.4
	Mod_Direct_RO	km^3	2220	2224	2206	2257	2200	2358	2173
	Mod_Baseflow	km^3	133.5	133.5	133.5	133.5	133.5	133.5	133.5
	Mod_Discharge	km^3	2353.3	2357.2	2339.2	2390.4	2333.4	2491.6	2306
	Obs_Discharge	km^3							

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			Precipitation model. 1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Mar_1998_1k	Mar_1998_2k	Mar_1998_4k	Mar_1998_6k	Mar_1998_8k	Mar_1998_10k	MAR98_Lumped
Subbasin	Output	Units							
WALNUT	Mod_Peak_flow	m^3/s	177.9	178	178.4	178	167.56	168.97	166.53
Area(km^2	Mod_Time_Peak	hr	3/21 100	3/21 100	3/20 2400	3/20 2400	3/21 100	3/21 100	3/21 100
269.12	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	84.2	84.2	84.2	84.1	81.3	81.2	84.8
	Mod_Precip_Loss	mm	41.4	41.4	41.2	41.5	41	40.8	42.6
	Mod_Precip_Excess	mm	42.8	42.8	43	42.6	40.3	40.4	42.2
	Mod_Direct_RO	km^3	11492	11501	11554	11456	10822	10847	11357
	Mod_Baseflow	km^3	801	801	801	801	801	801	801.2
	Mod_Discharge	km^3	12293	12302	12356	12257	11624	11648	12158
	Obs_Discharge	km^3							
Subbasin	Output	Units							
CARVIN	Mod_Peak_flow	m^3/s	82.9	83	81.6	84.429	95.977	80.72	51.7
Area(km^2	Mod_Time_Peak	hr	3/20 2200	3/20 2200	3/20 2200	3/20 2200	3/20 2200	3/20 2200	3/20 2200
37.04	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	69.9	70	68.5	72	78.3	70.2	67.6
	Mod_Precip_Loss	mm	45.6	45.7	44.9	46.1	48.6	45.4	47.9
	Mod_Precip_Excess	mm	24.3	243	23.6	25.8	29.6	24.8	1937
	Mod_Direct_RO	km^3	967.6	969.3	951.6	1046	1185	972.6	729.1
	Mod_Baseflow	km^3	285.8	285.8	285.8	285.8	285.8	285.8	285.8
	Mod_Discharge	km^3	1253.4	1255.1	1237.4	1331.9	1471.1	1258.4	1014.9
	Obs_Discharge	km^3							

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			Precipitation model.						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Mar_1998_1k	Mar_1998_2k	Mar_1998_4k	Mar_1998_6k	Mar_1998_8k	Mar_1998_10k	MAR98_Lumped
Subbasin	Output	Units							
TINKER	Mod_Peak_flow	m^3/s	61.43	61.41	60.34	61.92	65.28	55.04	44.88
Area(km^2	Mod_Time_Peak	hr	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300
30.12	Obs_Peak Flow	m^3/s	58.1	58.1	58.1	58.1	58.1	58.1	58.1
Num.Cells	Obs_Time_Peak	hr	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330
	Mod_Total_Precip	mm	63.3	63.7	62.7	63.1	66.6	65.2	63.4
	Mod_Precip_Loss	mm	37.8	37.9	37.7	37.8	38.5	38.3	38.4
	Mod_Precip_Excess	mm	25.5	25.8	25	25.3	28.1	26.9	25
	Mod_Direct_RO	km^3	855.5	861.2	845.4	853.4	938.5	917.3	753
	Mod_Baseflow	km^3	347.1	347.1	347.1	347.1	347.1	347.1	347.1
	Mod_Discharge	km^3	1202.6	1208.3	1192.5	1200.5	1285.6	1264.4	1100.1
	Obs_Discharge	km^3	1785	1785	1785	1785	1785	1785	1785
Subbasin	Output	Units							
NIAGARA	Mod_Peak_flow	m^3/s	122.9	123	123.6	122.74	122.94	117.93	117.44
Area(km^2	Mod_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 700	3/21 800	3/221 800
263.8	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	72.8	72.9	73.2	72.6	71.7	71.3	71.8
	Mod_Precip_Loss	mm	37.4	37.4	37.4	37.4	37.2	37.1	38.7
	Mod_Precip_Excess	mm	35.5	35.5	35.8	35.2	34.5	34.1	33.1
	Mod_Direct_RO	km^3	9283	9285	9369	9215	9020	8934	8689
	Mod_Baseflow	km^3	2038	2038	2038	2038	2038	2038	2038
	Mod_Discharge	km^3	11321	11322	11407	11252	11058	10972	10726
	Obs_Discharge	km^3							

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Precipitation model.

			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Mar_1998_1k	Mar_1998_2k	Mar_1998_4k	Mar_1998_6k	Mar_1998_8k	Mar_1998_10k	MAR98_Lumped
Subbasin	Output	Units							
BACK_CR	Mod_Peak_flow	m^3/s	46.6	46.6	46.8	46.27	45.89	47.26	44.41
Area(km^2	Mod_Time_Peak	hr	3/20 2400	3/20 2400	3/20 2400	3/20 2400	3/20 2400	3/20 2400	3/21 700
144.96	Obs_Peak Flow	m^3/s	77	77	77	77	77	77	77
Num.Cells	Obs_Time_Peak	hr	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215
	Mod_Total_Precip	mm	84.3	84.2	84.4	84	83.4	85.7	82.6
	Mod_Precip_Loss	mm	47.4	47.3	47.4	47.2	47.1	47.6	47.4
	Mod_Precip_Excess	mm	36.9	36.9	37	36.7	36.3	38.2	35.2
	Mod_Direct_RO	km^3	4813	4810	4830	4791	4733	4977	4607
	Mod_Baseflow	km^3	1122	1122	1122	1122	1122	1122	1122
	Mod_Discharge	km^3	5935	5932	5951.7	5912.9	5855.3	6098.8	5728.9
	Obs_Discharge	km^3	4941	4941	4941	4941	4941	4941	4941
Subbasin	Output	Units							
OUTLET	Mod_Peak_flow	m^3/s	19.1	19.1	18.9	20.2	18	18.86	16.092
Area(km^2	Mod_Time_Peak	hr	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100
15.69	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	70.8	70.8	70.8	71.9	70.5	70.5	70.9
	Mod_Precip_Loss	mm	41.4	41.4	41.4	41.7	41.4	41.3	41.6
	Mod_Precip_Excess	mm	29.4	29.4	29.3	30.1	29.2	29.1	29.3
	Mod_Direct_RO	km^3	460.8	461.1	460.4	473	457.6	457	459
	Mod_Baseflow	km^3	0	0	0	0	0	0	0
	Mod_Discharge	km^3	460.8	461.1	460.4	473	457.6	457	459
	Obs_Discharge	km^3							

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			Precipitation model.						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Mar_1998_1k	Mar_1998_2k	Mar_1998_4k	Mar_1998_6k	Mar_1998_8k	Mar_1998_10k	MAR98_Lumped
Gage	Output	Units							
LAFAYETT	Mod_Peak_Flow	m^3/s	219.5	219.4	221.1	218.95	222.49	216.95	211.58
Tot_area(k	Mod_Time_Peak	hr	3/21 200	3/21 200	3/21 200	3/21 200	3/21 200	3/21 200	3/21 1000
	Mod_Volume	km^3	30135	30131	30271	30166	30571	29931	30045
Total_Cells	Obs_Peak_Flow	m^3/s	218.9	218.9	218.9	218.9	218.9	218.9	218.9
	Obs_Time_Peak	hr	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215
	Obs_Volume	km^3	27873	27873	27873	27873	27873	27873	27873
Gage	Output	Units							
GLENVAR	Mod_Peak_Flow	m^3/s	226.9	226.8	227.6	227.1	230.92	225.48	230.2
Tot_area(k	Mod_Time_Peak	hr	3/21 400	3/21 400	3/21 400	3/21 400	3/21 400	3/21 400	3/21 300
	Mod_Volume	km^3	32143	32143	32263	32221	32556	32083	32002
Total_Cells	Obs_Peak_Flow	m^3/s	322.8	322.8	322.8	322.8	322.8	322.8	322.8
	Obs_Time_Peak	hr	3/21 430	3/21 430	3/21 430	3/21 430	3/21 430	3/21 430	3/21 430
	Obs_Volume	km^3	36364	36364	36364	36364	36364	36364	36364
Gage	Output	Units							
NIAGARA	Mod_Peak_Flow	m^3/s	481.21	481.28	482.9	480.7	479.2	465.42	479.95
Tot_area(k	Mod_Time_Peak	hr	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 900
	Mod_Volume	km^3	56992	57009	57228	57029	56762	56022	55773
Total_Cells	Obs_Peak_Flow	m^3/s	521	521	521	521	521	521	521
	Obs_Time_Peak	hr	3/21 0145	3/21 0145	3/21 0145	3/21 0145	3/21 0145	3/21 0145	3/21 0145
	Obs_Volume	km^3	61657	61657	61657	61657	61657	61657	61657

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			Precipitation model.						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			Mar_1998_1k	Mar_1998_2k	Mar_1998_4k	Mar_1998_6k	Mar_1998_8k	Mar_1998_10k	MAR98_Lumped
Gage	Output	Units							
WALNUT	Mod_Peak_Flow	m^3/s	362.69	362.67	364.17	360.59	360.25	348.38	360.03
Tot_area(k	Mod_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800
	Mod_Volume	km^3	43659	43668	43838	42126	43396	42965	43377
Total_Cells	Obs_Peak_Flow	m^3/s	365.29	365.29	365.29	365.29	365.29	365.29	365.29
	Obs_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800
	Obs_Volume	km^3	42126	42126	42126	42126	42126	42126	42126
Gage	Output	Units							
OUTLET	Mod_Peak_Flow	m^3/s	526.7	526.8	528.7	526.25	524.42	513.75	526.5
Tot_area(k	Mod_Time_Peak	hr	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 900	3/21 900
	Mod_Volume	km^3	63297	63312	63550	63325	62984	62489	61871
Total_Cells	Obs_Peak_Flow	m^3/s							
	Obs_Time_Peak	hr							
	Obs_Volume	km^3							

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All basin models are distributed with 1k cell size, excepting "lumped" uses the lumped basin model.

Precipitation model

			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			APR_1998_1k	APR_1998_2k	APR_1998_4k	APR_1998_6k	APR_1998_8k	APR_1998_10k	APR98_Lumped
			AMC3	AMC3	AMC3	AMC3	AMC3	AMC3	AMC3
Subbasin	Output	Units							
IRONTO	Mod_Peak_flow	m^3/s	67.94	67.96	68.09	67.92	67.08	68.64	67.42
Area(km^2	Mod_Time_Peak	hr	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/20 100
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	69.4	69.4	69.5	69.4	69.1	70.6	69.4
	Mod_Precip_Loss	mm	38.7	38.7	38.7	38.7	38.7	39	39
	Mod_Precip_Excess	mm	30.4	30.7	30.8	30.7	30.5	31.6	30.4
	Mod_Direct_RO	km^3	7800	7804	7831	7803	7744	8034	7760
	Mod_Baseflow	km^3	2532	2532	2532	2532	2532	2532	2532
	Mod_Discharge	km^3	10333	10337	10364	10335	10276	10567	10293
	Obs_Discharge	km^3							
Subbasin	Output	Units							
SHAWSVII	Mod_Peak_flow	m^3/s	52.167	52.09	52.71	51.55	52.93	53.5	51.4
Area(km^2	Mod_Time_Peak	hr	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100
	Obs_Peak Flow	m^3/s	46.72	46.72	46.72	46.72	46.72	46.72	46.72
Num.Cells	Obs_Time_Peak	hr	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100
	Mod_Total_Precip	mm	62.2	62.1	62.5	61.7	62.6	62.9	63.2
	Mod_Precip_Loss	mm	39.3	39.3	39.4	39.1	39.3	39.4	41.1
	Mod_Precip_Excess	mm	22.9	22.8	23.2	22.6	23.3	23.5	22
	Mod_Direct_RO	km^3	5646	5636	5721	5579	5751	5814	5440
	Mod_Baseflow	km^3	1336	1336	1336	1336	1336	1336	1336
	Mod_Discharge	km^3	6981.2	6971.5	7056.1	6914	7086	7149.6	6775.8
	Obs_Discharge	km^3	6245	6245	6245	6245	6245	6245	6245

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			APR_1998_1k	APR_1998_2k	APR_1998_4k	APR_1998_6k	APR_1998_8k	APR_1998_10k	APR98_Lumped
Subbasin	Output	Units							
LAFAYETT	Mod_Peak_flow	m^3/s	83.28	83.09	83.71	82.98	83.77	74.47	82
Area(km^2	Mod_Time_Peak	hr	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/19 2400
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	67.1	67	67.4	66.7	66.9	63.1	67.4
	Mod_Precip_Loss	mm	36.2	36.1	36.2	36.1	36.1	35.3	36.4
	Mod_Precip_Excess	mm	30.9	30.8	31.2	30.6	30.7	27.8	30.9
	Mod_Direct_RO	km^3	2939	2932	2969	2908	2922	2642	2941
	Mod_Baseflow	km^3	830	830	830	830	830	830	830
	Mod_Discharge	km^3	3768.6	3762.3	3799.3	3737.7	3752.3	3472.4	3771
	Obs_Discharge	km^3							
Subbasin	Output	Units							
GLENVAR	Mod_Peak_flow	m^3/s	42.98	43.04	43.18	43.59	43.8	46.25	37.8
Area(km^2	Mod_Time_Peak	hr	4/19 2200	4/19 2200	4/19 2200	4/19 2200	4/19 2200	4/19 2200	4/19 2400
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	60.5	60.6	60.4	61.2	61.2	62.9	64.3
	Mod_Precip_Loss	mm	36.5	36.6	36.4	36.7	36.7	37.1	38.2
	Mod_Precip_Excess	mm	24	24	24	24.5	24.5	25.8	26.2
	Mod_Direct_RO	km^3	1390	1392	1390	1419	1417	1496	1512
	Mod_Baseflow	km^3	133.5	133.5	133.5	133.5	133.5	133.5	133.5
	Mod_Discharge	km^3	1523.58	1525.5	1523.5	1552.8	1550	1629.2	1645.8
	Obs_Discharge	km^3							

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			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			APR_1998_1k	APR_1998_2k	APR_1998_4k	APR_1998_6k	APR_1998_8k	APR_1998_10k	APR98_Lumped
Subbasin	Output	Units							
WALNUT	Mod_Peak_flow	m^3/s	104.68	104.8	104.7	103.84	103.97	103.85	113.1
Area(km^2	Mod_Time_Peak	hr	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/20 100
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	59.9	59.9	60.1	59.6	59.3	58.5	66.1
	Mod_Precip_Loss	mm	35.9	35.9	35.9	35.8	35.8	35.2	38.6
	Mod_Precip_Excess	mm	24	24	24.2	23.7	23.6	23.3	27.6
	Mod_Direct_RO	km^3	6372	6375	6417	6303	6267	6204	7325
	Mod_Baseflow	km^3	1202	1202	1202	1202	1202	1202	1202
	Mod_Discharge	km^3	7574.3	7577.2	7619.4	7504.7	7468.9	7405.8	8527.1
	Obs_Discharge	km^3							
Subbasin	Output	Units							
CARVIN	Mod_Peak_flow	m^3/s	4.66	4.67	4.71	7.66	8.44	5.02	2.11
Area(km^2	Mod_Time_Peak	hr	4/19 2100	4/19 2100	4/19 2100	4/19 2100	4/19 2100	4/19 2100	4/19 2200
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	26.8	26.8	25.4	30.6	31.8	27.6	24.5
	Mod_Precip_Loss	mm	23.9	24	22.6	25.8	26.6	24.3	23.8
	Mod_Precip_Excess	mm	2.8	2.8	2.8	4.8	5.1	3.3	0.7
	Mod_Direct_RO	km^3	114	113.6	113.2	193.7	200.1	132.1	27.33
	Mod_Baseflow	km^3	282.5	282.5	282.5	282.5	282.5	282.5	282.5
	Mod_Discharge	km^3	396	396.1	395.7	476.2	482.6	414.6	309.82
	Obs_Discharge	km^3							

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			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			APR_1998_1k	APR_1998_2k	APR_1998_4k	APR_1998_6k	APR_1998_8k	APR_1998_10k	APR98_Lumped
Subbasin	Output	Units							
TINKER	Mod_Peak_flow	m^3/s	3.57	3.74	3.44	3.56	4.31	5.42	4.36
Area(km^2	Mod_Time_Peak	hr	4/19 2200	4/19 2200	4/19 2200	4/19 2200	4/19 2200	4/19 2200	4/19 2200
	Obs_Peak Flow	m^3/s	16.42	16.42	16.42	16.42	16.42	16.42	16.42
Num.Cells	Obs_Time_Peak	hr	3/17 1030	3/17 1030	3/17 1030	3/17 1030	3/17 1030	3/17 1030	3/17 1030
	Mod_Total_Precip	mm	21	21.2	20.3	20.7	20	24.5	27.4
	Mod_Precip_Loss	mm	19.1	19.3	18.5	19	17.7	21.2	23.9
	Mod_Precip_Excess	mm	1.8	1.9	1.7	1.7	2.3	3.2	3.6
	Mod_Direct_RO	km^3	59.3	62.83	57.17	56.21	76.9	106.6	107.7
	Mod_Baseflow	km^3	240.5	240.5	240.5	240.5	240.5	240.5	240.5
	Mod_Discharge	km^3	299.81	303.35	297.69	296.72	317.4	347.1	348.2
	Obs_Discharge	km^3	805.3	805.3	805.3	805.3	805.3	805.3	805.3
Subbasin	Output	Units							
NIAGARA	Mod_Peak_flow	m^3/s	75.05	75.03	76.87	73.44	69.33	70.3	68.9
Area(km^2	Mod_Time_Peak	hr	4/20 500	4/20 500	4/20 500	4/20 500	4/20 500	4/20 500	4/20 600
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	52.2	52.2	52.4	51.5	50	50.5	52
	Mod_Precip_Loss	mm	31.3	31.3	31	31.1	30.6	30.8	33.7
	Mod_Precip_Excess	mm	20.9	20.9	21.4	20.4	19.4	19.7	18.4
	Mod_Direct_RO	km^3	5453	5451	5605	5330	5066	5139	4813
	Mod_Baseflow	km^3	2015	2015	2015	2015	2015	2015	2015
	Mod_Discharge	km^3	7467.4	7465.4	7620	7345	7080.2	7153.8	6827.3
	Obs_Discharge	km^3							

APR_98

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			APR_1998_1k	APR_1998_2k	APR_1998_4k	APR_1998_6k	APR_1998_8k	APR_1998_10k	APR98_Lumped
Subbasin	Output	Units							
BACK_CRI	Mod_Peak_flow	m^3/s	28.28	28.28	28.16	28.46	28.37	30.41	27.58
Area(km^2	Mod_Time_Peak	hr	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400
	Obs_Peak Flow	m^3/s	20.59	20.59	20.59	20.59	20.59	20.59	20.59
Num.Cells	Obs_Time_Peak	hr	4/20 115	4/20 115	4/20 115	4/20 115	4/20 115	4/20 115	4/20 115
	Mod_Total_Precip	mm	61.7	61.7	61.6	62.1	61.9	64.4	61.2
	Mod_Precip_Loss	mm	41.1	41.1	41.1	41.2	41.2	41.9	41.3
	Mod_Precip_Excess	mm	20.6	20.6	20.5	20.8	20.8	22.5	19.9
	Mod_Direct_RO	km^3	2754	2755	2736	2785	2776	3016	2667
	Mod_Baseflow	km^3	1095	1095	1095	1095	1095	1095	1095
	Mod_Discharge	km^3	3849	3849.9	3831.1	3879.6	3871.4	4110.8	3761.6
	Obs_Discharge	km^3	2936	2936	2936	2936	2936	2936	2936
Subbasin	Output	Units							
OUTLET	Mod_Peak_flow	m^3/s	11.58	11.58	11.67	11.74	11.47	11.05	11.41
Area(km^2	Mod_Time_Peak	hr	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/19 2400	4/20 2300
	Obs_Peak Flow	m^3/s							
Num.Cells	Obs_Time_Peak	hr							
	Mod_Total_Precip	mm	60.4	60.4	60.6	61.4	59.7	59.3	62.2
	Mod_Precip_Loss	mm	38.5	38.6	38.6	38.9	38.3	38.2	39.2
	Mod_Precip_Excess	mm	21.9	21.9	22	22.6	21.4	21.1	23
	Mod_Direct_RO	km^3	342.9	342.9	34.7	353.9	335.1	330.9	360.1
	Mod_Baseflow	km^3	0	0	0	0	0	0	0
	Mod_Discharge	km^3	342.9	342.9	344.7	353.9	335.1	330.9	360.1
	Obs_Discharge	km^3							

APR_98

			Precipitation model						
			1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			APR_1998_1k	APR_1998_2k	APR_1998_4k	APR_1998_6k	APR_1998_8k	APR_1998_10k	APR98_Lumped
Gage	Output	Units							
LAFAYETT	Mod_Peak_Flow	m^3/s	202.71	202.45	203.81	201.81	203.1	195.7	197.36
Tot_area(k	Mod_Time_Peak	hr	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100	4/20 100
	Mod_Volume	km^3	21024	21012	21161	20930	21057	21129	20781
Total_Cells	Obs_Peak_Flow	m^3/s	133.09	133.09	133.09	133.09	133.09	133.09	133.09
	Obs_Time_Peak	hr	4/20 230	4/20 230	4/20 230	4/20 230	4/20 230	4/20 230	4/20 230
	Obs_Volume	km^3	19511	19511	19511	19511	19511	19511	19511
Gage	Output	Units							
GLENVAR	Mod_Peak_Flow	m^3/s	208.8	208.5	209.7	208.3	209	203.8	215.43
Tot_area(k	Mod_Time_Peak	hr	4/20 200	4/20 200	4/20 200	4/20 200	4/20 200	4/20 200	4/20 200
	Mod_Volume	km^3	22393	22383	22528	22328	22452	22598	22271
Total_Cells	Obs_Peak_Flow	m^3/s	176.7	176.7	176.7	176.7	176.7	176.7	176.7
	Obs_Time_Peak	hr	4/20 345	4/20 345	4/20 345	4/20 345	4/20 345	4/20 345	4/20 345
	Obs_Volume	km^3	22242	22242	22242	22242	22242	22242	22242
Gage	Output	Units							
NIAGARA	Mod_Peak_Flow	m^3/s	323.57	323.51	326.31	322	318.1	315.6	335.6
Tot_area(k	Mod_Time_Peak	hr	4/20 700	4/20 700	4/20 700	4/20 700	4/20 700	4/20 700	4/20 700
	Mod_Volume	km^3	37543	37536	37868	37634	37213	37321	37698
Total_Cells	Obs_Peak_Flow	m^3/s	222	222	222	222	222	222	222
	Obs_Time_Peak	hr	4/20 715	4/20 715	4/20 715	4/20 715	4/20 715	4/20 715	4/20 715
	Obs_Volume	km^3	36905	36905	36905	36905	36905	36905	36905

APR_98

			Precipitation model 1k_bilin	2k_bilin	4k	6k_bilin	8k_bilin	10k_bilin	Lumped
Model Run Name			APR_1998_1k	APR_1998_2k	APR_1998_4k	APR_1998_6k	APR_1998_8k	APR_1998_10k	APR98_Lumped
Gage	Output	Units							
WALNUT	Mod_Peak_Flow	m^3/s	256.05	255.92	257.13	255.26	254.8	251.04	269.81
Tot_area(k	Mod_Time_Peak	hr	4/20 600	4/20 600	4/20 600	4/20 600	4/20 600	4/20 500	4/20 500
	Mod_Volume	km^3	29609	29601	29787	29477	29561	29636	30440
Total_Cells	Obs_Peak_Flow	m^3/s	145.3	145.3	145.3	145.3	145.3	145.3	145.3
	Obs_Time_Peak	hr	4/20 645	4/20 645	4/20 645	4/20 645	4/20 645	4/20 645	4/20 645
	Obs_Volume	km^3	24734	24734	24734	24734	24734	24734	24734
Gage	Output	Units							
OUTLET	Mod_Peak_Flow	m^3/s	346.6	346.6	349.3	345.2	341.1	340.93	356.5
Tot_area(k	Mod_Time_Peak	hr	4/20 700	4/20 700	4/20 700	4/20 700	4/20 700	4/20 700	4/20 700
	Mod_Volume	km^3	41689	41683	41998	41552	41374	41717	41776
Total_Cells	Obs_Peak_Flow	m^3/s							
	Obs_Time_Peak	hr							
	Obs_Volume	km^3							

MAR_98_all_scale

			Precip and basin model scale							
			400m	500m	1km	2km	4km	5km	10km	Lumped
Model Run Name			MAR_98_400	MAR_98_500	MAR_1998_1k	Mar_98_2k	Mar_98_4k	Mar_98_5k	Mar_98_10k	MAR98_Lumped
			AMC3	AMC3	AMC3	AMC3	AMC3	AMC3	AMC3	AMC3
Subbasin	Output	Units								
IRONTO	Mod_Peak_flow	m^3/s	94.87	94.85	94.86	94.81	95.17	95.09	95.416	95.03
Area(km^2	Mod_Time_Peak	hr	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 1000	3/21 900	3/21 900
	Obs_Peak Flow	m^3/s								
Num.Cells	Obs_Time_Peak	hr								
	Mod_Total_Precip	mm	97.1	97.1	97.1	97.1	97.1	96.9	97	97.3
	Mod_Precip_Loss	mm	43.7	43.7	43.8	43.9	43.9	43.8	43.9	44.1
	Mod_Precip_Excess	mm	53.4	53.4	53.3	53.2	53.2	53	53	53.1
	Mod_Direct_RO	km^3	13096	13086	13062	13037	13022	12977	13010	13072
	Mod_Baseflow	km^3	1721	1721	1721	1721	1721	1721	1721	1721
	Mod_Discharge	km^3	14817	14807	14783	14759	14743	14698	14731	14793
	Obs_Discharge	km^3								
Subbasin	Output	Units								
SHAWSVII	Mod_Peak_flow	m^3/s	76.7	76.65	76.41	76.25	76.08	76.35	76.23	76.8
Area(km^2	Mod_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 900	3/21 800
	Obs_Peak Flow	m^3/s	114.1	114.1	114.1	114.1	114.1	114.1	114.1	114.1
Num.Cells	Obs_Time_Peak	hr	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330
	Mod_Total_Precip	mm	85.1	85.1	85.1	85	84.9	85.3	85.4	85.9
	Mod_Precip_Loss	mm	45.7	45.8	45.9	46	46.1	46.2	46.5	47.1
	Mod_Precip_Excess	mm	39.4	39.3	39.2	39.1	38.8	39.1	38.9	38.8
	Mod_Direct_RO	km^3	9305	9292	9236	9206	9148	9205	9135	9158
	Mod_Baseflow	km^3	1469	1469	1469	1469	1469	1469	1469	1469
	Mod_Discharge	km^3	10774	10761	10705	10675	10617	10674	10604	10627
	Obs_Discharge	km^3	10521	10521	10521	10521	10521	10521	10521	10521

MAR_98_all_scale

			Precip and basin model scale							
			400m	500m	1km	2km	4km	5km	10km	Lumped
Model Run Name			MAR_98_400	MAR_98_500	MAR_1998_1k	Mar_98_2k	Mar_98_4k	Mar_98_5k	Mar_98_10k	MAR98_Lumped
Subbasin	Output	Units								
LAFAYETT	Mod_Peak_flow	m^3/s	91.65	91.15	85.44	88.46	89.08	91.11	136.43	73.09
Area(km^2	Mod_Time_Peak	hr	3/21 200	3/21 200	3/21 200	3/21 200	3/21 300	3/21 300	3/21 200	3/21 100
	Obs_Peak Flow	m^3/s								
Num.Cells	Obs_Time_Peak	hr								
	Mod_Total_Precip	mm	83.6	83.6	83.6	83.6	83.9	84.2	89.1	83.5
	Mod_Precip_Loss	mm	39.2	39.2	39.2	39.3	39.4	39.4	40.3	39.4
	Mod_Precip_Excess	mm	44.4	44.4	44.3	44.3	44.5	44.8	48.9	44.1
	Mod_Direct_RO	km^3	4223	4222	4215	4213	4235	4258	4650	4194
	Mod_Baseflow	km^3	561.2	561.2	561.2	561	561.2	561.2	561.2	561.2
	Mod_Discharge	km^3	4784.1	4783.5	4776.6	4774.2	4795.9	4819.1	5210.7	4755.3
	Obs_Discharge	km^3								
Subbasin	Output	Units								
GLENVAR	Mod_Peak_flow	m^3/s	61.17	61.1	54.4	44.39	49.34	44.69	59.04	40.78
Area(km^2	Mod_Time_Peak	hr	3/20 2300	3/20 2300	3/20 2300	3/21 200	3/21 200	3/21 200	3/21 100	3/21 100
	Obs_Peak Flow	m^3/s								
Num.Cells	Obs_Time_Peak	hr								
	Mod_Total_Precip	mm	79.2	73.2	79.2	79.4	79	79.9	81.9	78.9
	Mod_Precip_Loss	mm	40.6	40.7	41	41.3	41.4	41.6	42	41.5
	Mod_Precip_Excess	mm	38.6	38.6	38.2	38.1	37.7	38.3	39.8	37.4
	Mod_Direct_RO	km^3	2242	2239	2220	2209	2185	2224	2313	2173
	Mod_Baseflow	km^3	133.5	133.5	133.5	133.5	133.5	133.5	133.5	133.5
	Mod_Discharge	km^3	2375.4	2372.1	2353.3	2342.2	2318.9	2357.8	2446.5	2306
	Obs_Discharge	km^3								

Precip and basin model scale

			400m	500m	1km	2km	4km	5km	10km	Lumped
Model Run Name			MAR_98_400	MAR_98_500	MAR_1998_1k	Mar_98_2k	Mar_98_4k	Mar_98_5k	Mar_98_10k	MAR98_Lumped
Subbasin	Output	Units								
WALNUT	Mod_Peak_flow	m^3/s	178.3	178.1	177.9	178.92	179.86	185.23	153.99	166.53
Area(km^2	Mod_Time_Peak	hr	3/20 2400	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100	3/21 200	3/21 100
	Obs_Peak Flow	m^3/s								
Num.Cells	Obs_Time_Peak	hr								
	Mod_Total_Precip	mm	84.2	84.2	84.2	84.2	84.1	85	78.2	84.8
	Mod_Precip_Loss	mm	41	41.1	41.4	41.6	41.9	42.2	40.7	42.6
	Mod_Precip_Excess	mm	43.1	43.1	42.8	42.6	42.2	42.9	37.5	42.2
	Mod_Direct_RO	km^3	11596	11577	11492	11449	11344	11520	10078	11357
	Mod_Baseflow	km^3	801.2	801.2	801	801.2	801.2	801.2	801.2	801.2
	Mod_Discharge	km^3	12397	12378	12293	12250	12145	12321	10879	12158
	Obs_Discharge	km^3								
Subbasin	Output	Units								
CARVIN	Mod_Peak_flow	m^3/s	73.12	72.85	82.9	83.68	93.38	92.58	112.3	51.7
Area(km^2	Mod_Time_Peak	hr	3/20 2100	3/21 2100	3/20 2200	3/20 2200	3/20 2200	3/20 2200	3/20 2200	3/20 2200
	Obs_Peak Flow	m^3/s								
Num.Cells	Obs_Time_Peak	hr								
	Mod_Total_Precip	mm	69.8	69.8	69.9	70	70.6	69.9	80.1	67.6
	Mod_Precip_Loss	mm	45	45.1	45.6	46.5	47.2	47.1	52	47.9
	Mod_Precip_Excess	mm	24.8	24.7	24.3	23.5	23.5	22.8	28.1	1937
	Mod_Direct_RO	km^3	987	985.5	967.6	932.7	953	879.9	1081	729.1
	Mod_Baseflow	km^3	285.8	285.8	285.8	285.8	285.8	285.8	285.8	285.8
	Mod_Discharge	km^3	1273.5	1271.3	1253.4	1218.5	1238.8	1165.7	1366.3	1014.9
	Obs_Discharge	km^3								

MAR_98_all_scale

			Precip and basin model scale							
			400m	500m	1km	2km	4km	5km	10km	Lumped
Model Run Name			MAR_98_400	MAR_98_500	MAR_1998_1k	Mar_98_2k	Mar_98_4k	Mar_98_5k	Mar_98_10k	MAR98_Lumped
Subbasin	Output	Units								
TINKER	Mod_Peak_flow	m^3/s	55.97	60.02	61.43	61.33	56.98	65.86	92.42	44.88
Area(km^2	Mod_Time_Peak	hr	3/20 2200	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300	3/20 2300
	Obs_Peak Flow	m^3/s	58.1	58.1	58.1	58.1	58.1	58.1	58.1	58.1
Num.Cells	Obs_Time_Peak	hr	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330	3/20 2330
	Mod_Total_Precip	mm	63.3	63.3	63.3	63.7	63.3	64.3	72	63.4
	Mod_Precip_Loss	mm	37.3	37.4	37.8	38	38.2	38.6	40.8	38.4
	Mod_Precip_Excess	mm	26	25.9	25.5	25.7	25.1	25.7	31.3	25
	Mod_Direct_RO	km^3	880.8	863.8	855.5	913.4	827.2	860.1	1021	753
	Mod_Baseflow	km^3	347.1	347.1	347.1	347.1	347.1	347.1	347.1	347.1
	Mod_Discharge	km^3	1228	1210.9	1202.6	1260.5	1174.3	1207.2	1368.1	1100.1
	Obs_Discharge	km^3	1785	1785	1785	1785	1785	1785	1785	1785
Subbasin	Output	Units								
NIAGARA	Mod_Peak_flow	m^3/s	123.3	123.2	122.9	122.9	121.66	121.31	124.19	117.44
Area(km^2	Mod_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 900	3/21 1000	3/221 800
	Obs_Peak Flow	m^3/s								
Num.Cells	Obs_Time_Peak	hr								
	Mod_Total_Precip	mm	72.9	72.9	72.8	72.9	72.7	73	74.3	71.8
	Mod_Precip_Loss	mm	37.1	37.2	37.4	37.6	37.9	38	38.7	38.7
	Mod_Precip_Excess	mm	35.8	35.7	35.5	35.2	34.9	35	35.6	33.1
	Mod_Direct_RO	km^3	9367	9341	9283	9219	9122	9156	9298	8689
	Mod_Baseflow	km^3	2038	2038	2308	2038	2038	2038	2038	2038
	Mod_Discharge	km^3	11405	11379	11321	11257	11160	11194	11335	10726
	Obs_Discharge	km^3								

MAR_98_all_scale

			Precip and basin model scale							
			400m	500m	1km	2km	4km	5km	10km	Lumped
Model Run Name			MAR_98_400	MAR_98_500	MAR_1998_1k	Mar_98_2k	Mar_98_4k	Mar_98_5k	Mar_98_10k	MAR98_Lumped
Subbasin	Output	Units								
BACK_CRI	Mod_Peak_flow	m^3/s	46.8	46.73	46.6	46.5	46.64	46.12	47.19	44.41
Area(km^2	Mod_Time_Peak	hr	3/20 2400	3/20 2400	3/20 2400	3/20 2400	3/20 2400	3/21 100	3/21 700	3/21 700
	Obs_Peak Flow	m^3/s	77	77	77	77	77	77	77	77
Num.Cells	Obs_Time_Peak	hr	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215
	Mod_Total_Precip	mm	84.3	84.3	84.3	84.2	84.3	84	84.7	82.6
	Mod_Precip_Loss	mm	47.2	47.2	47.4	47.4	47.5	47.4	47	47.4
	Mod_Precip_Excess	mm	37.1	37	36.9	36.8	36.8	36.6	377	35.2
	Mod_Direct_RO	km^3	4840	4833	4813	4797	4800	4770	4933	4607
	Mod_Baseflow	km^3	1122	1122	1122	1122	1122	1122	1122	1122
	Mod_Discharge	km^3	5961.5	5954.5	5935	5918.4	5921.7	5891.8	6054.7	5728.9
	Obs_Discharge	km^3	4941	4941	4941	4941	4941	4941	4941	4941
Subbasin	Output	Units								
OUTLET	Mod_Peak_flow	m^3/s	19.3	19.42	19.1	21.22	20.31	32.83	28.54	16.092
Area(km^2	Mod_Time_Peak	hr	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100	3/21 100
	Obs_Peak Flow	m^3/s								
Num.Cells	Obs_Time_Peak	hr								
	Mod_Total_Precip	mm	70.8	70.8	70.8	70.8	70.4	71.5	66.6	70.9
	Mod_Precip_Loss	mm	41.2	41.3	41.4	41.5	41.4	41.7	40.4	41.6
	Mod_Precip_Excess	mm	29.6	29.5	29.4	29.4	29	29.9	26.2	29.3
	Mod_Direct_RO	km^3	464.1	463.1	460.8	460.6	454.9	468.5	411	459
	Mod_Baseflow	km^3	0	0	0	0	0	0	0	0
	Mod_Discharge	km^3	464.1	463.1	460.8	460.6	454.9	468.5	411	459
	Obs_Discharge	km^3								

MAR_98_all_scale

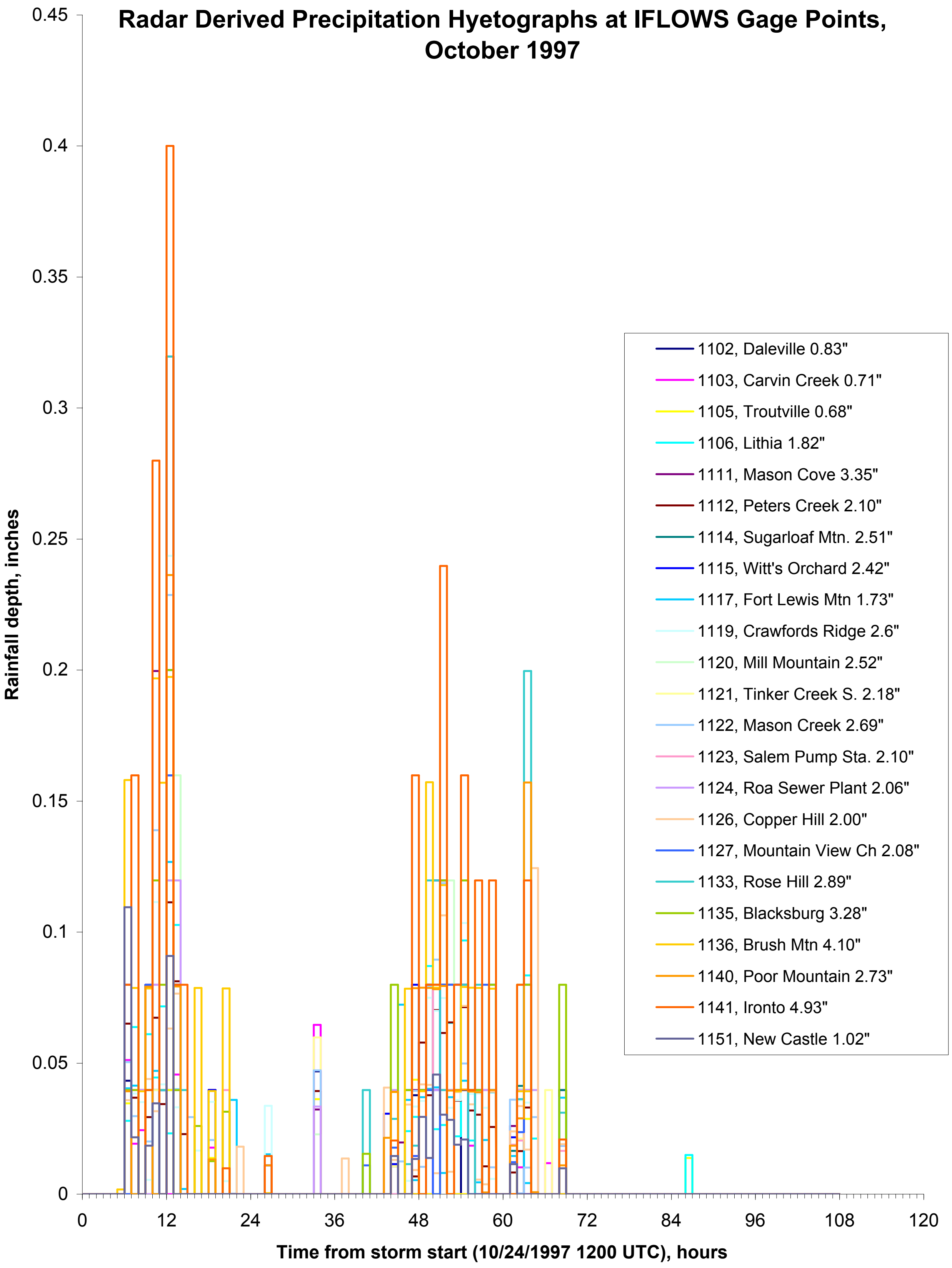
			Precip and basin model scale							
			400m	500m	1km	2km	4km	5km	10km	Lumped
Model Run Name			MAR_98_400	MAR_98_500	MAR_1998_1k	Mar_98_2k	Mar_98_4k	Mar_98_5k	Mar_98_10k	MAR98_Lumped
Gage	Output	Units								
LAFAYETT	Mod_Peak_Flow	m^3/s	225.5	224.9	219.5	222.4	219.7	221.6	270.7	211.58
Tot_area(k	Mod_Time_Peak	hr	3/21 200	3/21 200	3/21 200	3/21 200	3/21 200	3/21 300	3/21 200	3/21 1000
	Mod_Volume	km^3	30246	30222	30135	30078	30027	30061	30415	30045
Total_Cells	Obs_Peak_Flow	m^3/s	218.9	218.9	218.9	218.9	218.9	218.9	218.9	218.9
	Obs_Time_Peak	hr	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215	3/21 215
	Obs_Volume	km^3	27873	27873	27873	27873	27873	27873	27873	27873
Gage	Output	Units								
GLENVAR	Mod_Peak_Flow	m^3/s	229.87	229.65	226.9	239.21	238.84	240.7	269.35	230.2
Tot_area(k	Mod_Time_Peak	hr	3/21 400	3/21 400	3/21 400	3/21 300	3/21 300	3/21 300	3/21 300	3/21 300
	Mod_Volume	km^3	32278	32250	32143	32075	32001	32072	32516	32002
Total_Cells	Obs_Peak_Flow	m^3/s	322.8	322.8	322.8	322.8	322.8	322.8	322.8	322.8
	Obs_Time_Peak	hr	3/21 430	3/21 430	3/21 430	3/21 430	3/21 430	3/21 430	3/21 430	3/21 430
	Obs_Volume	km^3	36364	36364	36364	36364	36364	36364	36364	36364
Gage	Output	Units								
NIAGARA	Mod_Peak_Flow	m^3/s	481.5	481.98	481.21	489.27	487.39	488.82	484.62	479.95
Tot_area(k	Mod_Time_Peak	hr	3/21 1000	3/21 1000	3/21 1000	3/21 900	3/21 900	3/21 1000	3/21 1000	3/21 900
	Mod_Volume	km^3	57365	57274	56992	56838	56497	56731	56241	55773
Total_Cells	Obs_Peak_Flow	m^3/s	521	521	521	521	521	521	521	521
	Obs_Time_Peak	hr	3/21 0145	3/21 0145	3/21 0145	3/21 0145	3/21 0145	3/21 0145	3/21 0145	3/21 0145
	Obs_Volume	km^3	61657	61657	61657	61657	61657	61657	61657	61657

MAR_98_all_scale

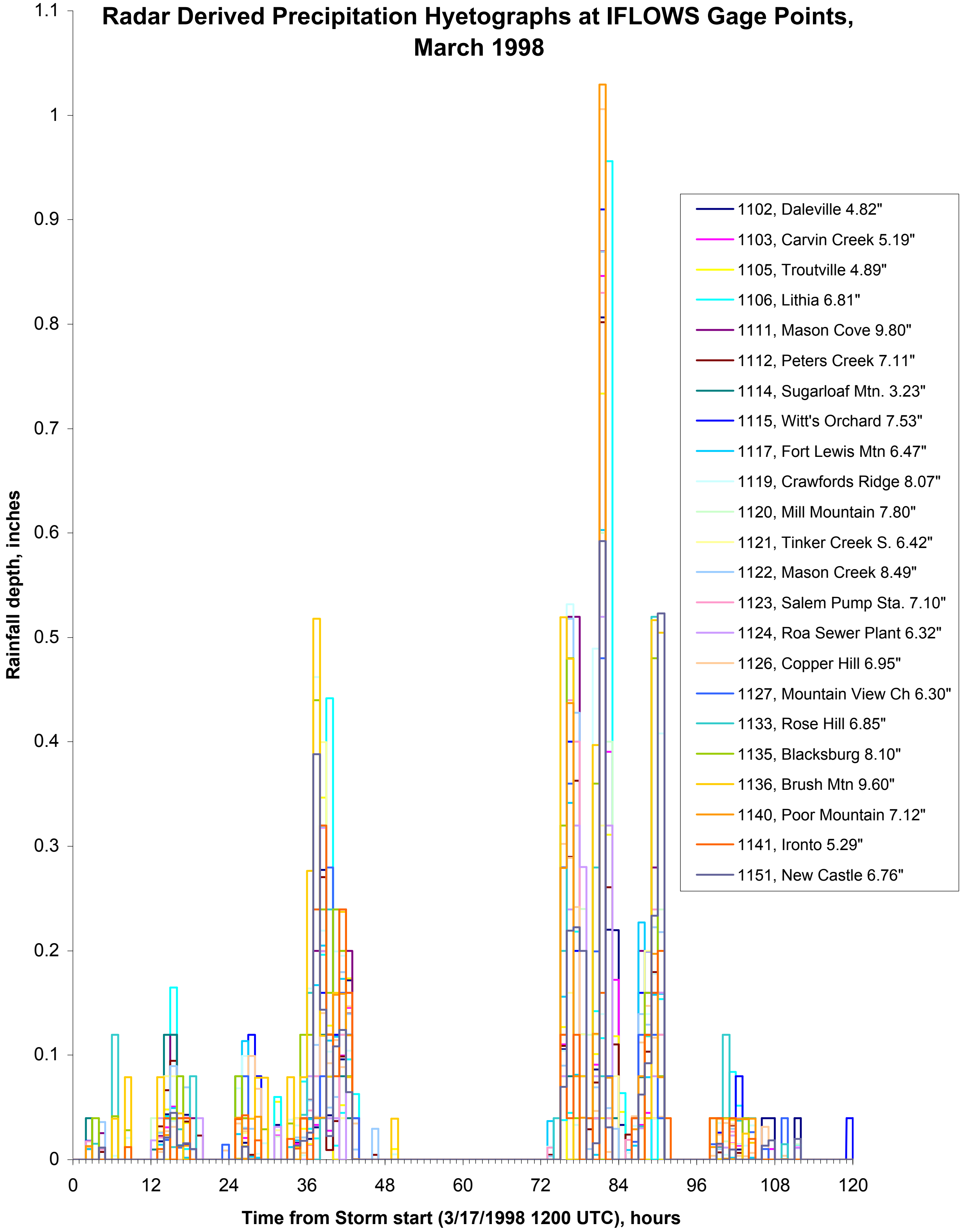
			Precip and basin model scale							
			400m	500m	1km	2km	4km	5km	10km	Lumped
Model Run Name			MAR_98_400	MAR_98_500	MAR_1998_1k	Mar_98_2k	Mar_98_4k	Mar_98_5k	Mar_98_10k	MAR98_Lumped
Gage	Output	Units								
WALNUT	Mod_Peak_Flow	m^3/s	364.14	363.92	362.69	369.87	367.97	366.75	354.77	360.03
Tot_area(k	Mod_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800
	Mod_Volume	km^3	43901	43855	43659	43547	43369	43612	42617	43377
Total_Cells	Obs_Peak_Flow	m^3/s	365.29	365.29	365.29	365.29	365.29	365.29	365.29	365.29
	Obs_Time_Peak	hr	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800	3/21 800
	Obs_Volume	km^3	42126	42126	42126	42126	42126	42126	42126	42126
Gage	Output	Units								
OUTLET	Mod_Peak_Flow	m^3/s	527.51	527.89	526.7	535.87	534.49	534.83	528.26	526.5
Tot_area(k	Mod_Time_Peak	hr	3/21 1000	3/21 1000	3/21 1000	3/21 900	3/21 1000	3/21 900	3/21 1000	3/21 900
	Mod_Volume	km^3	63701	63602	63297	63127	62783	63001	62615	61871
Total_Cells	Obs_Peak_Flow	m^3/s								
	Obs_Time_Peak	hr								
	Obs_Volume	km^3								

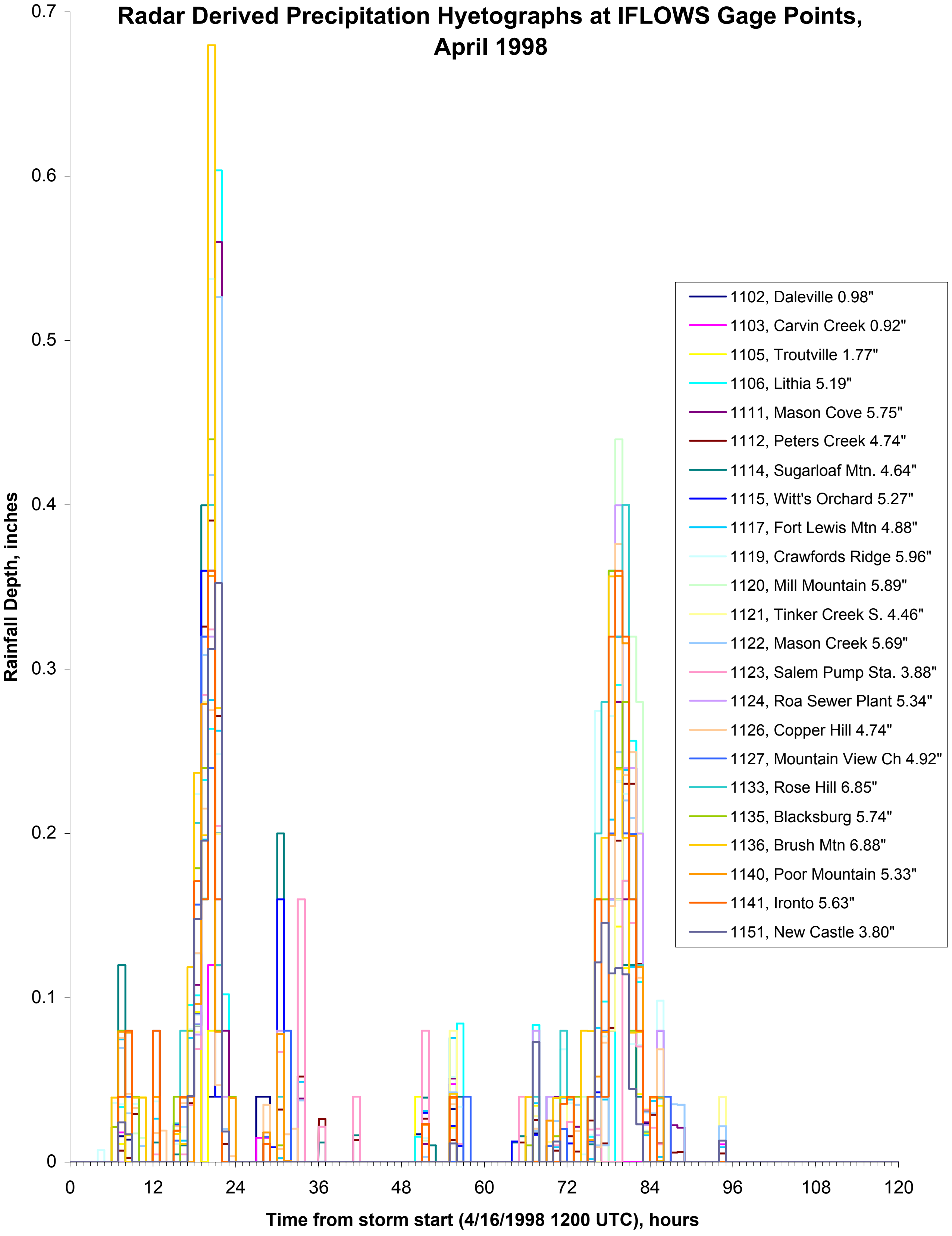
Appendix I: Precipitation Hyetographs

Radar derived precipitation hyetographs were created at the IFLOWS gage points in and around the upper Roanoke watershed to examine the spatial variability of the precipitation events chosen. Pages I-2, I-3, and I-4 show precipitation hyetographs for the October 1997, March 1998, and April 1998 storm events respectively. Each column in these plots represents an hour long time step. Each of these columns are cluttered with varied precipitation depths. This clutter makes it difficult to extract a hyetograph for a selected gage but provides strong evidence of the spatially variable nature of the precipitation events chosen. Gage IDs, gage names, and storm event total precipitation in inches are shown in the legend on each plot.



Radar Derived Precipitation Hyetographs at IFLOWS Gage Points, October 1997


Radar Derived Precipitation Hyetographs at IFLOWS Gage Points, March 1998
Rainfall depth, inches
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
12
24
36
48
60
72
84
96
108
120
Time from Storm start (3/17/1998 1200 UTC), hours
1102, Daleville 4.82"
1103, Carvin Creek 5.19"
1105, Troutville 4.89"
1106, Lithia 6.81"
1111, Mason Cove 9.80"
1112, Peters Creek 7.11"
1114, Sugarloaf Mtn. 3.23"
1115, Witt's Orchard 7.53"
1117, Fort Lewis Mtn 6.47"
1119, Crawfords Ridge 8.07"
1120, Mill Mountain 7.80"
1121, Tinker Creek S. 6.42"
1122, Mason Creek 8.49"
1123, Salem Pump Sta. 7.10"
1124, Roa Sewer Plant 6.32"
1126, Copper Hill 6.95"
1127, Mountain View Ch 6.30"
1133, Rose Hill 6.85"
1135, Blacksburg 8.10"
1136, Brush Mtn 9.60"
1140, Poor Mountain 7.12"
1141, Ironto 5.29"
1151, New Castle 6.76"


Radar Derived Precipitation Hyetographs at IFLOWS Gage Points, April 1998
Rainfall Depth, inches
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
12
24
36
48
60
72
84
96
108
120
Time from storm start (4/16/1998 1200 UTC), hours
1102, Daleville 0.98"
1103, Carvin Creek 0.92"
1105, Troutville 1.77"
1106, Lithia 5.19"
1111, Mason Cove 5.75"
1112, Peters Creek 4.74"
1114, Sugarloaf Mtn. 4.64"
1115, Witt's Orchard 5.27"
1117, Fort Lewis Mtn 4.88"
1119, Crawfords Ridge 5.96"
1120, Mill Mountain 5.89"
1121, Tinker Creek S. 4.46"
1122, Mason Creek 5.69"
1123, Salem Pump Sta. 3.88"
1124, Roa Sewer Plant 5.34"
1126, Copper Hill 4.74"
1127, Mountain View Ch 4.92"
1133, Rose Hill 6.85"
1135, Blacksburg 5.74"
1136, Brush Mtn 6.88"
1140, Poor Mountain 5.33"
1141, Ironto 5.63"
1151, New Castle 3.80"

Appendix J: VITA

Brian C. McCormick was born in Baltimore, Maryland in 1978. He graduated in 1996 from Middletown High School in Middletown, MD. Brian enrolled at Virginia Tech in Fall of 1996 and graduated with a degree in Civil Engineering, Environmental Option, in Spring 2001. During 1997 through 1999 he was employed by the Eastern Federal Lands Highway Division of the Federal Highway Administration through Virginia Tech's co-operative education program. Brian has also been employed at Philmont Scout Ranch in Cimarron, NM as a ranger and ranger trainer during the summers of 1999, 2000, and 2001. He began graduate study at Virginia Tech in Fall of 2001 in the Geographic Information Systems and Hydrosystems program areas in Civil Engineering, and is currently pursuing his masters degree in Civil Engineering. Brian plans to return to Philmont this summer to work with their GIS mapping and resource inventory program.