GISHYDRO: Developing Discharges and Watershed Parameters

A Case Study with Baltimore City Watersheds

by

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Baltimore City Watershed Study

- Conducted for City of Baltimore, MD
- Cooperating Technical Partner (CTP) agreement with FEMA
- H&H Analysis reviewed & approved by USACE
Scope

- The scope involved detailed H&H analysis of four major streams in the City and the remaining streams were studied by approximate analysis (Zone A)
  - Gywnns’ Falls, including Maiden’s Choice Run
  - Jones Falls
  - Herring Run & Tributary to Herring Run
Location of the Study Area
Choice of Hydrologic Methodology

HEC-HMS/ GISHYDRO
- Jones Falls
- Gwynns Falls (includes Maidens’ Choice Run)

GISHydro Regression Equations
- Herring Run
- Tributary to Herring Run
GISHYDRO 2000

- A GIS-based program for performing hydrologic analysis
  - Developed by State Highway Administration in cooperation with UMD
- Arc-view based platform, and it consists of large database of hydrologic layers.
  - Complete databases for DEM, Land use, and soils data for Maryland.
  - Develops stream network, watershed boundaries
- Computes peak discharges
  - USGS regional regression equations
  - Fixed Region Equations
- TR-20 input data generation
  - Sub-basin development
  - Curve Number, Tc, reservoir/ reach routing
Herrings Run and Tributary

- **Herring Run**
  - Originates near Towson
  - Flows Southerly direction
  - Joins Black River and into Chesapeake Bay

- **Tributary to Herrings’ Run**
  - Flows easterly direction
  - Less than 1 sq. mi.
  - Joins Herrings Run near mouth
Fixed Region Equations

- Developed by MD State Highway Administration in collaboration with University of Maryland
- Recommended for ungaged MD watersheds
- Supersedes 1996 USGS Equations
- Accepted for Flood Insurance Studies
- Applicable for Urban watersheds
- Five Hydrologic Regions: Appalachian Plateau, Blue Ridge, Piedmont, Western Coastal Plain, Eastern Coastal Plain
Hydrologic Regions

Source: GISHydro Manual
Herrings Run

- Piedmont Region
- Drainage Area
- Percentage imperviousness
- Discharges by GISHYDRO
  - Select the discharge locations
  - Watershed parameters and discharges computed
  - Time saved on collecting topographic and land use information
**Herrings Run: Sample Output**

Fixed Region Peak Flow Estimates for:
GISHydro Release Version Date: January 22, 2007
GIS/Extension Version Date: September 4, 2006
Analysis Date: February 6, 2007

Geographic Province(s):
- Piedmont (100.0% of area)

Q(1.25): 996 cfs
Q(1.50): 1340 cfs
Q(1.75): 1530 cfs
Q(2): 1650 cfs
Q(5): 2330 cfs
Q(10): 4050 cfs
Q(25): 8290 cfs
Q(50): 7460 cfs
Q(100): 9400 cfs
Q(200): 11700 cfs
Q(500): 15300 cfs

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<th>Area Weighted Prediction Intervals (from Tasker)</th>
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**Individual Province Tasker Analyses Follow:**

Flood frequency estimates for

REGION: Piedmont Urban

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<tr>
<th>Discharge (cfs)</th>
<th>Standard Error of Prediction (percent)</th>
<th>Equivalent Years of Record</th>
<th>Standard Error of Prediction (logs)</th>
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<td>20200</td>
<td>10300</td>
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Watershed Modeling - GISHYDRO

- GISHYDRO generates watershed parameters
  - Watershed and sub-basin boundaries
  - Drainage Areas, Time of concentration, and curve numbers, lag time.
  - Reach routing parameters suitable for TR-20.
  - Develops necessary input data for TR-20 model
- Data used in HEC-HMS model
Jones Falls/ Gwynns Falls

- Watershed Development
- Parameter Development
- Developing HEC-HMS Input Dataset
- Calibrating the HEC-HMS model
- Developing Peak discharges
HEC-HMS Model Development

- Delineate Watershed and sub-basins using GISHYDRO
- GISHYDRO - Time of concentration, curve number, reach-routing parameters computed by GISHYDRO
- Watershed parameters incorporated into HEC-HMS dataset
Parameters used in HMS

- Sub-basins
  - SCS Curve Number used as loss method
- Reaches connecting the junctions
  - Muskingum-Cunge reach routing used
  - Cross-sections from GIShydro
- Areas, curve numbers, initial abstraction, & impervious cover obtained from GISHYDRO
Subwatersheds – Gywnns Falls

- 65 sq.miles, 49 sub-basins

Subwatersheds – Jones Falls

- 57 sq.miles, 47 sub-basins
Rainfall from Atlas 14

### Precipitation Frequency Estimates (inches)

| ARI* (years) | 5 | 10 | 15 | 30 | 60 | 120 | 3 | 6 | 12 | 24 | 48 | 4 | 7 | 10 | 20 | 30 | 45 | 60 |
|-------------|---|----|----|----|----|-----|---|---|----|----|----|---|---|----|---|---|----|----|----|
| min | min | min | min | min | min | hr | hr | hr | hr | day | day | day | day | day | day | day | day | day | day |
| 1 | 0.35 | 0.55 | 0.69 | 0.95 | 1.18 | 1.42 | 1.53 | 1.9 | 2.33 | 2.69 | 3.12 | 3.45 | 4.02 | 4.58 | 6.19 | 7.64 | 9.65 | 11.52 |
| 2 | 0.41 | 0.66 | 0.83 | 1.15 | 1.45 | 1.73 | 1.86 | 2.31 | 2.83 | 3.26 | 3.77 | 4.17 | 4.84 | 5.5 | 7.36 | 9.04 | 11.38 | 13.55 |
| 5 | 0.49 | 0.79 | 1.42 | 1.82 | 2.19 | 2.36 | 2.92 | 3.6 | 4.19 | 4.84 | 5.34 | 6.13 | 6.87 | 8.89 | 10.75 | 13.3 | 15.66 |
| 10 | 0.55 | 0.88 | 1.11 | 1.61 | 2.1 | 2.54 | 2.75 | 3.42 | 4.25 | 5.01 | 5.76 | 6.34 | 7.22 | 8.01 | 10.14 | 12.13 | 14.79 | 17.25 |
| 25 | 0.62 | 0.99 | 1.26 | 1.86 | 2.48 | 3.04 | 3.31 | 4.16 | 5.26 | 6.27 | 7.14 | 7.84 | 8.86 | 9.68 | 11.89 | 14.03 | 16.75 | 19.31 |
| 50 | 0.67 | 1.07 | 1.36 | 2.05 | 2.77 | 3.44 | 3.78 | 4.79 | 6.15 | 7.38 | 8.35 | 9.15 | 10.28 | 11.07 | 13.29 | 15.54 | 18.23 | 20.84 |
| 100 | 0.73 | 1.15 | 1.46 | 2.23 | 3.08 | 3.87 | 4.26 | 5.47 | 7.13 | 8.65 | 9.69 | 10.6 | 11.84 | 12.58 | 14.75 | 17.09 | 19.69 | 22.31 |
| 500 | 0.84 | 1.32 | 1.67 | 2.65 | 3.8 | 4.95 | 5.53 | 7.31 | 9.93 | 12.3 | 13.46 | 14.66 | 16.14 | 16.58 | 18.38 | 20.83 | 22.97 | 25.49 |
| 1000 | 0.89 | 1.39 | 1.75 | 2.83 | 4.13 | 5.46 | 6.14 | 8.24 | 11.41 | 14.25 | 15.42 | 16.75 | 18.34 | 18.58 | 20.05 | 22.52 | 24.36 | 26.77 |
Frequencies

- Discharges were computed for 10, 50, 100 and 500 yr flood events
- In addition, 2004 flood event was also used to check the results obtained
USGS gages used for Calibration

<table>
<thead>
<tr>
<th>Streams</th>
<th>USGS Gage ID</th>
<th>Gage Description</th>
<th>Drainage Area (Sq.Mi)</th>
<th>From</th>
<th>To</th>
<th>No. of Years</th>
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<tbody>
<tr>
<td>Gwynns Falls</td>
<td>1589180</td>
<td>Glyndon</td>
<td>0.32</td>
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<td>7/8/2005</td>
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<td>1589200</td>
<td>Owings Mills</td>
<td>4.9</td>
<td>9/2/1959</td>
<td>9/26/1975</td>
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<td>Villa Nova</td>
<td>32.5</td>
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<td>7/7/2004</td>
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<td>1589352</td>
<td>Baltimore-Washington Blvd.</td>
<td>65.9</td>
<td>8/26/1999</td>
<td>6/25/2006</td>
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<td>Jones Falls</td>
<td>1589440</td>
<td>Jones Falls at Sorrento, MD</td>
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<td>1/25/1958</td>
<td>1/14/2005</td>
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<td>1589478</td>
<td>Jones Falls at MD Ave in Baltimore, MD</td>
<td>58.3</td>
<td>6/25/1981</td>
<td>7/7/2004</td>
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<td>1589480</td>
<td>Jones Falls Near Mouth in Baltimore, MD</td>
<td>60.4</td>
<td>6/25/1981</td>
<td>6/27/1982</td>
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- **USGS Gages**: Red markers
- **RainGage**: Black triangle
- **FIS Discharge Change Location**: Purple rectangle

[Map showing locations of gages with icons for USGS Gages, RainGage, and FIS Discharge Change Location.]

[Logos and text indicating Dewberry SM at the bottom right corner of the page.]
Calibration for 2004 flood event

- Using the ppt recorded at the gages, simulated hydrograph was generated using the input parameters.
- Observed hydrograph was generated at gage locations using the gage records obtained from www.usgs.gov
- The simulated and observed hydrographs were plotted and compared against to check the simulated results
Results of calibration

Gwynns Falls
USGS 01589352, At Washington Blvd

Jones Falls
USGS 01589478, at Maryland Ave
Summary

- GISHYDRO
  - Includes Basic Datasets necessary for discharge development
  - Fixed Regions Equations applicable to urban watersheds
  - Ease of developing TR-20 model
  - Watershed parameters can be transferred to other watershed models
Summary

- GIS HYDRO Wish List
  - Discharges computed one by one, Discharge locations taken from a shapefile and computations done at the same time.
  - Moving to Arc GIS platform would be useful.
  - Option to incorporate more recent data sets that those in-built in GISHYDRO
Questions??