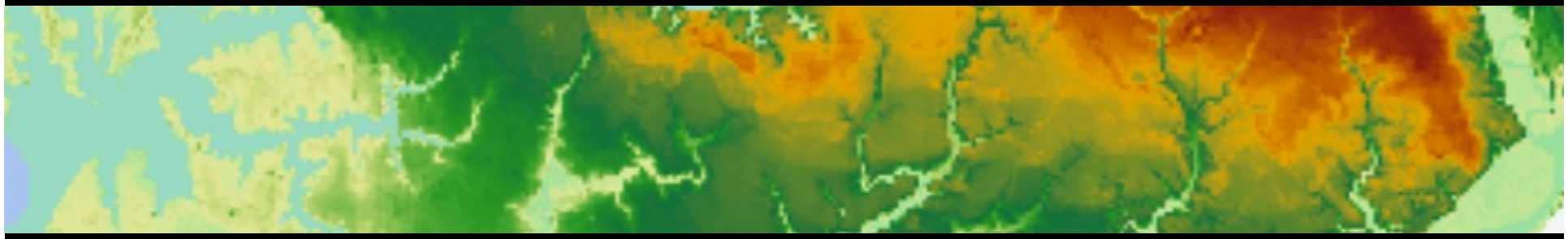
Recent Activities of the Maryland Hydrology Panel



Kaye L. Brubaker, University of Maryland, College Park
Wilbert O. Thomas, Jr., Michael Baker International

MAFSM 12th Annual Conference
Linthicum, Maryland
October 20, 2016

SHA State Highway Administration
Maryland Department of Transportation

Maryland Department of the Environment

Background: Maryland Hydrology Panel

- **Hydrology Panel convened in June 1996 by Maryland State Highway Administration (SHA) and Maryland Department of Environment (MDE)**

- **Mission of the Panel was**
  - **Review Maryland hydrologic practices and make recommendations concerning peak flood estimating procedures that will best serve to satisfy agency needs, Maryland laws and regulations.**

Background: Maryland Hydrology Panel

- **The Hydrology Panel was to**
  - explore the development of improved procedures that would ensure an optimal balance between preserving the environmental quality of Maryland streams and the hydraulic performance of highway drainage structures.
- **MDE had selected the NRCS TR-20 model for computing flood flows in Maryland; SHA wanted to make greater use of regional regression equations based on USGS stream-gaging records; methods often provided significantly different estimates**

Background: Need for the Hydrology Panel

- Different estimates of flood discharges caused SHA and MDE to spend a lot of time resolving hydrologic issues
- SHA proposed an independent group of experts to provide guidance on methods that both agencies could support
- MDE agreed to the concept and has participated on the Hydrology Panel since its inception
- The Hydrology Panel developed an approach that was acceptable to both agencies

The Maryland Hydrology Panel

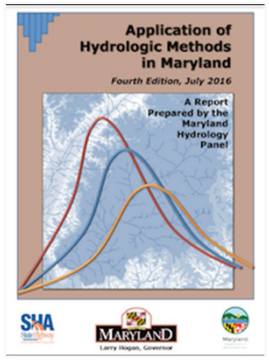
- **The current (2016) Maryland Hydrology Panel consists of:**
  - Richard Berich, EBA Engineering
  - William Merkel, Natural Resources Conservation Service (NRCS) (retired)
  - Quan Quan, NRCS
  - Glenn Moglen, Virginia Tech
  - Kaye Brubaker, University of Maryland
  - Will Thomas, Michael Baker International - Chair

  SHA represented by Andy Kosicki, Pawel Mizgalewicz

  MDE represented by Dave Guignet

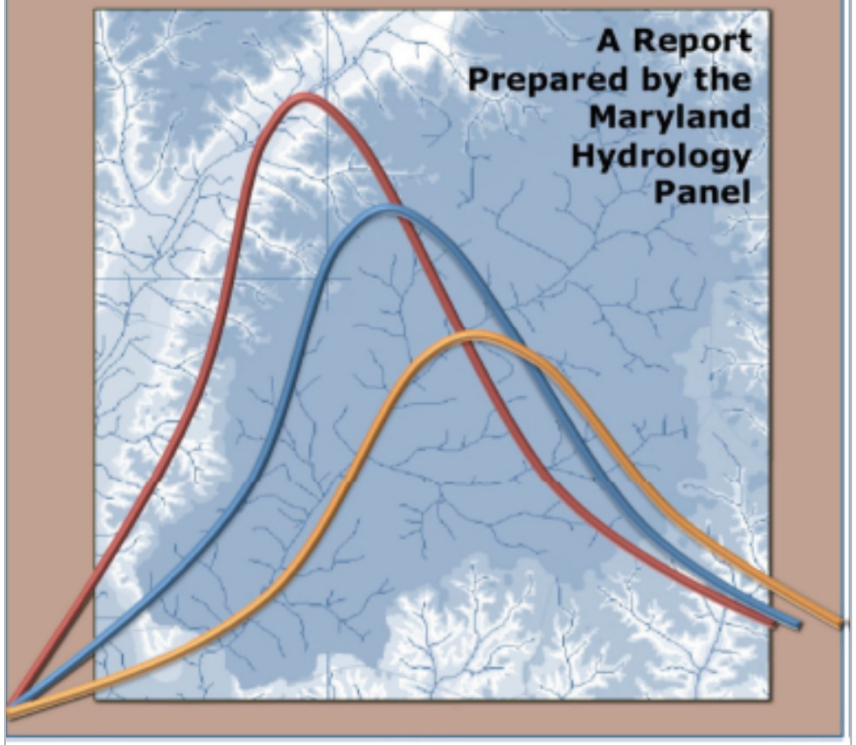
Hydrology Panel Reports

- **The Hydrology Panel has published four versions of the report: *Application of Hydrologic Methods in Maryland***
  - ***February 2001 – Art Miller, Penn State, Chair***
  - ***August 2006 – Bob Ragan, UMD, Chair***
  - ***September 2010 – Will Thomas, Baker, Chair***
  - ***July 2016 – Will Thomas, Baker, Chair***
- **The Fourth Edition, July 2016, is posted at:**
  - **http://www.gishydro.umd.edu/panel.htm**



Application of Hydrologic Methods in Maryland

Fourth Edition, July 2016



SHA State Highway Administration

MARYLAND
Larry Hogan, Governor

Maryland Department of the Environment

SHA State Highway Administration
Maryland Department of Transportation

Maryland Department of the Environment

July 2016

Subject: ***Application of Hydrologic Methods in Maryland***, Fourth Edition, July 2016

Users of this Manual:

On behalf of the State Highway Administration (SHA) and the Maryland Department of the Environment (MDE), we are delighted to endorse and recommend the use of this manual as it applies to hydrologic practices for State of Maryland projects. It is important to note that the manual will be the required criteria for all hydrologic analyses related to SHA bridge and highway design and is recommended for use by other State and local agencies.

This manual is intended to aid the practitioner in the prediction of peak flow rates and flood hydrographs for Maryland streams as well as to offer techniques and tools that will improve the results of rainfall-runoff computer models. The procedures outlined in this manual guide the user toward the development of more reliable and consistent watershed models that better reflect the historic stream gage data for the Maryland region. This manual is to be used in conjunction with State and federal technical manuals, computer user manuals, and technical papers.

We recognize that the technology of hydrology computer programs, geographic information systems software and databases, and remote sensing data collection are continually being advanced. Although parts of this manual will be updated periodically to reflect current technology, data, and methods, it contains many guidelines, recommendations, limitations on procedures, analysis philosophies, and computational tools that will be valuable for the practitioner even as the science progresses.

We appreciate the effort of all who participated in the preparation and review of this manual and pledge our commitment to the continual improvement of the science and applications of hydrology in the State of Maryland.

Very truly yours,

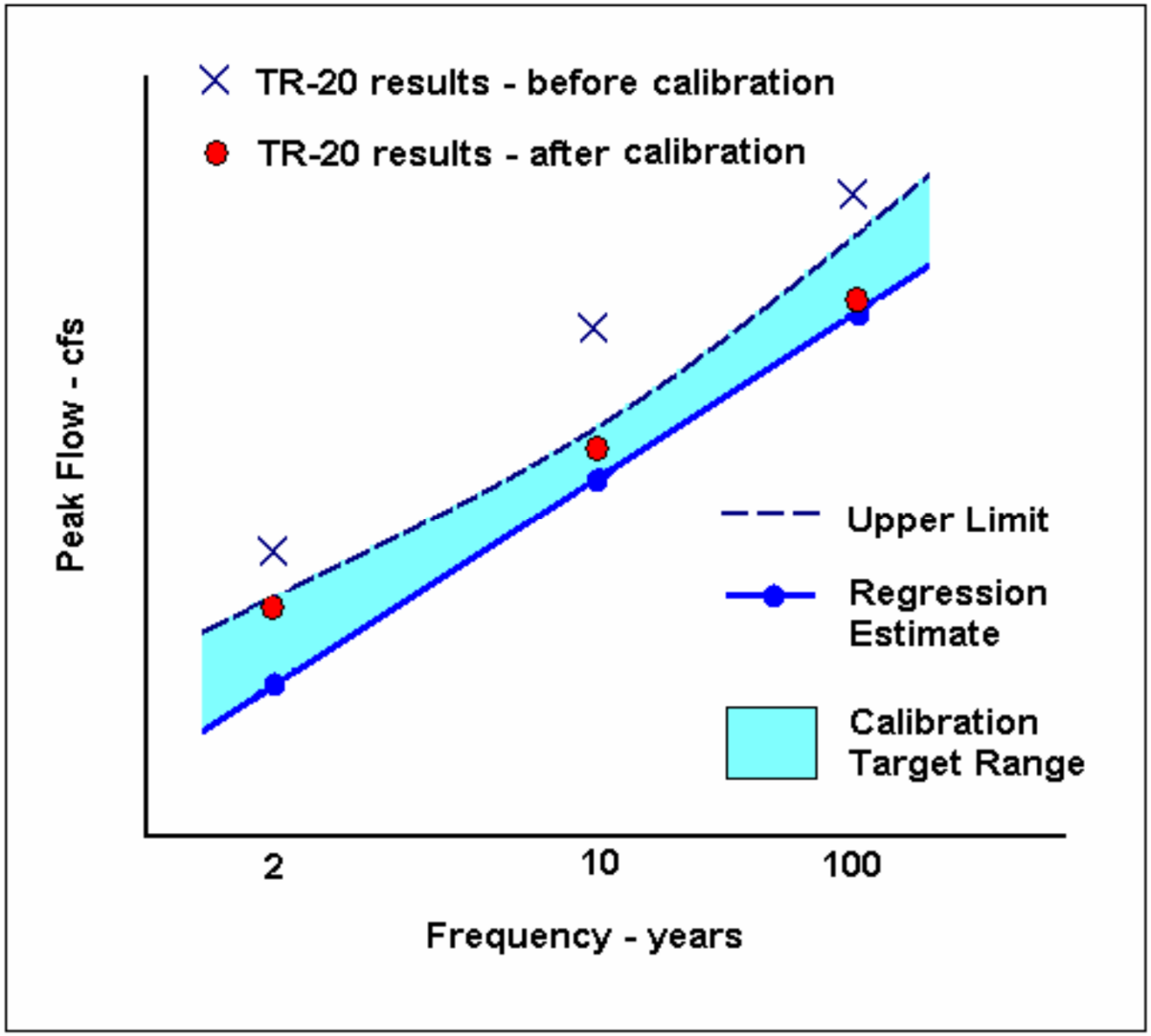
Gregory I. Slater, Deputy Administrator
Chief Engineer for Planning, Engineering,
Real Estate and Environment
State Highway Administration
Department of Transportation

Lynn Y. Buhl, Director
Water Management Administration
Department of the Environment

Hydrologic Procedures

- **In all versions of the Hydrology Panel report, the recommended hydrologic procedures include:**
  - WinTR-20 model developed by NRCS to serve as the base method
  - Design discharges based on ultimate development per Maryland Office of Planning land use data
  - WinTR-20 "calibrated" to flood discharges estimated at USGS gaging stations or from regional regression equations (updated over time)

Calibration of WinTR-20 Model



Purpose of Hydrology Panel Report

- **Panel report provides guidance on how to adjust model parameters to get within the calibration window:**
  - Runoff curve number
  - Time of concentration
  - Representative cross section (area, n value)
  - Reach routing length
  - Peak rate factor for NRCS unit hydrograph
  - Storm durations (6, 12, 24, or 48 hours)

Objective: Adjust parameters within bounds of standard hydrologic practice

Value of Hydrology Panel Guidance

- Has endorsement of SHA and MDE
- Cost savings for hydrologic analyses - reduces discussion, questions, and reanalysis
- Achieves closer agreement between statistical data and a deterministic model
- Provides more consistency among different analysts
- Input data developed using GIS techniques – expedites the hydrologic analysis

Implementation of Hydrologic Procedures

- **WinTR-20 and regional regression procedures implemented within GISHydro2000 – software package developed by the University of Maryland (Virginia Tech) with funding from SHA**
  - **GIS software based on ArcView Version 3 that includes statewide land use, soils, NOAA Atlas 14 rainfall data and topographic data (30m DEMs)**
  - **New version GISHydroNXT being developed based on ArcGIS 10 (ArcView software no longer supported)**

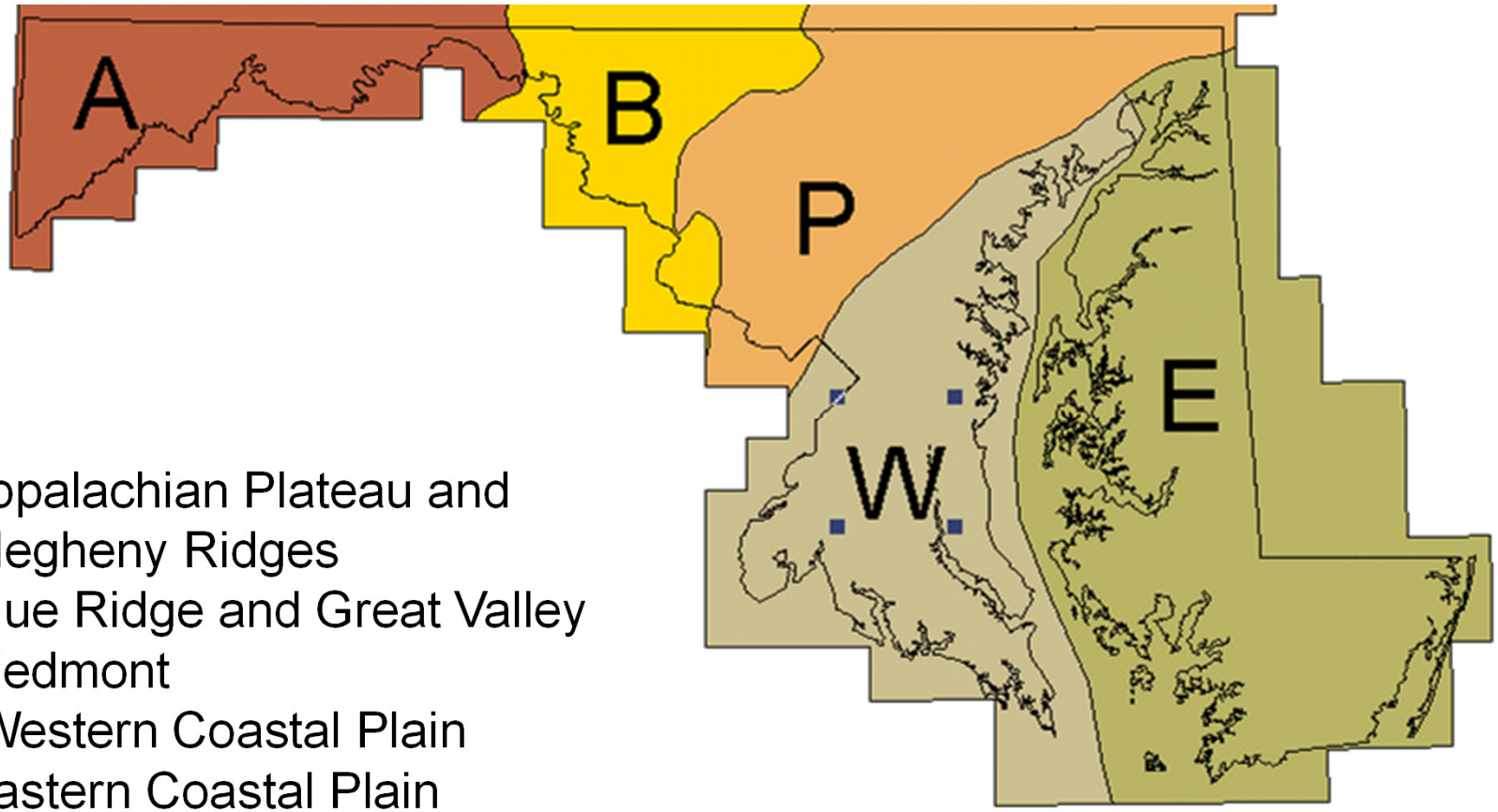
Major Revisions to Fourth Edition

- New regression equations for estimating flood discharges for the Piedmont-Blue Ridge Region and Appalachian Plateau Region
- New regression equations for estimating low flows for design of culverts to facilitate fish passage
- Guidance on estimating discharges in tidal reaches
- Improvements in GISHydro

Regression Equations Updated With Time

- **Regression equations used in February 2001 report for flood discharges developed by USGS (Dillow, 1996)**
- **For all subsequent versions of the Panel report, equations developed by W. Thomas and G. Moglen (funding from SHA)**
- **Hydrologic regions used in Thomas and Moglen analyses based on Dillow (1996) as shown in next slide**

Maryland's Physiographic Provinces



A = Appalachian Plateau and Allegheny Ridges
B = Blue Ridge and Great Valley
P = Piedmont
W = Western Coastal Plain
E = Eastern Coastal Plain

Recent Update to Regression Equations

- Regression equations for estimating flood discharges updated for combined Piedmont-Blue Ridge Region and Appalachian Plateau Region
- Piedmont and Blue Ridge combined because of similar flood characteristics and limestone geology in both regions
- Regression equations for Piedmont-Blue Ridge Region applicable to rural and urban (impervious area > 10 percent) watersheds

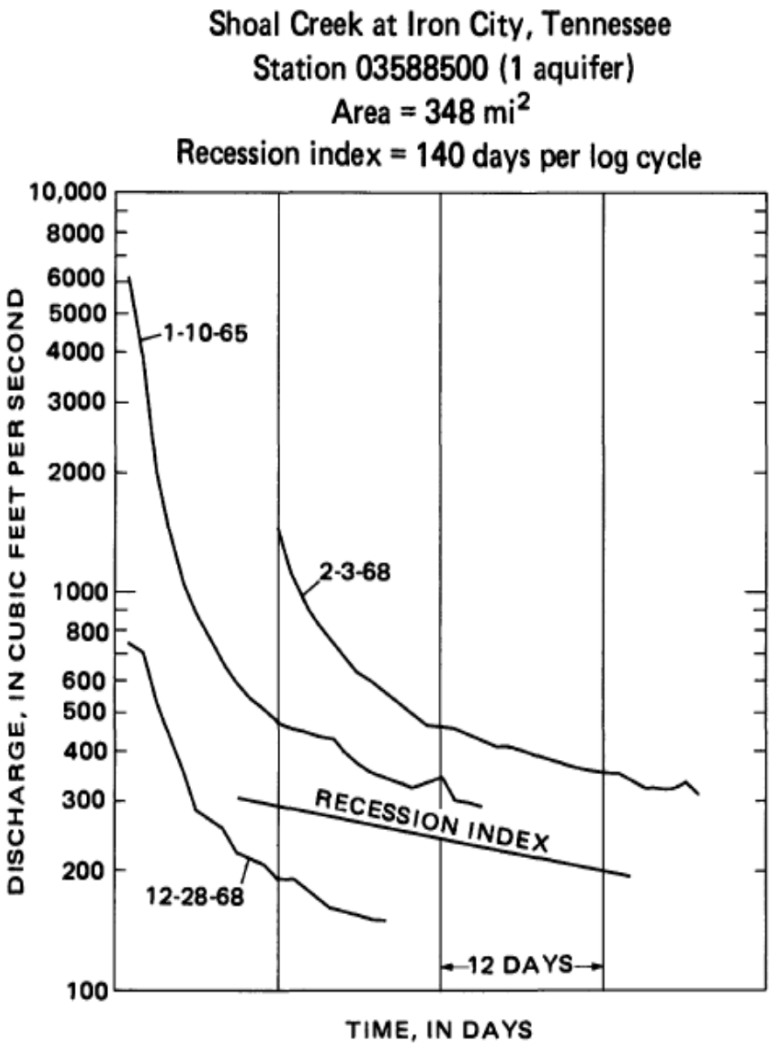
Recent Update to Regression Equations

- **Regression equations for Piedmont-Blue Ridge Region based on 96 rural and urban gaging stations and**
  - Drainage area, in square miles,
  - Limestone, in percent of watershed
  - Impervious area, in percent of watershed
  - Forest cover, in percent of watershed
- **Regression equations for Appalachian Plateau based on 24 rural gaging stations and**
  - Drainage area, in square miles, and
  - Land slope, in feet per foot

Regression Equations for Low Flows

- **Motivation: Fish passage**
- **Regression equations for low flows based on 50 rural and urban gaging stations with drainage areas < 10 square miles (emphasis on culvert design)**
- **Equations developed for 2- and 10-year 90-day consecutive low flow and 2- and 10-year 120-day consecutive low flow**
- **Watershed characteristics included**
  - **Drainage area, in square miles**
  - **Impervious area, in percent of the watershed**
  - **Land slope, in feet per foot**

Regression Equations for Low Flows



- **Recommendations provided for future research using more geologically based characteristics like a streamflow recession index (see figure), ratio of flow duration points, stream density, relative infiltration, etc.**

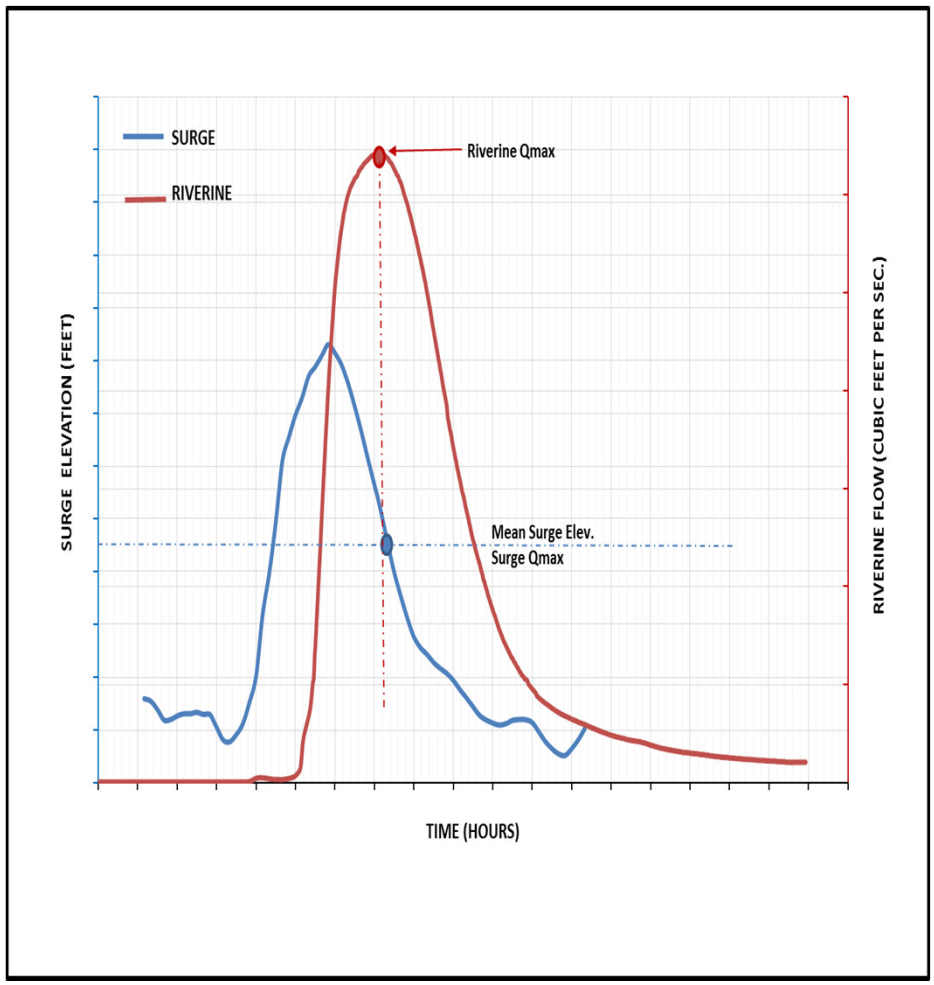
Estimation of Discharge in Tidal Reaches

- **SHA estimates discharges and bridge scour at many bridges affected by tides and storm surges**
- **Major question: What is the timing of the storm surge and riverine hydrographs?**
- **SHA uses two computer programs for estimating discharges and scour for bridge design**
  - **TIDEROUT2 Scour – flood routing and scour program developed by SHA**
  - **HEC-RAS – hydraulic model developed by USACE**

Estimation of Discharge in Tidal Reaches

- The Hydrology Panel analyzed the timing of observed storm surge and riverine hydrographs
- For streams > 25 square miles, the riverine hydrographs generally occur much later than the storm surge hydrographs (essentially independent in time)
- Different guidance provided for watersheds larger and smaller than 25 square miles

Estimation of Discharge in Tidal Reaches

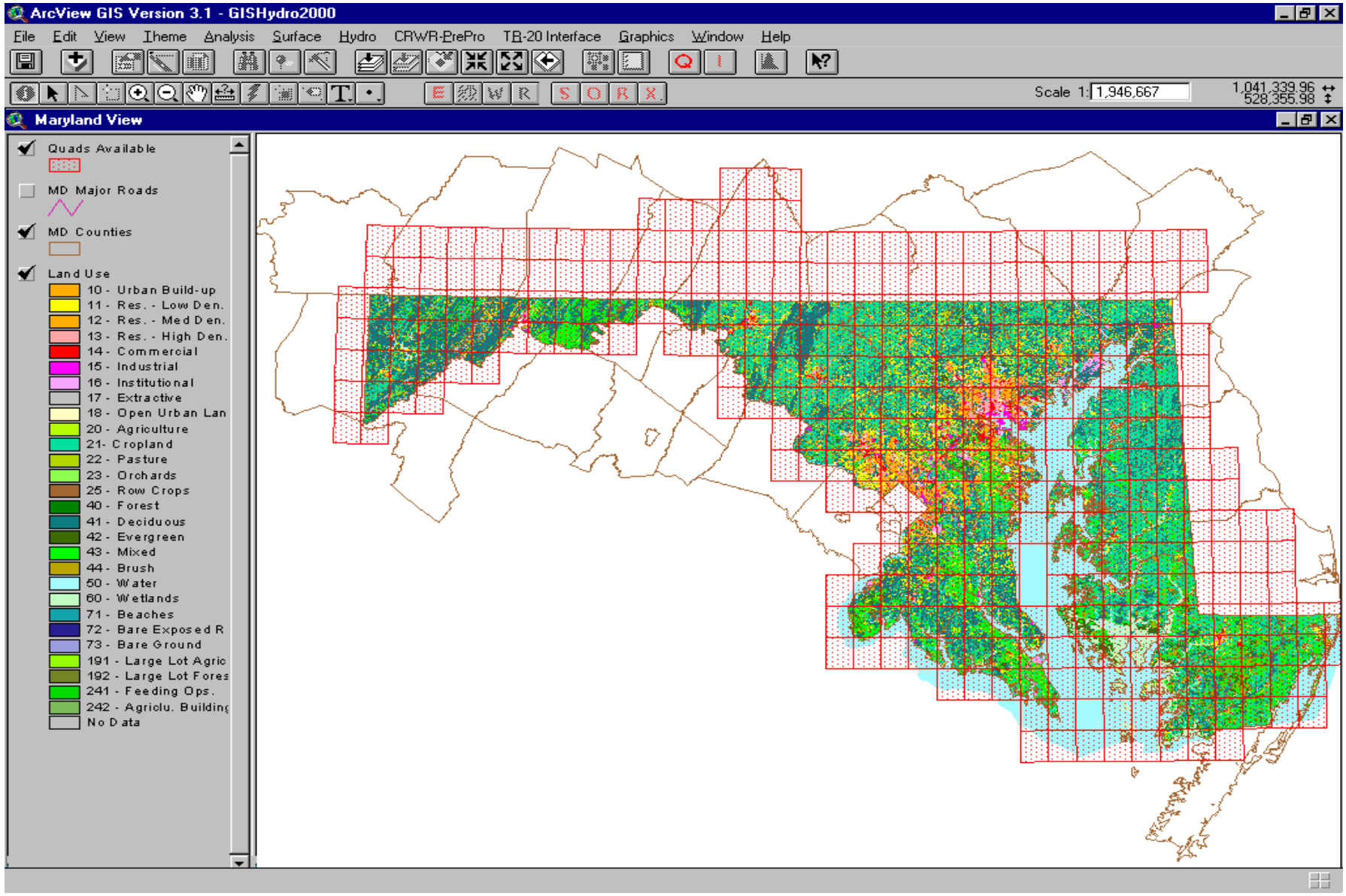


- For example, for watersheds < 25 sq. miles, the timing of the riverine hydrograph is assumed to occur at the time of maximum surge discharge at the mean surge elevation
- For estimating the 100-year event, storm surge for 100-year event is paired with a 10-year riverine event and vice versa
- Design for the worst case

GISHydro2000

- GISHydro2000 is available at no cost at
  - http://www.gishydro.umd.edu
- A web-based version of the software is available (registration required) at
  - http://www.gishydro.umd.edu/web.htm
- Note: Web service is in transition. Messages will be posted at http://www.gishydro.umd.edu
- Software is also available at SHA headquarters for firms performing work on state or county-funded projects by contacting Andy Kosicki at SHA

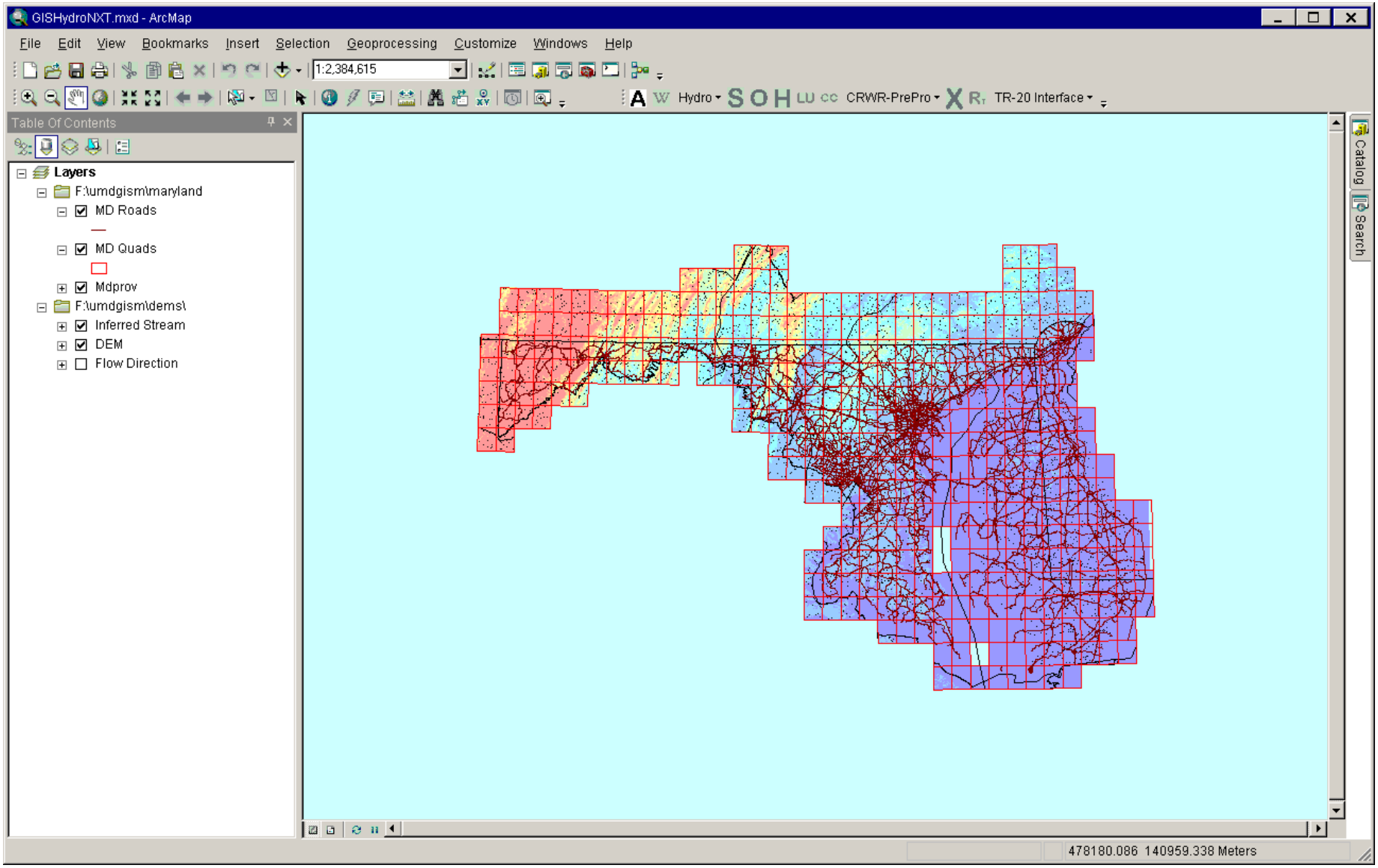
GISHydro2000



GISHydroNXT

- Built in ArcGIS 10.
- Under development with support from SHA
- Not yet in full release.
- Web-based version will be available.
- Some improvements to user interface.

GISHydroNXT



Future Work: Climate Change

- **Rising baseline water levels in tidally-influenced areas of Maryland**
- **2012 executive order (then Governor Martin O'Malley), "Climate Change and Coast Smart Construction Executive Order 01.01.2012.29"**
- **Shifts in precipitation intensity-duration-frequency (IDF) relationships, currently quantified by the NOAA Atlas 14 dataset**
- **MSHA structures have operational lifetimes of 50 years and more – need estimates of precipitation IDF for middle and end of the 21st century.**
  - **SHA is supporting research on climate-model-derived IDFs.**
  - **Panel will seek to provide guidance on incorporating this analysis into design.**

Future Work: Hydrograph Peak Rate Factors

- **Models such as WinTR-20 rely on a dimensionless unit hydrograph (DUH)**
- **Peak Rate Factor (PRF) defines shape of the DUH**
  - has been found to vary from about 600 in steep terrain to 100 in very flat swampy country
- **Commonly used PRF of 484 in NRCS DUH, but 284 is used in Eastern and Western Coastal Plain**
- **Panel plans further investigation of observed rainfall and runoff**

Contact Information

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Questions??