MICHAEL BAKER CORPORATION

Activities of the Maryland Hydrology Panel

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Linthicum, Maryland

ChallengeUs.

Baker

Outline of the Presentation

- **The objectives of the presentation are to describe:**
  - Purpose of the Hydrology Panel
  - Previous accomplishments and reports
  - Recommended hydrologic methods
  - Content of the current Panel report
  - Major improvements or changes in methodology
  - Revisions in methodologies that are underway

Purpose of 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.**

Purpose of 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 TR-20 model for computing flood flows in Maryland; SHA wanted to make greater use of regional regression equations based on USGS streamgaging records**

Hydrology Panel Reports

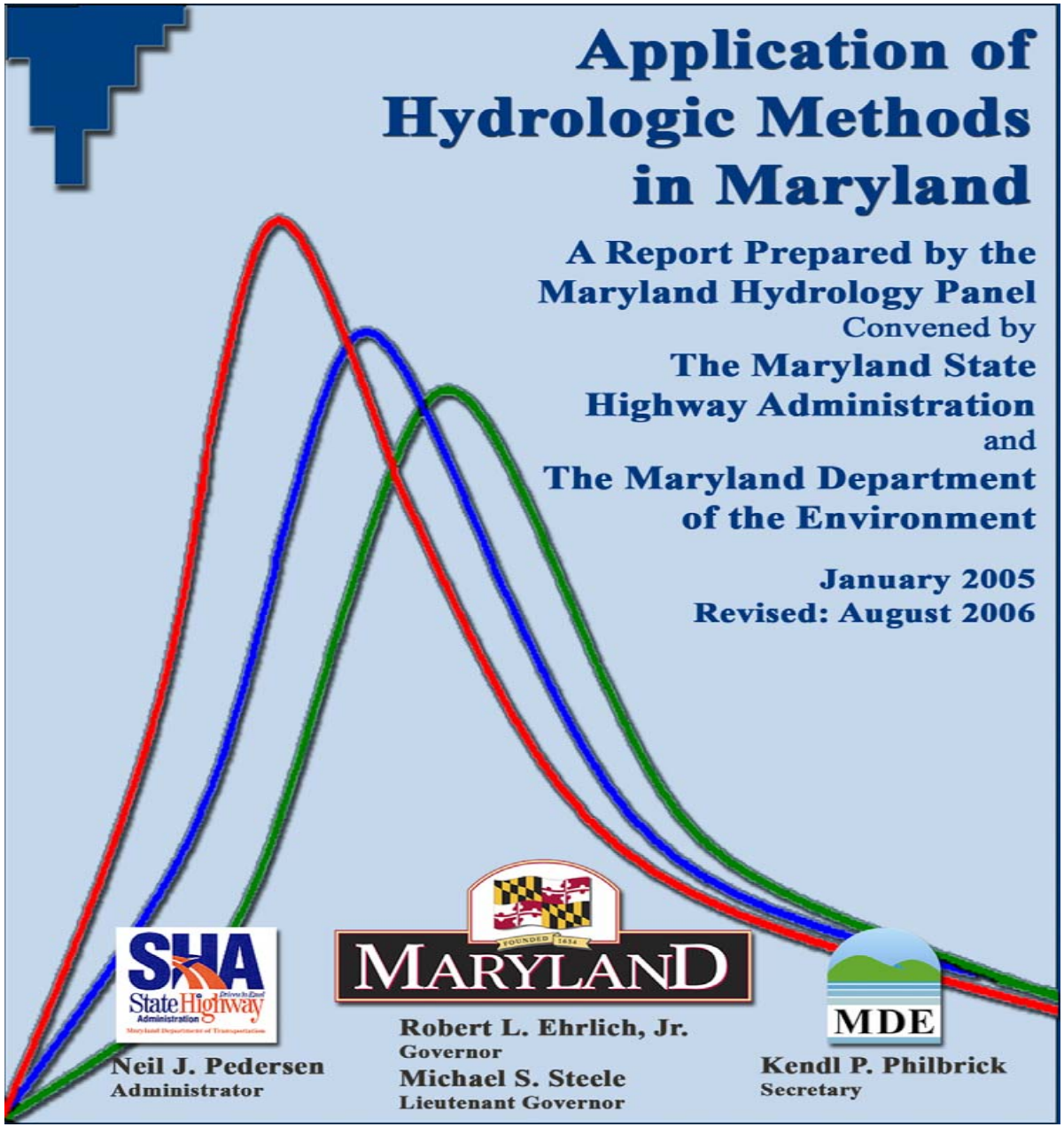
- **In February 2001, the Panel issued the report *Application of Hydrologic Methods in Maryland***

- **Recommended hydrologic procedures included**
  - **TR-20 model developed by NRCS to serve as the base method**
  - **Design discharges based on ultimate development**
  - **TR-20 calibrated to flood discharges estimated at USGS gaging stations or from regional regression equations**

Hydrology Panel Reports

- **With experience with the recommended methods, numerous suggestions for improvements were made**
- **In Fall of 2002, the Panel was reconvened to evaluate improvements in the hydrologic procedures**
- **In August 2006, a revised version of *Application of Hydrologic Methods in Maryland* was published**
  - **http://www.gishydro.umd.edu/panel.htm**

August 2006 Panel Report

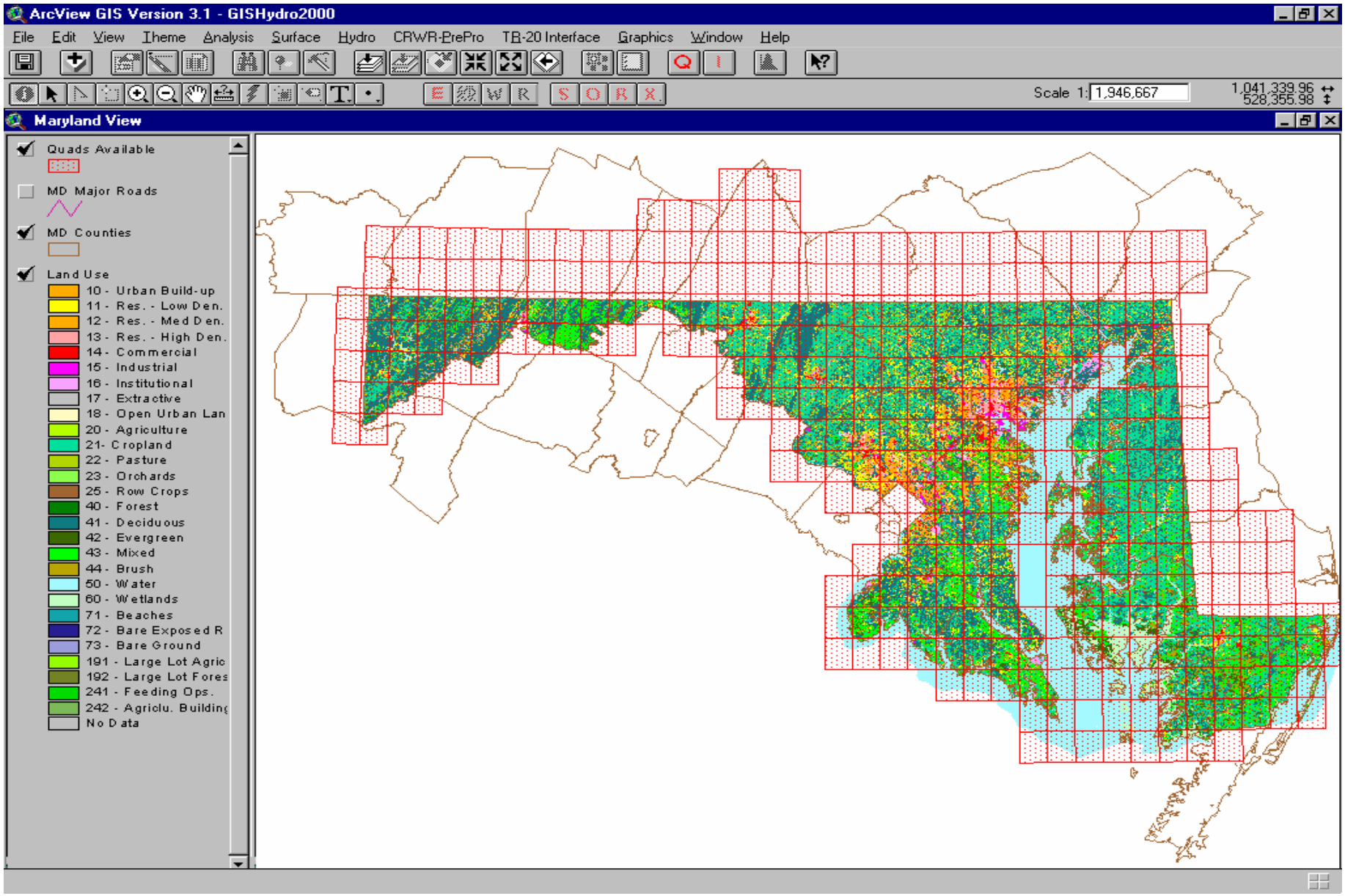


August 2006 Panel Report

- **August 2006 report continued to recommend**
  - **TR-20 model calibrated to flood discharges estimated at gaging stations or from regional regression equations**

- **TR-20 and regional regression procedures implemented within GISHydro2000 – software package developed by the University of Maryland with funding from SHA**
  - **GIS software based on ArcView Version 3 that includes statewide land use, soils and topographic data**

GISHydro2000



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What Does GISHydro2000 Do?

- **Data Assembly**
  - Current Data Sets
    - Topography (USGS NED 30-m DEMs)
    - Land Use (several dates from 1970 to 2002)
    - Hydrologic Soil Type (Ragan, STATSGO, SSURGO)
  - Visual Interface Developed to Access Database
  - Automatic Basin Delineation Implemented
- **Hydrologic Analyses**
  - Calculates Watershed Properties
  - Implements regional regression equations
  - TR-20 Pre-Processor

GISHydro2000

- **GISHydro2000 is available at no cost at**
  - **http://www.gishydro.umd.edu**
- **A web-based version of the software is available at**
  - **http://www.gishydro.umd.edu/web.htm**
- **Software is also available at SHA headquarters for firms performing work on state or county-funded projects by contacting Andy Kosicki at SHA**

The Maryland Hydrology Panel

- **The current Hydrology Panel consists of:**
  - Richard Berich, Dewberry & Davis
  - Donald Woodward, retired Natural Resources Conservation Service
  - Glenn Moglen, University of Maryland
  - William Merkel, Natural Resources Conservation Service
  - Michael Casey, George Mason University
  - Wilbert Thomas, Michael Baker, Jr.
  - Andy Kosicki and Len Podell, Maryland State Highway Administration
  - Dave Guignet, Maryland Dept of Environment

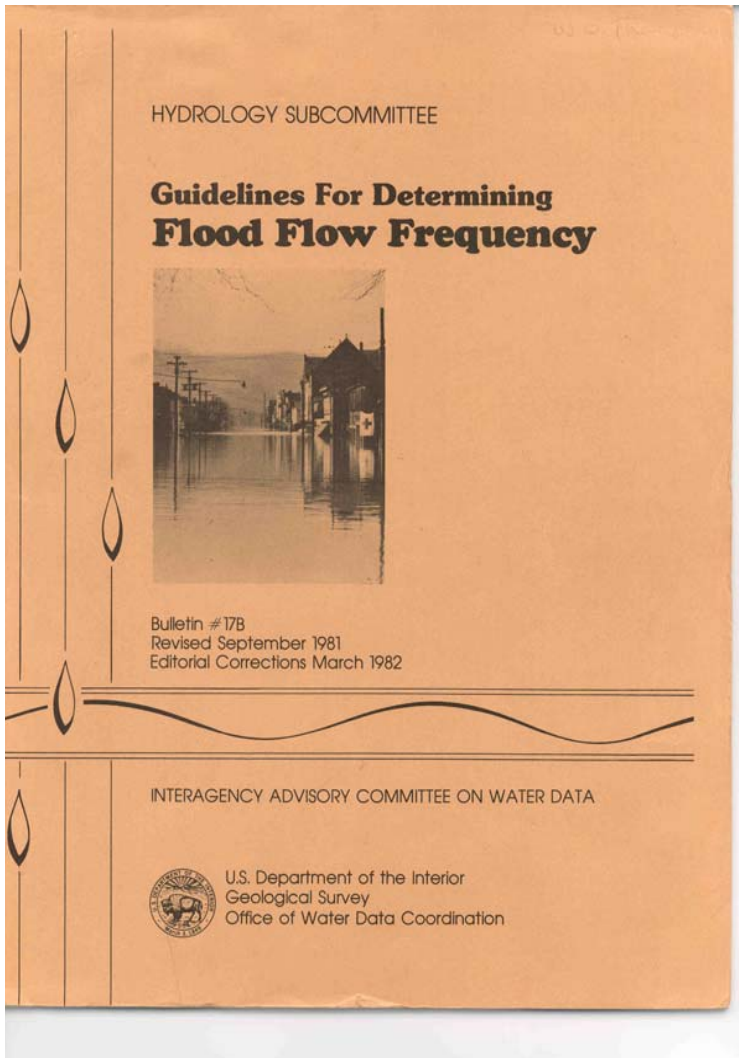
Description of Hydrologic Procedures

- **At a gaged site, Bulletin 17B (*Guidelines For Determining Flood Flow Frequency*) estimates weighted with regional regression estimates**

- **Within 50 percent of the drainage area of a gaged site, transpose weighted gaged estimates using procedures documented in USGS WRIR 95-4154**

- **Ungaged locations, TR-20 model calibrated to gaging station data or regional regression estimates**

Bulletin 17B



- **Bulletin 17B - Published in 1982, includes guidelines for:**
  - Fitting Pearson Type III distribution to logarithms of annual peak flows
  - Estimating generalized skew
  - Weighting generalized skew with station skew
  - Low- and high-outlier detection tests
  - Conditional probability adjustment for low outliers
  - Adjustments for historic flood data

Description of Hydrologic Procedures

- **Estimates at gaging stations**
  - Perform Bulletin 17B analyses at gage (USGS PeakFQ or USACE HEC-FFA)
  - Weight flood discharges with regression estimates using equivalent years of record (USGS WRIR 95-4154)
  - Weighted estimate is more accurate as described in Appendix 8 of Bulletin 17B

Description of Hydrologic Procedures

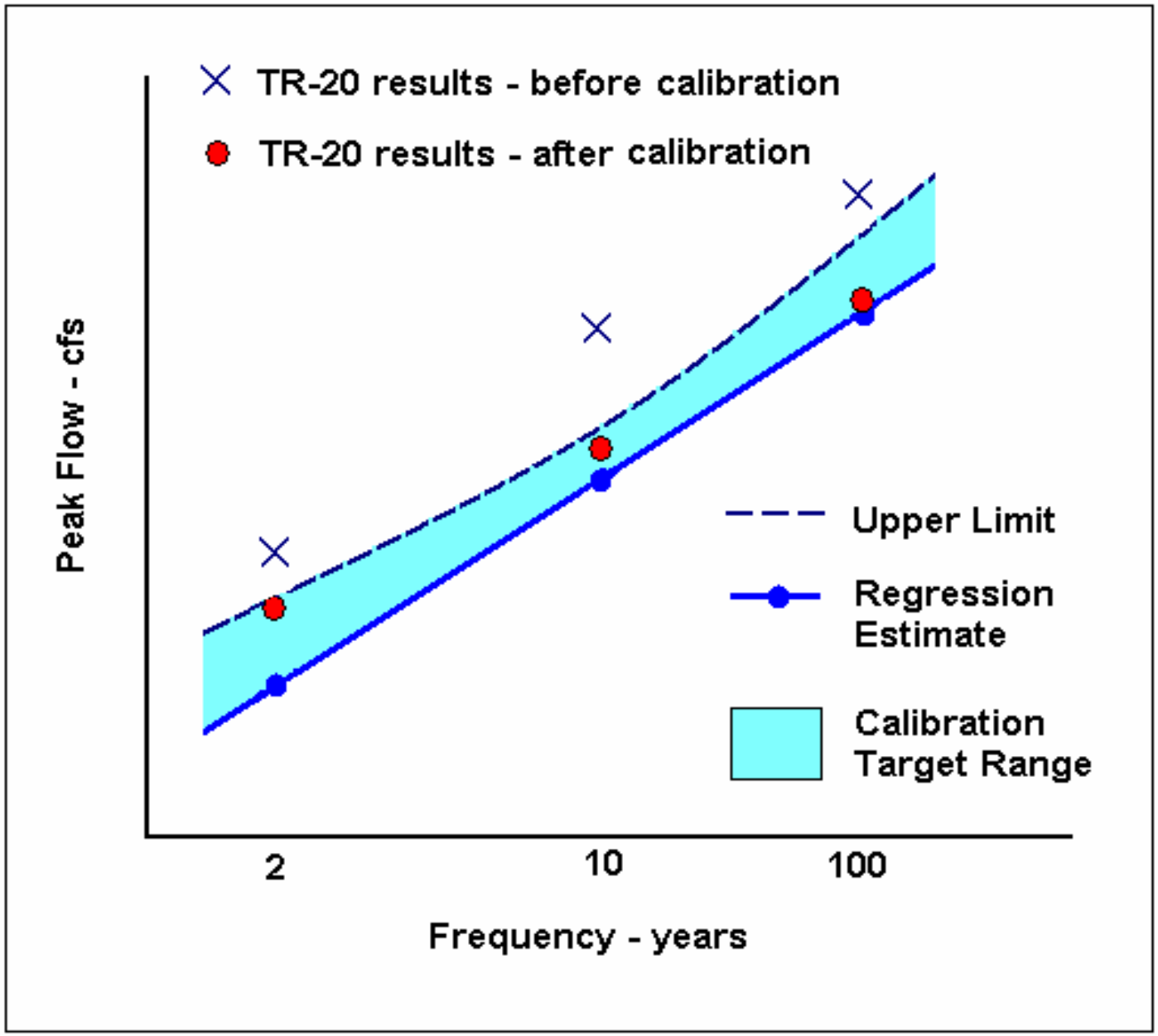
- **Estimates on a gaged stream within 50 percent of drainage area of gaged site**
  - Define ratio of weighted to regression estimate at gaged site, R = Qw/Qr
  - Scale R based on difference in drainage area between the ungaged site and gaging station to get Rw
  - Compute final discharge Qf = Rw * Qu where Qu is regression estimate

Concept: At gage use Qw and at plus or minus 50 percent of gaged drainage area, use regression estimates (Rw becomes 1.0)

Description of Hydrologic Procedures

- **Estimates at ungaged sites**
  - Calibrate TR-20 estimates using regional regression or gaging station estimates (existing land-use conditions)
  - Calibration window illustrated in next slide
  - Objective is to get TR-20 estimates within calibration window, between regression estimates and plus one standard error of prediction
  - Use TR-20 to estimate flood discharges for ultimate land-use conditions

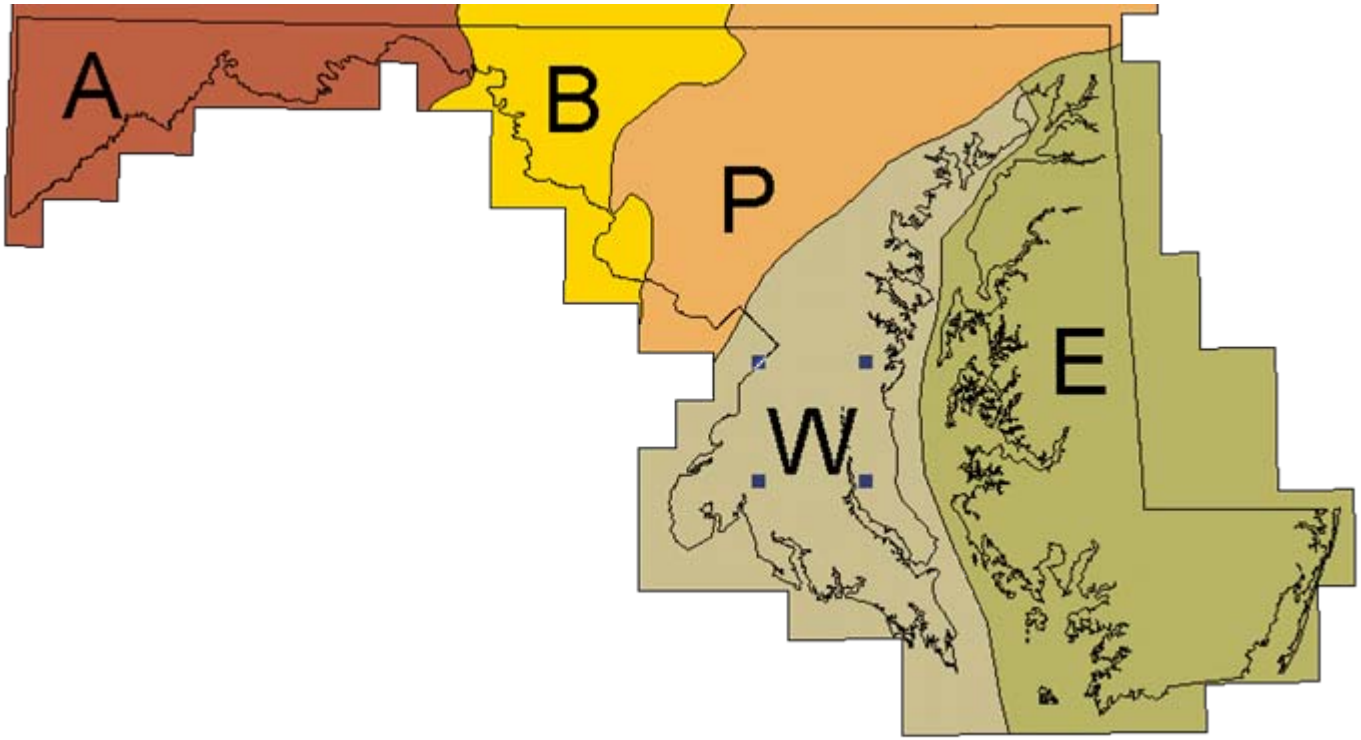
Calibration of TR-20 model



Calibration Procedures

- **Fixed region regression equations are used to "calibrate" TR-20 estimates**
- **Fixed region regression equations were developed through a UMD research project with SHA funding (Moglen and others, 2006)**
- **Regression equations developed using flood data and watershed characteristics for 154 stations in Maryland and Delaware**
- **Hydrologic regions were the same as those used in USGS WRIR 95-4154**

Maryland's Physiographic Provinces



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

Fixed Region Regression Equations

- **Piedmont Region has two sets of equations for rural and urban watersheds**

  - Rural (< 10 percent impervious area (IA))
  - $Q_{100} = 2897\ DA^{0.613}\ (FOR+1)^{-0.238}$

  - Urban (10 percent or greater IA)
  - $Q_{100} = 898.3\ DA^{0.619}\ (IA+1)^{0.222}$

  where DA is drainage area in square miles, FOR is forest cover in percent, and IA is impervious area in percent

Fixed Region Regression Equations

- **Western Coastal Plain region has equations applicable for rural and urban watersheds**

  - $Q_{100} = 143.56\ DA^{0.586}\ (IA+1)^{0.260}\ (S_D+1)^{0.469}$

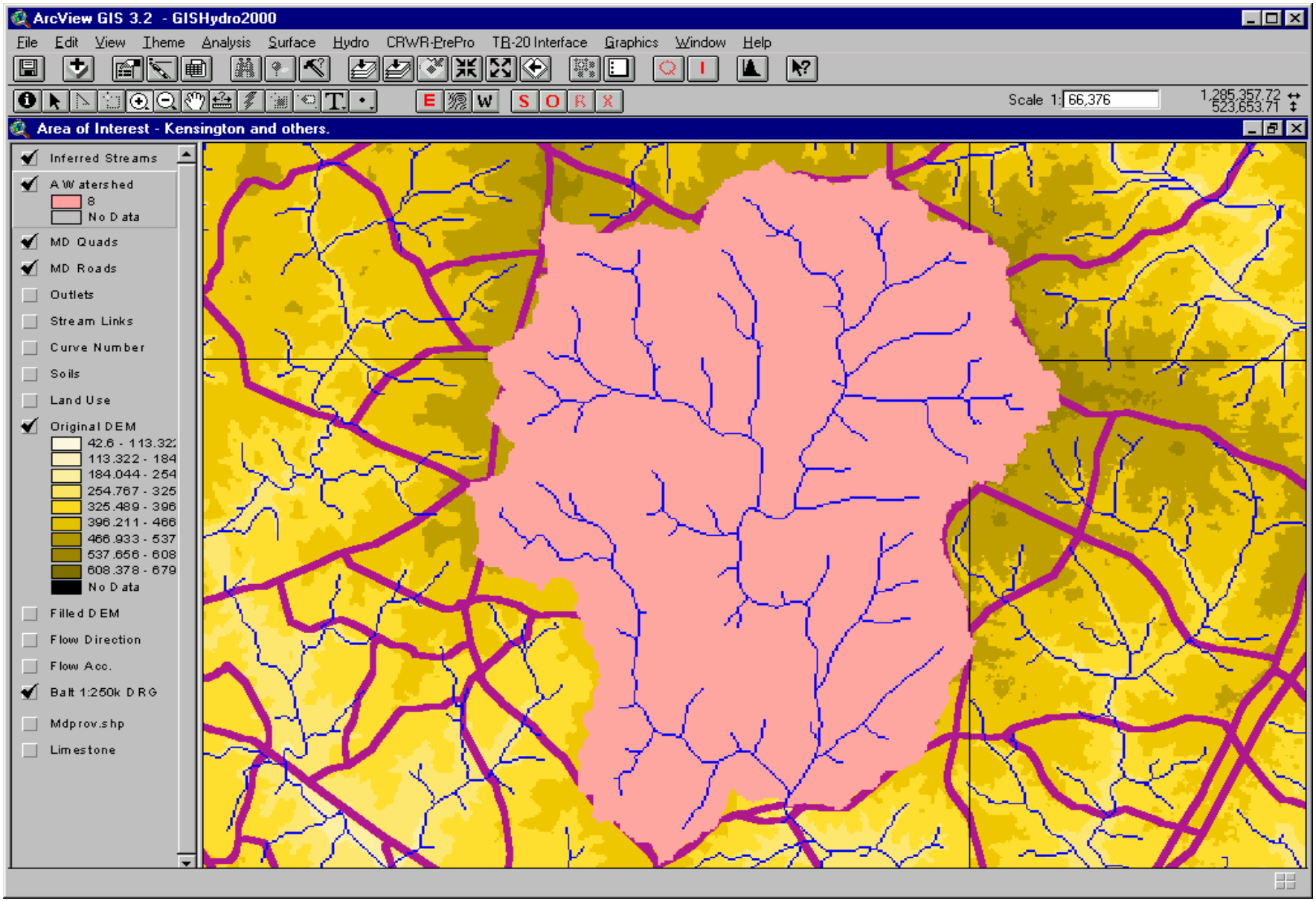
  where S_D is percent D soils (STATSGO data)

  Fixed Region Equations for Piedmont and Western Coastal Plain allow calibration of TR-20 model for **existing urban** conditions

Capabilities of GISHydro2000

- **Input parameters for Fixed Region equations and TR-20 model are estimated using GISHydro2000**
- **Fixed Region regression equations and TR-20 are implemented within GISHydro2000**
- **Following slides illustrate some of these capabilities**

Delineating the Watershed…



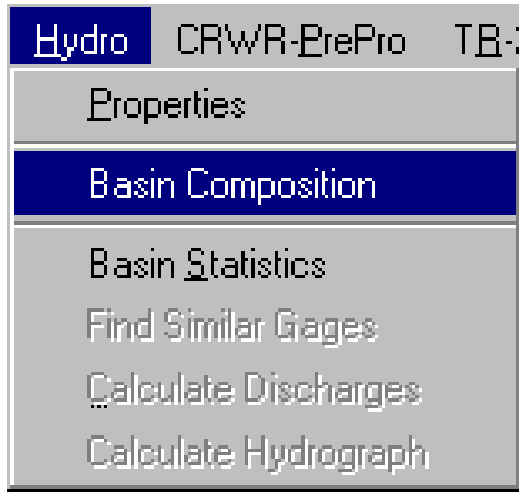
The "Basin Composition" Menu Choice

Distribution of Land Use and Curve Numbers Used

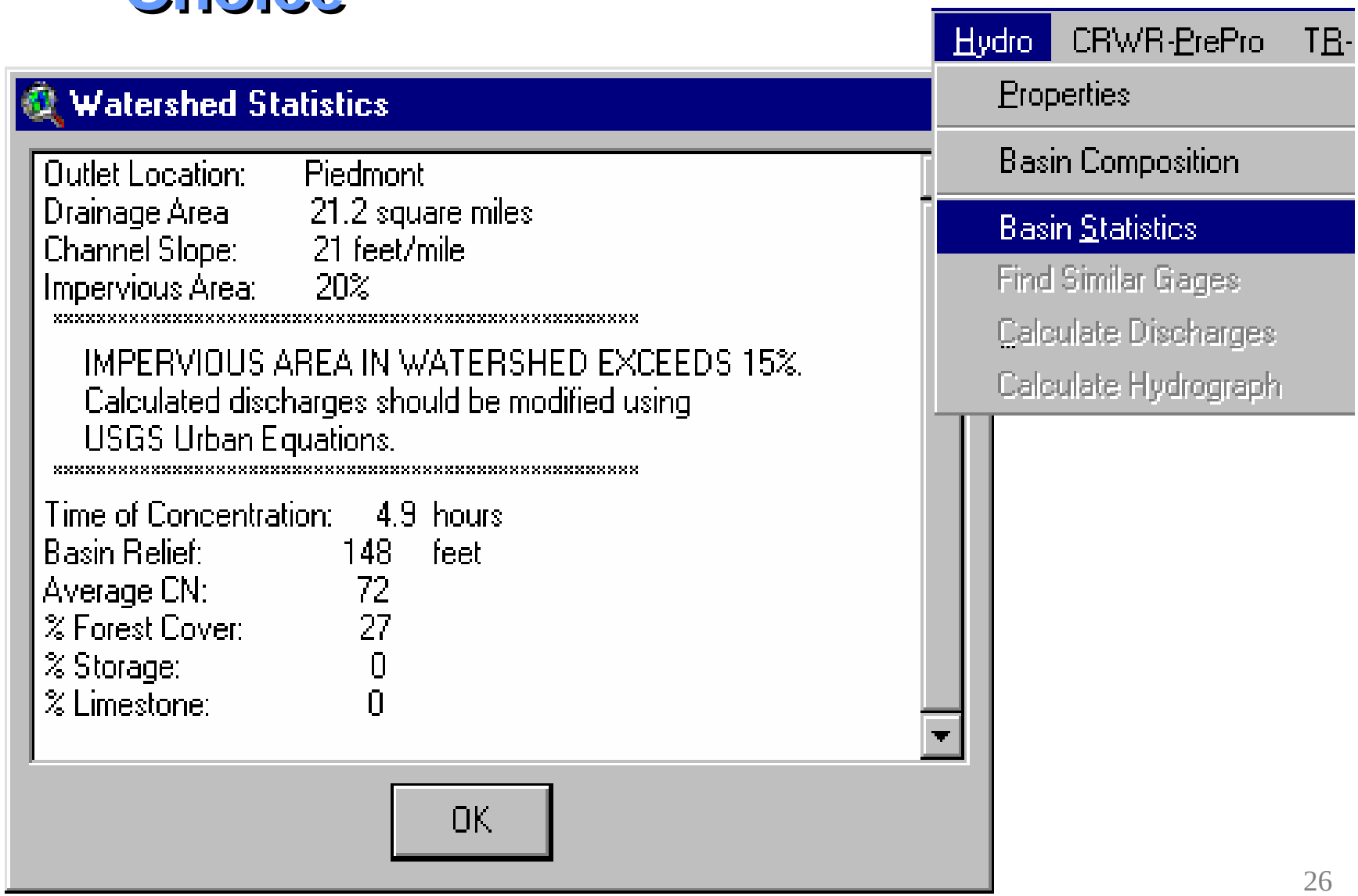
Land_Use	Acres	Percent	A	B	C	D
Low Density Residential	2865.47	21.16	54	70	80	85
Medium Density Residential	2521.12	18.61	61	75	83	87
High Density Residential	1016.99	7.51	77	85	90	92
Commercial	95.96	0.71	89	92	94	95
Institutional	468.09	3.46	81	88	91	93
Open Urban Land	1175.16	8.68	39	61	74	80
Cropland	756.20	5.58	72	81	88	91
Pasture	471.99	3.48	39	61	74	80
Orchards	20.20	0.15	32	58	72	79
Deciduous Forest	3559.23	26.28	30	55	70	77
Mixed Forest	112.72	0.83	30	55	70	77
Brush	158.63	1.17	30	48	65	73
Water	11.25	0.08	100	100	100	100
Bare Ground	311.29	2.30	77	86	91	94

Distribution of Land Use by Soil Group

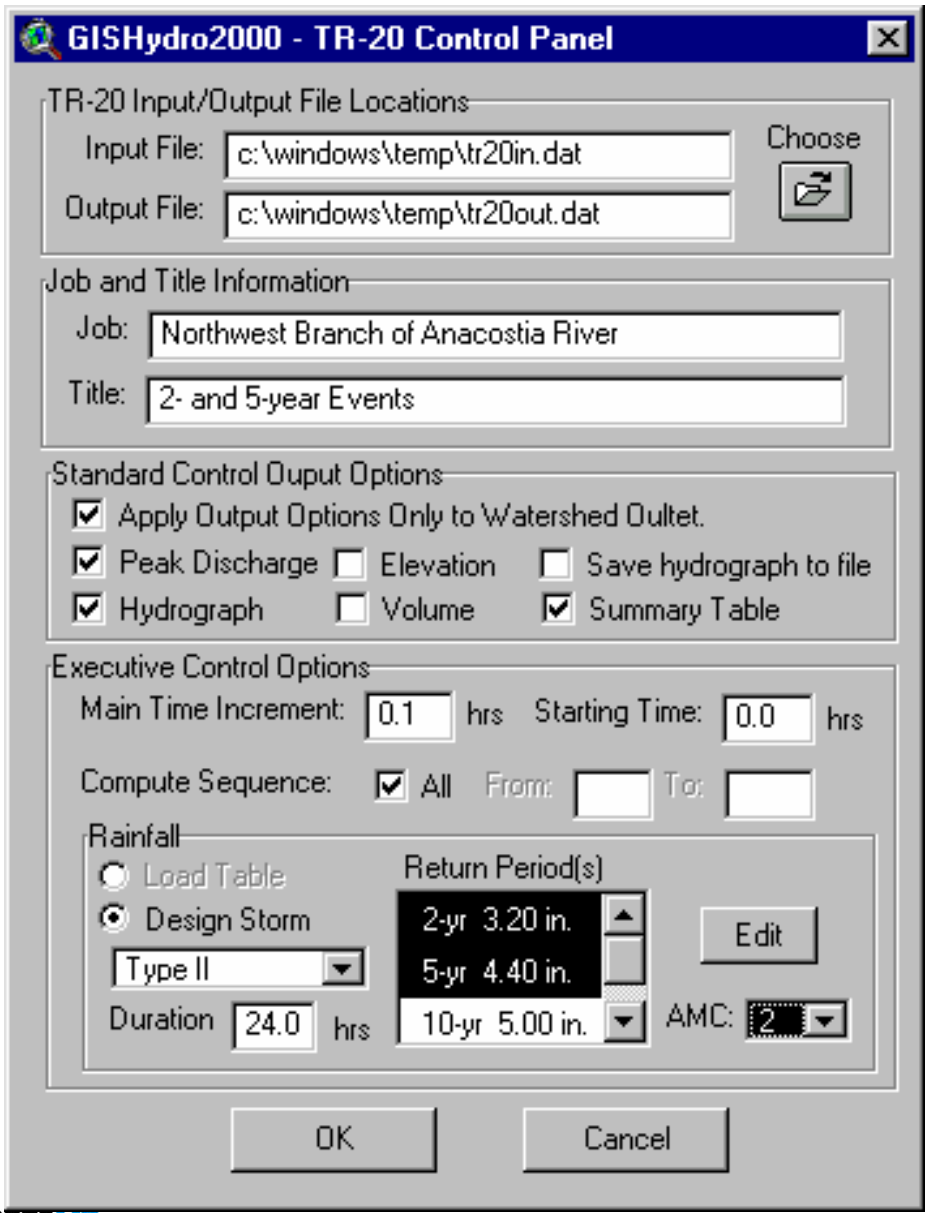
Land_Use	A_Soil	B_Soil	C_Soil	D_Soil
Low Density Residential	0.00	2546.37	146.46	170.34
Medium Density Residential	0.00	2244.95	64.97	209.37
High Density Residential	0.00	905.42	35.81	74.84
Commercial	0.00	53.95	2.75	39.03
Institutional	0.00	397.15	39.26	31.68
Open Urban Land	0.00	924.47	38.11	202.71
Cropland	0.00	636.36	58.08	61.75
Pasture	0.00	356.75	67.49	46.83
Orchards	0.00	17.91	2.07	0.23
Deciduous Forest	0.00	2258.26	330.58	965.56
Mixed Forest	0.00	79.66	31.22	1.84
Brush	0.00	138.66	3.67	16.30
Water	0.00	4.13	0.00	1.84
Bare Ground	0.00	298.90	11.25	1.15
Total Area:	0.00	10862.95	831.73	1823.46

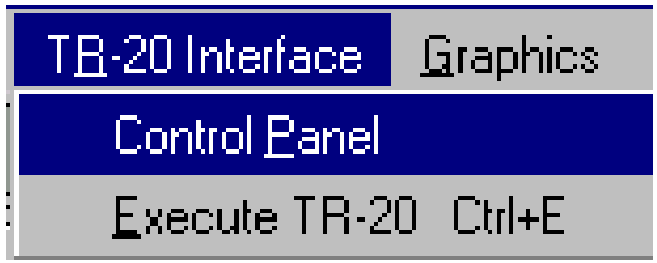


The "Basin Statistics" Menu Choice



TR-20 Control Panel





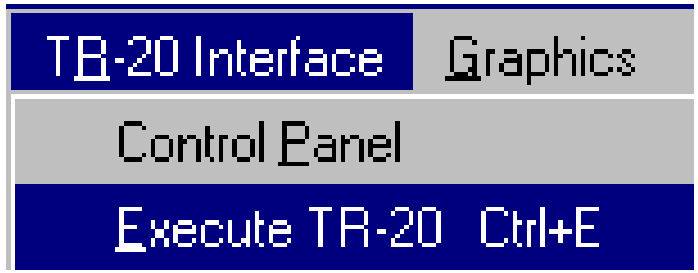
- **Creates TR-20 input file. Controls file I/O**
- **This menu choice controls all the non-"GIS-able" entries that must be conveyed to TR-20 program**
- **Can specify multiple storm events and magnitudes**

Execute TR-20

tr20out.dat - Notepad

File Edit Search Help

```
1
 TR20 ------------------------------------------------------------------------ SCS -
                     Northwest Branch of Anacostia River                  VERSION
 07/17/**            Northwest Branch of Anacostia River                 2.04TEST
 13:07:21                  PASS   1   JOB NO.   1                         PAGE   1


 EXECUTIVE CONTROL INCREM    MAIN TIME INCREMENT =    .100 HOURS


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   8  TO XSECTION   2
    STARTING TIME =   .00       RAIN DEPTH =  3.20       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 1            RAIN TABLE NO. = 2


 OPERATION ADDHYD   XSECTION   2

    PEAK TIME(HRS)              PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
       18.95                         1126.3                       (NULL)

                  HYDROGRAPH POINTS FOR   ALTERNATE = 1,   STORM = 1
     HRS      MAIN TIME INCREMENT =   .100 hr,      DRAINAGE AREA =  21.19 SQ.MI.
    11.60 CFS       .25     .64    1.76    4.86   10.86   18.33   23.67   25.23
    12.40 CFS     25.16   25.60   27.87   31.67   36.68   42.72   49.81   57.96
    13.20 CFS        67      77      88     101     114     128     144     161
    14.00 CFS       179     199     219     241     265     289     315     342
    14.80 CFS       370     399     428     459     489     520     550     581
    15.60 CFS       611     642     671     700     728     755     782     808
    16.40 CFS       832     856     878     900     921     941     959     976
    17.20 CFS       993    1008    1023    1037    1050    1062    1073    1083
    18.00 CFS      1092    1099    1106    1111    1116    1119    1122    1124
    18.80 CFS      1125    1126    1126    1125    1124    1122    1119    1116
    19.60 CFS      1112    1107    1101    1094    1087    1079    1071    1061
    20.40 CFS      1051    1041    1030    1019    1008     997     985     974
    21.20 CFS       963     952     942     931     921     910     900     890
    22.00 CFS       880     870     859     849     839     830     820     810
    22.80 CFS       801     791     782     773     764     755     746     737
    23.60 CFS       729     720     711     703     694     686     678     669
    24.40 CFS       661     653     645     637     629     622     614     607
    25.20 CFS       599     592     585     578     571     564     557     550
    26.00 CFS       543     536     530     523     516     509     503     496
    26.80 CFS       489     482     476     469     462     455     448     442
    27.60 CFS       435     428     421     414     407     400     393     386
```



- **TR-20 is executed from within ArcView/GISHydro 2000 Interface.**
- **Output automatically opened in "Notepad" editor for examination.**

Changes in Methodology

- **From the February 2001 to the August 2006 report, the following major changes were implemented:**
  - Fixed Region regression equations replaced USGS WRIR 95-4154 equations
  - Better guidance for estimating design flows in limestone areas (Blue Ridge Region)
  - Better guidance in applying hydrologic methods near regional boundaries
  - Use of NOAA Atlas 14 rainfall depths in lieu of TP-40 (plus 48-hour rainfall depths)
  - Web-based version of GISHydro2000

Ongoing Changes in Methodology

- **Conversion of GISHydro2000 based on ArcView Version 3 to ArcGIS Version 9 (Glenn Moglen and Mike Casey)**
- **Use of temporal rainfall distributions based on NOAA Atlas 14 rainfall data in lieu of the NRCS Type II distribution**
- **Updated Fixed Region regression equations for the Eastern Coastal Plains based on SSURGO soils in lieu of STATSGO soils**