

Updating and the Functionality of
GISHYDRO Including Digital
Terrain and Digital Line Data
SP707B4J

SUPPLEMENT TO
FINAL REPORT

DRAFT

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Contents

Contents.....	2
Introduction	3
Background	3
Tasks and Objectives	3
GISHydro2000 Second Edition.....	4
Program (General)	4
National Hydrography Dataset (NHD).....	5
Expanded DRG Coverage.....	5
Consistent Color Legends	6
Hydro Extension Improvements	6
Interfacing with the U.S.G.S. “Tasker” Program.....	6
Change of “W” (watershed) Tool Functionality.....	7
CRWR-PrePro improvements	8
TR-20 Interface Improvements.....	8
Cross Section Editor Dialog Box and Editing Procedure.....	8
TR-20 Interface Memu “Add Streams” Option.....	10
TR-20 Control Panel.....	10
Summary and Recommendations	11
Appendix A – Instructions.....	12
Cross Section Editor	12

Introduction

This document is a supplement to the final report submitted in January 2000 to the Maryland State Highway Administration (MSHA) for the project “Updating and Enhancing of the Functionality of GISHYDRO Including Digital Terrain and Digital Line Data”(SP707B4J). The project was extended through June 30, 2000 to include an expanded scope of work. This document describes the tasks associated with the extension and the work completed.

The embodiment of the work completed in this project has resulted in the creation of GISHydro2000. GISHydro2000 is an ArcView GIS-based application, which combines a complete database of terrain, land use, and soils data with tools for assembling and evaluating hydrologic models such as the USGS regional regression equations or TR-20. The extension for this project has focused on refining various facets of the program as well as adding new features. The result is a significant update to the software, called GISHydro2000 Second Edition.

This report presents the specific revisions and enhancements made to the GISHydro2000 including their rationale and discussion of their use. Reference should be made to the already submitted Final Report and User’s Manual for more detail about the overall project or operation of the program. One of the major enhancements completed as part of this extension was the redesign of the Cross Section Editor Dialog Box. Appendix A at the end of this report provides a detailed description of the new procedures to be followed when inputting cross section information for TR-20 modeling.

Background

The original release of the GISHydro software, for the current project, was in January 2000. From that date, MSHA personnel began testing the software and applying it for hydrologic analyses in the State of Maryland. During this testing period, some limitations and errors were identified in the software. After identifying features of the program in need of revision, MSHA was asked to compile a list of requests to be addressed in an extension of the project.

Two training workshops were held in March 2000 on the use of the GISHydro2000 software. The workshops allowed a broad audience of users to try the software and to test it at a large scale. During these workshops, many suggestions were made as to how the software could be improved. The combination of formal requests for changes by MSHA and informal requests by attendees of the GISHydro2000 training workshops formed the scope of work for the current project extension.

Tasks and Objectives

The list of requests compiled by MSHA was submitted to the University of Maryland by Mr. Jeffery Knaub in an e-mail message on February, 15 2000. Following this date, a request for an extension of the project, with an expanded scope based on the list of requests was submitted. Based on the resources and time available, a subset of these requests was selected to be addressed in the project extension. These requests included:

1. *After you “Add Streams” and incorporate them, the theme “Inferred Streams” is no longer available. This makes adding an outlet point on a main channel difficult because it is tough to balance the drainage area size.*

2. *We need some sort of check when we draw the cross-sections that assures the last point on either side is higher than the one in from it. It would also be helpful for people to have contours on the screen when they are drawing these cross-sections. We know how to do it but many others may not.*
3. *It would be useful to be able to obtain the data or plot the cross-section after we cut it. We always include these sections in our reports.*
4. *An editor that would allow us to input in-stream cross-section data would be very helpful instead of only having the option of using the bankfull characteristics.*
6. *We need to have the ability to run a homogeneous TR-20.*
7. *Running multiple rainfalls and determining multiple peak flows (2-, 10-, 25-, 50- and 100-year) within one run would be a time saver.*
11. *It would be useful if we could get the basin composition (the soils and landuse distribution table) for each subwatershed*

As a clarification of these requests, the following tasks were identified:

- **Item 1.** When a user creates streams with the “S” tool and selects “Add Streams” from the CRWR-PrePro menu, the “Inferred Streams” theme is modified to include only the traced streams or the traced streams plus the inferred streams. In either case, the theme is renamed ‘Modified Streams”, but never disappears.
- **Item 2, 3 and 4.** These items are related to the cross section/rating table procedure. A host of problems have been identified with this step. The re-working of this process represents the biggest portion of effort of the expanded scope.
- **Item 6.** This item has already been completed.
- **Item 7.** The TR-20 control panel can be expanded to allow multiple rainfalls to be considered in one TR-20 run.
- **Item 11.** Some existing procedures can be adopted to determine the land use composition for each subwatershed.

GISHydro2000 Second Edition

To complete the tasks states above, a new major release of the GISHydro2000 software is being released, GISHydro2000 Second Edition. This major release includes the requests made by MSHA in addition to enhancements suggested during the March 2000 training workshops. The improvements made are broken down according to the major sections of the program and are described in the sections that follow.

Program (General)

Enhancements and revisions to the GISHydro2000 program include the addition of new or revised datasets to support hydrologic analyses conducted with the program. These datasets include the National Hydrography Data (NHD) to replace the RF3 data and expanded coverage of the Digital Raster Graphics (DRG).

National Hydrography Dataset (NHD)

The river reach files (RF3s) have been replaced with a new vector coverage of streams and rivers from the U.S.G.S. National Hydrography Dataset or “NHD” at a map scale of 1:100,000. These data are essentially the same as the RF3s, except for two useful improvements.

1. We have taken the “route.rch” coverage for each Hydrologic Unit Code (HUC) within the GISHydro2000 extent. These data present stream centerlines instead of left and right banks. The centerlines are superior to the two banks when using the “burn streams” option of the “Select Quadrangles...” dialogue. The burned centerlines will provide a single, meaningful watershed drainage outlet where in the past there would have been two watersheds to delineate (one to each bank) and subsequently merge into a single watershed.
2. Most, but not all, streams are identified by a “Name” field, for example “Anacostia River” and “White Marsh Branch” appear as stream names in this data set. These labels should provide another source of location information valuable when navigating across a region.

All data were obtained directly from the U.S.G.S. NHD site (<http://nhd.usgs.gov/>). In total, we obtained 27 unique HUCs to cover the entire GISHydro2000 extent. As obtained from the U.S.G.S. these data are in Latitude/Longitude coordinates. Processing of these data proceeded as follows:

1. Merge all HUCs into a single coverage.
2. Project merged coverage to the Maryland Stateplane coordinate system, NAD ’83, feet from the native Latitude/Longitude coordinates.
3. Clip the resulting projected coverage to only that part which lies within the strict GISHydro2000 extent.

This data set resides in the “/umdgis/maryland/” subdirectory as “nhd_streams.shp”, “*.shx”, and “*.dbf” and supersedes the “rf3_stp” coverage previously found at this same location.

Expanded DRG Coverage

In the previous version of GISHydro2000, the 1:250,000 (1x2 degree) topographic maps for Baltimore and Washington were included for display in the “Maryland View”. In this manner, they served as a backdrop useful for finding landmarks or place names locating quads for hydrologic analysis. They were not directly available for locating watershed outlets in the “Area of Interest” view, however.

The complete coverage of 1:250,000 DRG maps was processed and assembled for the 347 7.5-minute quadrangles covering the Maryland Drainage Area. These maps are broken up into 5 files corresponding to the named USGS 1 by 2 degree cells intersecting the outer boundary of the quads: Baltimore, Cumberland, Salisbury, Washington, and Williamsburg. The figure below shows the arrangement of the DRG coverage:

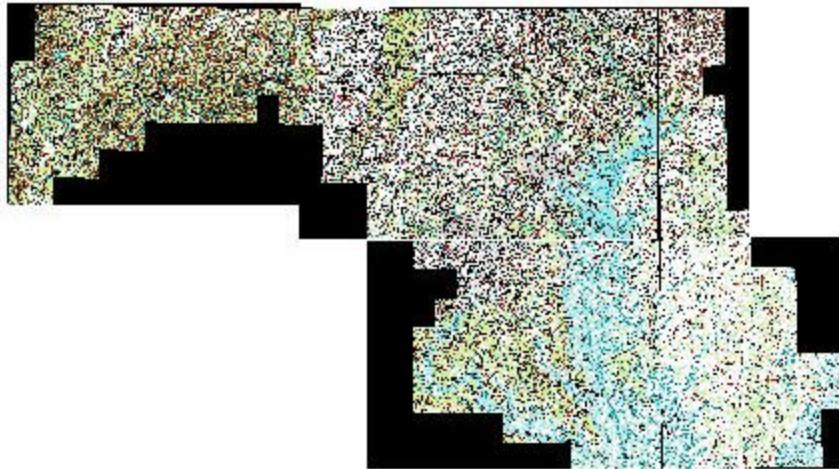


Figure 1: Statewide 1:250k DRG coverage now included in GISHydro2000.

Based on the selection of quads, the appropriate DRG coverage is now loaded into the area of interest view as a backdrop to locate watershed outlets or other map features. These files are stored in the “Maryland” directory with other state-wide datasets in *.TIF format and are approximately 12MB each in size.

Consistent Color Legends

One recurring difficulty in using GISHydro2000 is the random selection of colormaps for GIS themes added to the view. Many times overlying themes are difficult or impossible to see based on the color of the underlying themes. To mitigate this problem, some fixed color maps or legends have been implemented. When using the CRWR-PrePro and TR-20 interface options for example, the legends of the themes produced are now consistent for the subwatershed, streams, and transects themes.

Hydro Extension Improvements

Several changes and improvements were added to the “Hydro” extension as detailed below. These changes were intended to improve the usability of the program especially when delineating multiple watersheds and calculating statistics/discharges and corresponding Tasker analyses.

Interfacing with the U.S.G.S. “Tasker” Program

As part of the version of GISHydro2000 delivered in January 2000, we had successfully interfaced GISHydro2000 with the program developed by Gary Tasker of the U.S.G.S. This program takes as input all of the predictor variables outlined in Dillow’s (1996) Peak Flow Estimation report. Its output includes the predicted flood frequency behavior along with error bounds corresponding to several different confidence levels. An auxiliary input to this program is a request from the user to “Adjust for proximity to a known U.S.G.S. stream gage.” Previously we had used the areal extent of the user-defined watershed to locate any nearby streams. This was potentially erroneous for two reasons:

1. **Tasker's program does not allow for adjustment based on all gages in and around the state of Maryland.** It appears that for some reason, some gages are excluded from this adjustment feature, probably owing to short record length or non-stationary behavior. The list of gages that support this feature is evident from Tasker's "rat.dat" file (see "/umdgis/tasker/rat.dat"). We have added an additional field "Intasker" in the file, "/umdgis/Maryland/usgsgages.shp" that stores either a "y" or "n" depending on whether or not Tasker's program will support adjustment of the flood frequency record based on this gage.
2. **Adjustment for proximity to a gage is performed only if the study watershed and the gage are similar in drainage area to ± 50 percent.** The previous method of simply identifying all gages within the study watershed did not take heed of this criterion. Further, it neglected the possibility that a gage might exist downstream of the study watershed outlet, but within the ± 50 percent window. To account for this, we have derived and added the vector coverage: "/umdgis/Maryland/gagedstreams.shp" which is a polygon representation of that fraction of the gage network within Maryland that satisfies the ± 50 percent criterion. The software now compares the location of the study outlet with this "gagedstreams.shp" theme. If the study outlet is within 1000 feet of a gaged stream, this gage is offered to the users at the time of the execution of the Tasker program as a candidate for flood frequency adjustment. The 1000 foot cushion is to account for the possibility of minor discrepancies between the derived location of the "gagedstreams.shp" and the user determined streams that may result if the "burn stream" option is not used. (This value has been found to be adequate in our trials, but can be adjusted up or down as needed or desired.)

The result of these changes is an effectively running U.S.G.S. Discharges option that works seamlessly with the Tasker program and correctly offers a selection list to the user of only those gages for which flood frequency adjustment is possible and valid.

Change of "W" (watershed) Tool Functionality

The "W" tool is employed by the user to identify the watershed outlet to be used for basin delineation. Use of this tool generates a watershed theme that by default is called "A Watershed" but can actually take on any name provided by the user in the "Hydro:Properties" dialogue for the "Delineated Watershed" property. The problem that we have found often occurs is that the user will inadvertently initiate a second watershed delineation by accident because the "W" tool remains active until a different tool is selected by the user. If a second delineation is initiated some of the internal variables of GISHydro2000 may retain a "memory" of the first delineated watershed while other variables are reset to reflect properties of the second watershed. This can lead to erroneous or unpredictable behavior by GISHydro2000. We have changed the "W" tool behavior to present the following dialogue box:

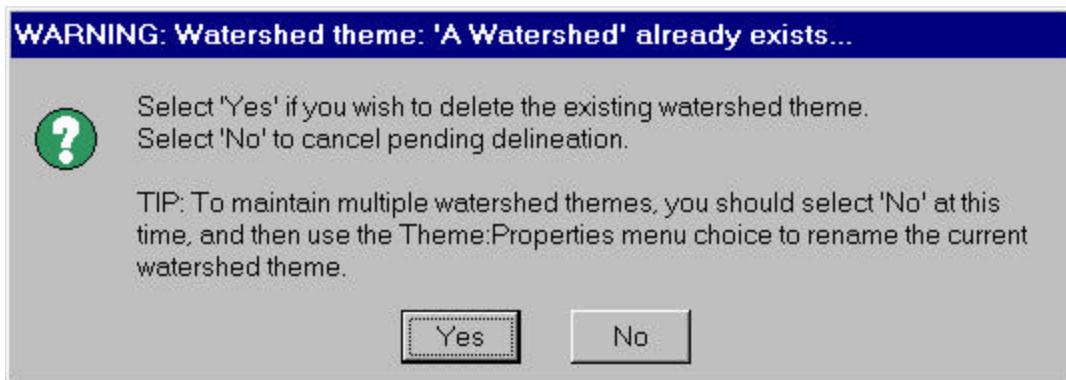


Figure 2: Watershed Tool Warning message.

where a “yes” response would indicate that the user does, in fact, wish to delineate a new watershed and a “no” response indicates that the delineation is not desired/intended. Responding “yes” refreshes all internal variables and deletes the original “A Watershed” theme so that all resulting calculations will be an accurate reflection of the new delineated watershed. We have also added some additional internal logic that automatically refreshes all internal variables should the user independently from GISHydro2000 delete the “A Watershed” theme. We believe the new functionality will serve to eliminate the possibility of erroneous analyses while also safeguarding the user from unintended delineations. It should also be pointed out that if the user genuinely wishes to have multiple watershed themes present in GISHydro2000, this can be accomplished through either the Hydro:Properties menu (“Delineated Watershed” property) to change the name of the theme resulting from a delineation before the fact, or after the fact, the “A Watershed” theme can be renamed using the Theme:Properties menu choice. Keep in mind that the watershed theme identified by the Hydro:Properties “Delineated Watershed” property is the one for which statistics, discharges, and the hydrograph will be calculated.

CRWR-PrePro improvements

There were relatively few changes to the use of the CRWR-PrePro menu options. Once change includes the removal of the option to use the Hydrology Panel (Will Thomas) time of concentration calculation method. This method has not been endorsed by the Maryland Hydrology Panel and was never fully implemented in GISHydro2000. For Second Edition, the option to use this method has been removed.

TR-20 Interface Improvements

Improvements to the TR-20 interface represent the biggest portion of the expansion in scope for this project. Specifically, the re-design of the cross section editing procedure has made for a more reliable and interactive experience for the user. Also, the TR-20 control panel has been expanded with new capabilities for considering multiple storms.

Cross Section Editor Dialog Box and Editing Procedure

The procedure for adding transect lines using the AddTransectTool and the Cross Section Editor dialog box was subject to numerous problems in the first release of GISHydro2000. Transect

lines were drawn for each routing reach after the model schematic was generated. No procedures for verifying user input or viewing/editing the calculated routing tables were available. For the Second Edition release, a new procedure has been implemented.

The improved Cross Section Editor is invoked by drawing a transect line across routing reaches in the TR-20 schematic or selecting an existing transect. There are two tools on a “tool drop-down menu” for each method:

-  **Add Transect Line**. Select this tool from the tool bar and "drag out" a transect line. New error checking will allow only one transect per routing reach, insure intersection with the routing reaches, and clip the transect line to subwatershed boundaries.
-  **Edit Transect Line**. Select this tool from the tool bar (tool bar drop down menu) to edit a transect already drawn. A "hand" cursor will open the Cross Section Editor when the user selects an existing transect. The user may then update cross section parameters as desired.

Upon applying either of these tools on a routing reach in the Area of Interest View, the revised cross section editor dialog box is invoked. Figure 3 shows the expanded dialog. It is now possible to view the calculated rating table for a given reach and to recalculate its values based on changes to reach slope, channel geometry, or roughness.

Also available is the ability to load an external rating table and assign it to a reach in the GIS-derived model (NOT YET IMPLEMENTED).

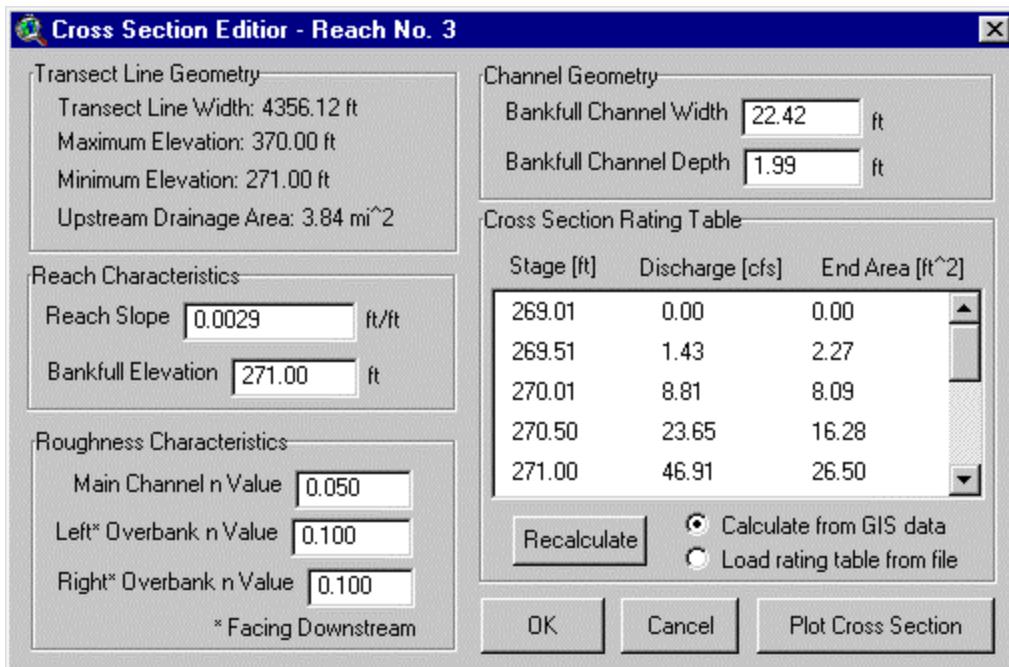


Figure 3: Screen capture of enhanced cross section editor.

The final major enhancement of the new dialog is the ability to plot the overbank and channel geometry associated with a given cross section. Figure 4 shows a screen capture of the invoke window when a user clicks on the “Plot Cross Section” in the Cross Section Editor. The ability to print or capture the cross section to a file is not currently in place.

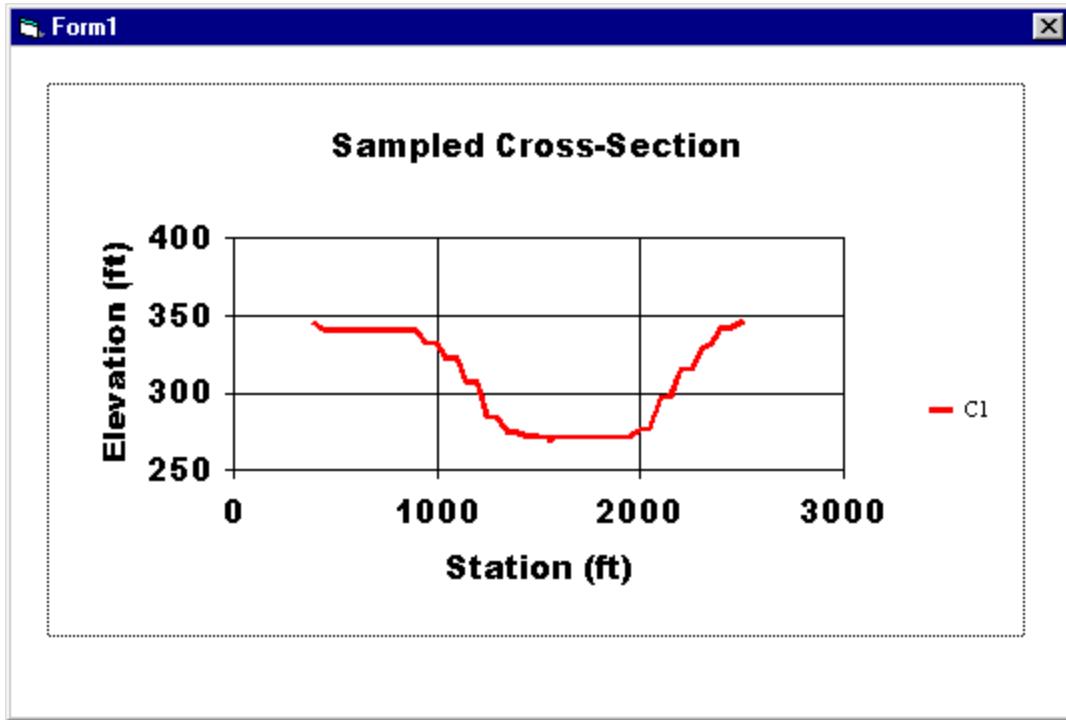


Figure 4: Screen capture of Cross Section Viewer.

The user is free to make changes to the rating table based on whatever values of slope, roughness, etc. are entered. Note that as soon as the rating table is recalculated, the rating table based on the pure GIS data is lost. At any time, the user may re-draw a transect at which time he or she is prompted to keep or replace an existing transect.

TR-20 Interface Menu “Add Streams” Option

The “Add Streams” menu option on the TR-20 Interface menu has been removed. This step is no longer necessary because the cross section editor assembles all information necessary for insertion of the calculated rating tables into the destination TR-20 input file.

TR-20 Control Panel

The TR-20 Control Panel has been augmented to include the ability to run multiple storms for during a single model execution. The ability to evaluate a watershed for multiple storm return periods including the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year events as well as an optional return period. Figure 5 shows the revised TR-20 control panel:

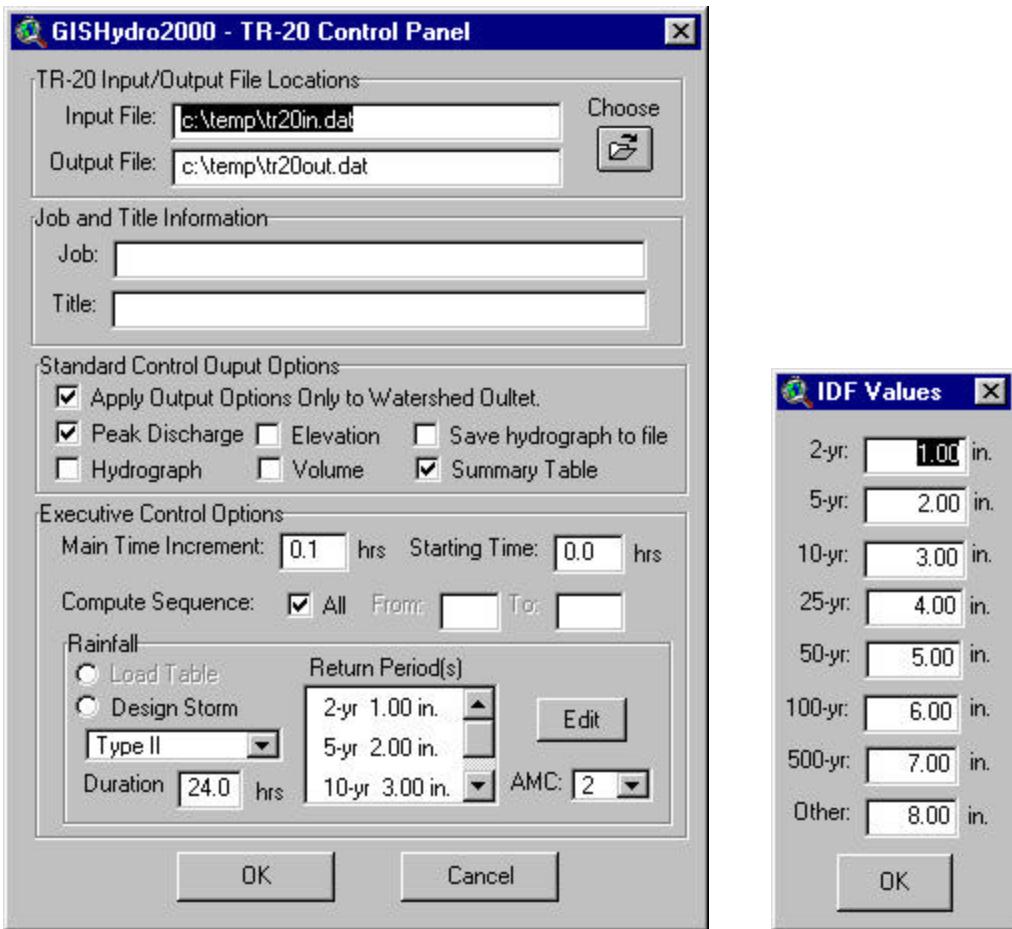


Figure 5: TR-20 Control Panel with multiple return period storms and IDF Editor.

The user can make multiple selections in the Return Period(s) list box by holding down the shift key and selecting the desired values. For each selected return period, TR-20 will calculate runoff for the study watershed. It is possible to edit the depths of rainfall used in the Return Period(s) list box by pressing the Edit button. A small IDF Value editor, also shown in Figure 5 provides the means to edit the rainfall depths corresponding to each return frequency.

Summary

The release of GISHydro2000 Second Edition is a significant step towards streamlining use of the program for conducting hydrologic analyses. The addition of the revised Hydro extension, supporting data such as the NHD and DRG data, as well as the revised cross section editor are all powerful improvements.

Based on the work described in this supplemental report, the tasks outlined for the project extension have been addressed. Each of the tasks have been met by a significant enhancement to the GISHydro2000 software.

Items 2,3 and 4 on the original request for changes submitted by MSHA have been dealt with by improving the cross section editor. The AddCrossSection tool now automatically adjusts the

transect for the presence of a drainage divide along its length. The transect is clipped to the subwatershed boundary and can only be drawn for the current routing reach thus preventing errors in the calculation of TR-20 input. The editor now displays the calculated rating table for the user to review. In this way, the table can be verified or changed based on known values of channel slope, roughness, or channel geometry. Finally, the cross section can be plotted to inspect the channel/overbank for the given transect line.

The TR-20 control panel enhancements have addressed Item 7 on the original task list. It is now possible for the user to examine multiple storms for a given watershed and TR-20 model structure.

Item 11 requests that the basin composition be made available for each subwatershed.....

Appendix A – Instructions

To be added.

Cross Section Editor