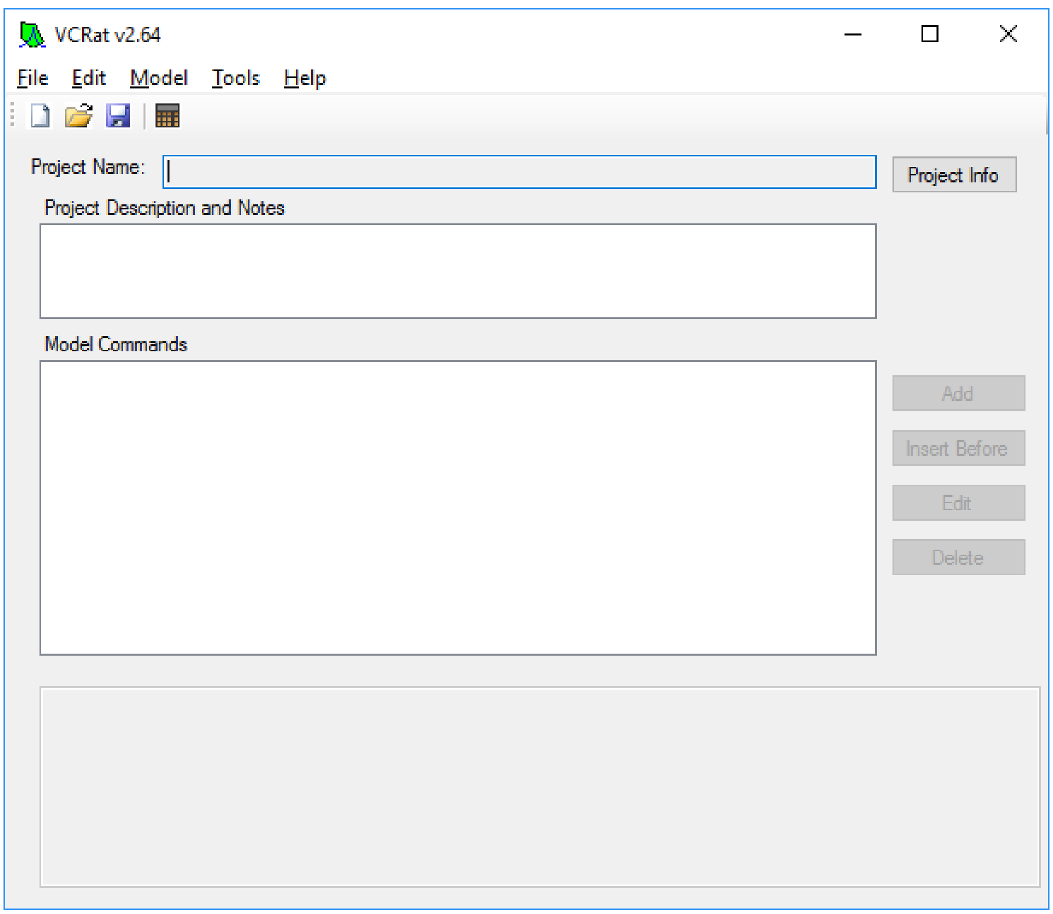
Ventura County
Watershed Protection District

Watershed Resources and Technology Division

Hydrology Section

VCRat2.64 and Tc Calculator Excel Model Training Materials

April, 2018



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VCWPD Tc Calculator Demonstration 1

Objective: Learn to use Tc Calculator Spreadsheet to do Tc calculations for undeveloped subareas using Legacy rain zones and C coefficients.

1) Open the Tc Calculator Spreadsheet (TcCalcExcelModel2017V61_35ZonesPublic.xlsx - Available for download from Hydrology Manual webpage, Appendix E files, E-27).

2) Use File->Options->Formulas to set the spreadsheet to Manual Calculations.

3) The fields available for User Entry are highlighted in light blue. Legacy rain zone boundaries are obtained from the 2010 Hydrology Manual and soil types are obtained from 2017 Hydrology Manual Appendix E files.

4) Enter the following information using the keyboard or dropdown menus and then save the file:

Project: Brown Barranca, 80013	
Subara Name – 1A	Rain/Storm Zone – K
% Effec. Impervious – 0	Land Use Description - Open
Storm Frequency – 100	Soil Type – 3

5) Data for up to 10 flowpaths can be entered in the flowpath data section. The first flowpath representing overland flow is the most critical one affecting the total time of the calculation as it has the slowest flow velocity and generally the longest travel time. For undeveloped areas, the runoff is assumed to travel as shallow overland flow while the contours are parallel and uniform. Where contours show that channels have formed, the flow is no longer overland. With the collection of detailed LiDAR data in 2005, most unincorporated areas of the County can now be evaluated with the resultant 1-ft contours from this data set. The resolution of the data set reduces the overland flow path length compared with historical calculations using 20-ft USGS contours.

   Figure 1 shows a typical undeveloped subarea in a steep canyon area of the Brown Barranca watershed. It is divided into three flowpath subareas based on slopes as follows: upper overland area, steep slope natural channel, and medium slope natural channel. Based on Figure 2 showing the overland flowpath, enter the following data for flowpath 1A-1:

Type – Overland-Undeveloped	Flowpath Area – 0.12
Length – 207 ft	Upper Elevation – 1,395 ft
	Bottom Elevation – 1,367 ft

6) Enter the required information for flowpaths 1A-2 and 1A-3 as follows:

ID	Type	Upper Elev. ft	Bottom Elev. ft	Length ft	Area ac
1A-2	Mtn channel	1,367	797	2,363	30.13
1A-3	Mtn channel	797	709	918	28.60

   A natural valley channel generally has a slope of less than 0.05 ft/ft and lower channel n values than a natural mountain channel.

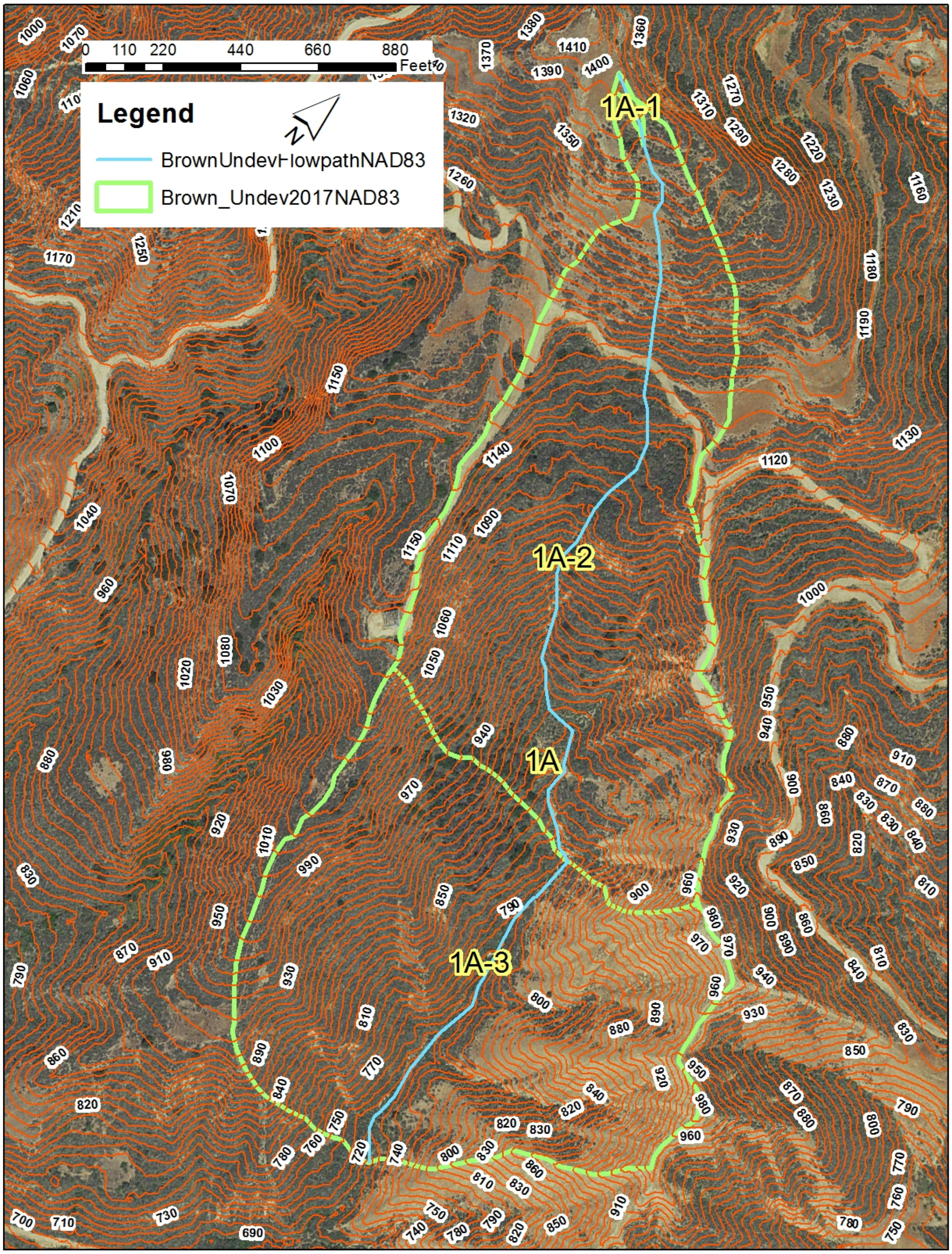

Figure 1. Brown Barranca Subarea 1A Flowpath Areas and Segments, 10-ft Contours

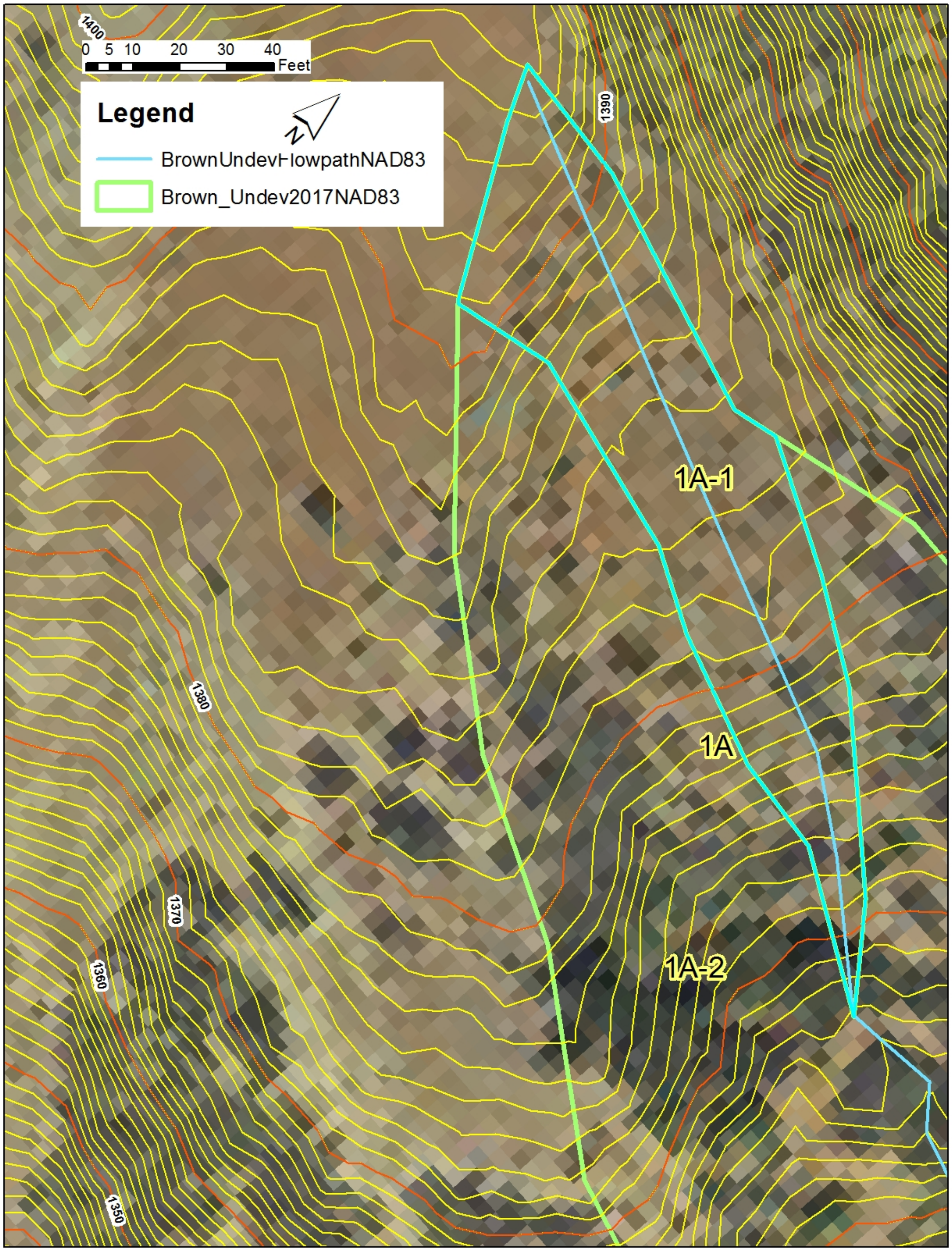

Figure 2. Brown Barranca Subarea 1A Overland Flowpath 1A-1, 2005 1-ft Contours

7) Press F9 to launch the iterative calculations and solve for the Tc. If the run is successful with no errors or warning messages, save your project. Common error messages are: Overland flow slope exceeds 0.25 ft/ft, flowpath slopes exceed maximum of 0.60 ft/ft, overland flow length exceeds 1,000 ft for undeveloped subareas or 200 ft for developed subareas.

8) Print the results, either to a printer or to a PDF file. This output can be included in drainage reports. Save the file. The resultant output is shown in Figure 3.

Notes:

1. The relatively short Tc time obtained from this calculation for a relatively large subarea of about 60 ac shows the challenges of delineating subareas in steep undeveloped areas. In some cases the District has used subareas larger than the recommended range of 40-80 ac in areas like this to obtain Tc's for their models.

2. The short Tc is due to the relatively short overland flow path which ends when the contours show the typical concave downstream shape associated with a stream channel. In this example the overland flow distance was little more than 200 ft with a slope of 13.5%.

3. The delineation of the overland flowpath area is also contingent on the flow converging to the point where the channelization occurs. Because of this, the contributing areas in steep slopes are generally very small – in this example, only 0.12 ac.

4. The mountain channels are assumed to be rocky with relatively high n values for the velocity calculations compared to lower slope (valley) channels. They use the effective slope concept in the velocity calculations. This is based on the concept that steep channels will scour and erode to create a series of natural drop structures and develop an equilibrium situation where the flow does not become highly supercritical.

5. The Tc Calculator spreadsheet was first developed with macros and solvers to converge to a solution. Because some consultants cannot download spreadsheets with macros, the spreadsheet was revised to obtain results without them. In some cases the simple error checking routines included in the spreadsheet cannot prevent the iterative calculations from causing an error. When an error occurs, it is difficult to undo the step that caused the error. Generally it is necessary to exit out of the spreadsheet without saving the changes that caused the error, and then start anew. You can also contact the District staff for help in resolving the error if you cannot fix it yourself at HydroData@ventura.org.

6. Remember to reset Excel to do automatic calculations once you finish your Tc work. Otherwise there is a chance that the next spreadsheet you open will not do automatic calculations as you enter data in the cells.

Tc Calculator Data Sheet V6.1

Project Name and Number: Brown Barranca, 80013

USER INPUT IN BLUE FIELDS:		
Subarea Name =	1a	User Input
Watershed Area ac =	58.9	Calculated from flowpath data
% Imperviousness =	0	User Input
Land Use Description =	Open	DropMenu
Storm Frequency	100	DropMenu
Storm Zone =	K	DropMenu
Zone ID =	K_100	Calculated
District Soil Number (1-7) =	3	DropMenu- Rev for Revised C Coefficients
Tc for Intensity Calc min =	**8.00**	**Rounded, Use for Peak Flow Calc.**
Intensity in/hr =	3.950	Calculated
C_undeveloped =	0.814	Calculated
C_composite =	0.814	Calculated
Peak cfs =	190.88	Calculated
Calculated Tc=	**7.91**	**Calculated**

Instructions:

1. Set to manual calculations with File->Options->Formulas
2. Set max iterative calculations to 50
3. Enter required subarea and flowpath data in blue fields
4. Use site-specific topo or District 2005 LiDAR data for elevations
5. LiDAR and rain zone data at: http://vcwatershed.net/publicMaps/data
6. Clear any unnessary flowpath data from blue fields
7. Manually calculate with F9 or Formulas->Calculate Now
8. If error or comments appear, revise input data accordingly
9. Tc's in cells C12 and C17 should converge to the nearest minute.
10. Use result in C12 for peak flow calculation.
11. Print area is set for printing this page on one sheet.

FLOWPATH DATA- UPSTREAM TO DOWNSTREAM

Flowpath Number	Type- Selected with DropMenus	Type#	Flowpath Area ac	Upper Elev. Ft	Bott. Elev. Ft	Length ft	Map Slope ft/ft	Mtn Chan. Eff. Slope ft/ft	Diam/ Width ft	n value	Side-slope X; XH:1V	% Area	Q cfs	Cum. Q cfs
1	Overland-Undeveloped	1	0.12	1395	1367	207	0.135					0.2%	0.4	0.4
2	Natural Mountain Channel	4	30.13	1367	797	2363	0.241	0.177				51.2%	97.7	98.1
3	Natural Mountain Channel	4	28.60	797	709	918	0.096	0.093				48.6%	92.8	190.9
4	None	0										0.0%	-	190.9
5	None	0										0.0%	-	190.9
6	None	0										0.0%	-	190.9
7	None	0										0.0%	-	190.9
8	None	0										0.0%	-	190.9
9	None	0										0.0%	-	190.9
10	None	0										0.0%	-	190.9
Sum			**58.9**									**100%**	**190.9**	

Figure 3. Undeveloped Tc Calculation Results, Brown Barranca Subarea 1A

VCWPD Tc Calculator Demonstration 1A

Objective: Learn to use Tc Calculator Spreadsheet to do Tc calculations for undeveloped subareas using updated NOAA Rain Zones and revised C coefficients.

1) Open the Tc Calculator Spreadsheet used in Demonstration 1 and rename it.

2) Use File->Options->Formulas to set the spreadsheet to Manual Calculations if not already set.

3) The fields available for User Entry are highlighted in light blue.

4) Find the NOAA rainfall zone for your project area using the public viewer (http://vcwatershed.net/publicMaps/data/). Brown Barranca is in the Upper Harmon Barranca Watershed as shown in Figure 4. The soil type is determined from the soils shapefile of 2017 Manual Appendix E, E-10. The suffix "Rev" for soil type indicates that the revised C coefficients will be used for the calculation. The revised C coefficients are used with the actual percent impervious value instead of the effective impervious value from Exhibit 14 of the 2017 Hydrology Manual.

5) Enter the following information using the keyboard or dropdown menus and then save the file:

Project: Brown Barranca, 80013	
Name – 1A	Rain/Storm Zone – Upper Harmon
% Impervious – 0	Land Use Description - Open
Storm Frequency – 100	Soil Type – 3Rev

6) Use the same flowpath information from Demonstration 1.

7) Press F9 to launch the iterative calculations and solve for the Tc.

8) The resultant output is shown in Figure 5.

Notes:

1) This Tc is a minute longer than the previous calculation due to the lower rainfall intensity from this NOAA rain zone and smaller C coefficient in this undeveloped subarea. This results in a smaller peak flow for use in design calculations. In general, the use of the NOAA rain zone data and revised C coefficients for undeveloped subareas will result in smaller peak flow than the District's legacy rain zone and C coefficient data sets.

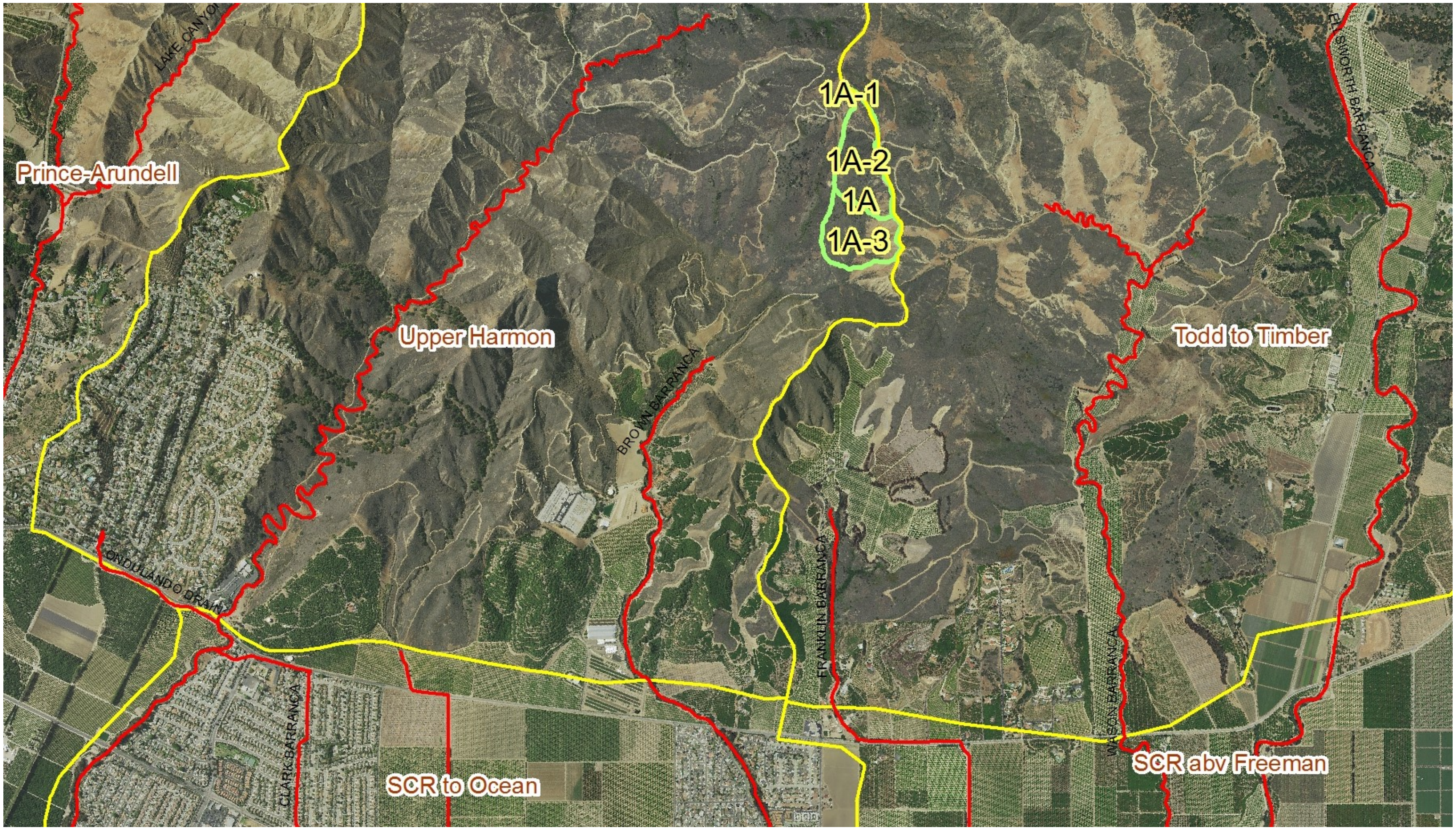

Figure 4. NOAA Rain Zone Map

Tc Calculator Data Sheet V6.1

Project Name and Number: Brown Barranca, 80013- NOAA Rain

USER INPUT IN BLUE FIELDS:		
Subarea Name =	1a	User Input
Watershed Area ac =	58.85	Calculated from flowpath data
% Imperviousness =	0	User Input
Land Use Description =	Open	DropMenu
Storm Frequency	100	DropMenu
Storm Zone =	Upper Harmon	DropMenu
Zone ID =	Harm1_100	Calculated
District Soil Number (1-7) =	3Rev	DropMenu- Rev for Revised C Coefficients
Tc for Intensity Calc min =	**9.00**	**Rounded, Use for Peak Flow Calc.**
Intensity in/hr =	3.996	Calculated
C_undeveloped =	0.471	Calculated
C_composite =	0.471	Calculated
Peak cfs =	111.57	Calculated
Calculated Tc=	**8.95**	**Calculated**

Instructions:

1. Set to manual calculations with File->Options->Formulas
2. Set max iterative calculations to 50
3. Enter required subarea and flowpath data in blue fields
4. Use site-specific topo or District 2005 LiDAR data for elevations
5. LiDAR and rain zone data at: http://vcwatershed.net/publicMaps/data
6. Clear any unnessary flowpath data from blue fields
7. Manually calculate with F9 or Formulas->Calculate Now
8. If error or comments appear, revise input data accordingly
9. Tc's in cells C12 and C17 should converge to the nearest minute.
10. Use result in C12 for peak flow calculation.
11. Print area is set for printing this page on one sheet.

FLOWPATH DATA- UPSTREAM TO DOWNSTREAM

Flowpath Number	Type- Selected with DropMenus	Type#	Flowpath Area ac	Upper Elev. Ft	Bott. Elev. Ft	Length ft	Map Slope ft/ft	Mtn Chan. Eff. Slope ft/ft	Diam/ Width ft	n value	Side-slope X; XH:1V	% Area	Q cfs	Cum. Q cfs
1	Overland-Undeveloped	1	0.12	1395	1367	207	0.135					0.2%	0.2	0.2
2	Natural Mountain Channel	4	30.13	1367	797	2363	0.241	0.177				51.2%	57.1	57.3
3	Natural Mountain Channel	4	28.60	797	709	918	0.096	0.093				48.6%	54.2	111.6
4	None	0										0.0%	-	111.6
5	None	0										0.0%	-	111.6
6	None	0										0.0%	-	111.6
7	None	0										0.0%	-	111.6
8	None	0										0.0%	-	111.6
9	None	0										0.0%	-	111.6
10	None	0										0.0%	-	111.6
Sum			**58.9**									**100%**	**111.6**	

Figure 5. NOAA Rain Zone Tc Calculation

VCWPD Tc Calculator Demonstration 2

Objective: Learn to use Tc Calculator to do Tc calculations for developed subarea.

1) Open the Tc Calculator Spreadsheet (TcCalcExcelModel2017V61_35ZonesPublic.xlsx - Available for download from Hydrology Manual webpage, Appendix E files, E-27).

2) Use File->Options->Formulas to set the spreadsheet to Manual Calculations.

3) The fields available for User Entry are highlighted in light blue. Legacy rain zones use the percent effective impervious and legacy C coefficients.

4) Enter the following information from the map provided in Figure 6 using the keyboard or dropdown menus and save the file:

Name – 29B	% Eff. Impervious – 23
Land Use Description – Residential ¼ ac lots (LowRes1/4)	Rain/Storm Zone – K
Storm Frequency – 100	Soil Type – 3

5) Enter the data for the overland flowpath shown in Figure 4. In residential areas this is generally a house parcel as the lots are usually graded to slope from the backyard to the street to control the drainage. The overland flow length is assumed to extend from the backyard to the sidewalk along a parcel line. Some flow concentration occurs along either side of the house, but not enough to affect the overland flow assumption significantly. If the lot is graded with swales or equipped with subdrains then this will affect the overland flowpath length. In commercial or industrial areas the overland flow area is generally a portion of a parking lot where flow is conveyed to a cross gutter or a grate inlet.

Name – 29B-1	Type – Overland Developed
Length – 122 ft	Upper Elevation – 355 ft
Bottom Elevation – 350 ft	Contributing Area = 0.2 acres
Development Type – Residential	

6) The next flowpaths consist of street flow conveying the residential runoff to the curb inlets for a pipe, and a pipe draining to a creek. The flowpaths are delineated based on the tributary areas to these two segments. The elevations for the street are based on the available topo information. The elevations for the pipe are preferably obtained from the drainage system plans. If the plans are not available, or the drainage system is in design, then the pipe slope can be estimated using the street or land surface elevations along the alignment as was done in this example. N values are obtained from the District's Design Manual or some other referenced source. Enter the information in the table for these flowpaths.

	Type	Top Elev ft	Bottom Elev ft	Length ft	Area ac	N value
29B-2	Street 32-ft wide, 6-in curbs	350	302	1,443	20.4	-
29B-3	Pipe (assumed 2 ft diam)	302	273	917	11.1	0.012

WPD N Values: RCP 0.012; RCB, 0.015; CMP 0.024-0.030

7) If your street is not one of the four available width/curb height combinations, choose the closest combination. For the pipe diameter, the Tc Calculator requires open channel flow so it will increase the pipe size if your specified diameter is not large enough to provide this. This often occurs because the actual drainage systems are designed for the 10-yr storm but Tc calculations are also done for the 25-, 50-, and 100-yr storms. For rectangular and trapezoidal channels, enter the bottom width in the spreadsheet. Boxes are are modeled as rectangular channels in the spreadsheet.

8) Press F9 to launch the iterative calculations and solve for the Tc. If the run is successful with no errors or warning messages, save your project. Common error messages are: Overland flow slope exceeds 0.25 ft/ft, flowpath slopes exceed maximum of 0.60 ft/ft, overland flow length exceeds 200 ft for developed subareas. If you left out a required data point for a channel type such as n value for a pipe or channel, the spreadsheet may get stuck in an error loop.

9) Print the results, either to a printer or to a PDF file. This output can be included in drainage reports. Save the file. The resultant output is shown in Figure 7.

Notes:

1. The local drainage features and detailed topo are critical in delineating developed area boundaries. In this example the location of the culvert inlets to the storm drain system affected the boundary. The County has a Unified Storm Drain Coverage that can be used for this. As with any large database, it is recommended that you verify the information that database contains for your project area with a field visit. The KMZ file for the Unified Coverage is at: http://vcstormwater.org/index.php/publications/maps/ventura-countywide-unified-storm-drain-map

   The geodatabase that the KMZ file is based on can be requested by filling out the Data User Agreement form at this site.

Figure 6. Brown Subarea 29B- Low Density Residential with Local Drainage Features

Tc Calculator Data Sheet V6.1

Project Name and Number: Brown Barranca, 80013

USER INPUT IN BLUE FIELDS:		
Subarea Name =	29b	User Input
Watershed Area ac =	31.7	Calculated from flowpath data
% Imperviousness =	23	User Input
Land Use Description =	LowRes1/4	DropMenu
Storm Frequency	100	DropMenu
Storm Zone =	K	DropMenu
Zone ID =	K_100	Calculated
District Soil Number (1-7) =	3	DropMenu- Rev for Revised C Coefficients
Tc for Intensity Calc min =	**6.00**	**Rounded, Use for Peak Flow Calc.**
Intensity in/hr =	4.590	Calculated
C_undeveloped =	0.830	Calculated
C_composite =	0.858	Calculated
Peak cfs =	125.84	Calculated
Calculated Tc=	**6.05**	**Calculated**

Instructions:

1. Set to manual calculations with File->Options->Formulas
2. Set max iterative calculations to 50
3. Enter required subarea and flowpath data in blue fields
4. Use site-specific topo or District 2005 LiDAR data for elevations
5. LiDAR and rain zone data at: http://vcwatershed.net/publicMaps/data
6. Clear any unnessary flowpath data from blue fields
7. Manually calculate with F9 or Formulas->Calculate Now
8. If error or comments appear, revise input data accordingly
9. Tc's in cells C12 and C17 should converge to the nearest minute.
10. Use result in C12 for peak flow calculation.
11. Print area is set for printing this page on one sheet.

FLOWPATH DATA- UPSTREAM TO DOWNSTREAM

Flowpath Number	Type- Selected with DropMenus	Type#	Flowpath Area ac	Upper Elev. Ft	Bott. Elev. Ft	Length ft	Map Slope ft/ft	Mtn Chan. Eff. Slope ft/ft	Diam/ Width ft	n value	Side-slope X; XH:1V	% Area	Q cfs	Cum. Q cfs
1	Overland-Developed	2	0.20	355	350	122	0.041					0.6%	0.8	0.8
2	Street-32'Wide6"Curbs	5	20.40	350	302	1443	0.033					64.4%	81.0	81.8
3	Pipe	9	11.10	302	273	917	0.032		2.0	0.012		35.0%	44.1	125.8
4	None	0										0.0%	-	125.8
5	None	0										0.0%	-	125.8
6	None	0										0.0%	-	125.8
7	None	0										0.0%	-	125.8
8	None	0										0.0%	-	125.8
9	None	0										0.0%	-	125.8
10	None	0										0.0%	-	125.8
Sum			**31.7**									**100%**	**125.8**	

Figure 7. Developed Subarea Tc Calculation Results

VCWPD Tc Calculator Demonstration 2A

Objective: Learn to use Tc Calculator to do Tc calculations for developed subarea using NOAA rainfall zone and revised C coefficients.

1) Open the Tc Calculator Spreadsheet used in Demonstration 2 and rename it.

2) Use File->Options->Formulas to set the spreadsheet to Manual Calculations if not already set.

3) Change the percent effective impervious value to the actual percent impervious value instead of the effective value.

4) Find the NOAA rainfall zone for your project area using the public viewer (http://vcwatershed.net/publicMaps/data/). This subarea is in the SCR to Ocean rain zone.

5) Enter the following information using the keyboard or dropdown menus and then save the file:

Name – 29B	% Impervious – 47
Land Use Description – Residential ¼ ac lots (LowRes1/4)	Rain/Storm Zone – SCR to Ocean
Storm Frequency – 100	Soil Type – 3Rev

6) Use the same flowpath information from Demonstration 2.

7) Press F9 to launch the iterative calculations and solve for the Tc.

8) The resultant output is shown in Figure 8.

Notes:

1) The calculated Tc is slightly longer than the previous calculation due to the lower rainfall intensity from this NOAA rain zone. The smaller C coefficient in this low density developed subarea is offset by the increase in imperviousness used in the calculation.

Tc Calculator Data Sheet V6.1

Project Name and Number: Brown Barranca, 80013- NOAA Rain

USER INPUT IN BLUE FIELDS:		
Subarea Name =	29b	User Input
Watershed Area ac =	31.7	Calculated from flowpath data
% Imperviousness =	47	User Input
Land Use Description =	LowRes1/4	DropMenu
Storm Frequency	100	DropMenu
Storm Zone =	SCR to Ocean	DropMenu
Zone ID =	SCR3_100	Calculated
District Soil Number (1-7) =	3Rev	DropMenu- Rev for Revised C Coefficients
Tc for Intensity Calc min =	**6.00**	**Rounded, Use for Peak Flow Calc.**
Intensity in/hr =	4.000	Calculated
C_undeveloped =	0.471	Calculated
C_composite =	0.696	Calculated
Peak cfs =	88.98	Calculated
Calculated Tc=	**6.33**	**Calculated**

Instructions:

1. Set to manual calculations with File->Options->Formulas
2. Set max iterative calculations to 50
3. Enter required subarea and flowpath data in blue fields
4. Use site-specific topo or District 2005 LiDAR data for elevations
5. LiDAR and rain zone data at: http://vcwatershed.net/publicMaps/data
6. Clear any unnessary flowpath data from blue fields
7. Manually calculate with F9 or Formulas->Calculate Now
8. If error or comments appear, revise input data accordingly
9. Tc's in cells C12 and C17 should converge to the nearest minute.
10. Use result in C12 for peak flow calculation.
11. Print area is set for printing this page on one sheet.

FLOWPATH DATA- UPSTREAM TO DOWNSTREAM

Flowpath Number	Type- Selected with DropMenus	Type#	Flowpath Area ac	Upper Elev. Ft	Bott. Elev. Ft	Length ft	Map Slope ft/ft	Mtn Chan. Eff. Slope ft/ft	Diam/ Width ft	n value	Side-slope X; XH:1V	% Area	Q cfs	Cum. Q cfs
1	Overland-Developed	2	0.20	355	350	122	0.041					0.6%	0.6	0.6
2	Street-32'Wide6"Curbs	5	20.40	350	302	1443	0.033					64.4%	57.3	57.8
3	Pipe	9	11.10	302	273	917	0.032		2.0	0.012		35.0%	31.2	89.0
4	None	0										0.0%	-	89.0
5	None	0										0.0%	-	89.0
6	None	0										0.0%	-	89.0
7	None	0										0.0%	-	89.0
8	None	0										0.0%	-	89.0
9	None	0										0.0%	-	89.0
10	None	0										0.0%	-	89.0
Sum			**31.7**									**100%**	**89.0**	

Figure 8. Developed Subarea Tc Calculation Results- NOAA Rain Zone

VCRat 2.64 Training Example Exercise 1

Objective: Enter data in a new VCRat2.64 model input file and run it to obtain a design peak flow.

1) Install the VCRat2.64 program from the WPD VCRat webpage.

2) Check to see that the required *c:\VCRatWorkspace* folder has been created. If not, create it.

3) Open VCRat2.64 program by double clicking on desktop shortcut or selecting VCRat 2.64 from the Start Menu.

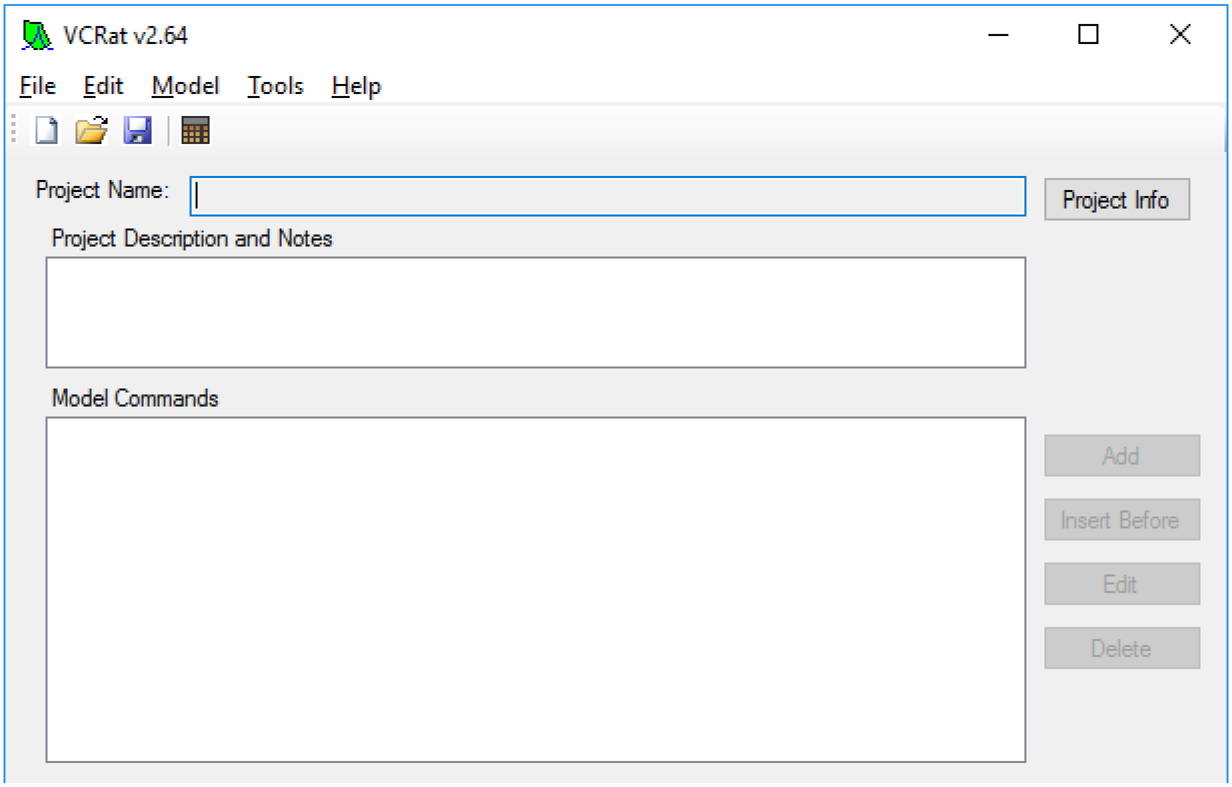

Figure 9. VCRat2.64 Main Program Window for New Project

4) Click on Project Info Button and in the window type the project name. If you do not provide a name, you cannot enter information in the model!
Note: The program may ask you to save the project before you can open the project dialog. Select 'Save' from the 'File' menu to save the project. After the save, click the Project Info button to enter the project information.
>Job number, a 1 to 5 digit project number, 82510 is used in this example.
>Subarea Start number- can be higher than 1 but 1 is fine for this example.
> If using relative pathways, output file and hydrographs will be stored in folder containing input file. If using absolute pathways, you can find hydrographs and store output files in different locations than the input file.

5) If a hydrograph needs to be imported, click on the folder and locate .hyd file. If there are no imported hydrographs in the run, the program will create a hydrograph file with nothing in it.

6) Under storm frequency, scroll down to 100 year. Click on "Add" button to add as many single line project descriptions as you want. In this case, type "start from scratch tutorial" and click OK. Use the VCRat 2.6 Legacy Curve Set.

7) Add any other descriptions to the project including names, dates, assumptions, and storm frequency. This information will be printed on the title page of the output. See screenshot of the resultant window below.

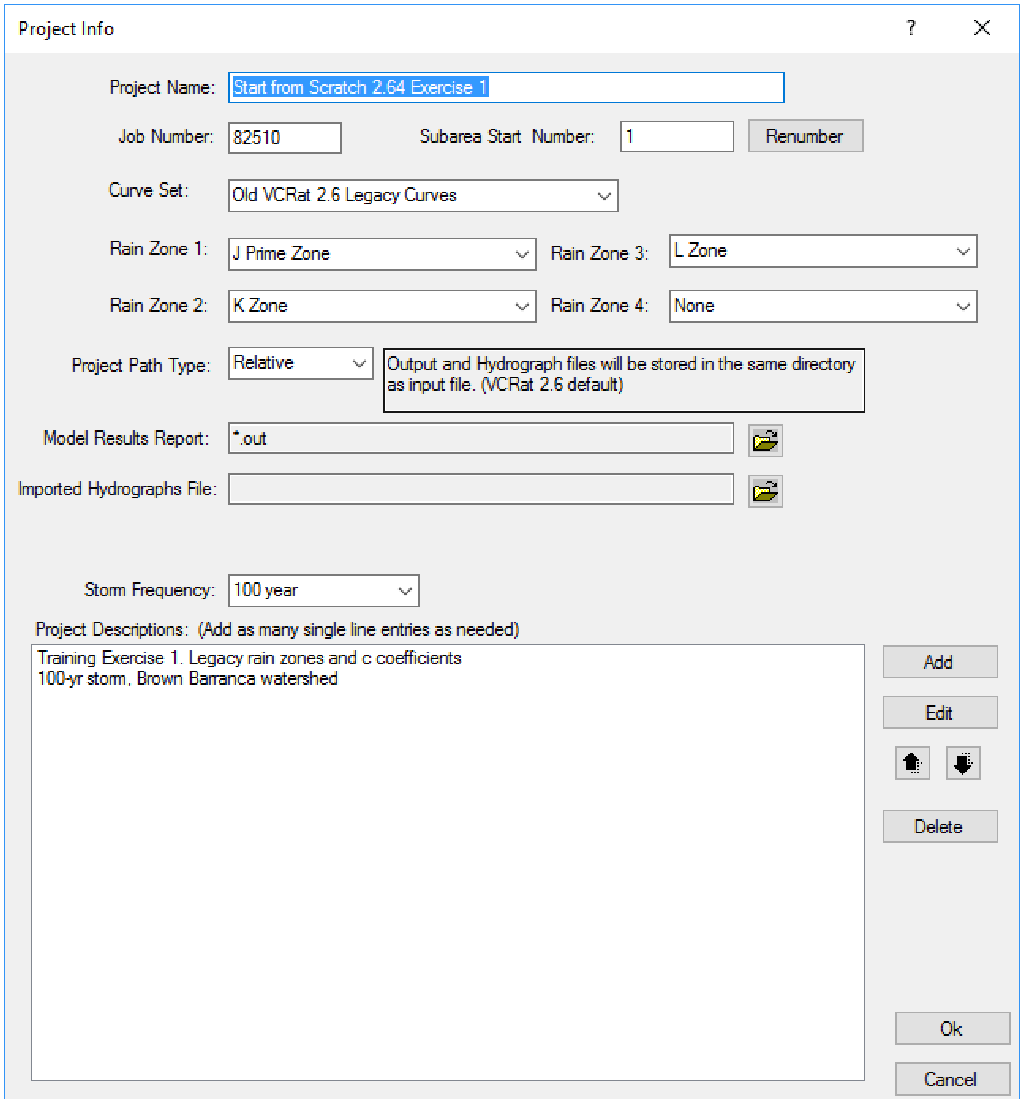

Figure 10. Project Info Window.

8) Click the Ok button to save edits and close window. Always click Ok to close a program window. If you click on the 'X' to close the window, your edits will not be saved and you will not be prompted to save them.

9) Now we can start adding model nodes. Click on Add → Subarea (which should be 1A) →Ok, and type or select the parameters given below, then click OK.

Soil Curve (type 2)	020
Area ac	54
Time of Concentration (min)	10
Percent (Effective) Impervious	0
Rain/Storm zone	K Zone

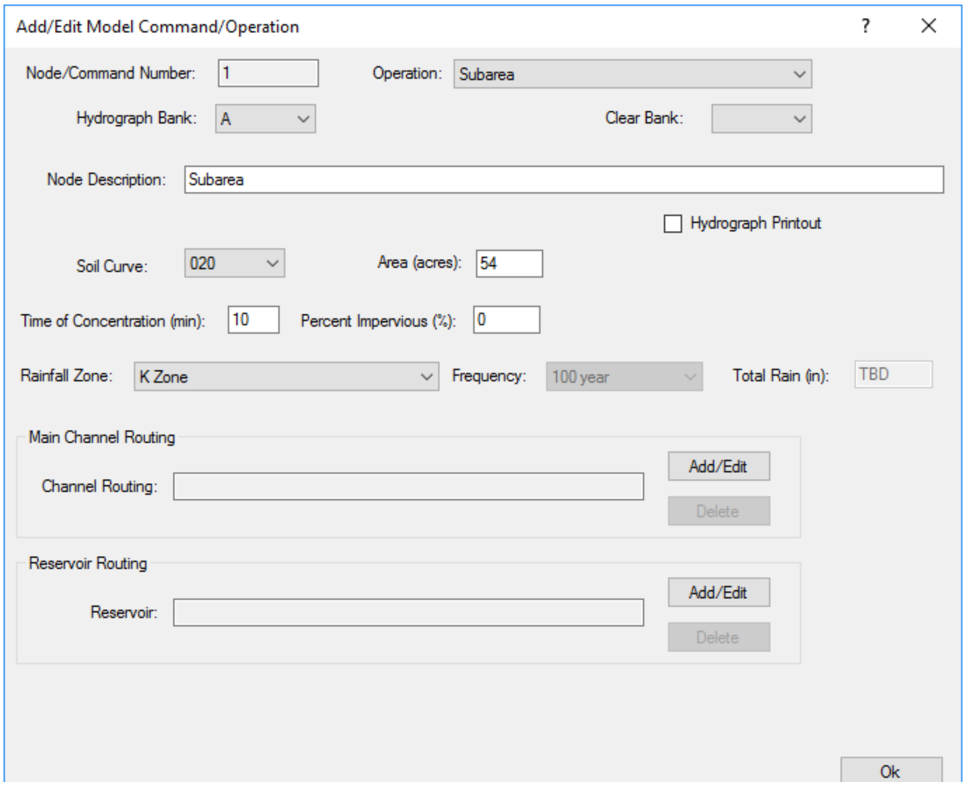

Figure 11. Subarea Editing Window- Subarea 1A

10) Click on Add → subarea (which should be 2A), and type in the parameters below.

Soil Curve (type 2)	020
Area	47
Time of Concentration (min)	10
Percent (Effective) Impervious	0
Rain/Storm zone	K Zone

11) Under Main Channel Routing, click on add/edit and type in the parameters below, then click OK to close the routing window. OK again to close operation window.

Routing type	Natural Mountain
Routing length	1750
Routing slope	0.04

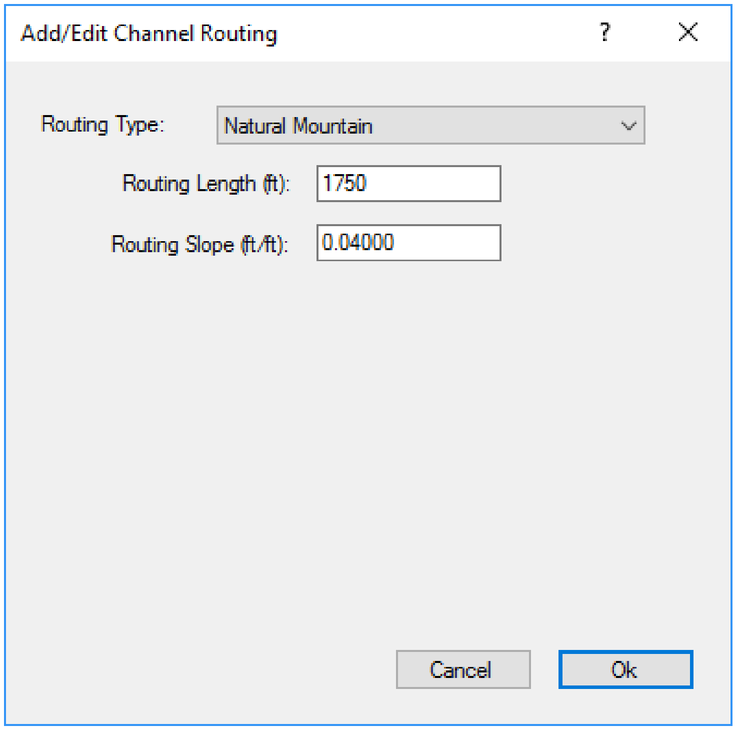

Figure 12. Channel Routing Editing Window

12) Add PLACE HOLD node 3A (also called “dummy” nodes). Adding a placeholder entry after routing allows you to evaluate the attenuation of the peak due to routing effects.

13) Add subarea 4B, and type in parameters given below.

Hydrograph Bank	B
Soil Curve (type 3)	030
Area	67
Time of Concentration (min)	8
Percent (Effective) Impervious	37
Rain/Storm zone	K zone

14) Add CONFLUENCE 5AB with hydrograph bank A, lateral bank B, and type in main channel routing parameters given below.

Routing type	40 Foot Road
Routing length	2525
Routing slope	0.01

Do not force flow to stay in the street by checking the available box, which then adds a street width to the model input data. Without the box checked, if the flow exceeds the street capacity, the program will then convert the street into a larger conveyance such as a pipe or channel.

15) Add subarea 6A and type in parameters given below. Check box for hydrograph printout.

Soil Curve (type 5)	050
Area	18
Time of Concentration (min)	10
Percent Effective Impervious	23
Rainfall zone	K zone

16) Under Reservoir routing, click on add/edit and type in the values below. (You can also enter SCS Curve Number and average watershed rainfall instead of runoff factor). Check the Route through Reservoir box. If you don't check this box, you can enter the reservoir information but the program will not route the hydrograph through the reservoir. The Hydrograph Adjustment (Areal Reduction- AR) factor is 1.0 due to total area less than 640 ac.

Hydrograph adjustment factor AR	1.0
Fatten Method	Runoff Factor
Runoff Factor (Yield) in.	4.0
Emergency Spillway Elevation ft	100.0
Top of Dam Elevation ft	105.0

Enter in the stage storage discharge data and click Add/Update for each elevation.

```
Stage - Storage - Discharge Curve for Reservoir at 6A
STAGE (ft)       STORAGE (ac-ft)     DISCHARGE (cfs)
----------------------------------------------------
    80.00               0.00                 0.00
    85.00              40.00               100.00
    87.50              80.00               150.00
    90.00             120.00               200.00
    95.00             160.00               250.00
   100.00             300.00               300.00
   105.00             400.00             5,000.00
```

For advanced users, do a couple of entries, export the file as a .csv file, do the remaining entries in Excel, and them import the final file. Click OK to save the data to the input file.

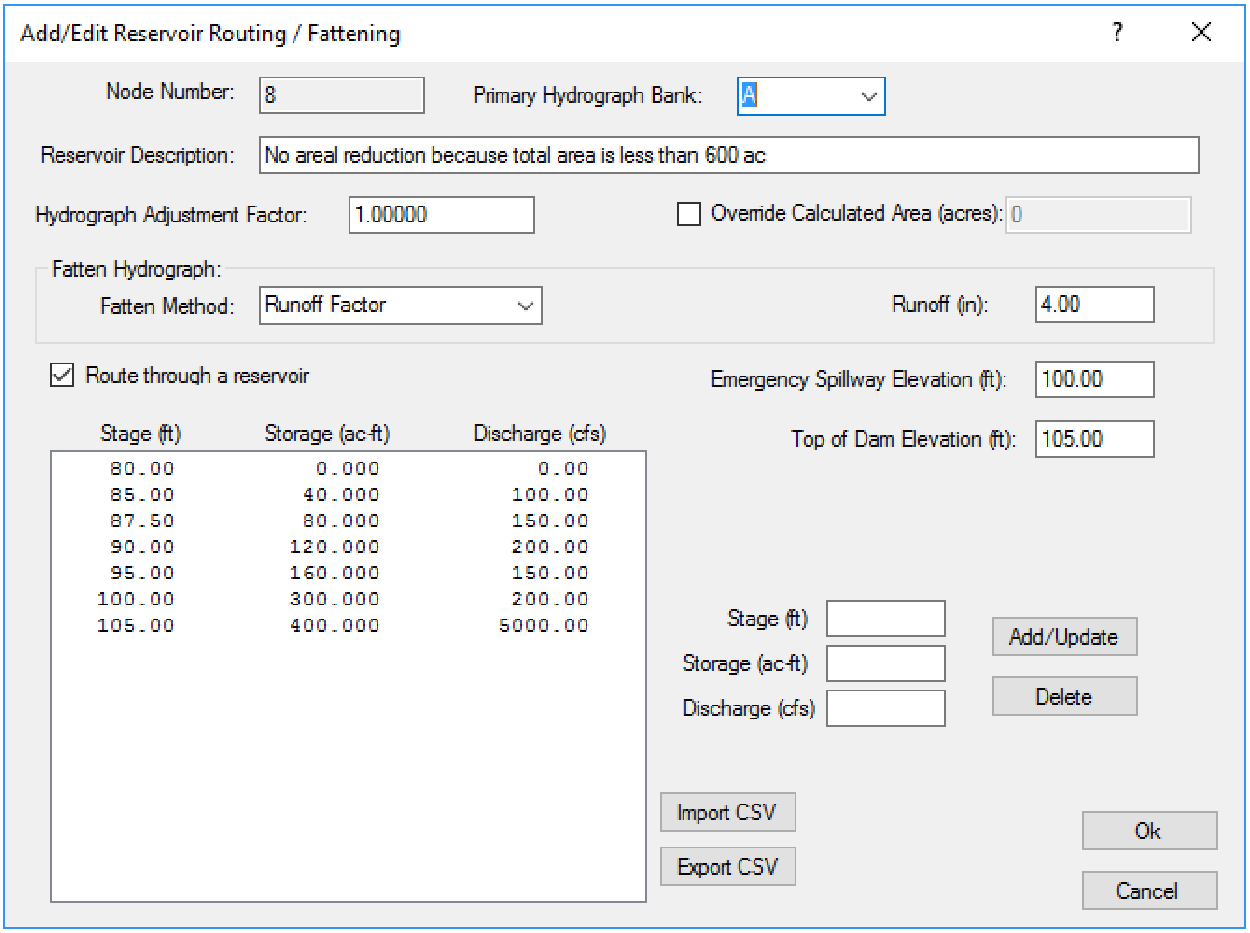

Figure 13. Reservoir Routing Edit Window

17) Export the stage-storage-discharge curve to use in the next exercise. Click the Export CSV button in the Add/Edit Reservoir Routing/ Fattening dialog. Save the file and note the location so you can find this file in Example Exercise 2.

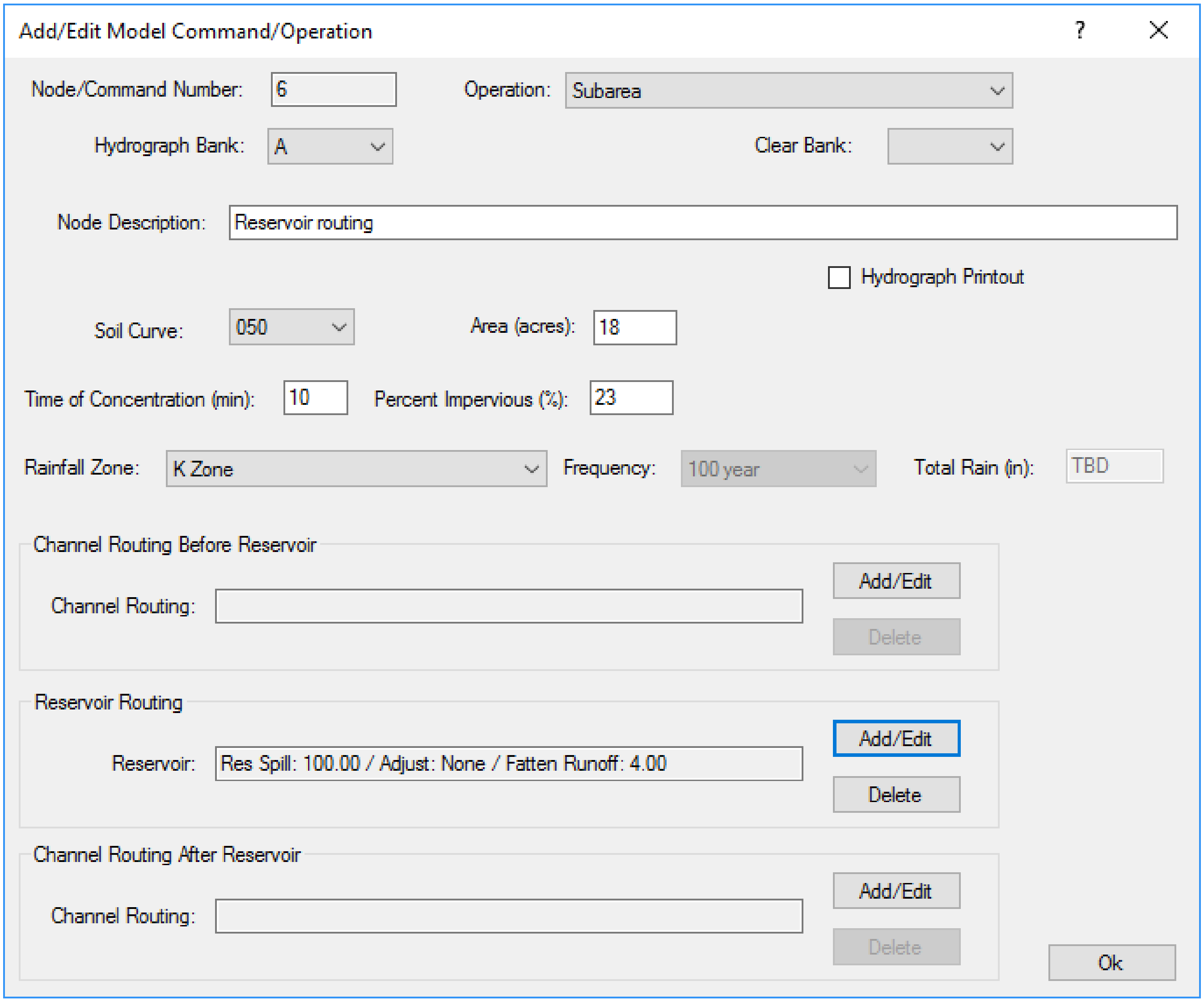

Figure 14. Subarea 6 Edit Window

18) Add PLACE HOLD node 7A. Check the box to obtain a hydrograph for this node. Save your file. The main program window will then show the info in Figure 14.

19) Run the Model by clicking the compute icon or Model-> Run Model.

20) To view model hydrograph select Mode Menu → View Final Hydrographs
Click on model point to view hydrographs. Use Export button to export (.hyd for VCRat model or .csv to plot in Excel). Click the Close Button to close window.

21) Notice that because you did not force the program to keep the flow in the street, the program switched to a 6 ft pipe and marked the change with a "#" in the output file. The program will also switch from a pipe to an open channel if the pipe diameter is not specified and the calculated diameter exceeds 8 ft.

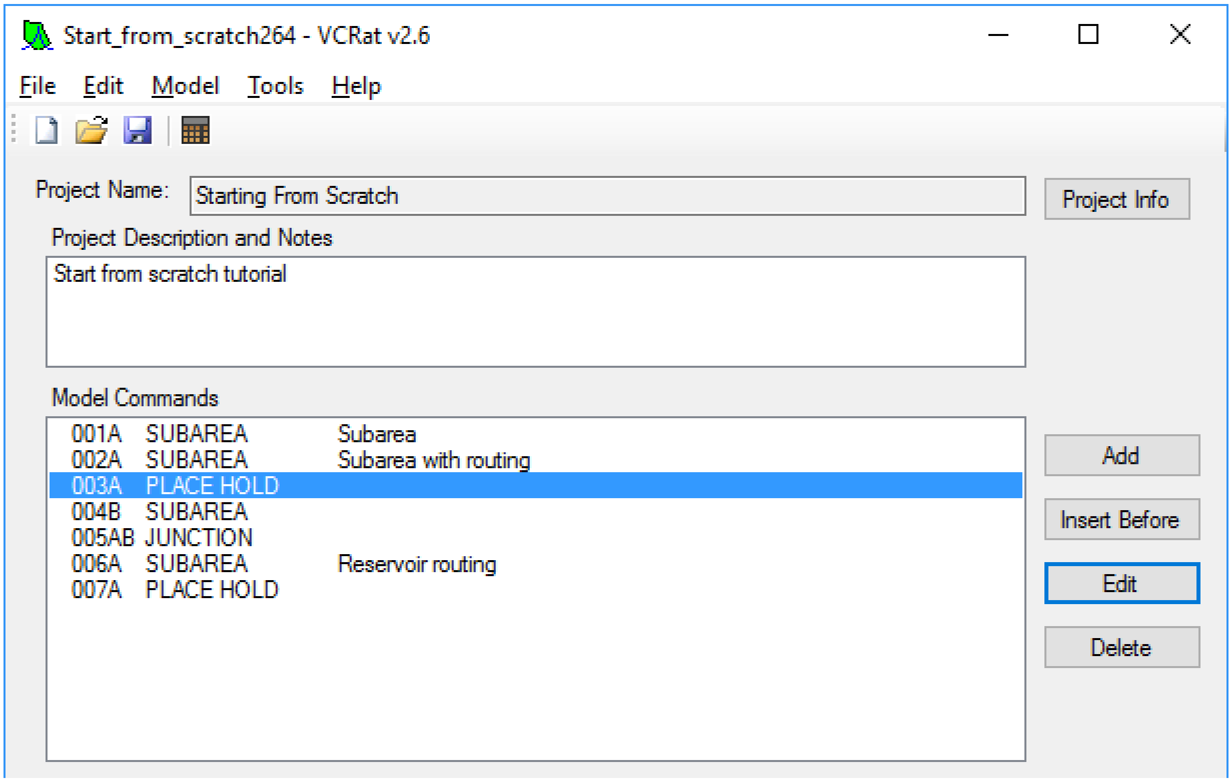

Figure 15. Main Program Window with Edits

Questions:

1) How much freeboard was there in the basin from the maximum water surface to the emergency spillway invert for this run?
2) How much was the hydrograph "fattened" with the yield adjustment factor of 4 inches?

Notes:

1) The more points you have in your stage-discharge-storage table, the more accurate the reservoir routing results will be. You should provide points for the elevations corresponding to significant changes in slope of the discharge curve and the invert of the emergency spillway. Points corresponding to changes in storage of 10% or less of the total volume usually give good results.
2) The Natural Mountain routing choice is used for rocky channels with higher n values than Natural Valley channels. Generally channels with slopes of 0.05 ft/ft or greater are assumed to be Mountain channels. For a Mountain channel in steep areas, the supercritical flow is assumed to scour and create drop structures and hydraulic jumps and the flow tries to create an equilibrium situation. Therefore, the slope used in the routing can be the effective slope as shown in Hydrology Manual Exhibit 7.
3) The placeholder entries in the model are useful to show the attenuation of peaks due to routing reaches. Consider using placeholders after every routing reach. This also gives you the flexibility to make small changes to your model without renumbering all of the nodes and revising all of your hydrology maps.

Ventura County Watershed Protection District
Modified Rational Method Hydrology Program (VCRat v2.64)
Modified Rational Model Results Report
Job: 1 Project: Starting From Scratch

Project Description

Start from scratch tutorial

```
VCRat version:    2.64.0.30
VCRain version:   201601
DOS EXE version:  PC 2.64-201605
VCRain Curve Set: Old VCRat 2.6 Legacy Curves
Curve A:    J':   J Prime Zone
Curve B:     K:   K Zone
Curve C:     L:   L Zone
Curve D:          None
```

Ventura County Watershed Protection District
Modified Rational Method Hydrology Program (VCRat v2.64)

Job: 1 Project: Starting From Scratch

SUBAREA DATA AND RESULTS							ACCUMULATED DATA			ROUTING AFTER ACCUMULATION								
NODE ID	SOIL TYPE	RAIN ZONE	TC (MIN)	% IMP	AREA (AC)	FLOW (CFS)	AREA (AC)	FLOW (CFS)	TIME (MIN)	CHANNEL TYPE	LENGTH (FT)	SLOPE (FT/FT)	SIZE (FT)	H:V (Z)	N VALUES CHNL	N VALUES SIDES	VEL (FT/S)	DEPTH (FT)
1A : Subarea																		
1A	020	B100	10	0	54	164	54	164	1154	-------	----	-------	---	----	-----	-----	--	--
2A : Subarea with routing																		
2A	020	B100	10	0	47	143	101	308	1154	MOUNTAIN	1750	0.04000	---	----	-----	-----	--	--
3A	---	---	--	--	---	---	101	273	1161	-------	----	-------	---	----	-----	-----	--	--
4B	030	B100	8	37	67	229	67	229	1154	-------	----	-------	---	----	-----	-----	--	--
5AB	---	---	--	--	67	229	168	422	1159	#PIPE	2525	0.01000	6.00	----	-----	-----	--	--
6A : Reservoir routing																		
6A	050	B100	10	23	18	49	186	431	1161	-------	----	-------	---	----	-----	-----	--	--

6A : No areal reduction because total area is less than 600 ac

```
*****************************************************************************************
*      INCOMING HYDROGRAPH  PEAK (cfs):    431.42         VOLUME (acre-ft):     44.39      *
*      NO HYDROGRAPH ADJUSTMENT                                                          *
*      RUNOFF FACTOR(in):   4.00                                                         *
*      FATTENED HYDROGRAPH  PEAK (cfs):    431.42         VOLUME (acre-ft):     61.98      *
*      RESERVOIR INFLOW:    PEAK (cfs):    431.42 @ 1161  VOLUME (acre-ft):     61.98      *
*      MAXIMUM ELEVATION:   STAGE (ft):     83.46 @ 1213  VOLUME (acre-ft):     27.68      *
*      EMERGENCY SPILLWAY:   ELEV (ft):    100.00         VOLUME (acre-ft):    300.00      *
*          DIFFERENCE:   IN STAGE (ft):    -16.54      IN VOLUME (acre-ft):    272.32      *
*          NO SPILL EXPECTED.       PERCNT OF VOLUME REMAINING TO SPILLWAY:     90.8%      *
*      TOP OF DAM:           ELEV (ft):    105.00         VOLUME (acre-ft):    400.00      *
*          DIFFERENCE    IN STAGE (ft):    -21.54      IN VOLUME (acre-ft):    372.32      *
*          NO OVERTOP EXPECTED.   PERCNT OF VOLUME REMAINING TO TOP OF DAM:     93.1%      *
*      RESERVOIR OUTFLOW:   PEAK (cfs):     69.28 @ 1213  VOLUME (acre-ft):     43.50      *
*****************************************************************************************
```

NODE ID	SOIL TYPE	RAIN ZONE	TC (MIN)	% IMP	AREA (AC)	FLOW (CFS)	AREA (AC)	FLOW (CFS)	TIME (MIN)	CHANNEL TYPE	LENGTH (FT)	SLOPE (FT/FT)	SIZE (FT)	H:V (Z)	N VALUES CHNL	N VALUES SIDES	VEL (FT/S)	DEPTH (FT)
6A	---	---	--	--	---	---	186	69	1213	-------	----	-------	---	----	-----	-----	--	--
7A	---	---	--	--	---	---	186	69	1213	-------	----	-------	---	----	-----	-----	--	--

VCRat 2.64 Training Example Exercise 2

Objective: Learn to use VCRat 2.64 to modify an existing file to add the following:
1. Missing subarea and routing information
2. Watershed yield, areal reduction, and detention basin routing

Problem Statement:

You work for the Watershed Protection District and are doing a review of a land development study. You notice that the consultant omitted two subareas from their hydrology model shown in Figure 15. They also designed a basin to attenuate their 100-yr developed flow back to the 10-yr undeveloped level, but neglected to include the basin. In the interests of client service, you have volunteered to revise their VCRat 2.64 file to add these features and see if they met their mitigation goals.

Steps:
1. Launch VCRat 2.64
2. Open the file EXER2A264.VIN
3. Revise with the provided information by editing PLACE HOLD nodes 2A and 40D by clicking on the node number and then the edit button. Don't forget to change the operation from dummy/place holder to subarea.
4. Edit subarea 70A to add a detention basin to mitigate the developed peak flow. Note- you need to add a placeholder node at 71A after the basin. Run the model. Compare your results to the results in the Exer2a264Final.out file.

Missing Subarea Information

Node	Soil	Tc min	Area ac	% Eff Imp.	Routing Info
002A	030	10	47	0 Undev	Mountain Channel length = 1750' S=0.04 ft/ft
040D	030	9	50	23 Res	Machine Routing, length = 960' S=0.0111ft/ft

Basin Information for Node 70A
Hydrograph Adjustment Factor 1.0   Runoff ('fattening') Factor 4.0 inches
Basin Spillway Elevation 100 ft   Top of Dam Elevation 105'
Check box for hydrograph printout

```
Stage - Storage - Discharge Curve for Reservoir at 70A
STAGE (ft)       STORAGE (ac-ft)     DISCHARGE (cfs)
----------------------------------------------------
    80.00              0.00                 0.00
    85.00             40.00               100.00
    87.50             80.00               150.00
    90.00            120.00               200.00
    95.00            160.00               250.00
   100.00            300.00               300.00
   105.00            400.00             2,000.00
```

Questions:

1) If the mitigation goal was the Q10 undeveloped peak of 1,200 cfs, did the developer meet their mitigation requirements without causing the basin to spill?
2) If you revise the maximum discharge to 500 cfs for elevation 105, how do the routing results change? Are the results valid? Look at the final outflow hydrograph by using Model-> View Final Hydrographs and clicking on 70A.
3) How can the basin be revised to meet the mitigation goal? Does it need more volume or a different operating spillway design? Which is more economical?

Notes:

1) Basin designed to VCWPD standards must have 1-ft of freeboard above the maximum 100-yr operating water surface elevation to the emergency spillway invert. The emergency spillway must be able to pass the routed 100-yr inflow hydrograph with 3-ft of freeboard to the dam saddle elevation if the operating spillway is completely blocked.
2) If your maximum discharge in the stage-storage-discharge table is less than computed outflow discharge during the model simulation, the routing routine crashes and ceases to calculate a routed outflow. However, VCRat does not crash and no warning messages are produced. You can check to make sure this has not happened by verifying the following in the basin routing section – a) max water surface is less than the dam elevation in your input; b) Outflow hydrograph volume is not significantly less than the basin inflow volume; c) Calculated maximum outflow peak is not close to the maximum discharge in the stage-discharge table; and d) Plot of final outflow hydrograph does not show it dropping to 0 during the run.

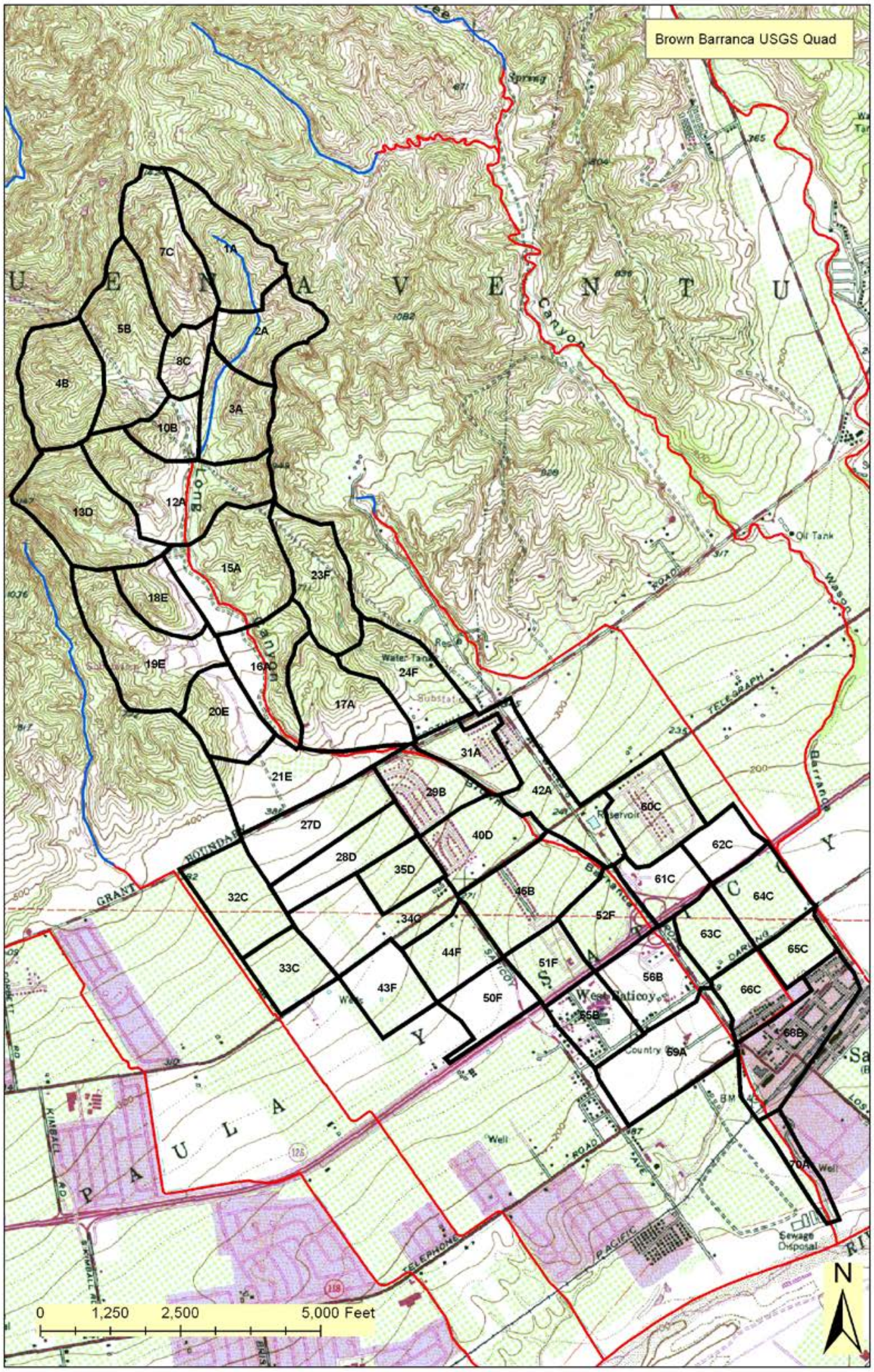

Figure 16 . Brown Barranca Watershed Model with USGS Quad Map Background