Spring 2014 EGR 356 HEC HMS Lab

EGR 356 HEC HMS lab: This lab is on using a hydrologic model to design a system and predict flows. The model is currently used by US army corps of engineers.

This assignment addresses the following CE program outcome(s) and performance indicator(s):

CE OUTCOME 15:
Be able to use the principles, techniques, skills and modern engineering tools necessary for successful engineering practice and design in their chosen fields associated with civil and environmental engineering.

Comments: This was a great lab, and lab reports improved.

Suggestions from 2010-2011: N/A

Actions taken: N/A

Suggestions from 2013-2014: Always search for better study site.

EGR 356L - Hydrology Lab

CALIFORNIA BAPTIST UNIVERSITY, spring 2014

Introduction to HEC-HMS: HEC-HMS Basin Model Development

This week's lab will focus on defining and setting up our Basin Model and gathering the various data and parameters we need to input into this section of the HEC-HMS model.

Development of the HEC-HMS model for as watershed requires several steps as outlined above. In short, these include:

1) Basin Model Development
2) Meteorological Model Development
3) Running simulations (with our given data and values)
4) Refining or tuning the model simulations against observed data ('calibration')

BASIN MODEL

The physical representation of the watershed or basin is configured in the Basin Model. Hydrologic elements are connected in a network to simulate runoff processes. The available elements are: subbasin, reach, junction, reservoir, diversion, source and sink. Computation proceeds from upstream elements in a downstream direction. We will have 2 subbasins in our watershed (as in our delineation), 1 junction and 1 reach. You can also add a reservoir to capture runoff.

Subbasin Loss:

As assortment of methods are available to simulation infiltration losses (to account for losses from precipitation). These methods apply only to pervious surfaces. Options for event (single rainfall-runoff storm) include:

- Deficit and constant
- Green and Ampt
- Gridded SCS curve number
- Gridded soil moisture accounting
- Initial and constant
- **SCS curve number**
- Soil moisture accounting

Runoff Transformation:

Once we have decided on the amount of excess precipitation (from our loss model), we need to turn this into surface runoff. The various methods available within HEC-HMS include:

- Clark unit hydrograph
- Synder unit hydrograph
- **SCS unit hydrograph**
- User-specified unit hydrograph
- Kinematic wave model
- ModClark

Open Channel Routing:

A variety of open channel routing methods are available for simulating flow in open channels (or reaches). Thses are:

- Kinematic wave
- Lag
- Modified Puls
- Muskingum
- Muskingum-Cunge 8 point section
- **Muskingum-Cunge standard section**

For each of the procedures above, we will use the designated methods for defining the physical characteristics of our basin. We will need to use our previous and future labs to define the parameters or values that go into each of theses methods that we will use. Your lab this week consists of determining setting up your model "structure". The goal is to finalize your Basin Model within the HEC-HMS system before spring break.

You can download and view the HEC-HMS User's Manual from our Blackboard to help you with setting up your Basin Model. Do NOT print the manual- it is an extremely large file!!!!!

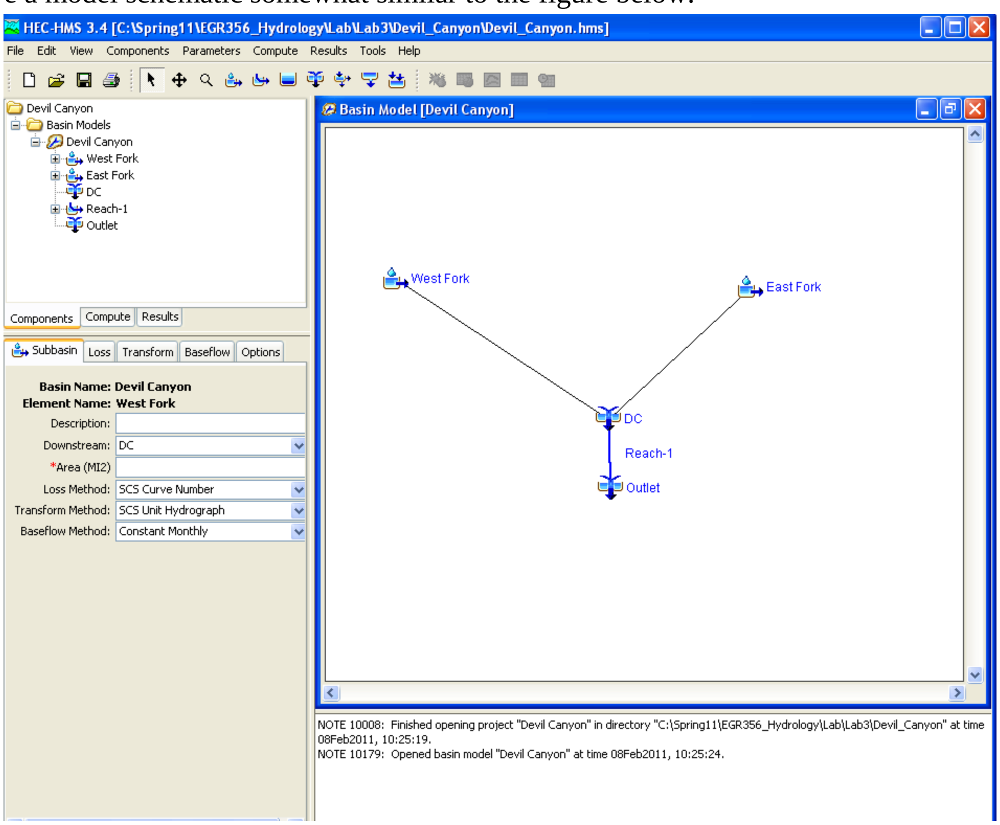
1) Open the HEC-HMS model system on computer. Under File- open New Project. Give your project a name (i.e. Devil Canyon). Decide where you want to save your model setup. Be sure to select ENGLISH customary units.

2) Go to Components – Basin Model Manager – create a "NEW" model- under your Devil Canyon Project. You can give your basin a name here also (Devil Canyon).

3) Now double click on your Basin Model Folder to see the Devil Canyon Basin Model. Double click on the Devil Canyon Basin Model. This should open a gridded screen (working area) with various tools to design your watershed in the HEC-HMS system. You will need to bring each of the various components into the main screen for your model. Move the cursor (mouse) over the various icons in the display.

4) You will need two sub-basins, as well as a junction and one reach to setup your entire system. Left click on the component you need, then move your cursor to the grid and left click again to place it on the grid. Select create to insert the component on the grid. You can also name each of the components.

5) You will also need to connect each of the subbasins to a junction, junction to a reach and reaches in some order to the outlet. Make sure you have the arrow cursor before proceeding. Connections are then made by left clicking on the component and designation where you want the downstream connection – then right click on the downstream component to connect. Proceed till all the components are connected. There may be several ways to set up the watershed structure, but you should have a model schematic somewhat similar to the figure below.



SUBBASIN PARAMETER:

6) Now for each **subbasin**, you need to select methods for Loss Rate, Transform and Baseflow. Select the **SCS method for Loss Rate**, the **SCS Unit Hydrograph method for Transform** and the **Constant Monthly for Baseflow Estimation**. For each subbasin, you will also need to enter the appropriate area of the drainage.

7) We will use the **SCS method** to simulate infiltration losses. You will need to define the parameters in each subbasin. These parameters will come mostly from your previous and future labs.

SCS Loss Method

Parameters	**Subbasin 1**	**Subbasin 2**
Area (sq. miles)		
Initial Loss (inches)	0.5	0.5
SCS Curve # (dimentionless)		
% Impervious **	1	1

** For our impervious %, we start with an assumption of 1% impervious for any developed area or exposed bedrocks. You will need to estimate the amount of this area in your subbasin later during the calibration process.

To enter the data for the Loss Method- double click on SCS Curve Number link under each subbasin. Initial Abstractions, CN and % impervious entry areas should pop up.

8) For the **SCS Unit Hydrograph method for Transform** in each subbasin, you will need to calculate the Lag Time parameter basin on our previous length and slope estimations.

SCS Unit Hydrograph

Parameters	**Subbasin 1**	**Subbasin 2**
SCS Lag Time (Minutes)		

This lag time is used as an adjustment factor for a synthetic SCS unit hydrograph within HEC-HMS. The depth of excess precipitation (runoff) will be converted to cfs based on this unit hydrograph – adjusted for the lag time of our basin. We will go over this method in class.

Calculations for the various SCS parameters:

Time of concentration

$T_c = 0.00526\ L^{0.8}(1000/CN\text{-}9)^{0.7}\ S^{-0.5}$

Lag Time:

$T_l = T_c/1.67$

Where:

T_l = Lag time in minutes

T_c=time of concentration in minutes

L= watershed length in ft

S = watershed slope (ft/ft)

CN = Curve number for each subbasin

9) We will use Constant monthly for baseflow estimation in each subbasin. For this method, we need to estimate a consistent baseflow value for each month we will run simulations. From the flow records for Devil Canyon, select the low flow values in between precipitation events to estimate a base flow volume for the months of November, December, January, February, March, and April (we will only analyze storms during the rainy season). Since the baseflow at the gage is an aggregate of two subbasins, you will need to estimate a reasonable value for each subbasin. One way to do this would be based on area contribution (take the total baseflow and multiply bye the % area of total for each subbasin).

Parameters	**Total Baseflow Value (cfs)**	**Subbasin 1 Baseflow (cfs)**	**Subbasin 2 Baseflow (cfs)**
November			
December			
January			
February			
March			
April			

<u>Reach/Routing:</u>

10) For the reaches connection the junction to the outlet, select the Muskingum-Cunge Method. We will make estimates of these channel physics to put into the model and then adjust (if needed) when we calibrate our model to some flow events that have occurred in the canyon.

Parameters	**Reach1**
Shape	PRISM
Length (ft)	
Energy Slope (ft/ft) *	
Bottom Width (ft) **	
Side Slope (ft/ft) **	
Manning's n **	

*Use channel slope as a first approximation

**Use an approximate value – this may change as we progress.

<u>Basin Model Correction/addition</u>

Basin Model → Reach -1 → Use Manning n: 0.05; Bottom Width of 20ft and side slope of 0.01

Basin model → Devil Canyon → East Fork → select “Options” tab → under observed flow, select the flow from DC.

Basin model → Devil Canyon → West Fork → select “Options” tab → under observed flow, select the flow from DC.

Basin model → Devil Canyon → Junction→ select “Options” tab → under observed flow, select the flow from DC.

Basin model → Devil Canyon → Rea ch-1→ select “Options” tab → under observed flow, select the flow from DC.

**If you have an “Outlet” do the same for the “Outlet”, if you do not have an “Outlet”, you are done.

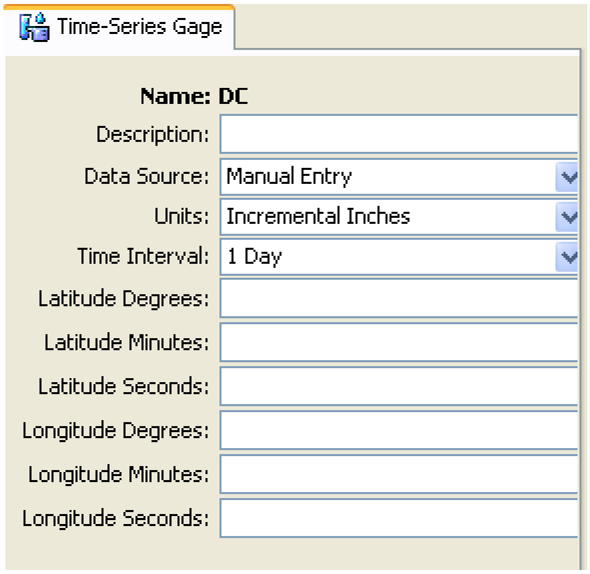
PART 2:

After all the values are entered into the Basin Models, we need to add Time-Series data.

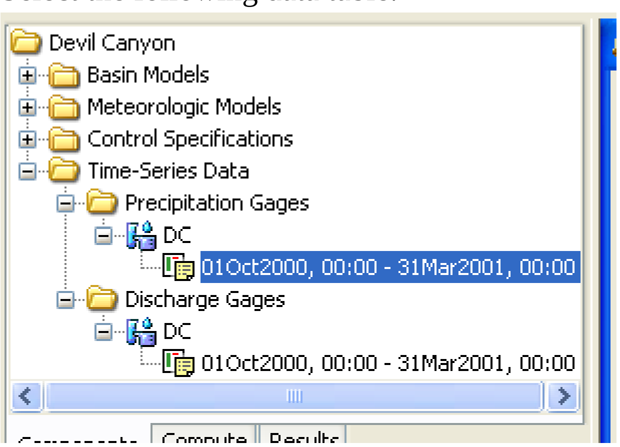
To do this, go to:

Components→ Time Series Data Manager → Data type, select "Precipitation Gages" from the drop down menu →New→name it (i.e. DC).

Double click on the left hand-side panel→double click on the gage that you created. And enter the following information:



Select the following data table:



Under the Time Window Tab:

The start date should be 01Oct1997

End Date should be 30Sep2006

Start and End Time is 00:00

Under the "Table" tab, copy and paste all your precipitation data from Lab 1.

Create another Time-Series data for discharge:

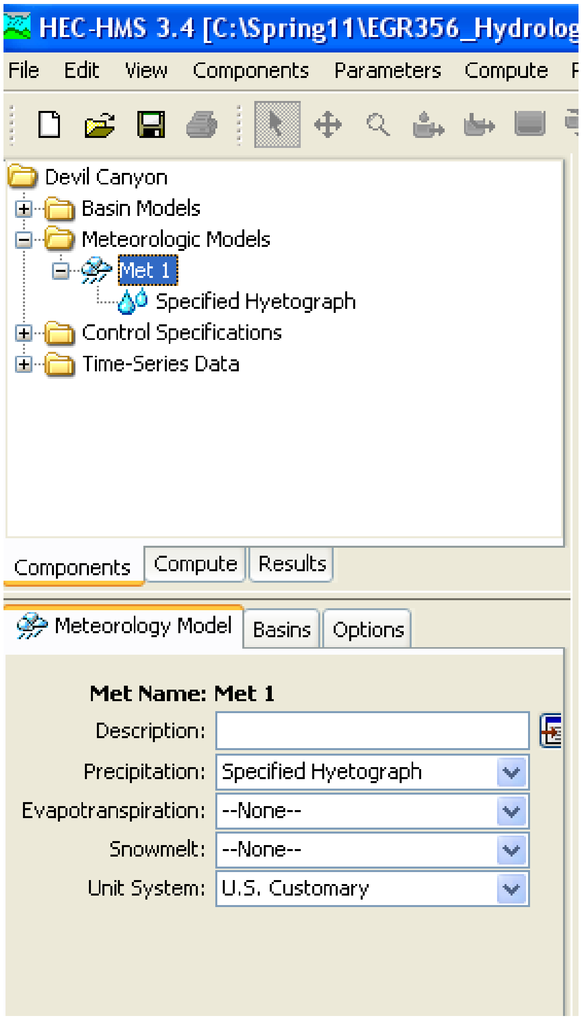
Components → Time Series Data Manager→ for Data Type, select "Discharge gages" from the drop down menu → New→ name it (i.e. DC)

Follow the same steps for Discharge data.

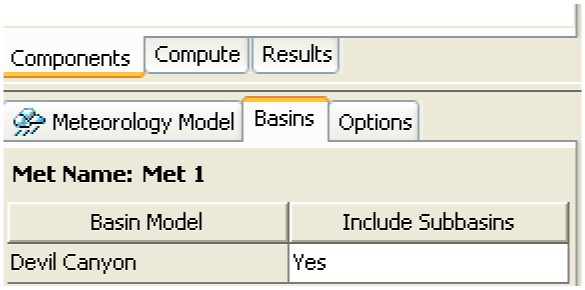
PART 3: Creating Meteorologic Models

Go to Components → Select "Meteorologic Model Manager" → New → name it.

Double click on the Meteorologic Models on left-hand side panel and click on the component you just created (and named) and enter the following (shown below):



Under "Basin" tab

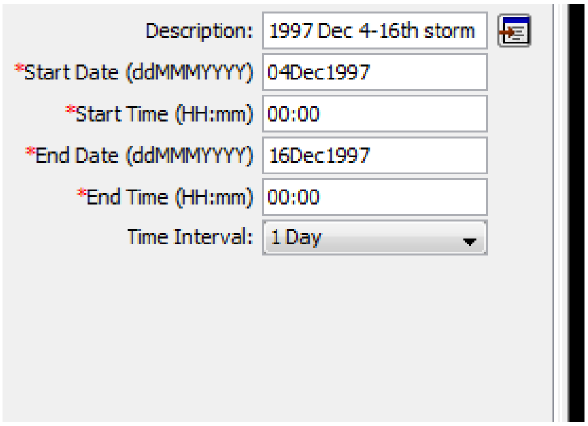


Lastly on Option's tab, input "No" for both

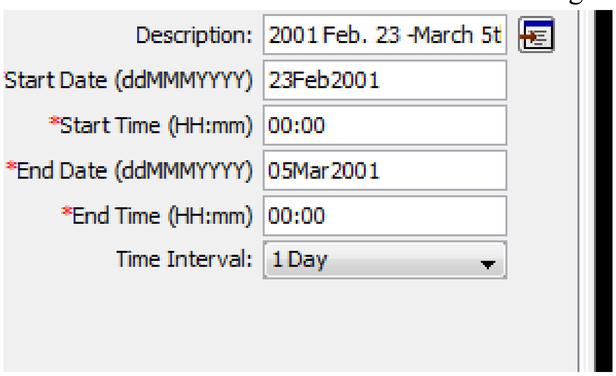
Part 4: Control Specifications Manager

Go to "Components" and select "Control Specifications Manager"

Click "New" and create Control 1 with following storm event



Go to “Components” and select “Control Specifications Manager”
Click “New” and create Control 2 with following storm event



<u>Part 5: Running the HEC-HMS Model</u>

Once all your data and storm dates are entered into the model, you are ready to run simulations to get your baseline runs and calibrate your model.
Select “Compute”
Select “Create a Simulation Run”
Name this Run 1
Click “Next”
Highlight your basin model (e.g. “Devil Canyon”) and click “Next”
Highlight your Met data (e.g. Met 1) and click “Next”
Highlight your Control 1 and click “Finish”

Select “Compute”
Select “Create a Simulation Run”
Name this Run 2
Click “Next”
Highlight your basin model (e.g. “Devil Canyon”) and click “Next”
Highlight your Met data (e.g. Met 1) and click “Next”
Highlight your Control 2 and click “Finish”
Select “Compute”
Select “Select Run” select the run you like to compute.
Click on  icon to run.

The model should now run.

If you see warnings-the model ran OK. The warnings are typically associated with the time of concentration or lag time (if our computed time of concentration (Tc) is less than our model time interval or the initial abstractions are unrealistic).
If you see errors the model did NOT run and you need to troubleshoot why your model is not running. Check all your start and stop times, and your data entry.

Part 6: Viewing Results

To view your results, RIGHT click on the OUTLECT JUCTION and go to VIEW RESULTS → graph or Summary or Time-series Table.

You should see the model simulations for this outlet and the observed flow for comparison to your simulation result graph. Make sure you understand which is the outlet flow. This is the flow that needs to match the "observed" streamflow.

Be sure to save your TIME-SERIES for all initial "baseline" runs and final "calibration" runs for each storm.

Also be sure to SCREEN CAPTURE THE BASELINE SIMULATIONS you have run before you start your calibrations.

Now you can view your results against the observed flow and re-run the model as needed, varying parameter to try and match the observed flow (CALIBRATE YOUR MODEL!)

Part 7: Calibrations

Boundaries or constraints for parameter values are a "realistic" range of possible parameter values that are determined by the user. Boundaries are set to insure that unreasonable parameter values are not used when searching for "best" values. The HEC-HMS model documentation has a table with realistic values for parameters (HEC HMS User's Manual, page 133).

The optimization procedure is an iterative process. A set of parameters is selected by the user, the model is run, a hydrograph is produced, and the resulting simulation is compared to the observed time series. The process is repeated until an acceptable fit is obtained (correct volume, timing, shape, etc).

We have several parameters we can adjust to correct for errors in our simulations. The ones we will primarily focus our calibration on include:

		Constraints
Loss Function Parameters:	SCS Curve Number	40-100
	% Impervious	0-100%
	Initial Loss or Abstraction	0-20 inches
Runoff Transformation Parameters (timing):	SCS Lag Time	0-30000 minutes
Routing Parameters (Reach 1):	Energy Slope	0.01-1(?)
	Bottom Width	0-50 feet
	Side Slope	0.01-10
	Manning's n	0-1.0

During your calibrations – You should try to capture both the VOLUME of the runoff and the TIMING (or peak) of the runoff (and the shape of the hydrograph).

For volume – The SUMMARY RESULTS table shows the observed runoff (inches) and the simulated runoff (inches) – you should try to match these two values as close as possible to get the total storm runoff to be as accurate as possible (< 0.2 inches between these two values preferred, however if you cannot get this close reason what might be the issue, for example, watershed is too small, storm durations are too long to calibrate too, time intervals are large and etc,.).

For Timing – The GRAPH of observed vs. simulated will show how well your simulations match the peak flow (your peak should be at the same time period as the observed peak).

The parameters that we will change to try and match these two variables are **CN, %Impervious and Initial Loss.** You can also try changing other parameters, but other parameters are less 'sensitive (don't affect the models simulations as strongly)'. You may need different parameters values for each of the storms. **BE SURE you keep your parameter values reasonable.**

Record all final parameter values and save all initial and final simulation data (graphs and tables) to turn in for your final report (FOR ALL STORMS).

HEC HMS – Devil Canyon Lab Report

Due April 23rd, 2014 (Email the lab write-up to hjung@calbaptist.edu)

(/60 points)

Introduction (5 pts)

- Talk about what hydrologic models do and what model you are using (HEC HMS).
- Talk about why it is important

Study Site (10 pts)

- Describe your watershed (more details are found on my paper)
    - Location (state, county…)
    - Area (in sq mi. is okay)
    - Weather pattern / discharge pattern
        - Include your precipitation graph from lab 1
        - Include your hydrograph from lab 1
        - label the axis, number the figures and explain
    - Land Use
        - Include your land use classification (lab 2)
        - briefly summarize your table, top two on the list, in your writing

Methods (12pts)

- Include HEC HMS download site
- Briefly describe the model (consists of basin model, time series model, meteorological model, control specification and run manager)
- List your inputs (precipitation, observed discharge, and parameters)
    - Include where and how you obtained the data: USGS.gov (discharge) and San Bernardino Flood Control District (precipitation), and NOAA (land use).
- How did you obtain CN, Length of watershed, slope, and etc.

Results (10 pts)

- Screen captures of your results (before and after the calibration)
- Summary Tables of your results (before and after the calibration)
- Table of parameters (before and after the calibration)

Discussion (15 pts)

- Reason about your parameters: Are your parameters physically reasonable for your watershed? Explain why.

Conclusion (7 pts)

- Is your model accurate and/or precise?
- What would you improve next time?

	Out of 60
1	60.0
2	60.0
3	60.0
4	60.0
5	60.0
6	58.0
7	58.0
8	57.0
9	57.0
10	57.0
11	56.0
12	55.0
13	54.0
14	53.0
15	51.3
16	51.0
17	50.0
18	49.0
19	47.5
20	42.6
21	40.0
22	35.5
Average	**53.3**
MAX	60.0
MIN	35.5

Grade Analysis

Total points: 60
Number of students: 22
Average grade: 53.3(B)
Average%: 88.8%
Maximum grade: 60
Median grade: 53
Minimum grade: 35.3
70% target grade (C or better): 45
Number of students above or equal to the target: 19
Percentage of students above or equal to the target: 86.3%
Goal of percentage of students above or equal to target: 80% (set by the instructor)
Is the goal met? Yes

<u>Hydrology Lab Report</u>

California Baptist University

College of Engineering

EGR 356 Hydrology- Spring 2014

Lab Report: HEC-HMS

Submitted to: Dr. Jung

By

Christian Morris

Date: April 23, 2014

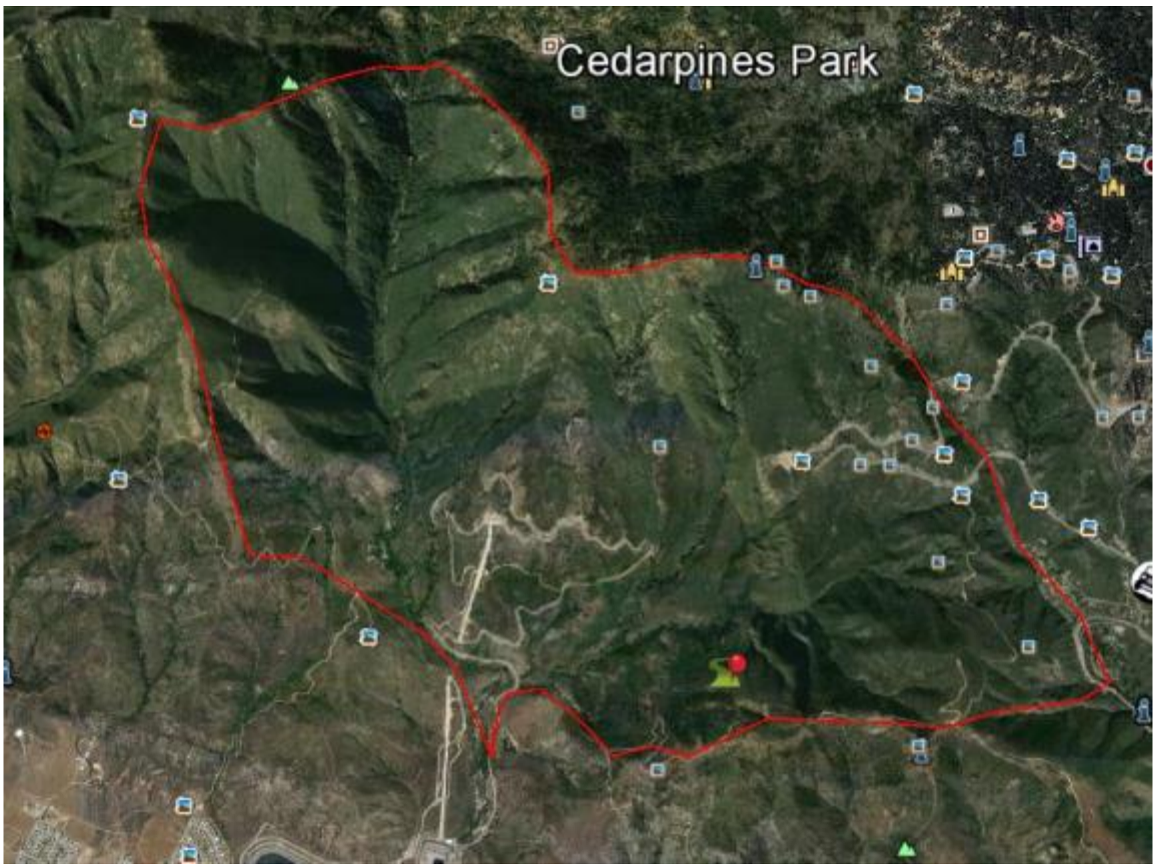
Introduction

This lab experiment involved creating a hydrologic model for Devil Canyon. Devil Canyon is a watershed located in San Bernardino, California. A hydrologic model is meant to simulate the hydrologic cycles of a watershed system. The hydrologic cycle is the process in which water vapor from the atmosphere falls as precipitation on the earth and returns to the atmosphere through evaporation and transpiration (Hydrologic Cycle). The hydrologic cycle consists of runoff, evaporation, precipitation, infiltration, and transpiration. The HEC-HMS modeling system was used for this particular experiment. It contains a database, data entry utilities, computation engine, and results reporting tools (HEC-HMS). "HEC-HMS modeling systems include analysis procedures for infiltration, unit hydrographs, and hydrologic routing" (HEC-HMS). Infiltration is when water seeps into the soil (Mays, 266). A hydrograph is the relationship between flow rate and time (Mays, 284). "A unit hydrograph is the direct runoff hydrograph resulting from 1 in. (or 1 cm in SI units) of excess rainfall generated uniformly over a drainage area at a constant rate for an effective duration" (Mays, 291). Hydrologic routing determines the time and magnitude of flow on a watercourse or hydrograph at points upstream using lumped system methods (Mays, 331). Knowing the flow rate and other hydrologic processes in a watershed are very important. Hydrologic modeling reveals these processes within a watershed. Modeling can be used to help control flood damage and aid in urban planning (HEC-HMS). Hydrologic modeling helps engineers design structures that will save people's lives and property from flooding. This modeling may also aid an engineer in deciding whether it is safe to build houses or other buildings by a certain area.

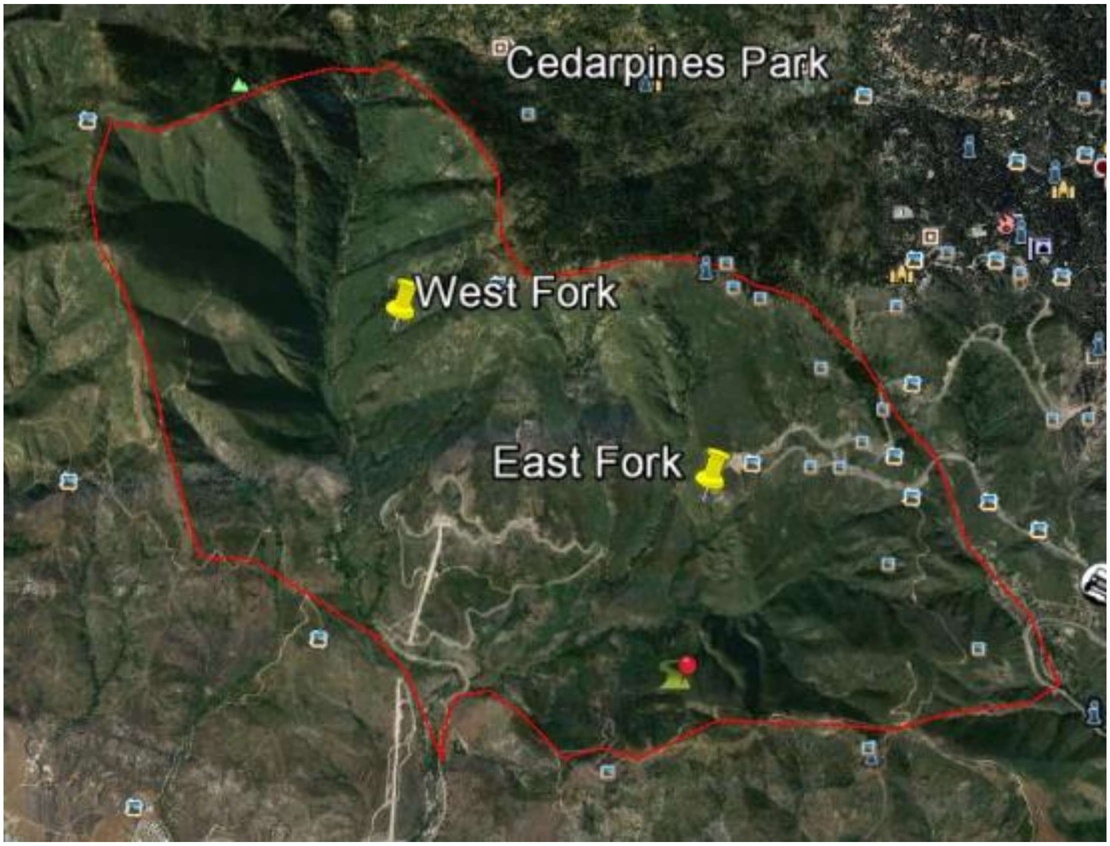
Study Site

The site used for this hydrologic modeling is called Devil Canyon located in San Bernardino, California (San Bernardino County). The watershed has an area of about 14 km^2 and receives about 703 mm of rainfall every year (Jung). The weather in San Bernardino is fairly typical to the rest of the region. The city of San Bernardino experiences chilly winters that rarely results in snow. However, the San Bernardino Mountains do receive snow in winter. Summers in San Bernardino are dry and hot. During these dry hot summers, wildfires become a cause for concern. In 2003, 97% of Devil Canyon was burned by wildfires (Jung). This caused infiltration in the area to decrease and overland flow to increase (Jung). Another feature of Devil Canyon involves the San Andreas Fault. Devil Canyon's southern section is divided by the fault. This fault has caused the bedrock in that area to become weathered and fractured (Jung). The two major tributaries of Devil Canyon are the West and East Fork. The West Fork has a length of about 5872.97 meters and encompasses a large portion of the watershed. It also has exposed bedrock in some areas (Jung). The East Fork has a length of about 3861.22 meters.

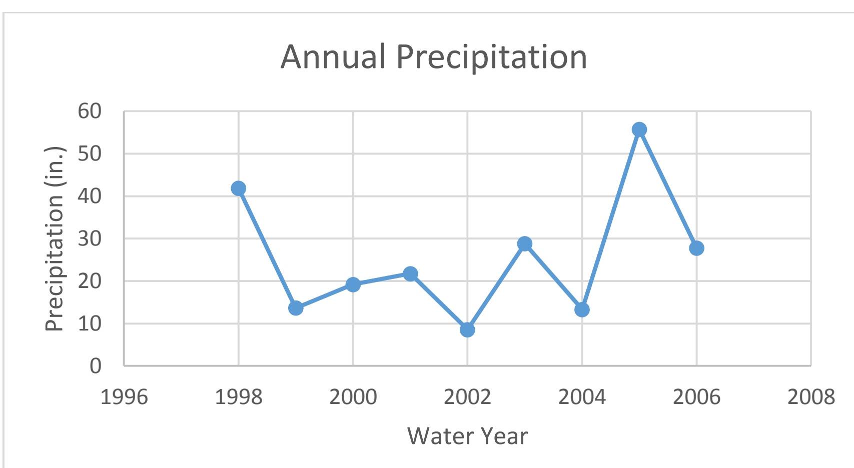
The picture below is a rough outline of the Devil Canyon Watershed. The following picture is a rough outline of the watershed with the West Fork and East Fork labeled.



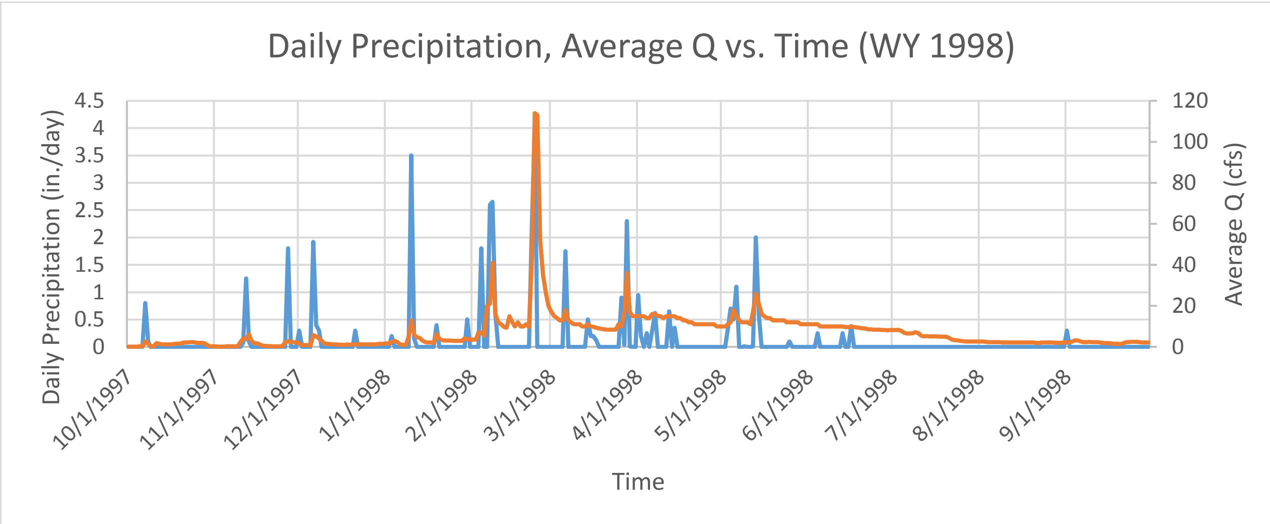
The picture below is a rough outline of the Devil Canyon Watershed. West Fork and East Fork are labeled.

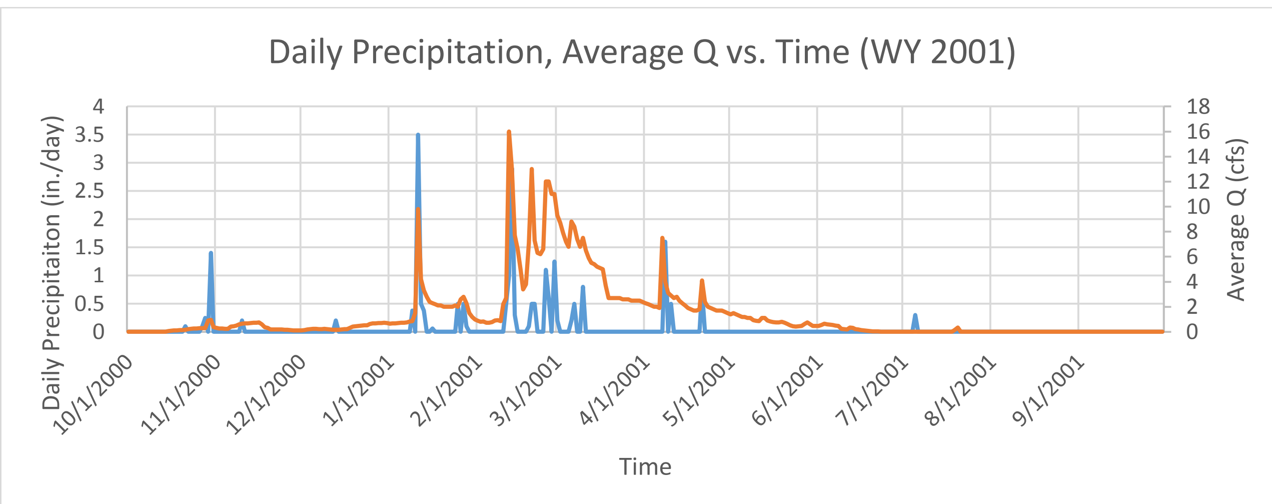


The graph below is the precipitation that Devil Canyon received every water year from 1998 until 2006. A water year begins on October 1st of the previous year and ends on September 30th of the current year.



The plots below are the hydrographs of Devil Canyon in 1998 and 2001. This measures the amount of runoff the watershed experienced during the water years of 1998 and 2001.





There are many different types of land cover in Devil Canyon, but there are two major types. The first type of land cover is chaparral and the second type is mixed conifer and woodlands. Conifer and woodlands are located mostly at the higher elevations (Jung).

The following table displays the West and East Fork's attributes.

	West Fork	East Fork
Length (m)	5872.97	3861.22
Elevation High (m)	1550	1100
Elevation Low (m)	650	650
Slope	0.153	0.117

These next tables display how much area each land cover encompasses and what percent of the total watershed that it covers. The land cover was found using the National Oceanic and Atmospheric Administration website which can be found using the following link: www.csc.noaa.gov/landcover .

	West Fork	
Land cover Type	Area (m^2)	% Area
Developed, Medium Intensity	3124.415646	0.02170519
Developed, Low Intensity	66563.39909	0.46241317
Developed, Open Space	75759.36356	0.52629715
Cultivated Crops	4442.28723	0.03086038
Pasture/ Hay	756.4703658	0.00525517
Grassland/ Herbaceous	156162.8874	1.08485709
Deciduous Forest	9073.862383	0.06303574
Evergreen Forest	2206813.555	15.3306421
Mixed Forest	403757.0988	2.80488379
Scrub/ Shrub	4483202.494	31.1446214
Palustrine Forested Wetland	1393.728513	0.00968217
Palustrine Scrub/ Shrub Wetland	378.3450774	0.00262835
Barren Land	6434.222333	0.04469828
Sum=	**14394788.85**	**51.53158**

Land cover Type	East Fork Area (m^2)	% Area
Developed, Medium Intensity	3001.889543	0.020854
Developed, Low Intensity	63953.06971	0.44427932
Developed, Open Space	72788.40813	0.50565805
Cultivated Crops	4268.079888	0.02965017
Pasture/ Hay	726.8048612	0.00504908
Grassland/ Herbaceous	76519.81485	0.53157997
Deciduous Forest	8718.024645	0.06056375
Evergreen Forest	2120271.847	14.7294404
Mixed Forest	387923.4871	2.69488835
Scrub/ Shrub	4307390.631	29.9232637
Palustrine Forested Wetland	1339.072492	0.00930248
Palustrine Scrub/ Shrub Wetland	363.5080156	0.00252528
Barren Land	6181.899888	0.0429454
Sum=	**14394788.85**	**49**

Methods

One piece of equipment used for this experiment was the HEC-HMS hydrologic modeling system. This system can be downloaded at the following website: http://www.hec.usace.army.mil/software/hec-hms/downloads.aspx . HEC-HMS 3.5 is the latest model and was used in this experiment. The second piece of equipment used was ARC GIS. This system was used to obtain Devil Canyon's physical characteristics such as length and slope.

Development of HEC-HMS Model Steps

1. Basin Model Development
2. Meteorological Model Development
3. Running simulations
4. Refining or tuning model against observed data (calibration)

The HEC-HMS model consists of several different aspects. Developing the Basin Model is the first aspect. This is where a physical representation of the watershed or basin is configured. The runoff process is simulated by connecting elements such as: sub-basin, reach, junction, reservoir, diversion, source, and sink. Devil Canyon has two sub-basins, which are the West and East Fork, one junction, and one reach. Accounting for sub-basin loss is another step in developing the Basin Model. The SCS Curve Number was chosen in order to account for the losses from precipitation. This method applies only to pervious surfaces. Now that the excess precipitation is established through the SCS Curve Number, the excess must be turned into runoff. This was done by using an SCS Unit Hydrograph. To simulate the water flow through open channels such as rivers and streams, an open channel routing method must be chosen. The Muskingum-Cunge standard section was used for this experiment.

The initial parameters for the sub-basin loss were entered into the model first. Initial abstraction, curve number, and percent impervious needed to be input into the model. The following table shows the initial parameters for both sub-basins.

Parameters	West Fork	East Fork
Initial Abstraction (in.)	0.5	0.5
SCS Curve Number	50.1	50.1
% Impervious	1	1

The curve number was calculated using the type of land cover. The West Fork land cover was used to determine the curve number for the entire watershed because it makes up 51% of the Devil Canyon basin. The two major land cover types in the West Fork were evergreen forest and scrub/ shrub, chaparral can be placed in this category. Assuming soil B, the curve numbers obtained using these two land covers were 65 and 50, respectively. Next, the percent of area that corresponded to the land covers was divided by 100 and multiplied by their respective curve numbers. Finally, the two values calculated were added together. This revealed a curve number of 50.1.

$$CN(Evergreen) = \left(\% \frac{Area}{100}\right) \times estimated\ CN(65) = 19.539$$

$$CN(Scrub/Shrub) = \left(\% \frac{Area}{100}\right) \times estimated\ CN(50) = 30.534$$

$$Final\ CN = CN(Evergreen) + CN(Scrub) = 50.1$$

In order for HEC-HMS to develop the SCS Unit Hydrograph the lag time was calculated. This was done by using the following equations.

Time of Concentration

$$T_c = 0.00526L^{0.8}(\frac{1000}{CN} - 9)^{0.7}S^{-0.5}$$

Lag Time

$$T_1 = T_c/1.67$$

T_1= Lag time in minutes

T_c = Time of concentration in minutes

L= Watershed length in ft

S= Watershed slope (ft/ft)

CN= Curve Number for each sub-basin= 50.1

	West Fork	East Fork
Lag Time (minutes)	115.34	94.31

Two lag time calculations were done. One calculation for the West Fork and one for the East Fork were made. The length of the watershed was found using ARC GIS. A line was drawn from the outlet of the basin to the end of the watershed. This was done for both the West and East Fork. Devil Canyon's slope for the West and East Fork were found using the difference in the highest and lowest elevations for each fork. The difference was then divided by the length of the fork. The equation is as follows: $slope = (high - low)/length$.

The next step in the modeling process involved setting a baseflow. In this experiment, a constant baseflow for each sub-basin was used. These values were obtained through the discharge and precipitation values from 1998 to 2006. Discharge values were found using the U.S. Geological Survey (http://USGS.gov). Precipitation values were found using the San Bernardino Flood Control District website (http://www.sbcounty.gov/dpw/floodcontrol/default.asp).

The Muskingum-Cunge Method was selected for the reach/routing connection from the junction to the outlet. Estimating was done on the characteristics of the channel. The following are the parameters entered.

Parameters	Reach1
Shape	Trapezoid
Length (ft)	1500
Energy Slope (ft/ft)	0.153
Bottom width (ft)	20
Side Slope (ft/ft)	0.01
Manning's n	0.05

Next, the Time-Series data was entered. The simulation was set to begin on October 1, 1997 and set to end on September 30, 2006. A precipitation data table was filled using the values from the San Bernardino County Flood Control District’s website. Another Time-Series was created for discharge. Discharge values were found using the U.S. Geological Survey website.

The Meteorological Model was established and called Met 1. Under precipitation, specified hyetograph was selected. Both sub-basins were to be included in the calculations as well.

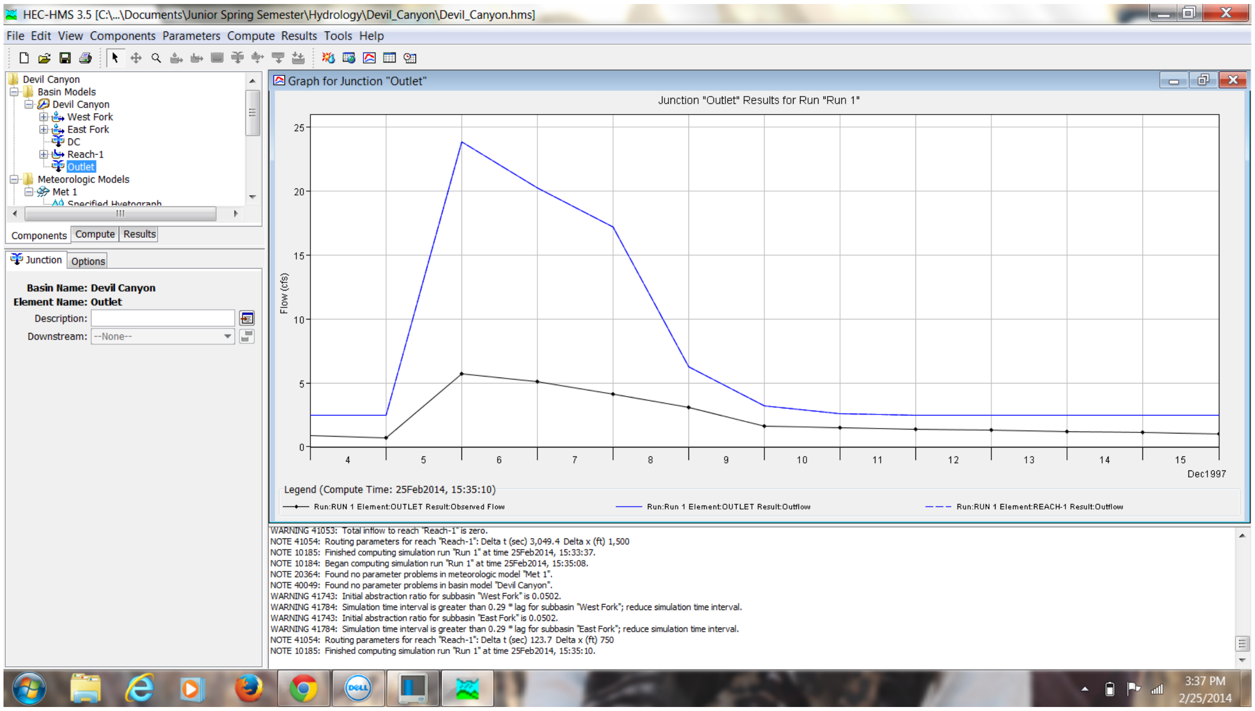
A Control Specifications Manager was created and called Control 1. This allowed a storm event to be inserted into the simulation. The first storm event was set to take place on December 4, 1997 and end on December 16, 1997. Another specifications manager was created and called Control 2. This storm’s beginning and end date was February 23, 2001 and March 5, 2001.

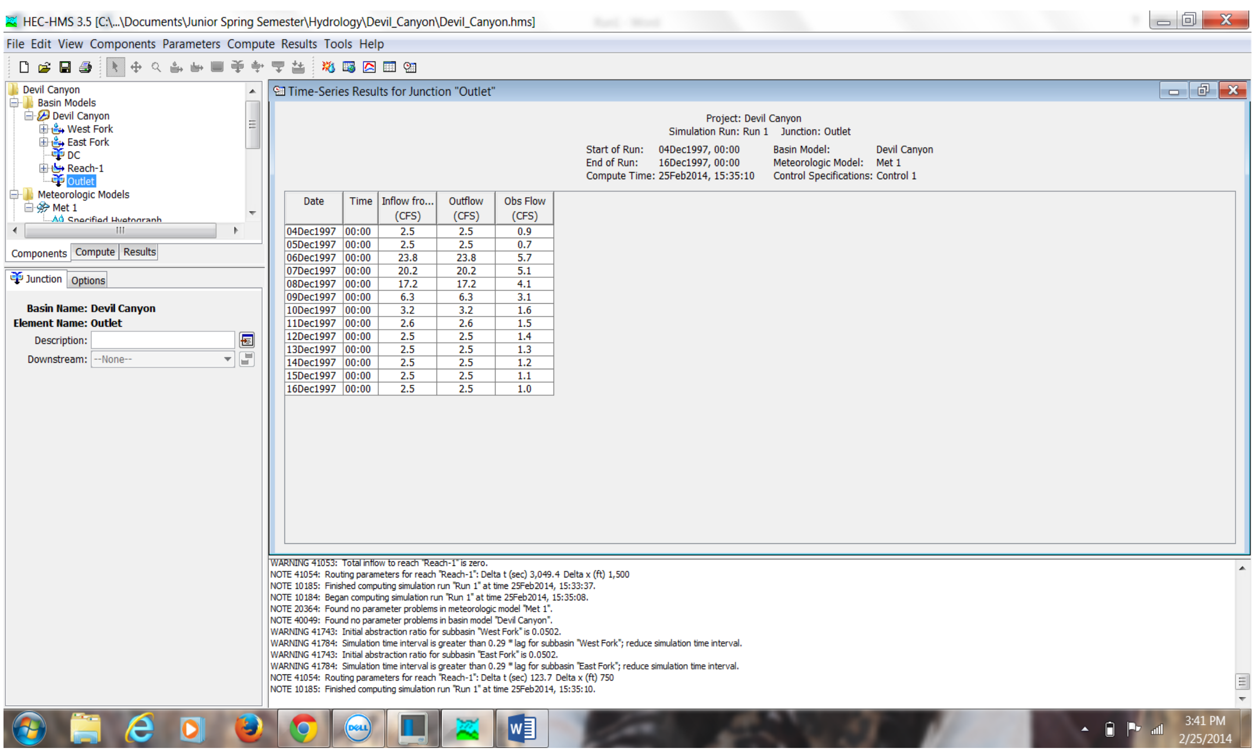
Finally, the simulation was ready to be run. Two runs were created for the simulation. Run 1 was to simulate a wet season and Run 2 simulated a dry season. The results were viewed by right clicking on the outlet junction and selecting “view results”. Results could be displayed through a graph, summary table, or Time-Series table. Now that the results could be seen against the actual observed flow of the basin, the calibration process could begin.

Results

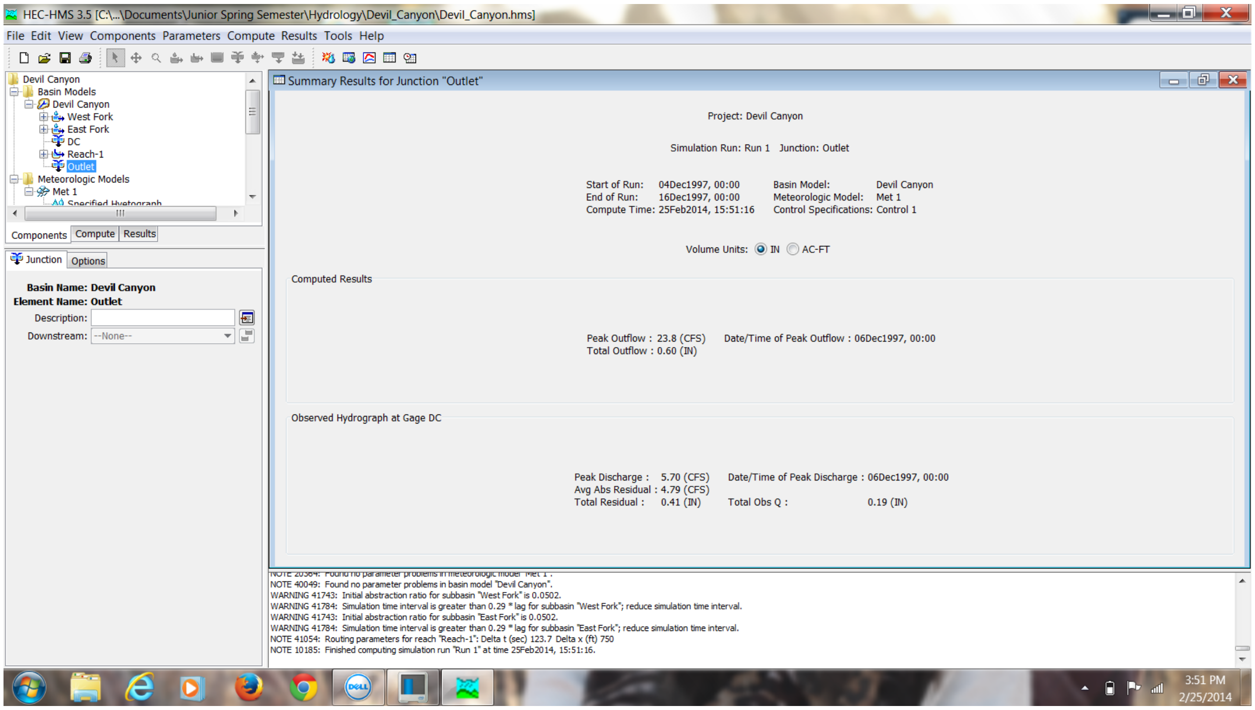
<u>Before Calibration Run 1</u>

Run 1: Wet Season





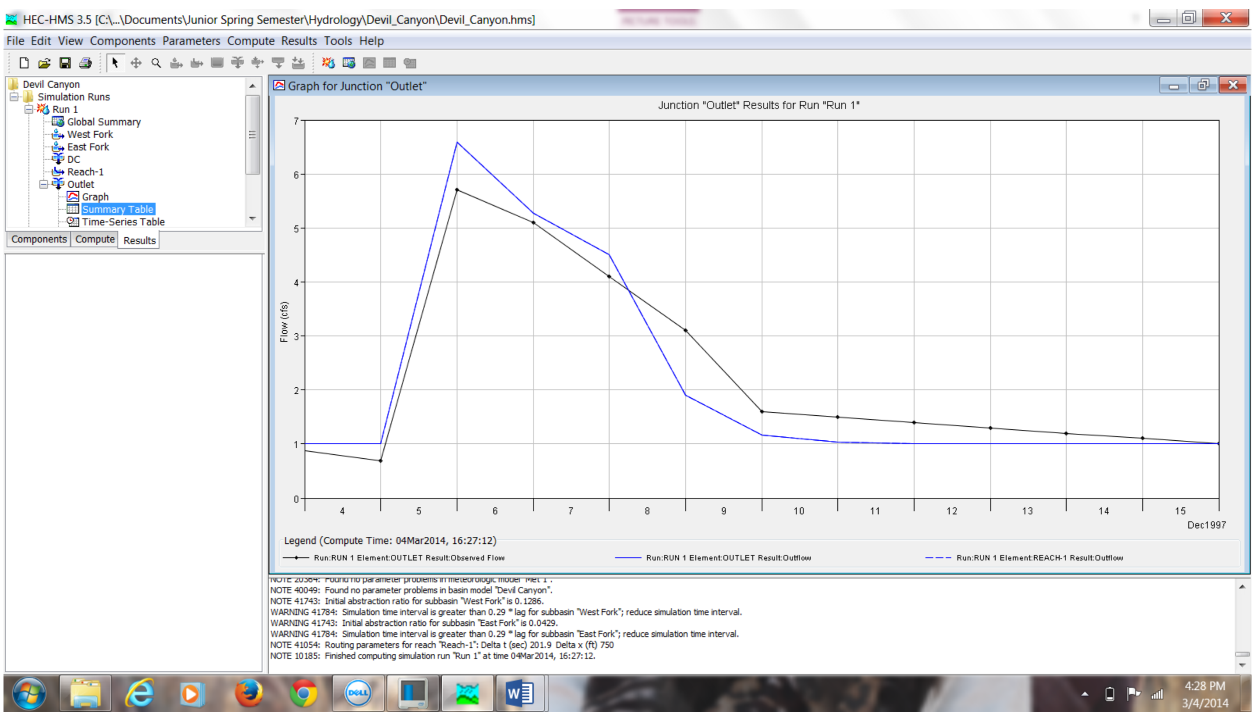
Date	Time	Inflow fro... (CFS)	Outflow (CFS)	Obs Flow (CFS)
04Dec1997	00:00	2.5	2.5	0.9
05Dec1997	00:00	2.5	2.5	0.7
06Dec1997	00:00	23.8	23.8	5.7
07Dec1997	00:00	20.2	20.2	5.1
08Dec1997	00:00	17.2	17.2	4.1
09Dec1997	00:00	6.3	6.3	3.1
10Dec1997	00:00	3.2	3.2	1.6
11Dec1997	00:00	2.6	2.6	1.5
12Dec1997	00:00	2.5	2.5	1.4
13Dec1997	00:00	2.5	2.5	1.3
14Dec1997	00:00	2.5	2.5	1.2
15Dec1997	00:00	2.5	2.5	1.1
16Dec1997	00:00	2.5	2.5	1.0

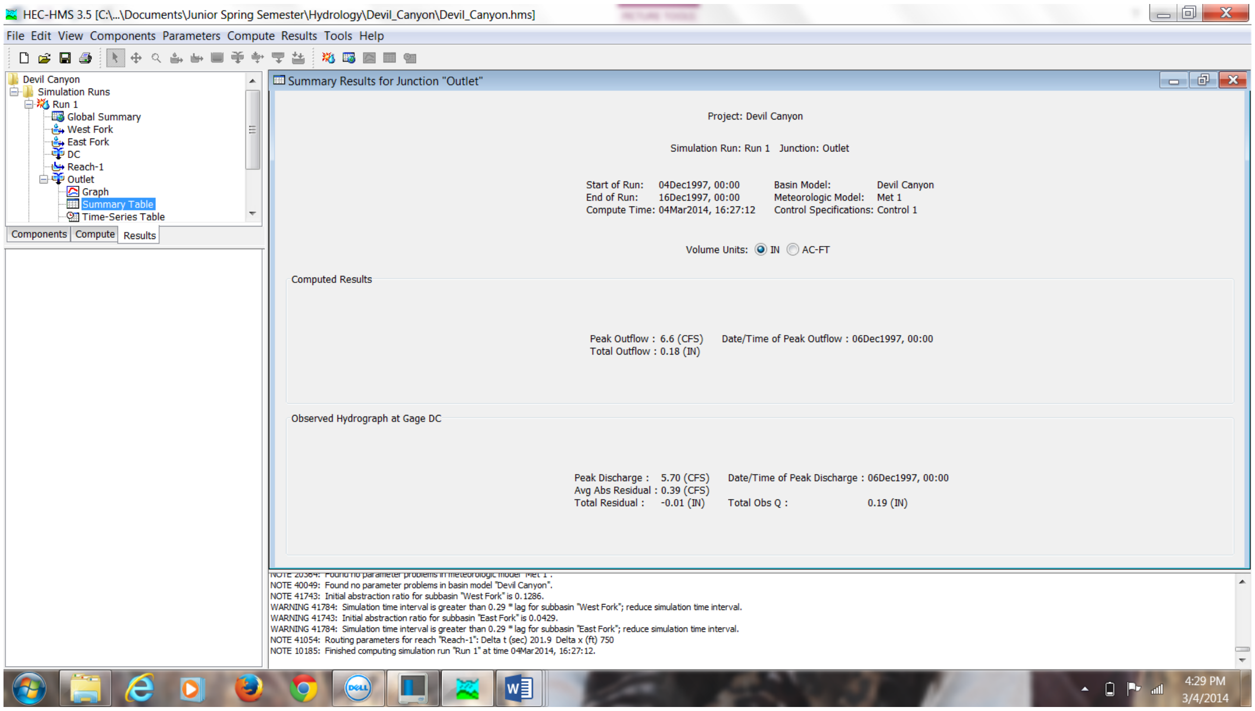


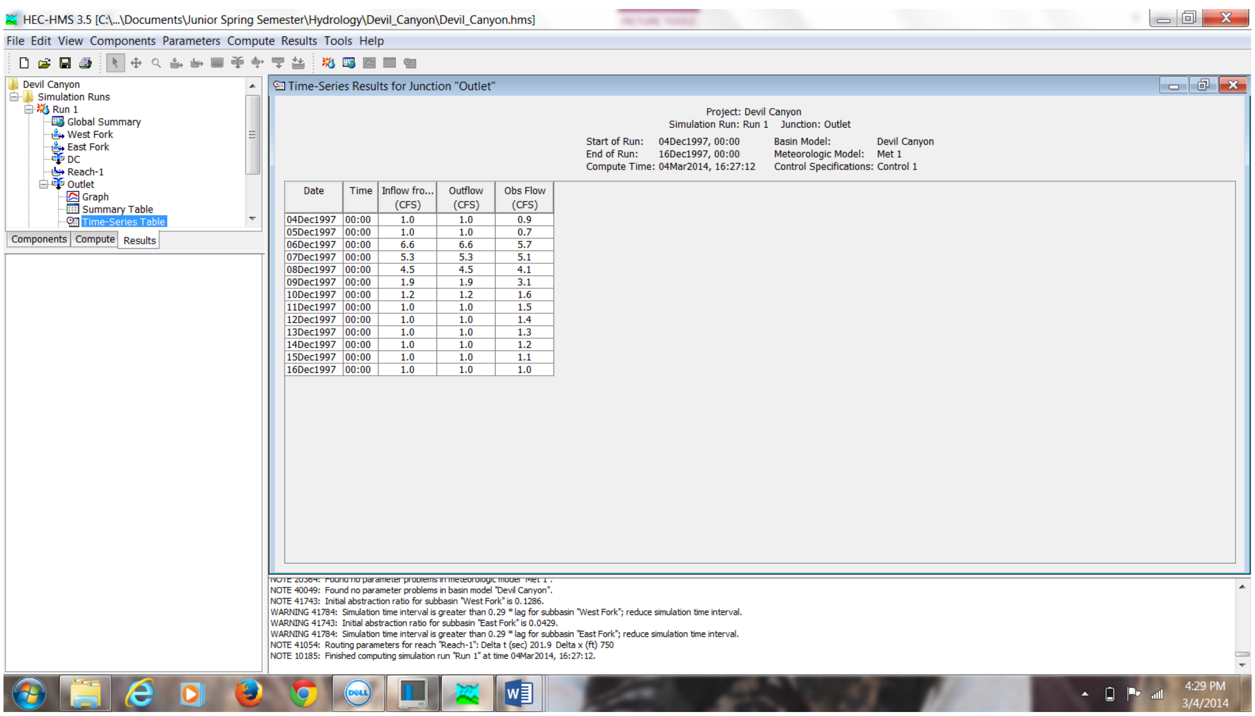
Above are the results from the first run. The first picture shows the results in graph form. The blue line is result due to the parameters and other input data, and the black line is what the actual observed flow should look like. The Time-Series data can be seen in the second picture, and the third picture shows the summary of results for the junction outlet. The total residual is 0.41 inches and the residual should be about 0.2 inches. Below is the table of data input for this run.

	West Fork	East Fork
Initial Abstraction	0.5	0.5
Curve Number	50.1	50.1
%Impervious	1	1
Lag Time	115.34	94.31
Baseflow:	1.275	1.225
January	1.275	1.225
February	1.275	1.225
March	1.275	1.225
April	1.275	1.225
May	1.275	1.225
June	1.275	1.225
July	1.275	1.225
August	1.275	1.225
September	1.275	1.225
October	1.275	1.225
November	1.275	1.225
December	1.275	1.225

After Calibration Run 1





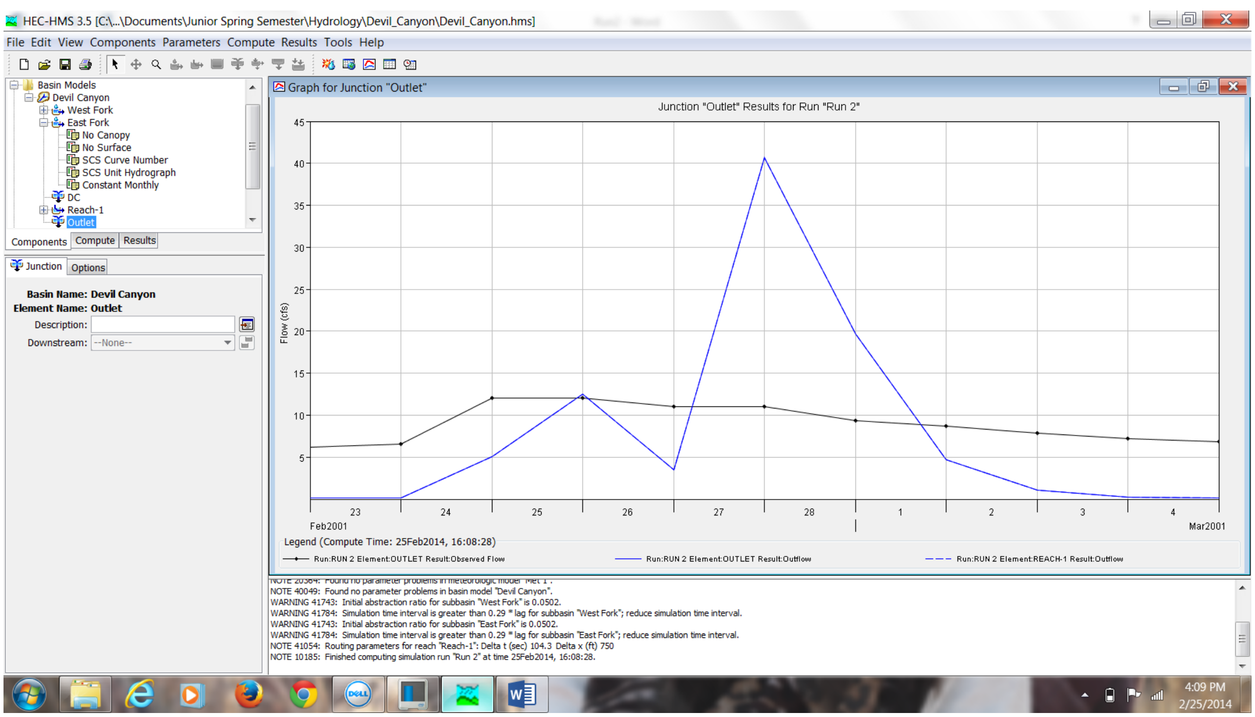


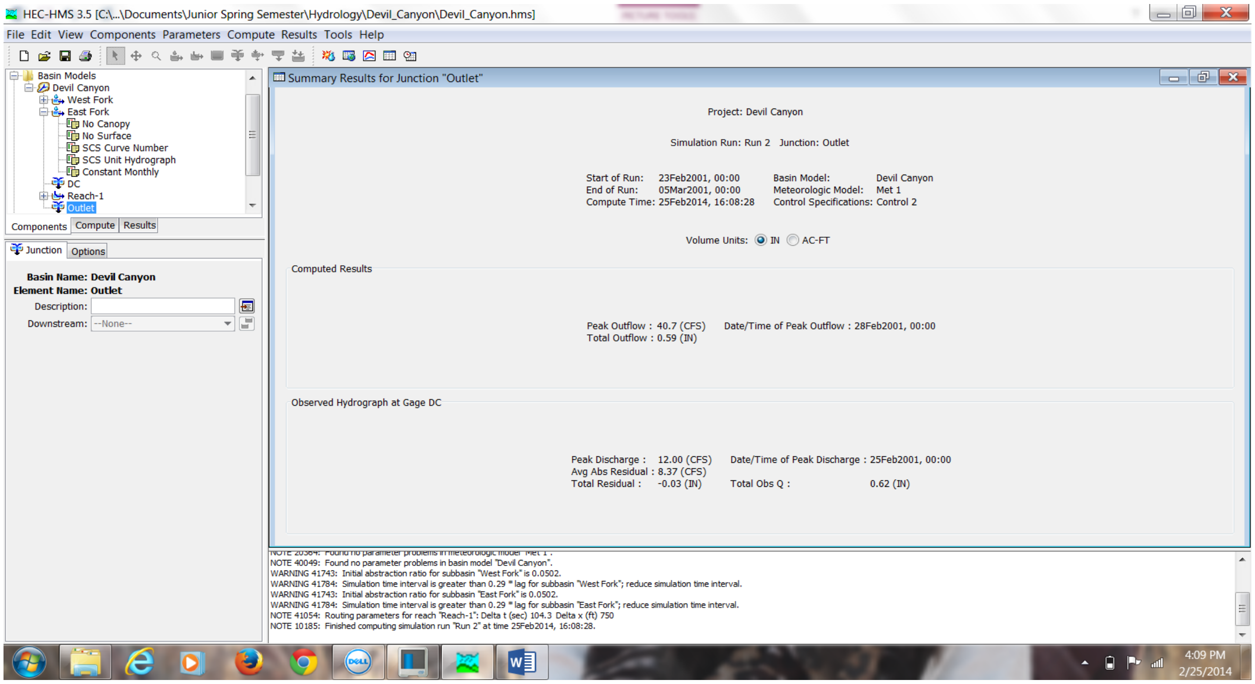
Above are the results for Run 1 after calibration. The total residual is -0.01 which falls within range of 0.2. The blue line is now closer to the actual observed flow which is the goal of calibration. Below is a table of the new data input.

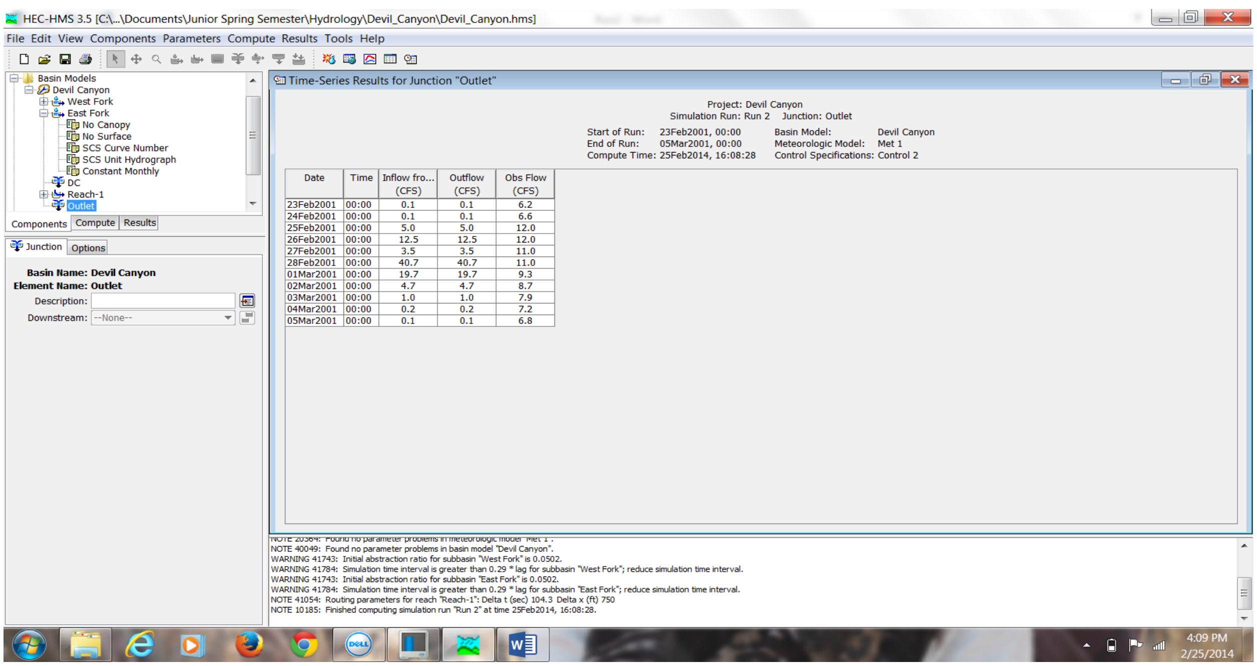
	West Fork	East Fork
Initial Abstraction	1	3
Curve Number	30	30
%Impervious	3	0.5
Lag Time	115.34	94.31
Baseflow:	0.6	0.4
January	0.6	0.4
February	0.6	0.4
March	0.6	0.4
April	0.6	0.4
May	0.6	0.4
June	0.6	0.4
July	0.6	0.4
August	0.6	0.4
September	0.6	0.4
October	0.6	0.4
November	0.6	0.4
December	0.6	0.4

<u>Before Calibration Run 2</u>

Run 2: Dry Season



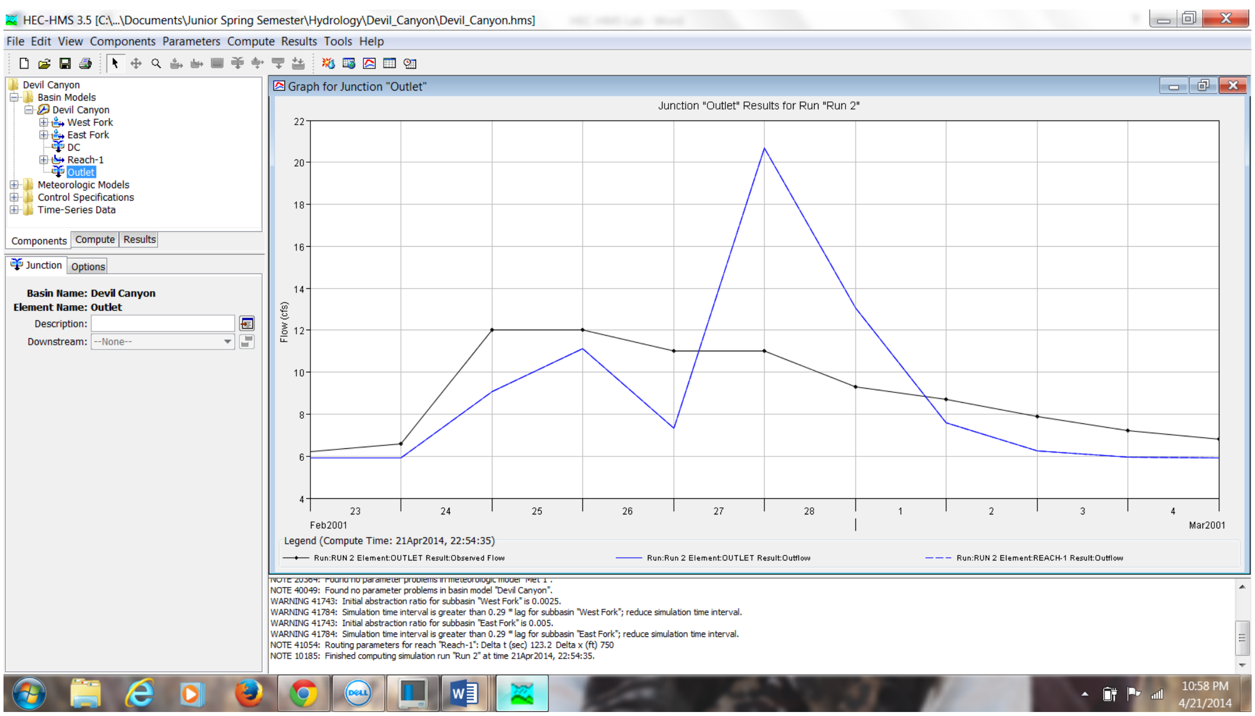


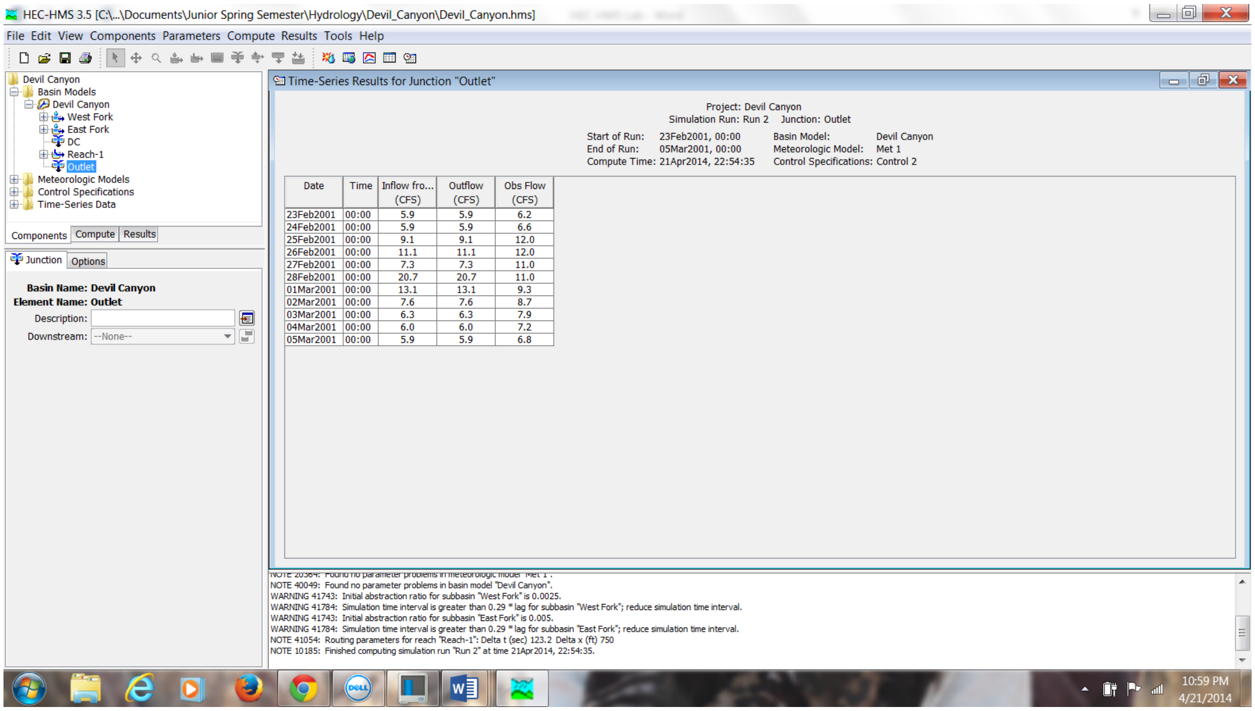


Above are the results from the second run. The first picture shows the results in graph form. The blue line is the result due to the parameters and other input data, and the black line is what the actual observed flow should look like. The summary table can be seen in the second picture, and the third picture shows the Time-series results for the junction outlet. The total residual is -0.03 inches which falls within range, but calibration was done to increase the accuracy of the model. Below is the table of data input for this run.

	West Fork	East Fork
Initial Abstraction	0.5	0.5
Curve Number	50.1	50.1
%Impervious	1	1
Lag Time	115.34	94.31
Baseflow:	0.06477	0.06223
January	0.06477	0.06223
February	0.06477	0.06223
March	0.06477	0.06223
April	0.06477	0.06223
May	0.06477	0.06223
June	0.06477	0.06223
July	0.06477	0.06223
August	0.06477	0.06223
September	0.06477	0.06223
October	0.06477	0.06223
November	0.06477	0.06223
December	0.06477	0.06223

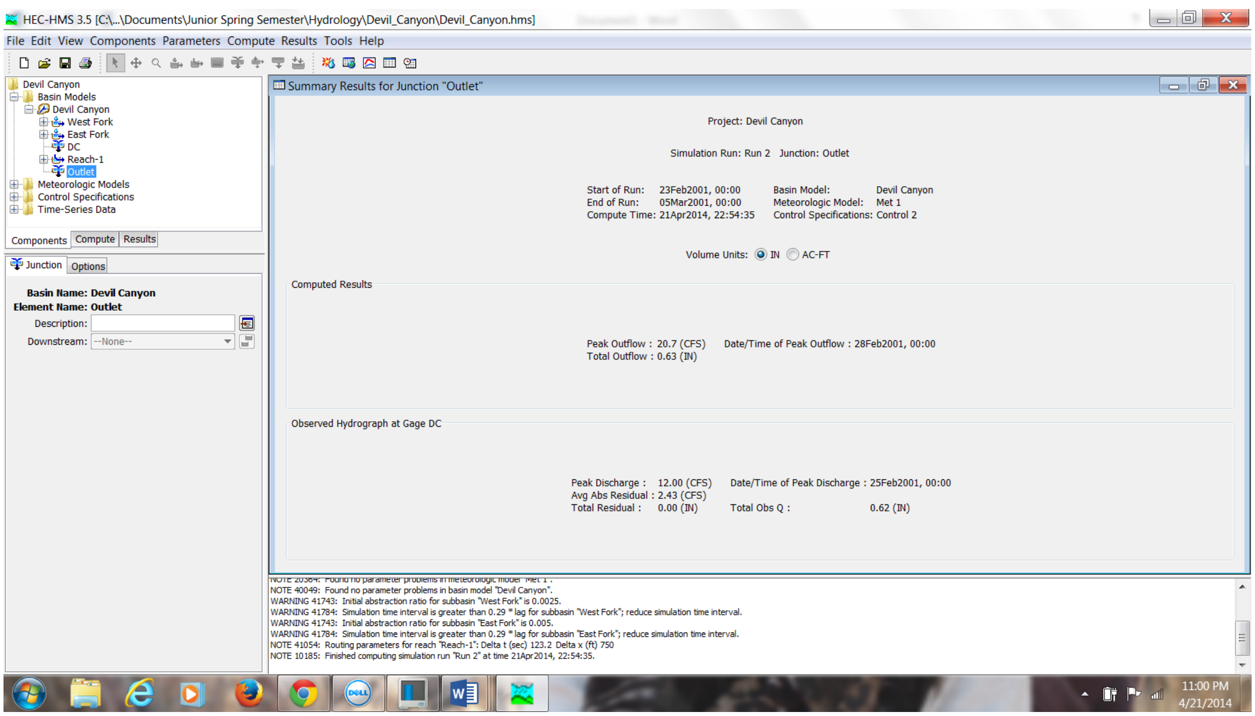
After Calibration Run 2




HEC-HMS 3.5 [C:\...\Documents\Junior Spring Semester\Hydrology\Devil_Canyon\Devil_Canyon.hms]
File Edit View Components Parameters Compute Results Tools Help
Devil Canyon
Basin Models
Devil Canyon
West Fork
East Fork
DC
Reach-1
Outlet
Meteorologic Models
Control Specifications
Time-Series Data
Components Compute Results
Junction Options
Basin Name: Devil Canyon
Element Name: Outlet
Description:
Downstream: --None--
Time-Series Results for Junction "Outlet"
Project: Devil Canyon
Simulation Run: Run 2 Junction: Outlet
Start of Run: 23Feb2001, 00:00 Basin Model: Devil Canyon
End of Run: 05Mar2001, 00:00 Meteorologic Model: Met 1
Compute Time: 21Apr2014, 22:54:35 Control Specifications: Control 2

Date	Time	Inflow fro... (CFS)	Outflow (CFS)	Obs Flow (CFS)
23Feb2001	00:00	5.9	5.9	6.2
24Feb2001	00:00	5.9	5.9	6.6
25Feb2001	00:00	9.1	9.1	12.0
26Feb2001	00:00	11.1	11.1	12.0
27Feb2001	00:00	7.3	7.3	11.0
28Feb2001	00:00	20.7	20.7	11.0
01Mar2001	00:00	13.1	13.1	9.3
02Mar2001	00:00	7.6	7.6	8.7
03Mar2001	00:00	6.3	6.3	7.9
04Mar2001	00:00	6.0	6.0	7.2
05Mar2001	00:00	5.9	5.9	6.8

NOTE 40049: Found no parameter problems in basin model "Devil Canyon".
WARNING 41743: Initial abstraction ratio for subbasin "West Fork" is 0.0025.
WARNING 41784: Simulation time interval is greater than 0.29 * lag for subbasin "West Fork"; reduce simulation time interval.
WARNING 41743: Initial abstraction ratio for subbasin "East Fork" is 0.005.
WARNING 41784: Simulation time interval is greater than 0.29 * lag for subbasin "East Fork"; reduce simulation time interval.
NOTE 41054: Routing parameters for reach "Reach-1": Delta t (sec) 123.2 Delta x (ft) 750
NOTE 10185: Finished computing simulation run "Run 2" at time 21Apr2014, 22:54:35.
10:59 PM
4/21/2014


HEC-HMS 3.5 [C:\...\Documents\Junior Spring Semester\Hydrology\Devil_Canyon\Devil_Canyon.hms]
File Edit View Components Parameters Compute Results Tools Help
Devil Canyon
Basin Models
Devil Canyon
West Fork
East Fork
DC
Reach-1
Outlet
Meteorologic Models
Control Specifications
Time-Series Data
Components Compute Results
Junction Options
Basin Name: Devil Canyon
Element Name: Outlet
Description:
Downstream: --None--
Summary Results for Junction "Outlet"
Project: Devil Canyon
Simulation Run: Run 2 Junction: Outlet
Start of Run: 23Feb2001, 00:00 Basin Model: Devil Canyon
End of Run: 05Mar2001, 00:00 Meteorologic Model: Met 1
Compute Time: 21Apr2014, 22:54:35 Control Specifications: Control 2
Volume Units: IN AC-FT
Computed Results
Peak Outflow : 20.7 (CFS) Date/Time of Peak Outflow : 28Feb2001, 00:00
Total Outflow : 0.63 (IN)
Observed Hydrograph at Gage DC
Peak Discharge : 12.00 (CFS) Date/Time of Peak Discharge : 25Feb2001, 00:00
Avg Abs Residual : 2.43 (CFS)
Total Residual : 0.00 (IN) Total Obs Q : 0.62 (IN)
NOTE 40049: Found no parameter problems in basin model "Devil Canyon".
WARNING 41743: Initial abstraction ratio for subbasin "West Fork" is 0.0025.
WARNING 41784: Simulation time interval is greater than 0.29 * lag for subbasin "West Fork"; reduce simulation time interval.
WARNING 41743: Initial abstraction ratio for subbasin "East Fork" is 0.005.
WARNING 41784: Simulation time interval is greater than 0.29 * lag for subbasin "East Fork"; reduce simulation time interval.
NOTE 41054: Routing parameters for reach "Reach-1": Delta t (sec) 123.2 Delta x (ft) 750
NOTE 10185: Finished computing simulation run "Run 2" at time 21Apr2014, 22:54:35.
11:00 PM
4/21/2014

Above are the results for Run 2 after calibration. The total residual is 0.00 which falls within range of 0.2. The blue line is now closer to the actual observed flow which is the goal of calibration. Below is a table of the new data input.

	West Fork	East Fork
Initial Abstraction	0.1	0.2
Curve Number	20	20
%Impervious	1	0.2
Lag Time	115.34	94.31
Baseflow:	3.36477	2.56223
January	3.36477	2.56223
February	3.36477	2.56223
March	3.36477	2.56223
April	3.36477	2.56223
May	3.36477	2.56223
June	3.36477	2.56223
July	3.36477	2.56223
August	3.36477	2.56223
September	3.36477	2.56223
October	3.36477	2.56223
November	3.36477	2.56223
December	3.36477	2.56223

Discussion

Calibrations were required because it involved matching the watershed's physical features and, therefore, providing a more accurate hydrologic model. This involved some trial and error, however, one needed to know how each parameter being changed affected the model. The main goal was to enter new parameters that made the model more accurate to Devil Canyon's actual physical features.

Calibration for each model began by matching the actual baseflow with the resultant baseflow. Adjusting the baseflow changes the y-axis of the graph and allows the model to be more accurate. The actual baseflow for Run 1was higher than the calculated baseflow. In order to obtain a more accurate model the baseflow was decreased. This was done by opening the baseflow tab for the West and East Fork and decreasing the baseflow values for each month. In the case of Run 2, the observed baseflow was higher than the calculated baseflow. This required the baseflows for the West and East Fork to be increased until it accurately represented the observed flow.

Adjusting the arc of the graph was done by altering the curve number, percent impervious, and initial abstraction. For Run 1 and Run 2, the initial abstraction was the first value to be changed. Initial abstraction is the amount of water lost before runoff begins. This would include evaporation and infiltration. The West Fork has exposed bedrock that would prevent infiltration. Therefore, the initial abstraction for the West Fork would be lower than that of the East Fork. The next value to be adjusted was the curve number. Both calculated graphs were above the observed flow which required the curve number to be decreased. The next value to be changed was the percent impervious. Percent impervious refers to the amount of man-made structures in a certain area, or when a soil has been oversaturated and all of its voids are filled with water. The West Fork has bedrock which would be considered impervious because it prevents water from entering the ground. The percent impervious for Run 1 was increased for the West Fork due to the bedrock. For Run 2, the percent impervious was left at 1 in the West Fork and was lowered to 0.2 in the East Fork. Doing this lowered the curve and made the graph more accurate.

Conclusion

The model is fairly accurate. Run 1 is accurate because its curve fits well with the observed flow curve. Run 2 is less accurate because its curve does not fit well with the observed flow curve. However, it is more accurate than the original model. Adjusting the baseflows of each run brought the end points of the actual flow and the calculated flow closer together. This made the graphs more accurate. Correcting the initial abstraction, curve number, and percent impervious caused the arc of the calculated flow to match the arc of the actual flow. These values made the simulated model portray the physical attributes of Devil Canyon more accurately. The exposed bedrock in the West Fork played a part in determining the initial abstraction and percent impervious. Bedrock caused the initial abstraction value to increase while also causing the percent impervious value to increase. One way of improving the model before calibration would have been to obtain the curve numbers for each individual type of land cover instead of using the two major land covers. This would have resulted in a more precise curve number to begin with.

One observation that took place during calibration related to the baseflows. During the wet season, the baseflow had to be decreased, and during the dry season the baseflow had to be increased. This seems strange because it would be assumed that the dry season would have less baseflow than the wet season. A higher baseflow during a dry season might be caused by a wet season that occurred prior to the dry season. More testing must be done in order to account for the higher baseflow during the dry season.

References

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Jung, Helen Y., Terri S. Hogue, Laura K. Rademacher, and Tom Meixner. “Impact of Wildfire on Source Water Contributions in Devil Creek, CA: Evidence from End-member Mixing Analysis.” Diss. University of California Los Angeles, 2008. Print.

Mays, Larry. *Water Resources Engineering*. United States: John Wiley & Sons, Inc., 2011. Print.

EGR 356 – Hydrology

Devil Canyon Basin Hydrological Model Lab Report

Prepared for: Dr. Jung

By:

School of Engineering

California Baptist University

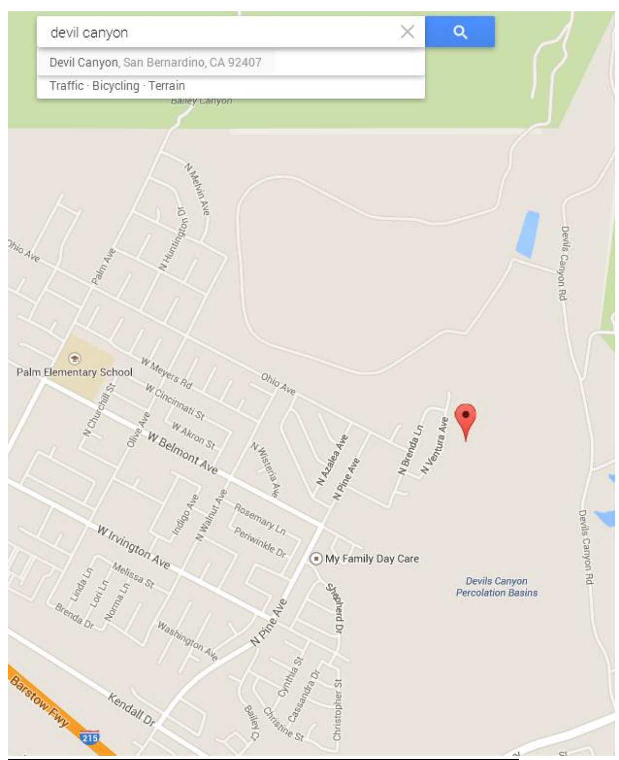
Introduction

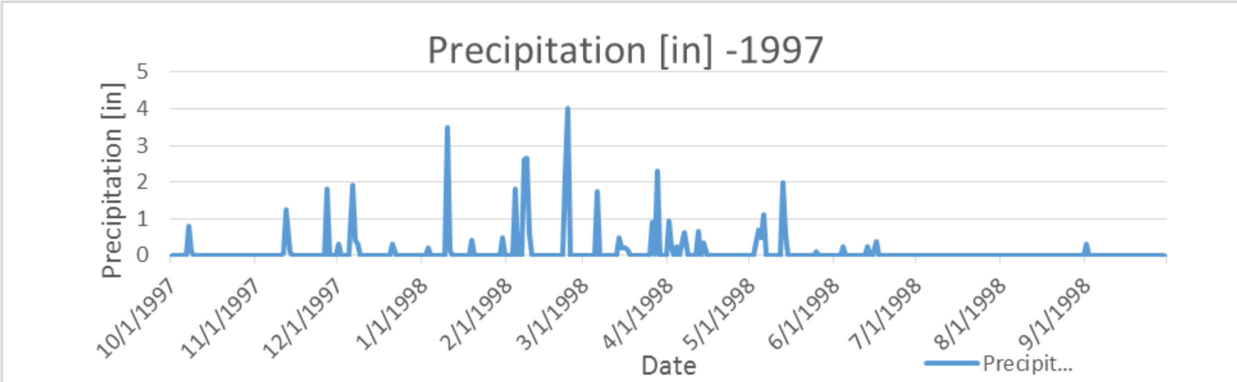
In this lab, Hydrological Modeling system (HEC-HMS) was used to discover the precipitation – runoff processes of the watershed systems. This is used to produce hydrographs which tell the availability for water, urban drainage, flow forecasting, future urbanization impact and reservoir spillway. HEC – HMS is used frequently in different locations such as large basin water supply and other hydrology projects. It is generally used to model different watersheds. This program is used in the work environment for data entry utility purposes and its results reporting tools.

The model that we used is the runoff model, which explains how much precipitation that an area receives over time and how much runoff it produces. The curve number that we discover in the lab tell us a hypothesis of how much rainfall and runoff we may receive in the near future. This is important as this information gives us an understanding of what the hydrological cycle looks like as well as how stable the watershed is without it have to flood a specific area.

Study Site

Devil Canyon is located in San Bernardino County, California, which is located about 60 miles east of Los Angeles and spans approximately 81 square miles. The Climate tends to be a bit warmer, especially in the summer which can average from 80-100 degrees. The record temperature was set in 1971 with a temperature of 117 degrees. The Precipitation graph shown below shows that it barely rains from the month of May to the end of December. Between January through May are considered the months with the most precipitation. The following graphs on the next two pages show how much precipitation was in one year.

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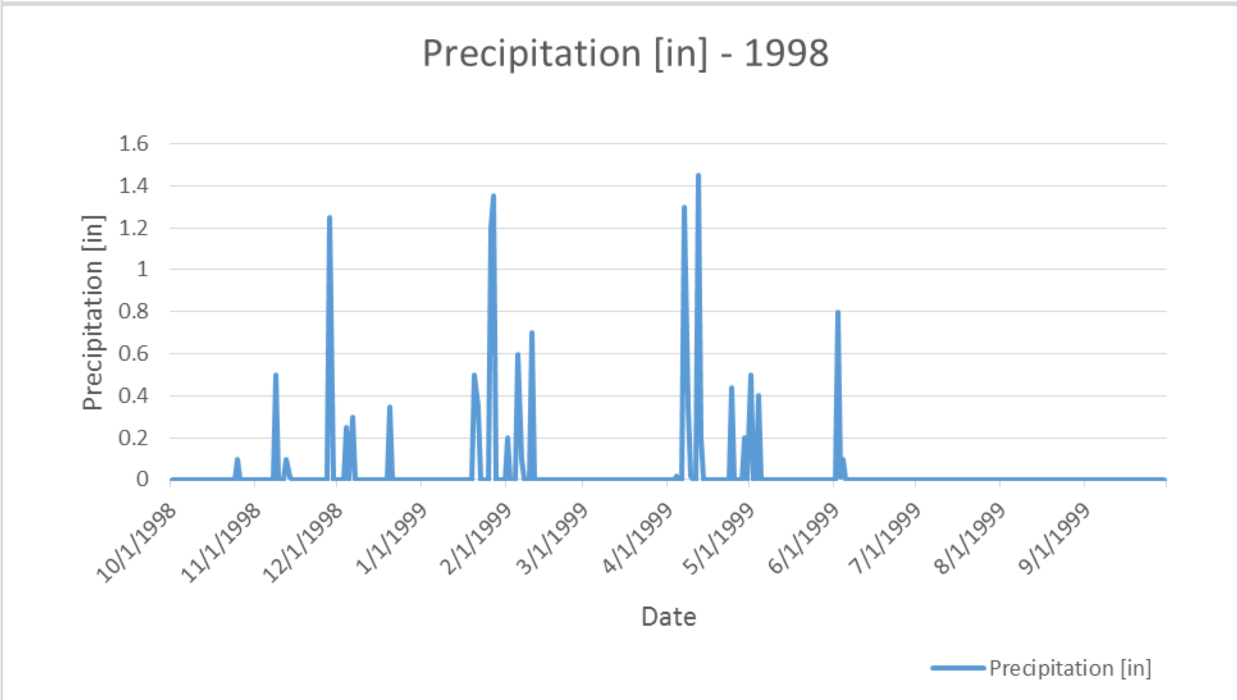
Date
Precipit...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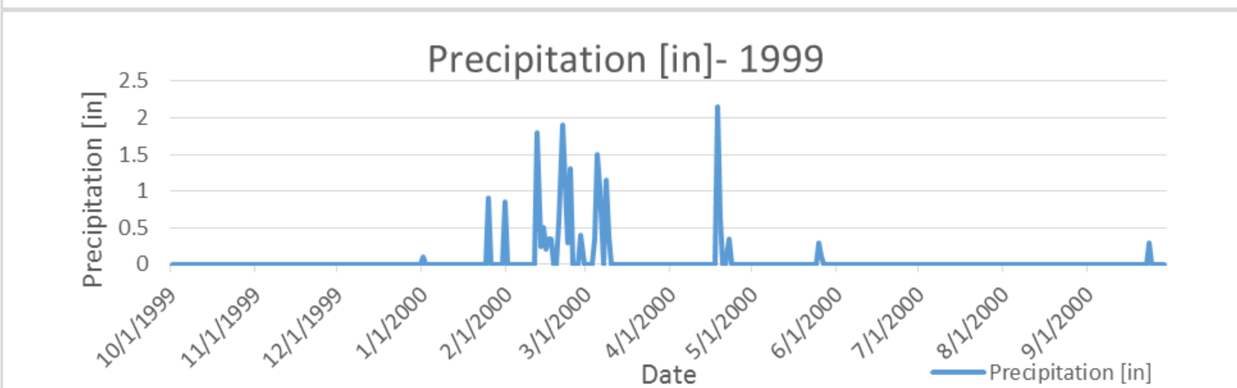
Date
Precipitation [in]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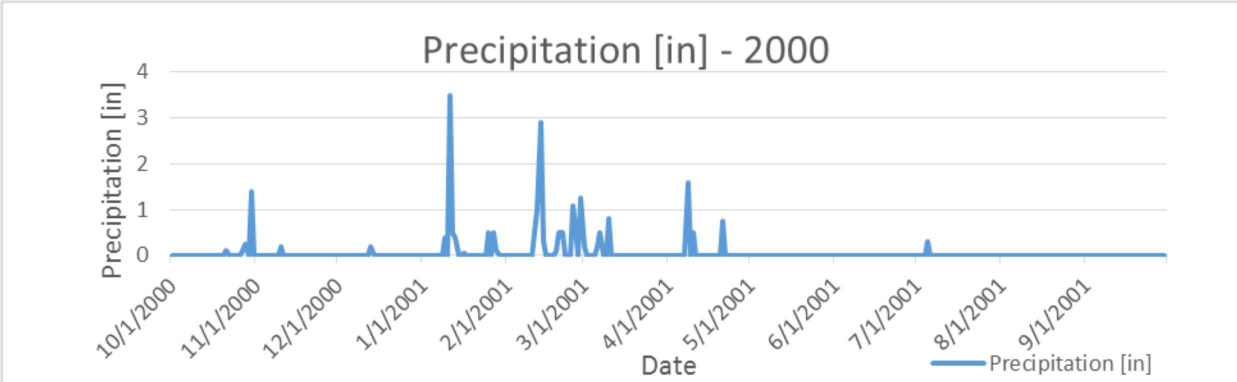
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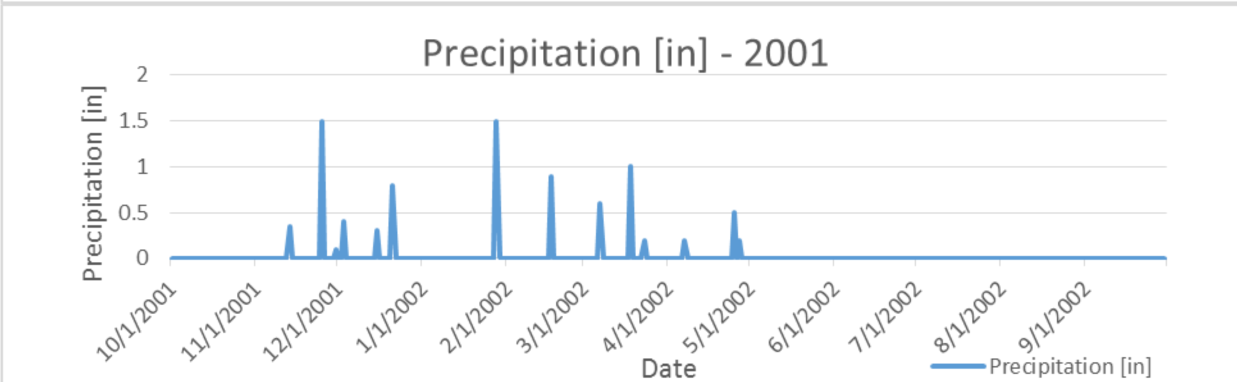
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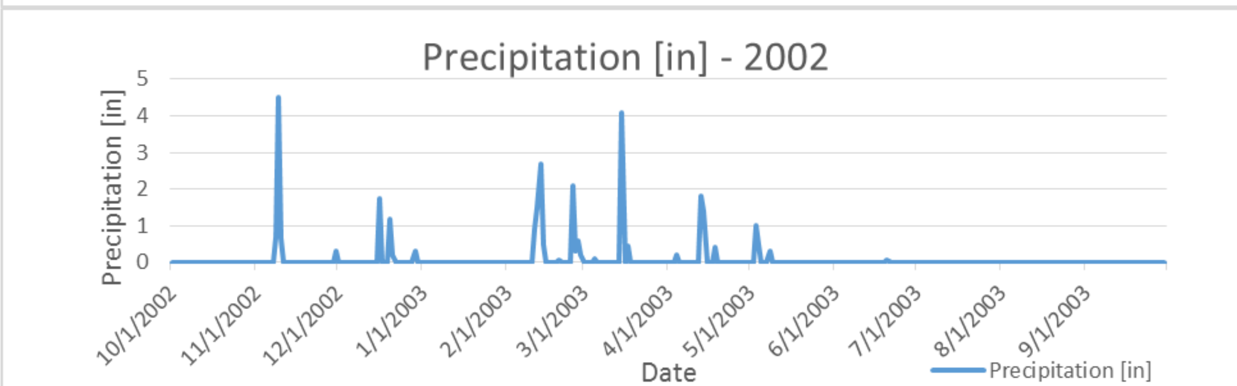
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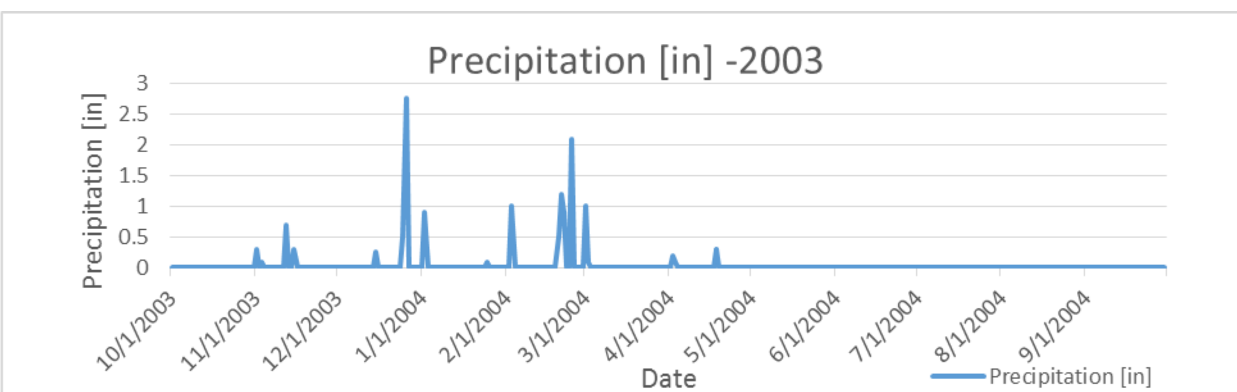
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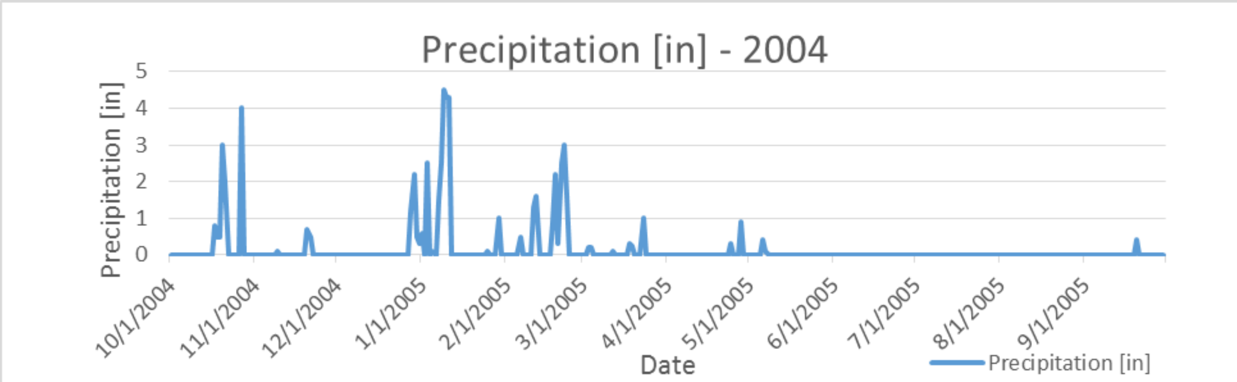
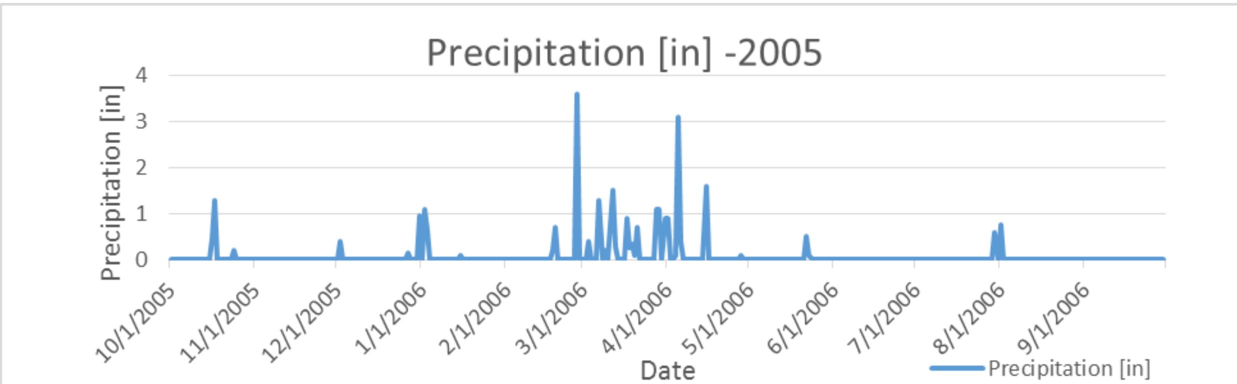




Devil's Canyon is divided into two forks: East and West and is divided into the Developed Land, Agricultural Land, Grassland, Forest Land, Scrub Land, Barren Land, and Palustrine Wetlands. In the table below shows the slope of the land, the length, Percent area, the area each division is and the curve number.

	Watershed length and the West Fork	**Watershed length and the East Fork**
Length	6514.83	3964.87
Slope	0.3105	0.1135
Percent area	100	49

Length in feet	**Length in feet**
21374.1	13008.1

Developed Land	Sum of Area	Percent	(CN)
Medium intensity	6126.305	0.042559186	
Low Intensity	130516.469	0.906692487	
Open Space	148547.77	1.031955186	
Agricultural Land	**Sum of Area**	**Percent**	**(CN)**
Cultivate Crops	8710.37	0.060510578	
Pasture/Hay	1483.28	0.010304285	
Grassland	**Sum of Area**	**Percent**	**(CN)**
Grassland/Herbaceous	156162.887	1.084857087	
Forest Land	**Sum of Area**	**Percent**	**(CN)**
Deciduous Forest	17791.887	0.1235995	
Evergreen Forest	4327085.4	30.06008247	19.53905361
Mixed Forest	791680.586	5.499772135	3.574851887
Scrub Land	**Sum of Area**	**Percent**	**(CN)**
Scrub/Shrub	8790593.125	61.06788517	30.53394258
Barren Land	**Sum of Area**	**Percent**	**(CN)**
Barren Land	12616.12	0.087643661	
Palustrine Wetlands	**Sum of Area**	**Percent**	**(CN)**
Palustine Forested Wetland	2732.801	0.018984655	
Palustrine Scrub/Shrub Wetland	741.85	0.005153601	

DEVIL CANYON	
Total Sum	14394788.85

Sum of CN (CN II)
53.64784808

	CN (I)	CN(II)	CN(III)
CN	19.420521	53.64785	72.69262
T_c	379.0353293	134.1904	81.84082
T_1	226.967263	80.35355	49.00648

Methods

The Basin Model consists of the Basin Model Development, Meteorological Model Development, Running simulations and Refining or tuning the model simulations against observed data.

In The Basin Model Development, We had two sub-basins: East and West. The Model included a time series model, a meteorological model, control specification and run manager. We named the Meteorological model ‘Met 1’. the sub basin loss infiltration loss is the SCS curve number which is used to calculate the run-off. The Method that we used is the Muskingum-Cunge Standard Section.

The SCS method is used to calculate infiltration losses. The equations below are used to calculate the Lag.

Time of concentration (in minutes): $T_c = 0.00526L^{.8}(1000/CN – 9)^{.7}S^{-.5}$

Lag Time (in minutes): $T_1 = T_c/1.67$

L = watershed length in ft

S = watershed slope (ft/ft)

CN = Curve number for each sub-basin

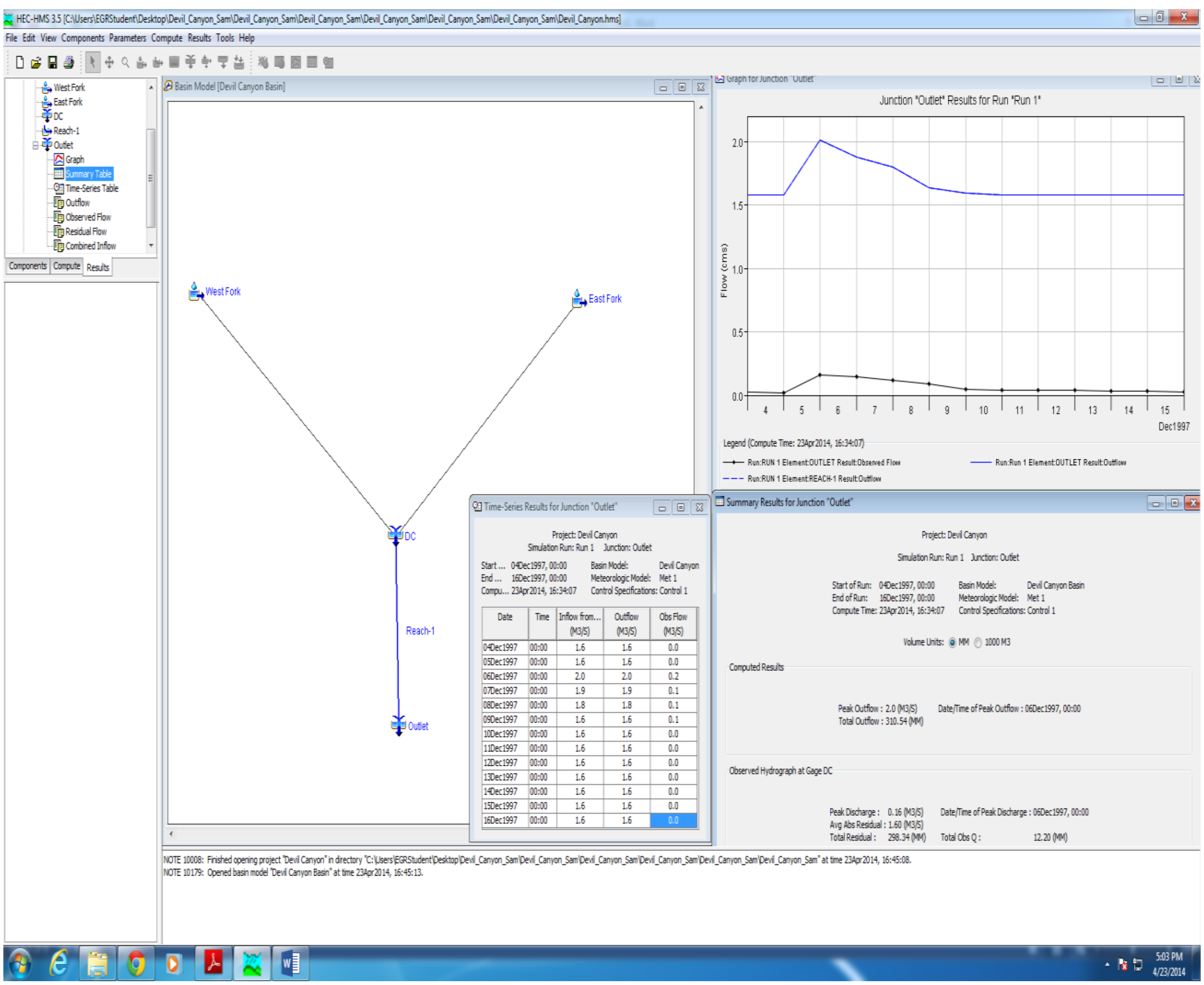
The CN number of our watershed was found by multiplying the CN by the percent area of each land use and then adding it

Parameters	**Reach 1**
Shape	Prism
Length (ft)	1500
Energy slope (ft/ft)	.15562
Bottom Width (ft)	15
Side Slope (ft/ft)	.01
Manning’s n	.05

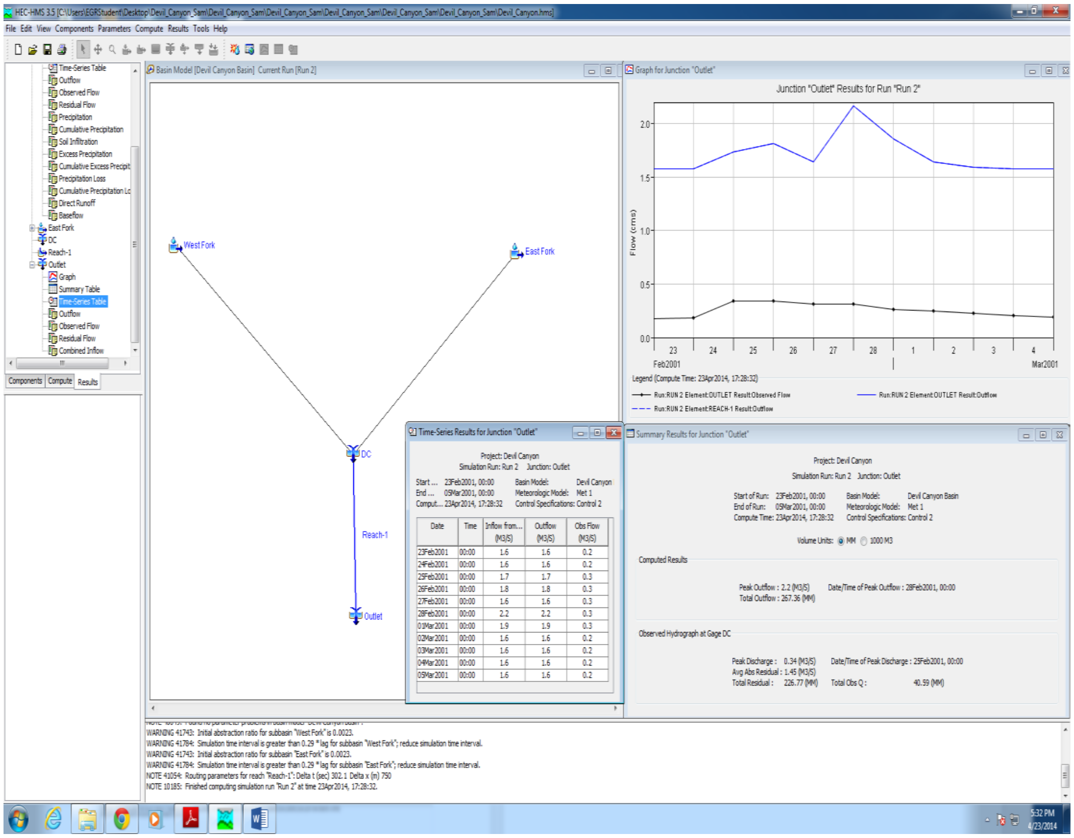
The data that was inputted into the model was precipitation and observed discharge from past labs and land use information to obtain the CN number. The precipitation was obtained from the San Bernardino Water Control District website (http://www.sbcounty.gov/dpw/floodcontrol/default.asp). The discharge was obtained from the U.S. Geological Survey website (http://www.usgs.gov), and the land use, which was used to find the CN number, was obtained from the National Oceanic and Atmospheric Administration website (http://www.noaa.gov)

Results

Screenshot of Run 1 before Calibration:



Screenshot of Run 2 before Calibration:

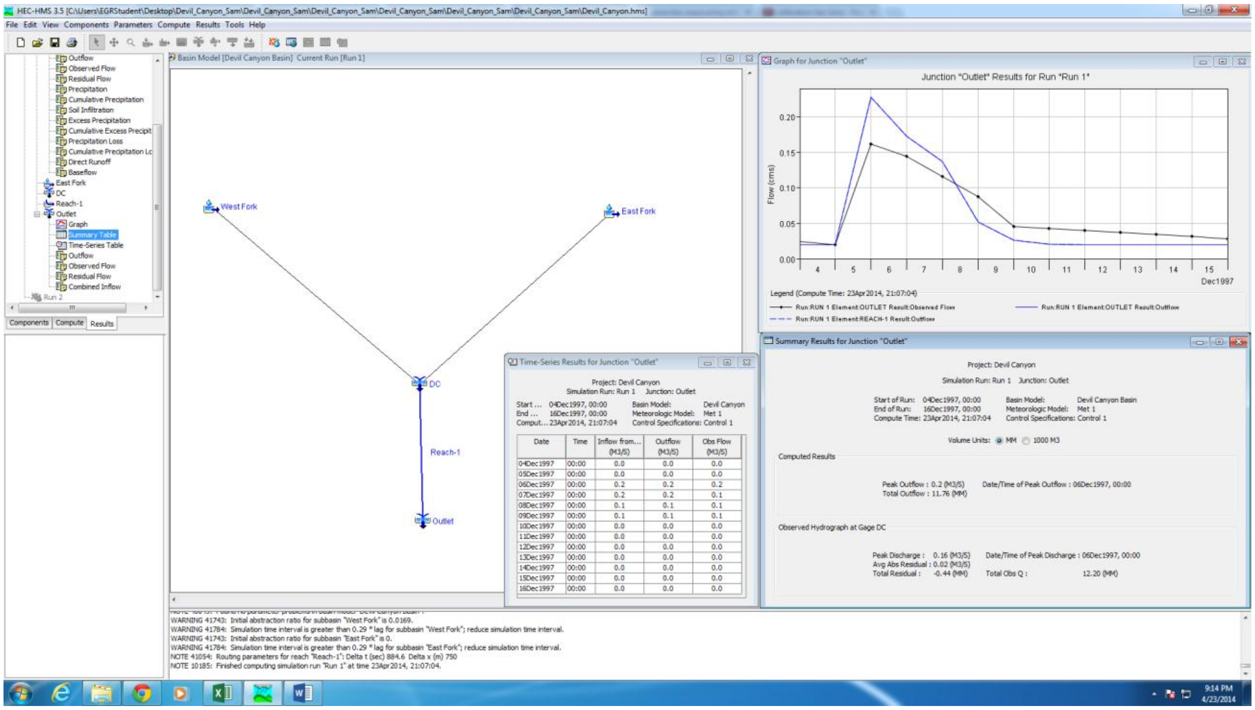


Parameters Before Calibration for both Run 1 and Run 2

Baseflow	**West**	**East**
January	0.8058	0.7742
February	0.8058	0.7742
March	0.8058	0.7742
April	0.8058	0.7742
May	0.8058	0.7742
June	0.8058	0.7742
July	0.8058	0.7742
August	0.8058	0.7742
September	0.8058	0.7742
October	0.8058	0.7742
November	0.8058	0.7742
December	0.8058	0.7742

Initial Abstraction	0.5	
Curve Number	53.648	
Impervious (%)	1	
Lag Time	27.35	25.43

Screenshot for Run 1 After Calibration

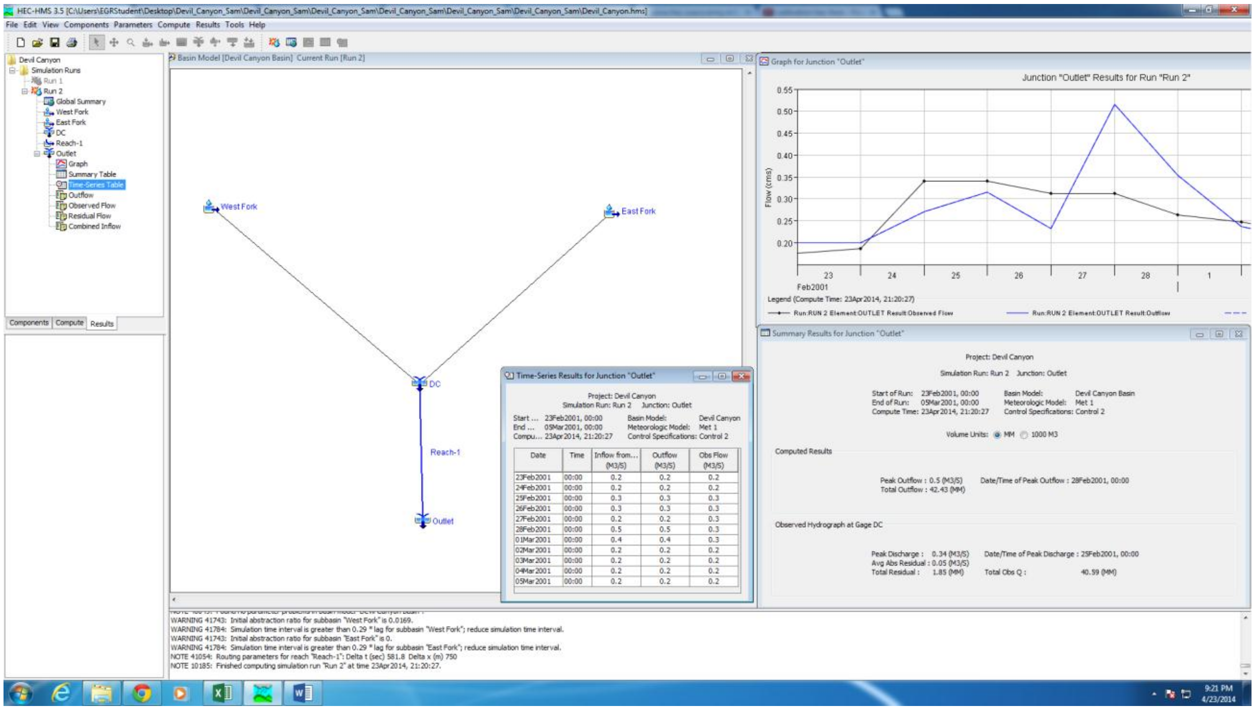


Parameters After Calibration for Run 1

Baseflow	**West**	**East**
January	0.01	0.01
February	0.01	0.01
March	0.01	0.01
April	0.01	0.01
May	0.01	0.01
June	0.01	0.01
July	0.01	0.01
August	0.01	0.01
September	0.01	0.01
October	0.01	0.01
November	0.01	0.01
December	0.01	0.01

Initial Abstraction	0.5	
Curve Number	25	30
Impervious (%)	2	
Lag Time	20	25

Screenshot of Run 2 After Calibration



Parameters After Calibration for Run 2

Baseflow	West	East
January	0.1	0.1
February	0.1	0.1
March	0.1	0.1
April	2	2
May	0.1	0.1
June	0.1	0.1
July	0.1	0.1
August	0.1	0.1
September	0.01	0.1
October	0.1	0.0001
November	0.1	0.1
December	0.1	0.1

Initial Abstraction	0.5	
Curve Number	25	30
Impervious (%)	2	
Lag Time	20	25

Discussion

The Parameters are closer to what the graphs shape should look like. The base flow of this needed to be closer to zero for the both graphs to be similar. The Impervious didn't need to be changed a lot since it didn't seem to effect the graph entirely. The lag numbers were very similar as well to before they were calibrated and didn't seem to effect the graph. The Curve numbers were changed to a lower number to fit similarly to the graph. The Initial abstraction was not changed. The graphs were not perfect but were close enough to be similar. These parameters are close enough to be reasonable as there are more precipitation in some months than there is other.

Conclusion

In this lab, the model was definitely Precise as we needed a lot of repetition of changing values to get a similar graph. The process was a little tedious but I definitely learned a lot in this lab and I am sure it will help me in the near future when I get a civil engineering job. The next time I do this lab, I would focus more on trying to change more factors other than base flow to try to get a more accurate graph and try to get more accurate data

Hydrology Lab Report

California Baptist University

College of Engineering

EGR 356 Hydrology– Spring 2014

HEC-HMS Basin Model Development: Devil Canyon

Submitted to: Dr. Helen Jung

By

Date: April 23, 2014

1 Introduction

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They are primarily used for hydrologic prediction and for understanding hydrologic processes. There are many different types of hydrologic models, and each one is used in its own unique way. For example, there is the MIKE 11 which simulates flood hydrographs at different locations along streams using unit hydrograph techniques. There is also PRMS, PRMS is a modular-designed, deterministic, distributed-parameter modeling system that can be used to estimate flood peaks and volumes for floodplain mapping studies. For this lab report, the hydrologic modeling software used is HEC-HMS, HEC stands for Hydrologic Engineering Center and HMS stands for Hydrologic Modeling System. HEC-HMS was developed by the U.S. Army Corps of Engineers and is available to the public domain.

The Hydrologic Modeling System provides a variety of options for simulating precipitation-runoff processes. It now includes snowmelt and interior pond capabilities, plus enhanced reservoir options. It can be used for calculating either single storm events, or continuous simulation. The Hydrologic Modeling System includes two different soil moisture models suitable for continuous modeling, one with five layers and one with a single layer. Two approaches to evapotranspiration are provided and snowmelt is available. Calibration runs should be used wherever possible to determine model parameters. With the aid of this program, we were able to create a basin model and determine the effects on a specific area, Devil's Canyon in San Bernardino. Once the model was created using HEC-HMS, factors such as peak outflow, total outflow and peak discharge could be calculated easily.

2 Study Site

The location that was used for this project was Devil's Canyon in San Bernardino County, California. Devil's Canyon is in the San Bernardino Mountains, making it an ideal location. The shape of the watershed that located there, and the type of land, are all important factors when analyzing precipitation data. The calculated area of the watershed is 14,403,138.12 m^2. This area consists of two different rivers, flowing into one outflow. The two rivers are split into two sides, West Fork and East Fork. The size of West Fork is 7345600.443 m^2, while the size of East Fork is 7057537.68 m^2.

Devil's Canyon will have many storms a year, the intensity of the storms vary, though, according to the time of year. Precipitation vs Time graphs can be made from the data obtained using the San Bernardino Flood Control District's website. To obtain the data, go to this website: http://www.sbcounty.gov/dpw/floodcontrol/water_resources.asp, then click on Online Data, then select Daily Precipitation, selecting area number two on the map shown below will bring up a page that consists of the many different precipitations stations that are in that area. The station dedicated to Devil's Canyon is Station #2071. By clicking on the number 2071, a file will download that has storm data spanning from 1927 to 2007, a total of 80 years. The data used for our analysis took place in the years 1998 – 2007, starting in October of 1997 and ending in October of 2006. The following graphs show the precipitation over time for each year.

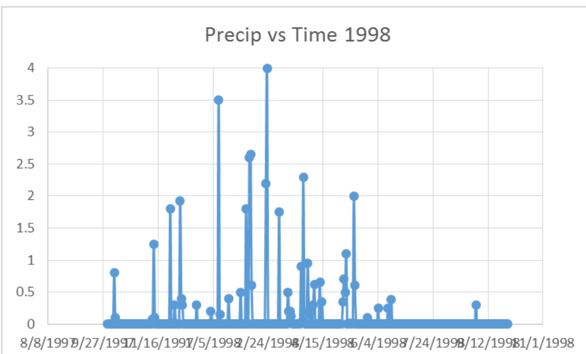


Figure 1 - Precip vs Time for WY1998

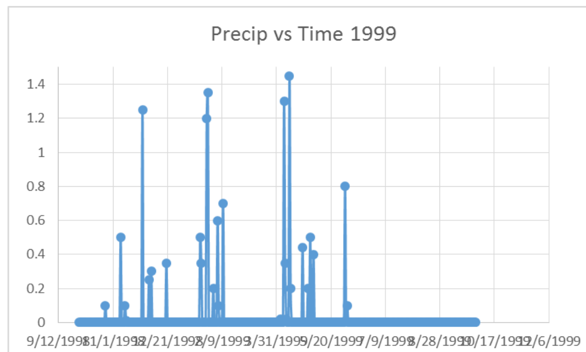


Figure 2 - Precip vs Time for WY1999

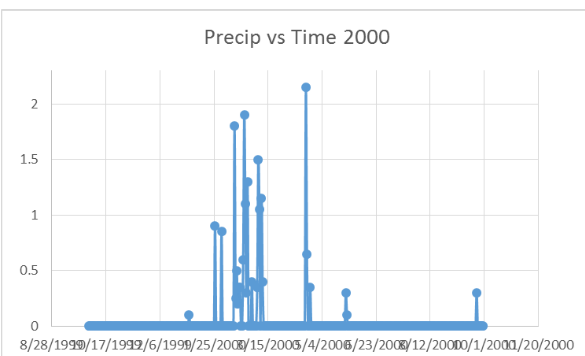


Figure 3 - Precip vs Time for WY2000

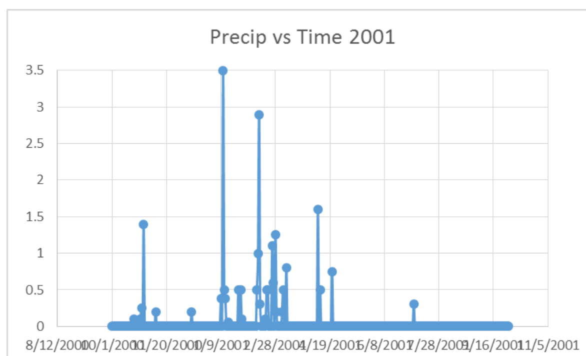
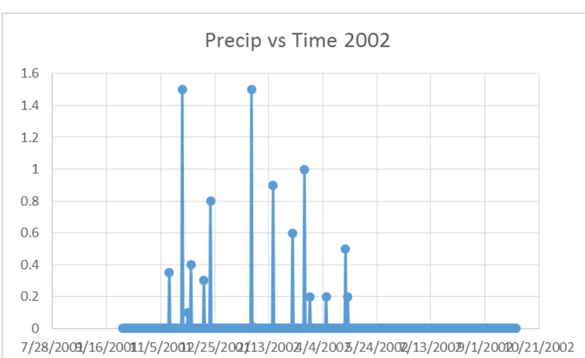


Figure 4 - Precip vs Time for WY2001



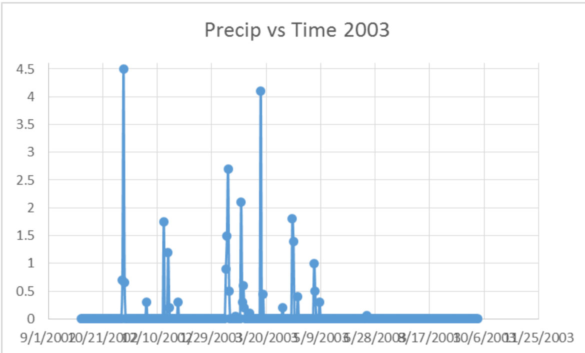
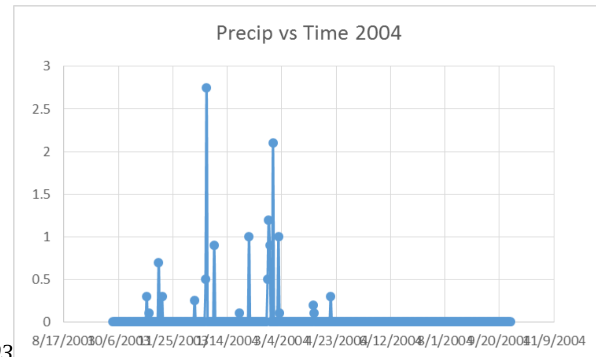


Figure 5 - Precip vs Time for WY2002

Figure 6 - Precip vs Time for



WY2003

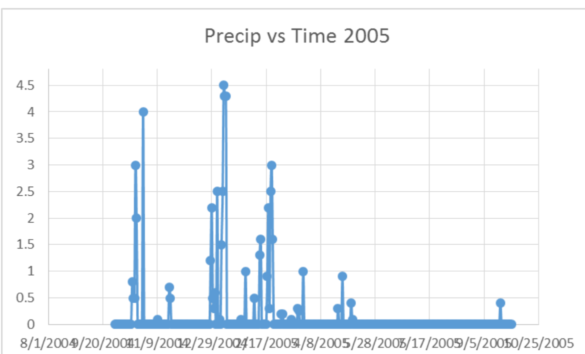
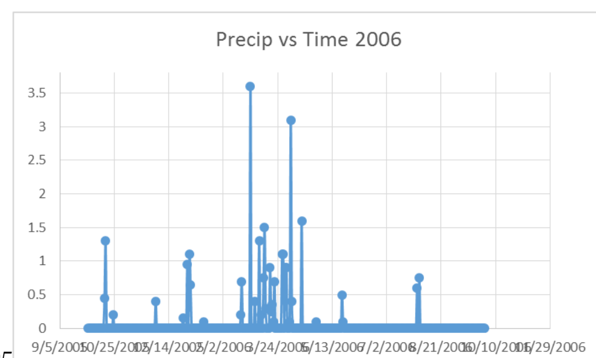


Figure 7 - Precip vs Time for WY2004

Figure 8 - Precip vs Time for



WY2005

Figure 9 - Precip vs Time for WY2006

Another characteristic that was obtained by from this data was the flow vs. time. This data shows how much water was flowing through of the watershed over the months in each year.

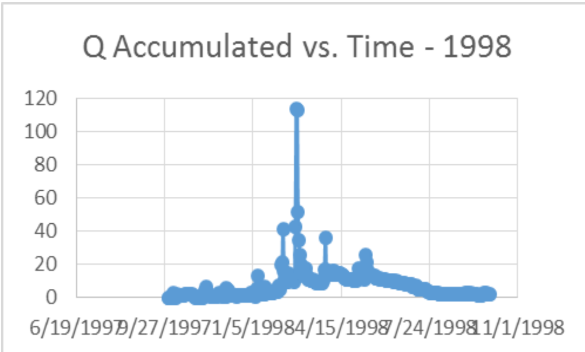


Figure 10 - Flow vs Time for WY1998

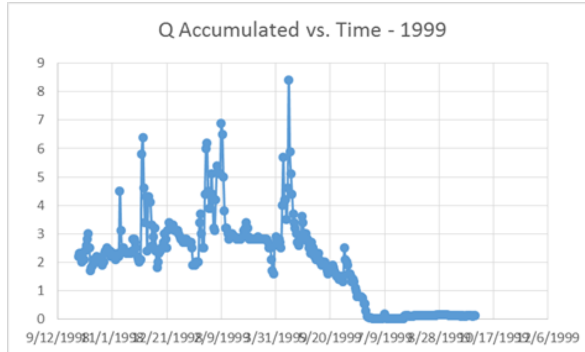
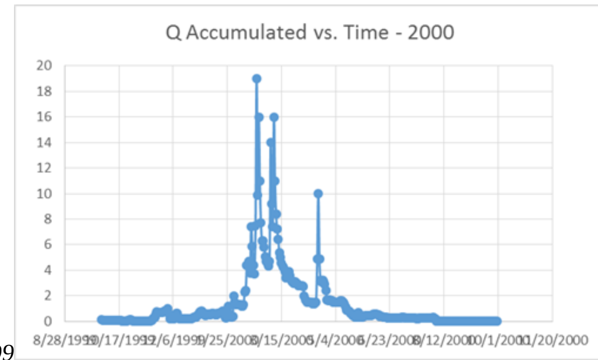


Figure 11 – Flow vs Time for
WY1999



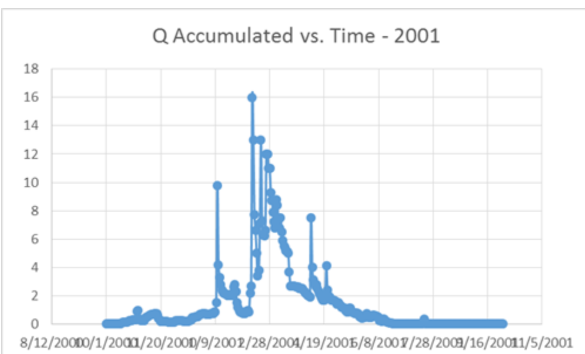
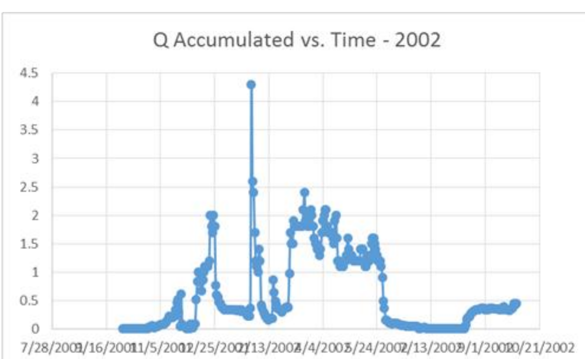


Figure 12 - Flow vs Time for WY2000

Figure 13 – Flow vs Time for
WY2001



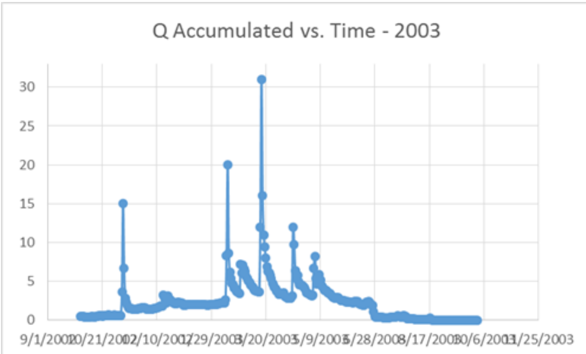
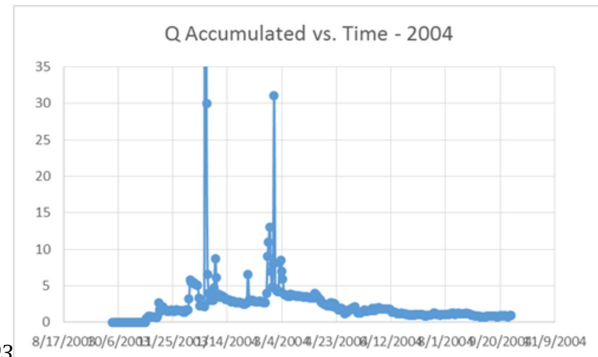


Figure 14 - Flow vs Time for WY2002 *Figure 15 - Flow vs Time for WY2003*



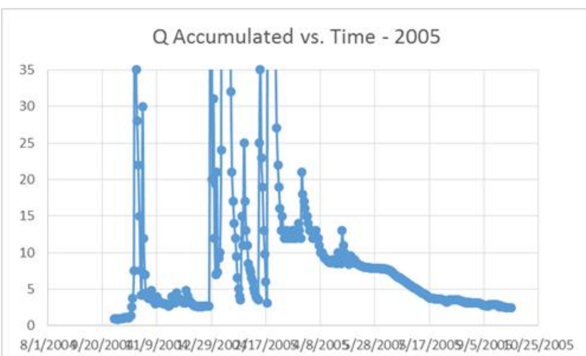


Figure 16- Flow vs Time for WY2004 *Figure 17 - Flow vs Time for WY2005*

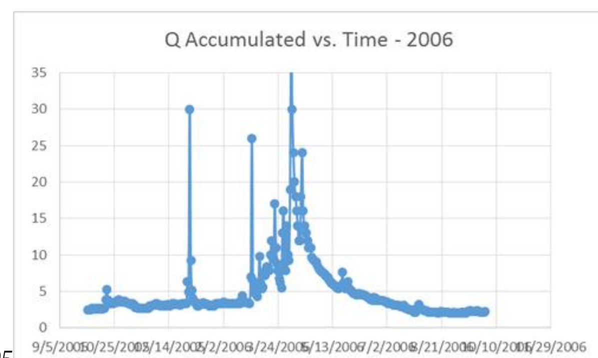


Figure 18- Flow vs Time for WY2006

From data obtained using ARCGIS software, a geographic information system (GIS) for working with maps and geographic information, land cover of the entire watershed was able to be recorded and classified using the C-CAP Land Cover Classification Scheme. GIS software is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. The following spreadsheet data lists the type of land found in Devil's Canyon, along with how much area each type of land took up. Other variables that can be found using ARCGIS are the area, slope, length of channel, and elevation.

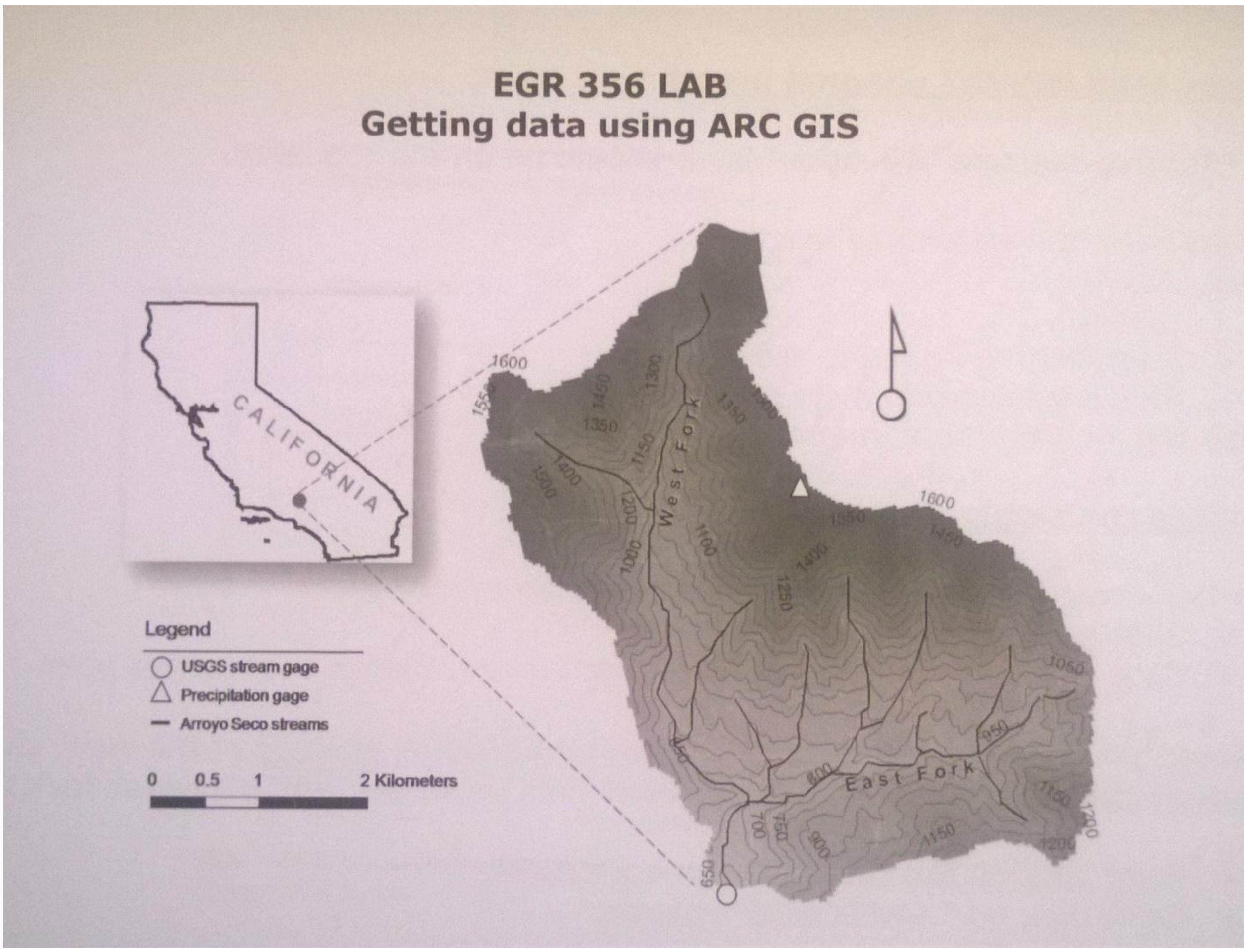


Figure 19- Devil's Canyon Watershed

<u>Overall</u>

Devil's Canyon				
High Elev.	Low Elev.	Length(m)	Slope	
1300	650	5231.987526	0.12423577	
Landcover Type		Area(m^2)	% Total Area	
Number	Classification			CN
3	Developed, Medium Intensity	6126.305183	0.000425345	70
4	Developed, Low Intensity	130516.4701	0.009061669	75
5	Developed, Open Space	148547.8436	0.010313575	61
6	Cultivated Crops	8710.367119	0.000604755	78
7	Pasture/Hay	1483.275227	0.000102983	61
8	Grassland/ Herbaceous	155892.888	0.010823536	61
9	Deciduous Forest	17791.88703	0.001235279	58
10	Evergreen Forest	4326674.089	0.300398014	58
11	Mixed Forest	791410.583	0.054947094	58
12	Scrub/Shrub	8799893.697	0.610970583	50
13	Palustrine Forested Wetland	2732.801005	0.000189736	61
14	Palustrine Scrub/Shurb Wetland	741.853093	5.15064E-05	35
20	Barren Land	12616.06376	0.000875925	59
Total Area	14403138.12			53.35

Table 1 – Overall Land Cover of Devil's Canyon

West Fork

West Fork			
High Elev.	Low Elev.	Length(m)	Slope
1600	650	5226.09276	0.181780164
Landcover Type		Area(m^2)	% Total Area
Number	Classification		
3	Developed, Medium Intensity	3124.415643	0.000216926
4	Developed, Low Intensity	66563.39974	0.004621451
5	Developed, Open Space	75759.40023	0.005259923
6	Cultivated Crops	4442.287231	0.000308425
7	Pasture/Hay	756.4703658	5.25212E-05
8	Grassland/ Herbaceous	79505.3729	0.005520004
9	Deciduous Forest	9073.862383	0.000629992
10	Evergreen Forest	2206603.785	0.153202987
11	Mixed Forest	403619.3973	0.028023018
12	Scrub/Shrub	4487945.785	0.311594997
13	Palustrine Forested Wetland	1393.728513	9.67656E-05
14	Palustrine Scrub/Shurb Wetland	378.3450774	2.62682E-05
20	Barren Land	6434.192517	0.000446722
West Fork Area	7345600.443		

Table 2 – Land Cover of Devil's Canyon West Fork

<u>East Fork</u>

East Fork			
High Elev.	Low Elev.	Length(m)	Slope
1050	650	3654.382919	0.109457604
Landcover Type		Area(m^2)	% Total Area
Number	Classification		
3	Developed, Medium Intensity	3001.88954	0.000208419
4	Developed, Low Intensity	63953.07034	0.004440218
5	Developed, Open Space	72788.44335	0.005053652
6	Cultivated Crops	4268.079888	0.00029633
7	Pasture/Hay	726.8048612	5.04616E-05
8	Grassland/ Herbaceous	76387.51514	0.005303533
9	Deciduous Forest	8718.024642	0.000605286
10	Evergreen Forest	2120070.303	0.147195027
11	Mixed Forest	387791.1857	0.026924076
12	Scrub/Shrub	4311947.911	0.299375586
13	Palustrine Forested Wetland	1339.072492	9.29709E-05
14	Palustrine Scrub/Shurb Wetland	363.5080156	2.52381E-05
20	Barren Land	6181.871241	0.000429203
East Fork Area	7057537.68		

Table 3 – Land Cover of Devil's Canyon East Fork

From these tables, it can be seen that the most abundant land coverage is Scrub/Shrub, followed by Evergreen Forest. These land cover types make sense since the area being analyzed is a mountainous area.

3 Methods

The hydrological method used for this lab, as stated in the introduction, was HEC-HMS. This method provides a variety of options for simulating precipitation-runoff processes. Development of the HEC-HMS model for a watershed requires several steps. These include:

1) Basin Model Development

2) Meteorological Model Development

3) Running Simulations (with given data and values)

4) Refining or tuning the model simulations against observed (collected) data

The current version, and previous versions, of HEC-HMS, 4.0, can be downloaded from: http://www.hec.usace.army.mil/software/hec-hms/downloads.aspx

When using HEC-HMS, there are four sub-categories listed under the overall project. The first is Basin Model. Here, a digital model of the watershed is created. Figure 19 shows what the actual watershed looks like, Figure 20 is the watershed created using HEC-HMS. As the image shows, there are two sub-basins: West Fork and East Fork, one Junction: DC, a Reach and an Outlet. Each of these items has its own parameters that affect the data once the tests are run. West and East Fork take in parameters such as Baseflow, Initial Abstraction, Curve Number, % Impervious, and lag time, all of which will, when manipulated, will change the look of the Flow vs. Time graph (ref. Figures 21 and 24). The Loss Method was SCS Curve Number., and the Transform Method was SCS Unit Hydrograph.

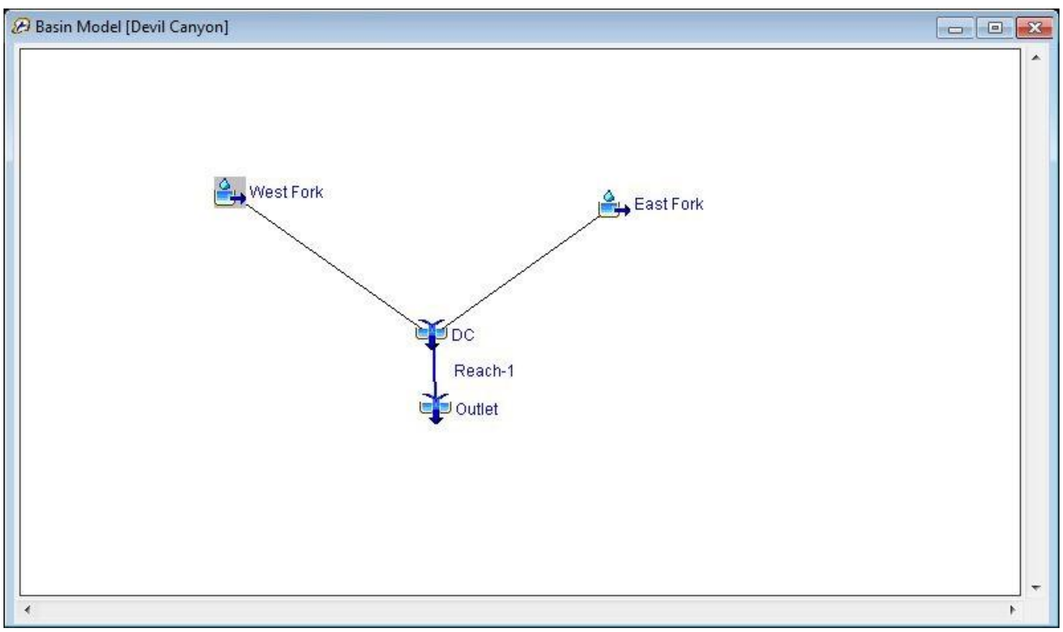


Figure 20 – HEC-HMS Representation of the Devil Canyon Watershed

The Time-Series Model is consists of Precipitation and Discharge Gages. This is where the data from the ARCGIS software will go. It tells HEC-HMS what the precipitation and discharge values are for every day out of each year that data was collected for. Specific time windows can be given for these sets of data. The Meteorological Models section refers to the hyetographs used in the watershed. The overall basin model in this case was Devil Canyon, while the Specified Hyetographs are East and West Fork. The Control Specifications Sections are where the data being used for each Control group is defined. For Control 1, the dates December 4th – 16th, 1997 are used at an interval of one day. For Control 2, the dates February 23rd – March 5th, 2001 are used at an interval of one day as well. With these values defined, a proper graph, time-series table and summary table can be created using the Create Simulation Run function.

The data that was used in the HEC-HMS program came from many different sources. The discharge data came from USGS.gov, and was input manually, but it was easily accessible thanks to ARCGIS. The precipitation data came from http://www.sbcounty.gov/dpw/floodcontrol/water_resources.asp, and was also entered manually. This data was especially important because without it, there would be no way to see how storms act in the watershed. Entering this data correctly was critical because if one number was out of place, it would take a very long time to go back and fix the mistake. The land use or land cover types came from www.csc.noaa.gov/lancover, which lists all the types of land cover that can be encountered in any area.

ARCGIS was the tool used to obtain the curve number, length of the watershed, slope, and other parameters. This program was able to determine all of that information by moving the mouse from one point to another, and analyzing the two points against each other.

4 Results

The following tables represent the values of certain parameters before and after the calibration of the control groups. As you can see, in the before and after figures of the graphs (Fig. 21, 24, 27, 30) the change parameters made it to where the observed data and the calculated data matched up with one another as best as possible. By changing the Baseflow, the initial flow of the graphs, the y-axis, was able to match up. By changing the % impervious, CN and Initial Abstraction, the height of the curves changed. And by manipulation the lag time, the time was able to be changed, the x-axis.

Control 1		
	Initial Values	Final Values
CN	70	30
% Impervious	1	2.3
Initial Abstraction	0.5	1.85
Baseflow:		
West Fork	0.836	0.45
East Fork	0.836	0.45

Table 4 – Control 1 Data Before and After Calibration

Control 2		
	Initial Values	Final Values
CN	70	30
% Impervious	1	4.5
Initial Abstraction	0.5	3
Baseflow:		
West Fork	0.836	3.15
East Fork	0.836	3.15

Table 5 – Control 2 Data Before and After Calibration

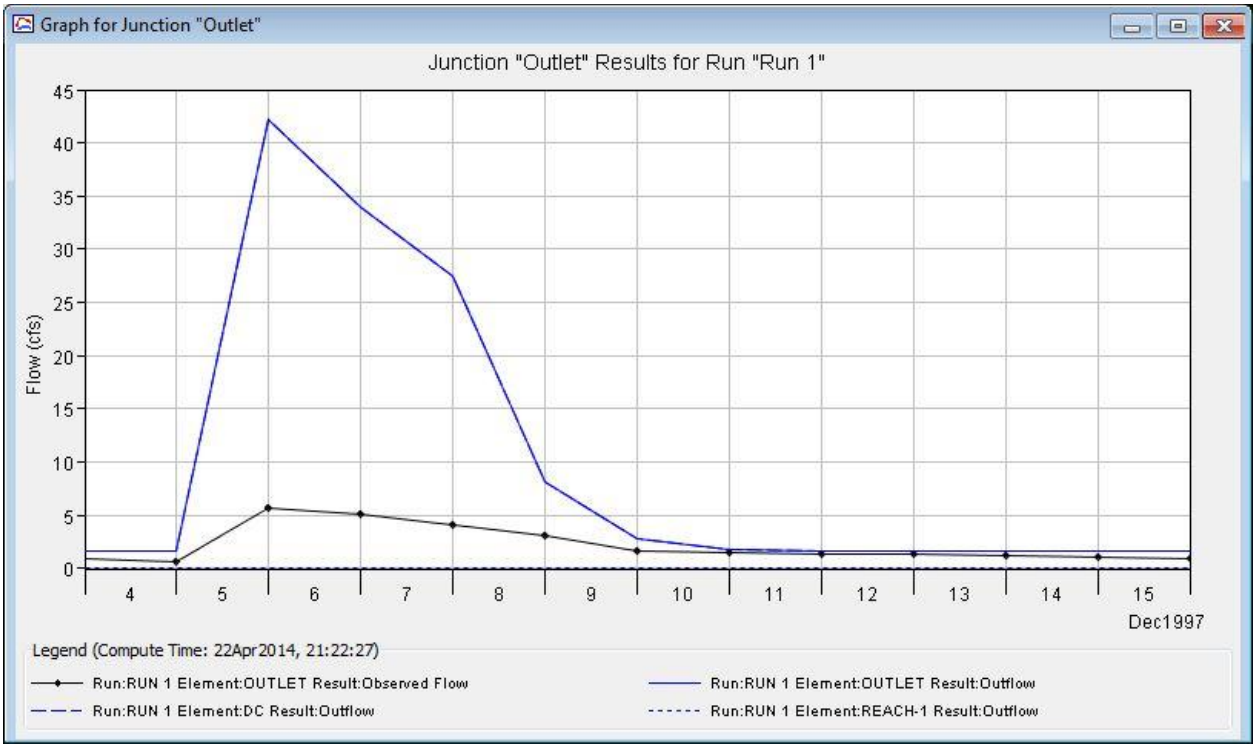


Figure 21 – Graph of Initial Control 1 Values

Time-Series Results for Junction "Outlet"

Project: Devile Canyon
Simulation Run: Run 1   Junction: Outlet

Start of Run: 04Dec1997, 00:00   Basin Model: Devil Canyon
End of Run: 16Dec1997, 00:00   Meteorologic Model: DC
Compute Time: 22Apr2014, 21:22:27   Control Specifications: Control 1

Date	Time	Inflow from... (CFS)	Inflow from... (CFS)	Outflow (CFS)	Obs Flow (CFS)
04Dec1997	00:00	1.7	0.0	1.7	0.9
05Dec1997	00:00	1.7	0.0	1.7	0.7
06Dec1997	00:00	42.2	0.0	42.2	5.7
07Dec1997	00:00	34.0	0.0	34.0	5.1
08Dec1997	00:00	27.4	0.0	27.4	4.1
09Dec1997	00:00	8.2	0.0	8.2	3.1
10Dec1997	00:00	2.9	0.0	2.9	1.6
11Dec1997	00:00	1.9	0.0	1.9	1.5
12Dec1997	00:00	1.7	0.0	1.7	1.4
13Dec1997	00:00	1.7	0.0	1.7	1.3
14Dec1997	00:00	1.7	0.0	1.7	1.2
15Dec1997	00:00	1.7	0.0	1.7	1.1
16Dec1997	00:00	1.7	0.0	1.7	1.0

Summary Results for Junction "Outlet"

Project: Devile Canyon
Simulation Run: Run 1   Junction: Outlet

Start of Run: 04Dec1997, 00:00   Basin Model: Devil Canyon
End of Run: 16Dec1997, 00:00   Meteorologic Model: DC
Compute Time: 22Apr2014, 21:22:27   Control Specifications: Control 1

Volume Units: IN   AC-FT

Computed Results

Peak Outflow : 42.2 (CFS)   Date/Time of Peak Outflow : 06Dec1997, 00:00
Total Outflow : 0.86 (IN)

Observed Hydrograph at Gage DC

Peak Discharge : 5.70 (CFS)   Date/Time of Peak Discharge : 06Dec1997, 00:00
Avg Abs Residual : 7.67 (CFS)
Total Residual : 0.67 (IN)   Total Obs Q : 0.19 (IN)

Figure 22 – Control 1 Initial Time-Series   *Figure 23 – Control 1 Initial Summary Table*

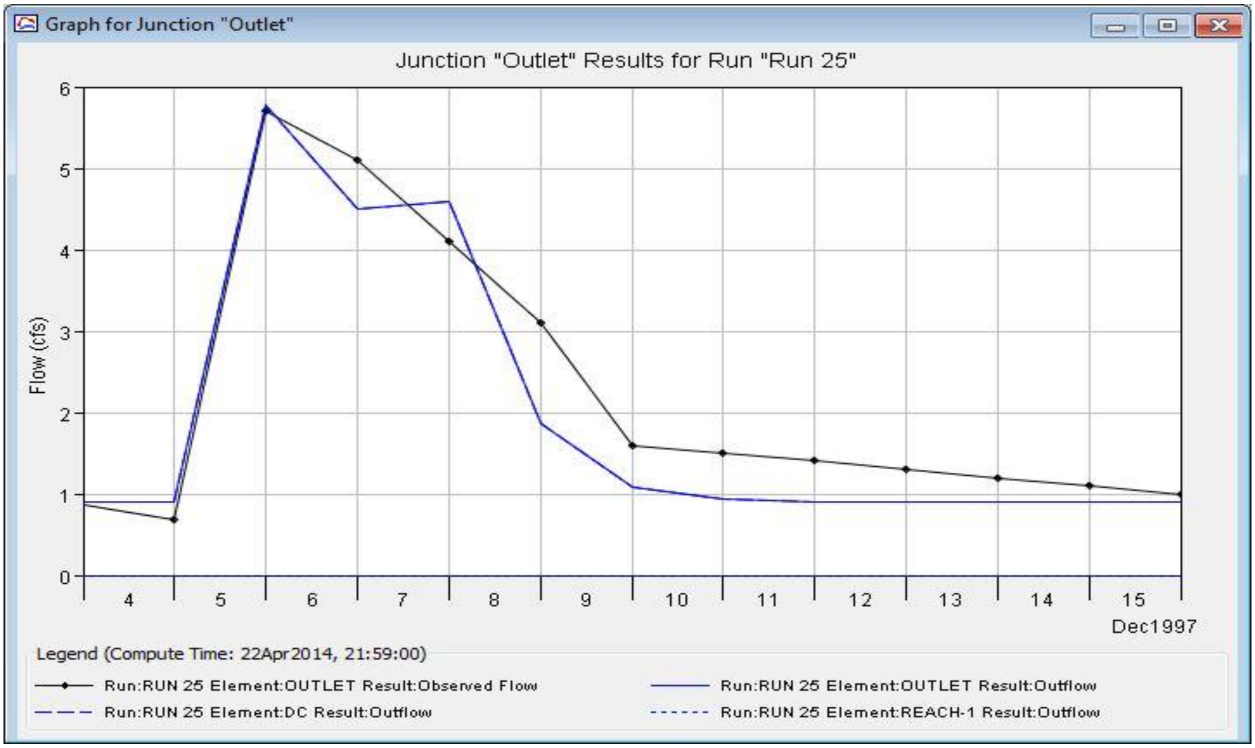
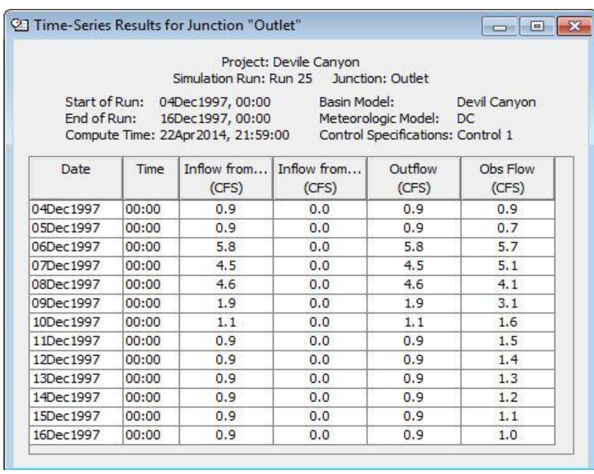


Figure 24 – Graph of Final Control 1 Values



Time-Series Results for Junction "Outlet"

Project: Devile Canyon
Simulation Run: Run 25 Junction: Outlet

Start of Run: 04Dec1997, 00:00 Basin Model: Devil Canyon
End of Run: 16Dec1997, 00:00 Meteorologic Model: DC
Compute Time: 22Apr2014, 21:59:00 Control Specifications: Control 1

Date	Time	Inflow from... (CFS)	Inflow from... (CFS)	Outflow (CFS)	Obs Flow (CFS)
04Dec1997	00:00	0.9	0.0	0.9	0.9
05Dec1997	00:00	0.9	0.0	0.9	0.7
06Dec1997	00:00	5.8	0.0	5.8	5.7
07Dec1997	00:00	4.5	0.0	4.5	5.1
08Dec1997	00:00	4.6	0.0	4.6	4.1
09Dec1997	00:00	1.9	0.0	1.9	3.1
10Dec1997	00:00	1.1	0.0	1.1	1.6
11Dec1997	00:00	0.9	0.0	0.9	1.5
12Dec1997	00:00	0.9	0.0	0.9	1.4
13Dec1997	00:00	0.9	0.0	0.9	1.3
14Dec1997	00:00	0.9	0.0	0.9	1.2
15Dec1997	00:00	0.9	0.0	0.9	1.1
16Dec1997	00:00	0.9	0.0	0.9	1.0

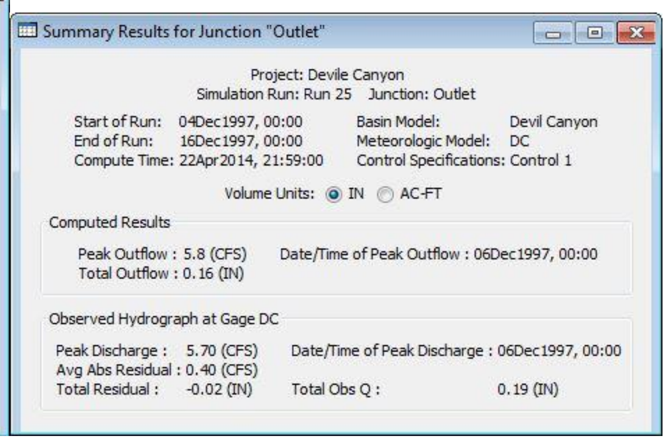


Figure 25 – Control 1 Final Time-Series Table

Figure 26 – Control 1 Final Summary

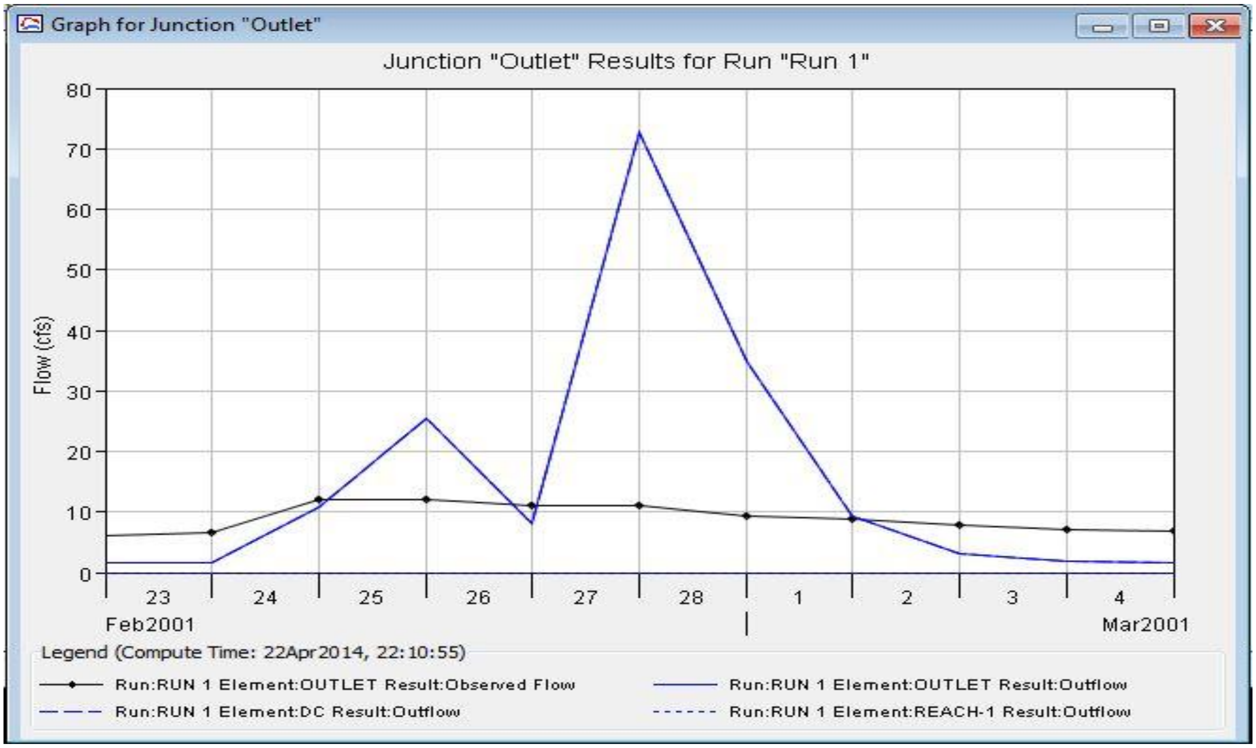


Figure 27 – Graph of Initial Control 2 Values

Time-Series Results for Junction "Outlet"

Project: Devile Canyon
Simulation Run: Run 1 Junction: Outlet

Start of Run: 23Feb2001, 00:00 Basin Model: Devil Canyon
End of Run: 05Mar2001, 00:00 Meteorologic Model: DC
Compute Time: 22Apr2014, 22:10:55 Control Specifications: Control 2

Date	Time	Inflow from... (CFS)	Inflow from... (CFS)	Outflow (CFS)	Obs Flow (CFS)
23Feb2001	00:00	1.7	0.0	1.7	6.2
24Feb2001	00:00	1.7	0.0	1.7	6.6
25Feb2001	00:00	10.9	0.0	10.9	12.0
26Feb2001	00:00	25.5	0.0	25.5	12.0
27Feb2001	00:00	8.1	0.0	8.1	11.0
28Feb2001	00:00	72.7	0.0	72.7	11.0
01Mar2001	00:00	34.9	0.0	34.9	9.3
02Mar2001	00:00	9.3	0.0	9.3	8.7
03Mar2001	00:00	3.2	0.0	3.2	7.9
04Mar2001	00:00	1.8	0.0	1.8	7.2
05Mar2001	00:00	1.7	0.0	1.7	6.8

Summary Results for Junction "Outlet"

Project: Devile Canyon
Simulation Run: Run 1 Junction: Outlet

Start of Run: 23Feb2001, 00:00 Basin Model: Devil Canyon
End of Run: 05Mar2001, 00:00 Meteorologic Model: DC
Compute Time: 22Apr2014, 22:10:55 Control Specifications: Control 2

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 72.7 (CFS) Date/Time of Peak Outflow : 28Feb2001, 00:00
Total Outflow : 1.15 (IN)

Observed Hydrograph at Gage DC

Peak Discharge : 12.00 (CFS) Date/Time of Peak Discharge : 25Feb2001, 00:00
Avg Abs Residual : 11.81 (CFS)
Total Residual : 0.52 (IN) Total Obs Q : 0.62 (IN)

Figure 28 – Control 2 Initial Time-Series *Figure 29 – Control 2 Initial Summary Table*

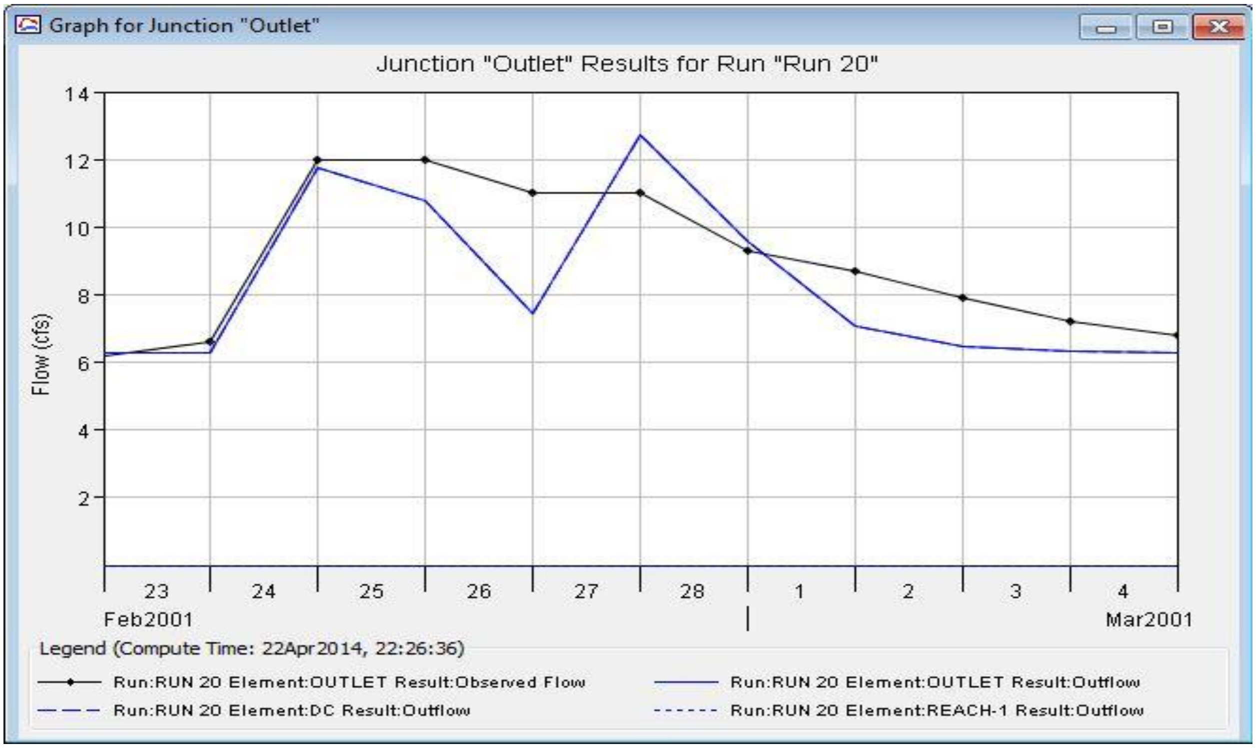
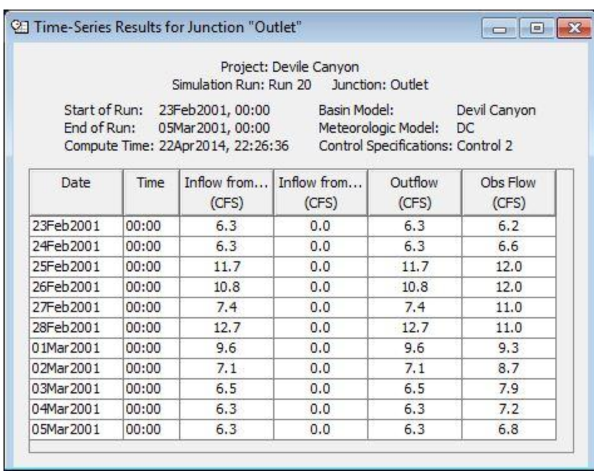


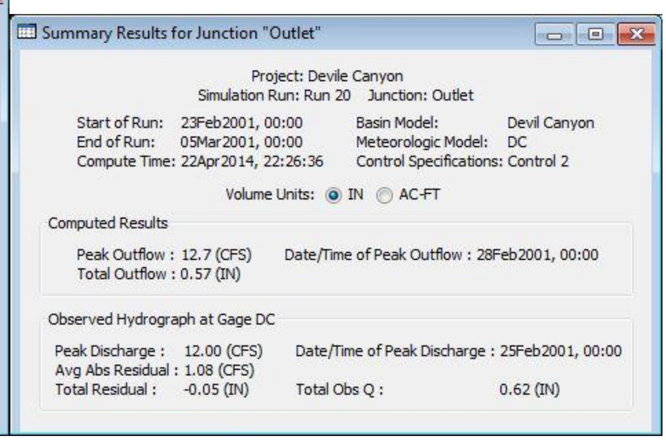
Figure 30 – Graph of Final Control 2 Values


Time-Series Results for Junction "Outlet"

Project: Devile Canyon
Simulation Run: Run 20 Junction: Outlet

Start of Run: 23Feb2001, 00:00 Basin Model: Devil Canyon
End of Run: 05Mar2001, 00:00 Meteorologic Model: DC
Compute Time: 22Apr2014, 22:26:36 Control Specifications: Control 2

Date	Time	Inflow from... (CFS)	Inflow from... (CFS)	Outflow (CFS)	Obs Flow (CFS)
23Feb2001	00:00	6.3	0.0	6.3	6.2
24Feb2001	00:00	6.3	0.0	6.3	6.6
25Feb2001	00:00	11.7	0.0	11.7	12.0
26Feb2001	00:00	10.8	0.0	10.8	12.0
27Feb2001	00:00	7.4	0.0	7.4	11.0
28Feb2001	00:00	12.7	0.0	12.7	11.0
01Mar2001	00:00	9.6	0.0	9.6	9.3
02Mar2001	00:00	7.1	0.0	7.1	8.7
03Mar2001	00:00	6.5	0.0	6.5	7.9
04Mar2001	00:00	6.3	0.0	6.3	7.2
05Mar2001	00:00	6.3	0.0	6.3	6.8


Summary Results for Junction "Outlet"

Project: Devile Canyon
Simulation Run: Run 20 Junction: Outlet

Start of Run: 23Feb2001, 00:00 Basin Model: Devil Canyon
End of Run: 05Mar2001, 00:00 Meteorologic Model: DC
Compute Time: 22Apr2014, 22:26:36 Control Specifications: Control 2

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 12.7 (CFS) Date/Time of Peak Outflow : 28Feb2001, 00:00
Total Outflow : 0.57 (IN)

Observed Hydrograph at Gage DC

Peak Discharge : 12.00 (CFS) Date/Time of Peak Discharge : 25Feb2001, 00:00
Avg Abs Residual : 1.08 (CFS)
Total Residual : -0.05 (IN) Total Obs Q : 0.62 (IN)

Figure 31 – Control 2 Final Time-Series *Figure 32 – Control 2 Final Summary Table*

5 Discussion

When looking at the parameters in the figures and tables in section 4, it can be seen that the values are pretty reasonable. By changing things like the Baseflow and Initial Abstraction, the graphs were able to match up quite well, and the numbers make sense. The Peak flows of each control are only off by a few tenths. Although, for Control 2, the peak flows occur at different times. This is expected though because we are comparing actual data to calculated data, which can sometimes be misleading. The fact that the peaks are close shows that the data is good enough to use when predicting how a storm will affect the area in question.

6 Conclusion

I believe that my model is precise. When looking at the calculated data, it may not match up perfectly with the actual data, but it is consistent enough to be used by an engineer who is looking for information on the Devil’s Canyon site. Because the data in the summary tables is only off by a little bit more than .2, I can say that it is not very accurate. Accuracy and precision are very different categories, and I believe that my data can be used when wanting to look for something precise about the watershed.

To improve next time, I would look at the data more closely. I was able to grasp the basics of hydrologic modeling, but now with a better understanding of how the software works, and knowing which parameters can be manipulated to get the desired results, I feel as though I could take another watershed and complete a hydrologic model for that area.