

## *Integrating HEC HMS generated flow hydrographs with FLO-2D*

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# Focus of this Presentation

- Introduction
- Methodology
- Challenges & Solutions
- Cost Effectiveness
- Conclusion
- Q & A

# Introduction

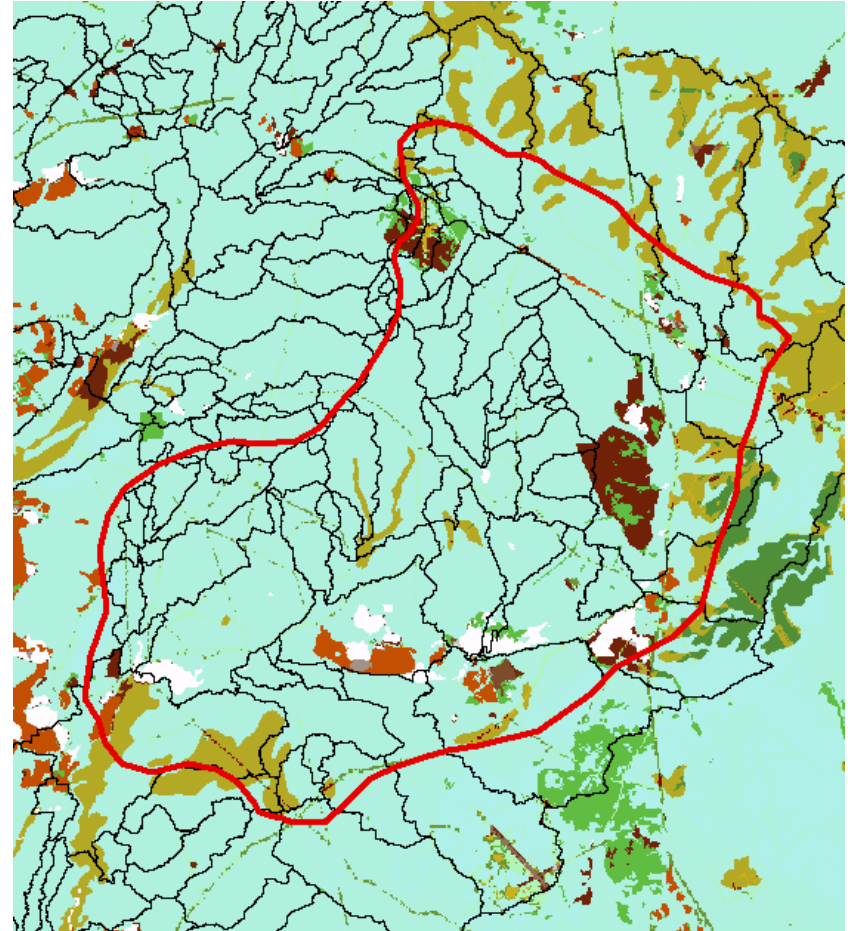
- Study Area – New Jersey
  - 420 Sq. Mi., 320 miles of study scope
  - Northern portion of study area - Moderate to Steep slope
  - Southern portion – Flat terrain
  - 2D model proposed to accommodate wide floodplains
  - 3 HMS models and 20 FLO-2D models
- Selection of Hydrology Method
  - Regression Analysis
    - Constant Hydrograph
  - FLO-2D
    - Rain on Grid approach - Not approved for Hydrology by FEMA yet.

# Introduction

- Selection of Hydrology Method
  - Rainfall –Runoff Model
    - Adequately produces stream flow hydrographs that represent the physical characteristics of the watershed
    - Applicable in the areas of significant floodplain storage
    - Used HEC-HMS version 4.0
    - Subbasin flow hydrographs

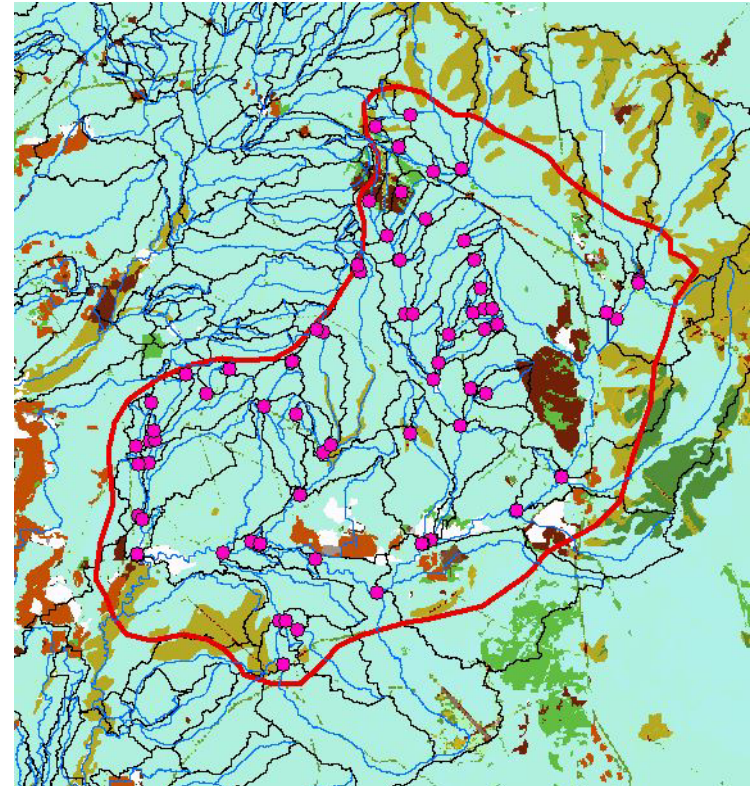
# Methodology

- Hydrology
  - Watershed Delineation
    - Streams with moderate to steep slopes – USGS 10m DEM
    - Flat Streams – 2 m LiDAR
  - Precipitation
    - Frequency Storm method – NOAA Atlas 14
  - Infiltration/Loss Method
    - Curve Number from SSURGO and 2011 NLCD dataset
  - Lag Time
    - Watershed Lag method



# Methodology

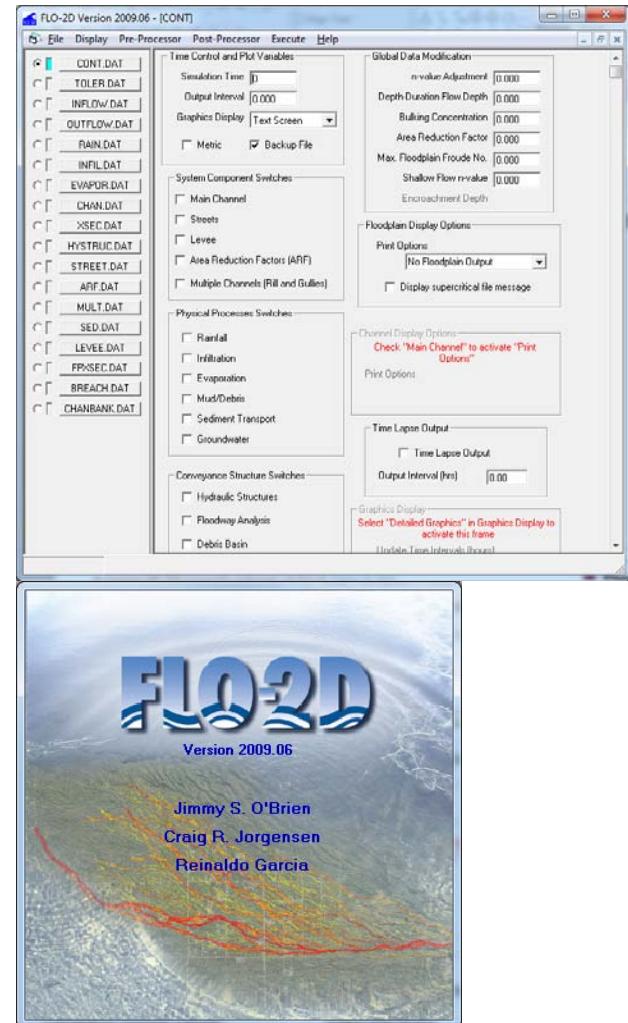
- Hydrology
  - Channel Routing
    - Attained through FLO-2D
  - Comparison
    - Regression Equation Discharges – Headwater Basins
  - Discharges
    - Hydrographs for each sub basin generated





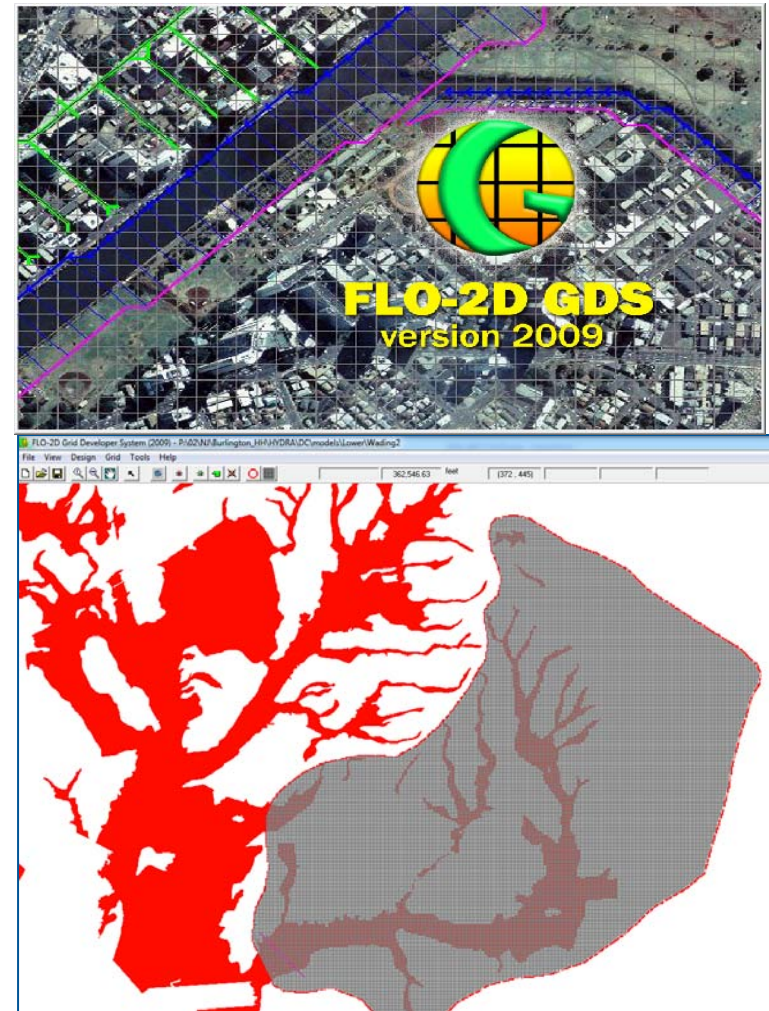
# Methodology

- Hydraulics
  - FLO-2D
    - Volume conservation flood routing model
    - Routes rainfall-runoff and flood hydrographs over unconfined flow surfaces or in channels
    - Governing equations are the continuity equation and the equation of motion
    - Moves blocks of volume around on the grid system in eight directions



# Methodology

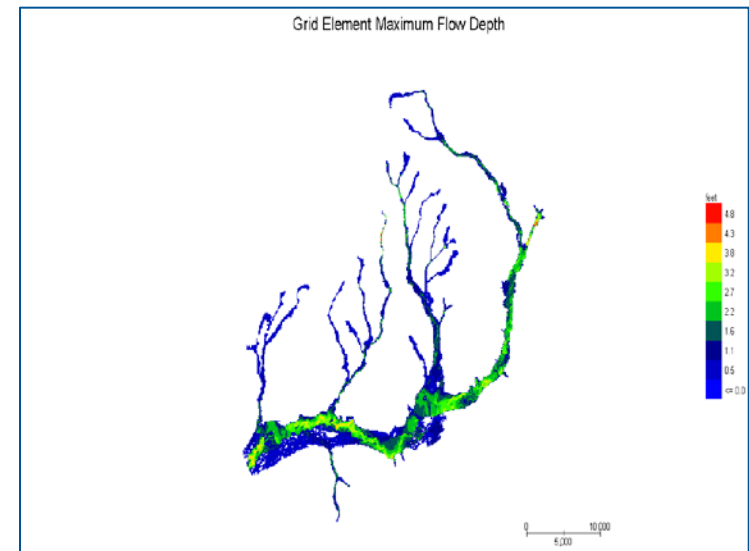
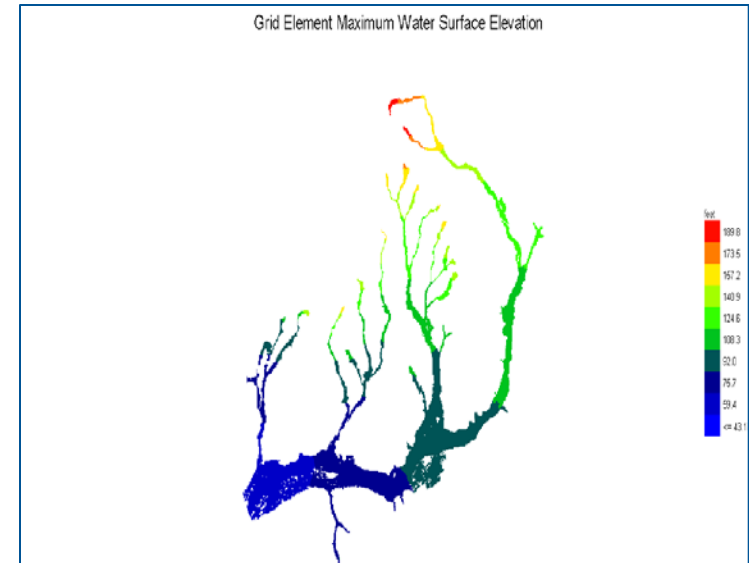
- Hydraulics
  - FLO-2D
    - Grid Developer System (GDS)
      - Pre-processor program –  
Overlays the grid system on the  
DTM points, interpolates and  
assign elevations to the grid  
elements
      - Roughness, Inflow & Outflow  
nodes, Area and width reduction  
factors.
      - Prepares the basic input files for  
the FLO-2D model
      - Grid Element Size of 50 feet –  
100 feet





# Methodology

- Hydraulics
  - FLO2D
    - MAPPER
      - Primary program for displaying results
      - Creates Ground Elevation, & Water Surface Elevation and Flood Depth maps
      - Creates an approximate Area of Inundation layer
      - Floodplain Delineation based on detailed topo data – ArcGIS methods work best



# Challenges & Solutions

## 1) Challenge

*Grid Developer System – Long Loading times due to detailed topo data and roughness data*

## Solution

- Used the 100 feet grid from GDS in ArcGIS – Extracted elevation and manning's n values using Zonal Statistics
- Used 'R' (a programming language) scripts to write the elevation & manning's n values into FPLAIN.DAT file, an input file for FLO-2D

The screenshot shows the RStudio interface. The main editor window contains an R script with the following code:

```
1 # @DESCRIPTION
2 #
3 # Overview: populate interpolated elevation & friction attributes to FPLAIN.DAT
4 #
5 # 1. Convert #PLAIN.DAT to .txt, save to WD
6 # 2. Save attributes.txt to WD
7 # 3. Set null values for manning's n & Elevation
8 # 4. Set WD, verify file names & run the script
9 #
10 # Author: a.law@arbore.com
11 # 6/23/2015
12
13
14 #---Set working directory & look inside
15 setwd("C:/Burlington/HH/DC/models/Lower/Wading2/FPLAIN")
16 list.files()
17
18 #---Load data
19 input <- read.table("FPLAIN.TXT", header=FALSE, sep = "")
20 attr <- read.table("attributes.txt", header = TRUE, sep = "\t")
21 nullElev <- 500
22 nullMann <- 0.04
23
24 #---Load Packages
25 library("sp")
26
27 # End of script
```

The console window on the right shows the R version (3.2.1) and copyright information for the R Foundation for Statistical Computing. The Environment pane at the bottom shows the user library and system library.

The screenshot shows a Notepad++ window with the following data in the FPLAIN.DAT file:

1	1	2	12	0	0	0.046999	52.559051
2	2	3	13	1	0	0.119999	53.362545
3	3	4	14	2	0	0.119999	53.483013
4	4	5	15	3	0	0.119999	53.711936
5	5	6	16	4	0	0.119999	54.073703
6	6	7	17	5	0	0.119999	54.46062
7	7	8	18	6	0	0.119999	55.000034
8	8	9	19	7	0	0.119999	55.697353
9	9	0	20	8	0	0.119999	57.248592
10	10	11	32	0	0	0.1	51.30548
11	11	12	33	10	0	0.1	51.437316
12	12	13	34	11	1	0.084937	51.490936
13	13	14	35	12	2	0.0665	52.041839
14	14	15	36	13	3	0.119999	52.068244
15	15	16	37	14	4	0.119999	52.37973
16	16	17	38	15	5	0.119999	52.852245
17	17	18	39	16	6	0.119999	53.300197
18	18	19	40	17	7	0.119999	53.677967
19	19	20	41	18	8	0.119999	54.456546
20	20	21	42	19	9	0.119999	55.557136

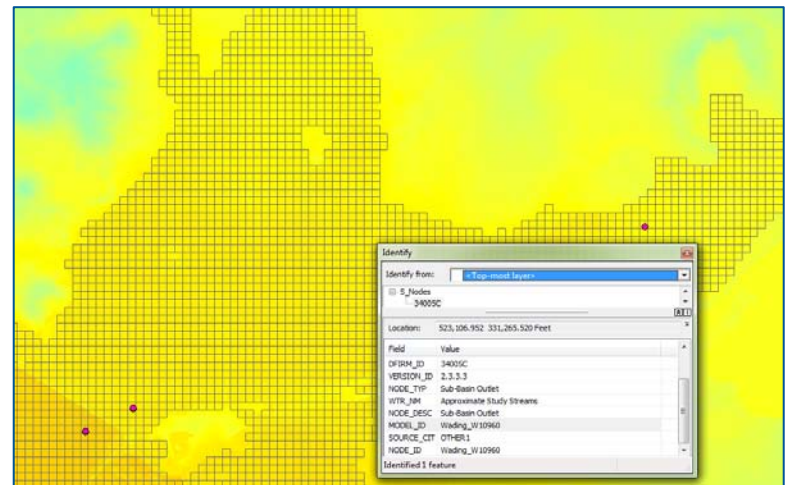
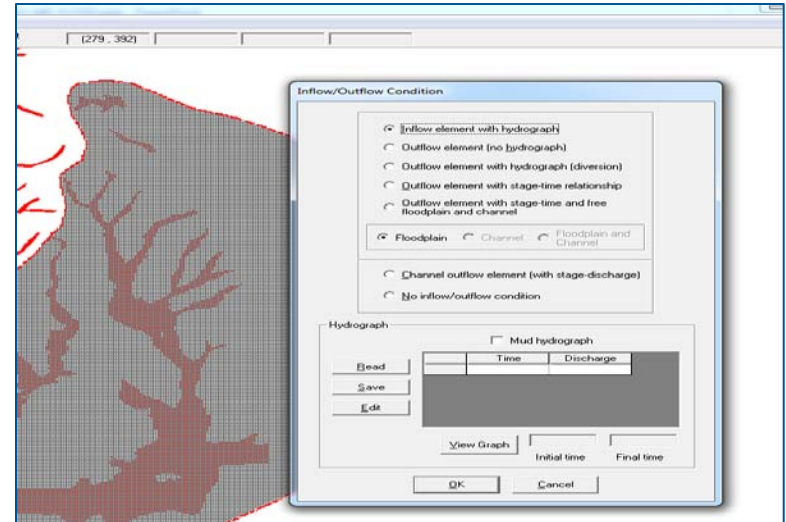
# Challenges & Solutions

## 2) Challenge

*Inflow nodes – Laborious process to get the outflow hydrograph from HEC-HMS and input into the GDS – more than 600 flow change locations*

## Solution

- Used HEC-DSSVue to export all the hydrographs into a spreadsheet.
- Linked the flow change points spatial file and grid spatial file
- Used 'R' scripts to extract specific hydrographs for each point and write them into INFLOW.DAT file



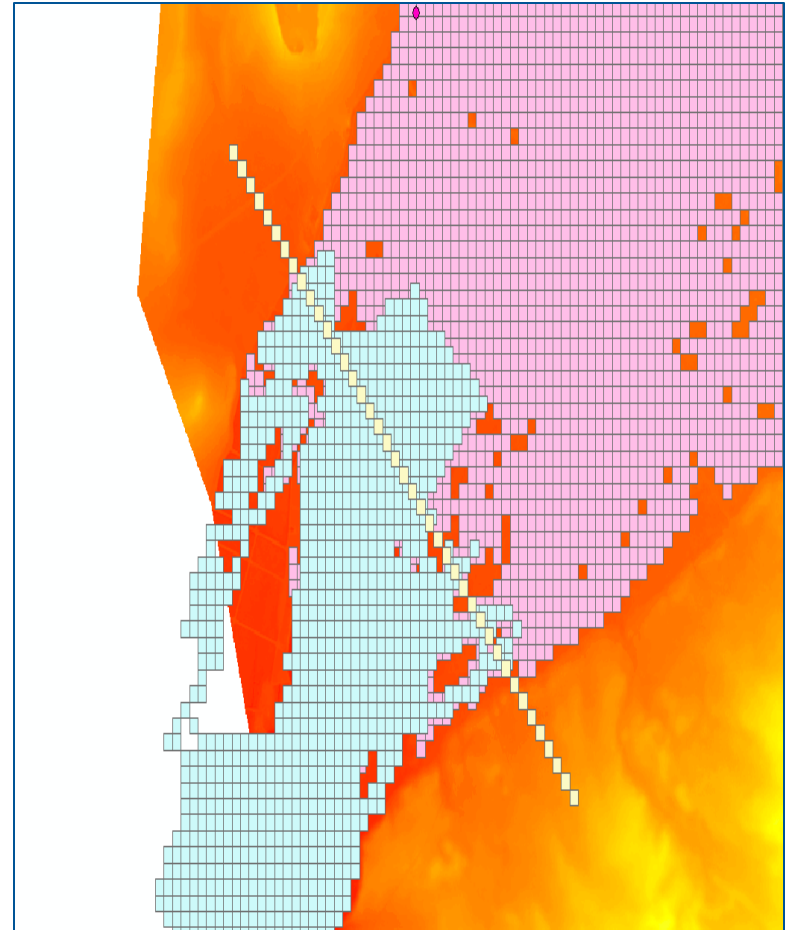
# Challenges & Solutions

## 3) Challenge

*Handoff Points – To reduce computation times, study area was divided into multiple models – Outflow hydrograph of U/S becomes inflow hydrograph of D/S model*

## Solution

- FPXSEC.DAT identifies grid cells where the user wants flow computations
- Read the CROSSQ.OUT (output files) from the U/S model run – Identify grid cells that are intersecting from D/S model
- Used 'R' scripts to extract specific hydrographs for each grid cell and write them into INFLOW.DAT file for the D/S model



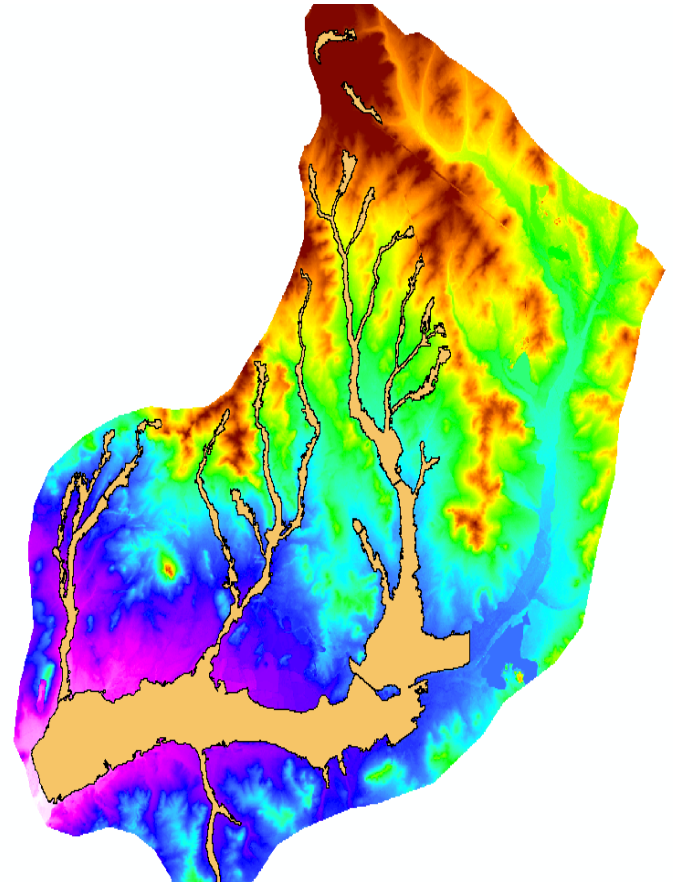
# Challenges & Solutions

## 4) Challenge

*Floodplain Mapping – Extremely time consuming in FLO-2D to delineate floodplain based on high resolution LiDAR data. Example: 5 feet LiDAR based raster*

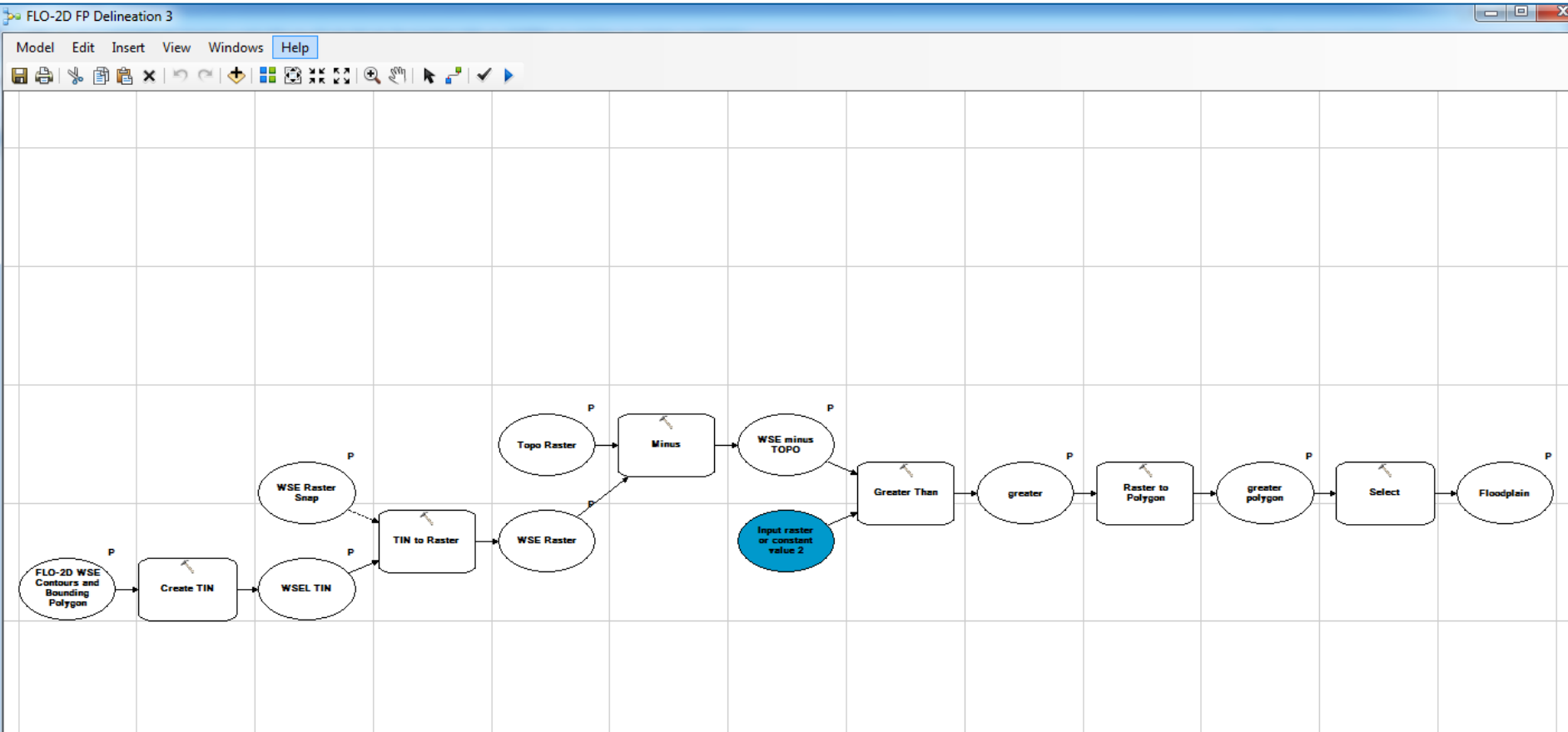
## Solution

- Used ArcGIS to develop the work flow to delineate floodplains.
- Flood Depth at each grid cell is used
- Model builder is to used to reduce any redundancies





# Challenges & Solutions



# Cost Effectiveness

- Cost/Time matched the 1-D HECRAS approach.
- Cost includes learning time, overcoming challenges (script development)
- Next application of this method (HEC-HMS/FLO-D) – 75% of the 1-D HECRAS approach.

# Conclusion

- Integrating HEC-HMS results into FLO-2D is a challenging process, if FLO-2D's GUI (2009 version) is solely used
- Process Improvements such as R scripts to reduce computation times do help.
- Rain-on-Grid approach i.e., generating the flood hydrograph at a specific location by modeling the rainfall-runoff in FLO-2D might be an approach that needs consideration
- With HEC-RAS 2D on the horizon, it needs to be seen how cost effective FLO-2D can still be.



# Questions?