# 2-Dimensional Model Challenges
# Floodplain Management Association

**MODEL** **Challenge 1 – Urban Riverine**

1. **Challenge Description Brief:**

   Challenge Model 1 represents an urban Riverine condition with an urbanized overbank floodplain. The model includes several hydraulic structures/bridges within the main stream system which will impact flood elevations. Flooding within the urbanized overbank floodplain is expected.

   Data for this model is provided via ZIP compressed file posted on the internet/FTP for download.

2. **Datum Notes** – The original data for this analysis has been modified from its original datum and original elevations have been altered and corrupted such that the data would not be usable for real world modeling, analysis and mapping. Datum data has been stripped from the files provided. A combination of statute (ft) and metric (m) data is provided in the challenge data. Analysis may be performed in metric or Statute units, however all returned data shall be delivered to FMA in Statute (ft) units. Additionally, some of the provided data indicates vertical Datums 29 and 88. We have verified all data provided is in the same vertical datum and for this model challenge assume that is the vertical datum "FMA 12".

3. **Instructions To Modelers**

   - Assignment of all parameters for this analysis are at the discretion of the modeler. A high resolution aerial image is provided so that land cover details can be inspected. Several stream photographs and structure photographs are also provided. Several Data sets are also provided to assist the modeler in determining model parameters. A starting set of overland N-Values is provided in the land use data set, however, the modeler can modify these as needed.
   - Terrain data is provided in elevation contours. Depending on the system the modeler will use to create terrain data for their model, the modelers may need to add supplemental break line data to these contours to obtain a more accurate model in the overbank floodplain, which demonstrates valid flow and storage paths/volumes.
   - The modeler is to assume that the terrain data provided represents the ground conditions at the time the runoff event occurs, and that the ground conditions will not change during the event. Terrain data is provided in DEM data file formats.
   - The Inflow Hydrograph for the main stream and tributary are provided in the EXCEL spreadsheet contained in the "INFLOWS" directory. The inflows are referenced to CHAINAGE locations along the creek (matching survey cross section CHAINAGE).
   - Previous studies indicate that backwater conditions at the mouth of the discharge of this stream into the larger downstream river do not extend more than a couple hundred feet into this stream. For the purposes of this model, assume the stream freely discharges into the downstream river.

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

- There are no accredited levees within the model domain.
- In the case that standards and specifications need to be referenced, please refer to FEMA guidelines, assuming the event described in this challenge represents the 100-year event. (Except, you are not limited by FEMA's approved software list, and may use any software you have available for the numerical analysis of this Challenge)
- Depth grids should be developed based on the provided "Appendix N - Flood Risk Data Development and Analysis (Public Review).pdf" guidelines. The modeler will determine an appropriate grid size.

4. **Deliverables:** Deliverables will be due to be electronically delivered to FMA prior to end of business on August 24th, 2012. All parties(individuals, agency representatives, private parties and corporations) are welcome to submit challenge model results to FMA that they performed themselves. The Modeling Challenge results received from participating modelers will be presented at the September 4, 2012 Modeling Symposium (Sacramento). FMA will preserve the anonymity of modelers who are providing information in response to this Modeling Challenge, and will therefore compile and present at this Symposium such information on an anonymous basis for the purpose of showing variability in results. All parties submitting challenge models will be acknowledged in the symposium program separately.

    - Please provide a shape file (contents including areas) mapping the maximum extent of floodplain which occurred in your simulation.
    - Depth Grid for Maximum Flood Elevations (Parameters: (Filetype: Shapefile Elevation/Depth attributed Area Type)
    - Outflow Hydrograph of The Urban stream at the downstream confluence. (Excel)
    - Flow Profile along Stream for Maximum Flood Elevation (Excel – Statute Units please)

5. **Enjoy!:** While there are serious reasons behind FMA presenting these modeling challenges, and we do hope modelers will take them seriously, FMA would also like this to be an enjoyable experience for all of those that choose to participate.

6. **Questions and Contact Information:** Question and Answers on the Challenge models are being addressed in a public forum format at the following link: http://www.floodplain.org/pages/floodplain-modeling-forum. Representatives from FMA, FEMA and other interested parties are monitoring and responding to postings made in the challenge forums. If you really need a quick answer to a question, or find a mistake in the data, you can email us at 2-DSymposium@floodplain.org.

7. **CONDITIONS FOR PARTICIPATION IN THE MODELING CHALLENGE**
By submitting any information to FMA in response to the Modeling Challenge, I agree to all of the following:

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

**INTELLECTUAL PROPERTY RELEASE**
I give permission to FMA (including all FMA officers, directors, employees, volunteers and contractors) to publish, distribute and/or present information I provide in response to the Modeling Challenge free of charge, and copies may be distributed worldwide, in perpetuity, in whole or in part, in any form of media, without compensation to me.

**LIABILITY RELEASE**
I agree to indemnify and hold harmless FMA (including all FMA officers, directors, employees, volunteers and contractors) of and from any and all claims, demands, losses, causes of action, damage, lawsuits, judgments, including attorneys' fees and costs associated with these, in connection with the use, publication, distribution and/or presentation of information I provide as part of the Modeling Challenge or part of the September 4 2012 2-D Modeling Symposium activities.

8. **Methods/Software allowed:** There are no restrictions, you may use any means you have available to perform these challenges.

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

# Model Submittal Questionnaire – Challenge 1

Modeler Name/Agency: Phillip Ryan and Bill Syme / BMT WBM (TUFLOW Software)
Data Prepared Date: 23/08/2012

☑ I agree to keep any data I received for this Challenge Model Confidential

☑ I agree to comply with the Conditions for Participation in this Challenge Model

☑ I would be willing to provide my model data to FMA in the future for additional review (Confidentially) (Not required)

Contact me for this information @: Bill Syme or Phillip Ryan at support@tuflow.com

**Challenge 1 Model Information:**

SELECT THE MODEL TYPES USED IN YOUR ANALYSIS (select more than one if applicable to your analysis and describe as needed in space below)

☐ 1-D Network ☐ 1-D Cross Sections ☐ 2-D GRID ☐ 2-D MESH

☐ 3-D ☑ Coupled 1-D/2-D ☐ OTHER____________________

Indicate the cross section spacing, grid size, mesh element size characteristics of your computational domain. Explain if the effects of Hydraulic Structures were modeled, How was that performed?:

The modeling approach represented the in-bank area with 1D elements dynamically linked to a 2D grid domain to represent the overbank floodplain.

The 1D sections provided were used for the in-bank topography. The overbank (2D) areas were modeled using 10ft and 15ft resolutions. The 2D grid dimension (rotated) was 17,500ft by 8,000ft. A total of 87 cross-sections were used for the 1D in-bank domain.

Structures were modeled as a combination of bridges and culverts. For bridges, height varying energy loss tables were used based on the Hydraulics of Bridge Waterways (Bradley, 1978). For culverts, TUFLOW simulates all possible inlet and outlet controlled flow regimes with automatic switching between regimes. The calculations of culvert flow and losses are carried out using techniques from “Hydraulic Charts for the Selection of Highway Culverts” and “Capacity Charts for the Hydraulic Design of Highway Culverts”, together with additional information provided in the literature such as Henderson 1966.

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

Indicate the number of cross sections, grids, or mesh elements used:

| 2D Cell Size | 1D Sections | Active 2D cells |
|---|---|---|
| 15ft | 87 | 286,434 |
| 10ft | 87 | 643,565 |

Describe the processes used to assemble your computational domain, execute it, and post process it into floodplain limits files. Indicate anything else you want us to know about your data and methods:

TUFLOW directly reads GIS data layers to construct models. The layers used/created for Challenge 1 are:

1. A DEM TIN created from the provided terrain data (2ft contours) and exported to ESRII ASCII format as a 2ft DEM grid. When TUFLOW reads this DEM it interpolates the elevations onto the 2D computation grid.
2. GIS layers of cross-section locations and 1D network including structure details.
3. GIS land-use layer digitized in .shp format.
4. GIS layer of 1D/2D interface lines along the left and right banks of the channels.

All model inputs are independent of the 2D grid cell size, orientation and extent, allowing for different 2D resolutions, dimensions and orientation to be easily simulated.

Peak flood depths and water levels were exported to ESRII ASCII grids, and the flood extent was created by contouring the grid into a single region. Flows are outputted in .csv format and directly loaded into Excel. Profiles were created using the post processing utility TUFLOW_to_GIS and outputted into a .csv file.

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

Describe the “Challenges” you encountered in preparing this floodplain analysis and in mapping the flood limits:

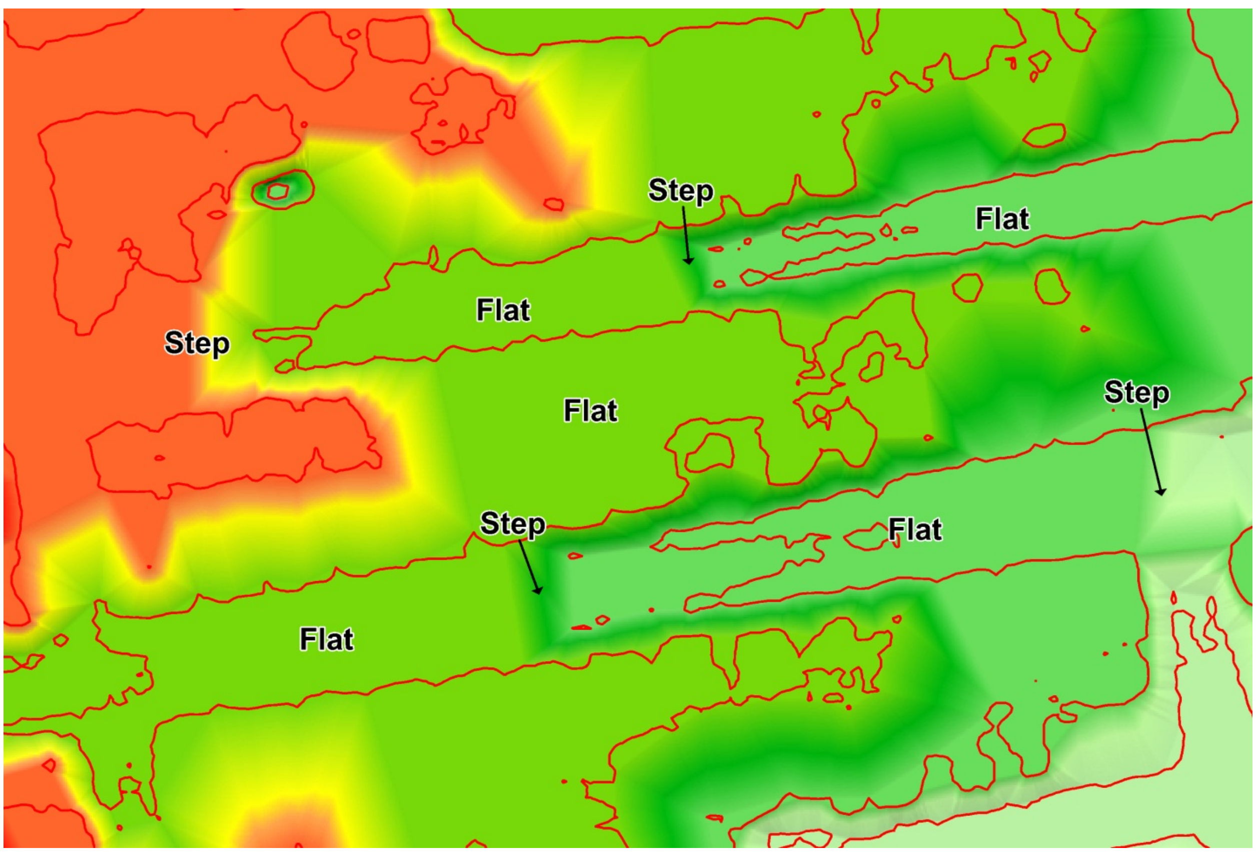
The “challenges” with Challenge 1 that we experienced were:

1. The use of contour data to create the DEM.
2. The model boundary/terrain data does not extend beyond the flooded area.

**1. Use of Contour Data to Create the DEM**

Contour data, without additional point elevations and/or 3D breaklines, is difficult to triangulate or interpolate to create an accurate DEM. The consequence of solely using contours is the resulting DEM can have a terraced or stair-step surface that contains flat sections where the contours form a U shape.

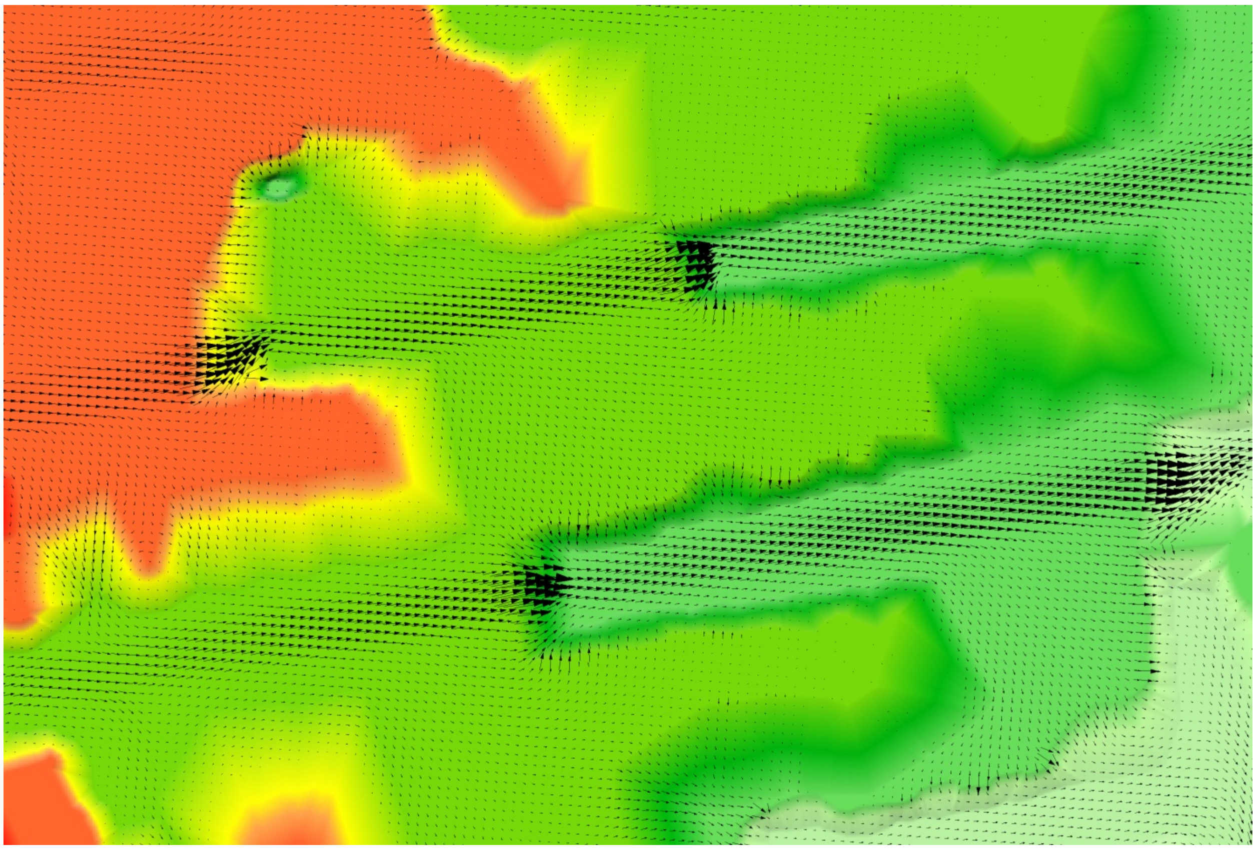
For example, the image below shows a part of the DEM. The red lines are the 2ft contours provided. Where the contours form a U shape, the triangulation or interpolation method typically forms flat (horizontal) areas inside the U as labeled “Flat” in the image. Between the Flats, Steps occur representing the drop in elevation to the next contour level.




Submitted by: BMT WBM (TUFLOW Software)

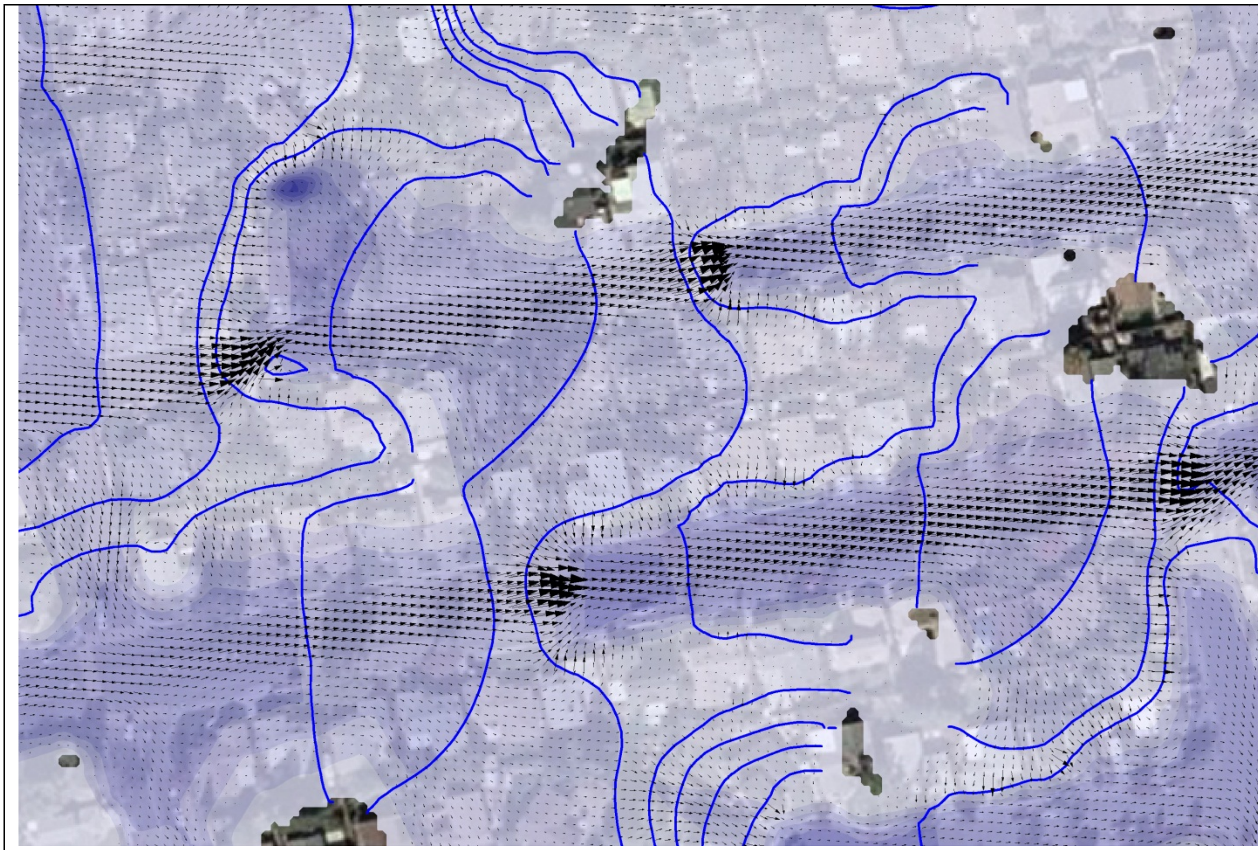
Date: Aug 24, 2012

When the 2D flow patterns are observed, as per the velocity arrows in the image below, the water appears to be "cascading" down the roads. Along the flat areas the velocities are low, and where the elevations suddenly drop to the next flat section the velocities are high, thereby creating the cascading effect.



The 2D flow patterns reflect the terraced or stepped nature of the DEM, which is not a realistic representation of the road topography. Some interpolation methods such as IDW (Inverse Distance Weighting) can provide a smoother DEM, but may not preserve the contours, and where the U shapes are pronounced they will still have a strongly terraced effect.

The resulting 2D depths and water levels are also unrealistic as can be seen in the image below. The blue shades are the depths and the blue lines the water level contours every 0.5ft. Where the steps occur in the DEM, the water level contours are closely spaced, and along the flats they are wide apart. The depths vary significantly along the road when they should be reasonably uniform.



For 2D modeling, especially in flat urban areas, contours should not be used to create the DEM. If the contours were generated from a DEM, then the original DEM should be used or the original terrain data should be provided and the DEM recreated from this data. If contours are used, additional point data and/or 3D breaklines along the low and high points need to be provided to prevent the terraced effect from occurring.

**2. The Model Boundary and Terrain Extent**

The flooding in the overbank 2D domain extends to the edge of the model boundary and terrain data. The terrain data needs to be extended further afield to high ground.

Estimate computation time required for the analysis execution: __:___:__:__ DHMS

| | Typical Run time (dd:hh:mm:ss) (Based on using a single CPU on a 3GHz chip) | |
|---|---|---|
| **2D Cell Size** | **To peak outflow (8 hours)** | **24 hours** |
| **15ft** | 00:00:35:00 | 00:02:20:00 |
| **10ft** | 00:02:25:00 | 00:12:00:00 |

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

## Challenge 1 Model Results:

- ☑ I am providing a shapefile containing the maximum flood inundation area which occurred in my model
- ☑ I am providing a Depth Grid file set
- ☑ I am providing an Excel Spreadsheet containing the outflow hydrograph
- ☑ I am providing an Excel Spreadsheet containing the peak flow profile along the stream.

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

**Notes:** (Please provide any feedback you would like us to consider on this Challenge Model. You could explain your element size selection, N Value selection, model type/software selection or anything else you would like us to know about how you assembled this model)

**2D Grid Resolution**

A 15ft 2D grid resolution is extensively used for urban modeling, and in this case provides a good trade-off between resolution and run time. 15ft cells are small enough that flow paths down roads are adequately represented (provided the DEM accurately represents the roads as discussed above).

To test the effect of different resolutions, simulations were made using grid resolutions of 5, 10, 15, 20 and 40 ft. Upon examination of the results, the flood extents varied by unexpected amounts between different resolutions. For example, the 10ft grid scenario (provided as part of the ftp download) produces a more extensive flood extent, even though the profile down the 1D channel is almost identical to the 15ft case. The extended flooding is the result of very shallow flow (less than 0.01ft deep) over large flat (horizontal) areas caused by the use of contours to create the DEM as discussed above. Due to the slightly coarser resolution the 15ft grid does not let water on to some of these flats, and they remain dry. Should an accurate DEM be made available for this Challenge, the flood extents are likely to be very different and much more consistent between different grid resolutions!

This does raise one issue indirectly of flood mapping in urban areas where the flood depths are very shallow, or if using direct rainfall modeling. In these instances, mapping of urban areas may specify that flooding must be of a minimum depth to be mapped. For example, where the flooding is less than say, 0.05m, it is not mapped.

**Manning's n Values**

The Manning's n values were based on the aerial photo and structure photos as tabulated below. A sensitivity simulation was carried out increasing the Manning's n value along the main channel from 0.03 to 0.04. The results for the sensitivity simulation are provided in the long-profile of maximum water surfaces along the channel (depth grids and other data can be provided upon request). The maximum increase in peak water level along the profile is 1.94 ft.

| Land Use | Manning's n |
|---|---|
| Main Channel | 0.030 |
| Roads | 0.020 |
| Properties (Buildings, Gardens and Fences) | 0.100 |
| Crop | 0.050 |
| Parkland | 0.035 |
| Vegetated area adjacent creek | 0.060 |
| Pasture | 0.045 |

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

To submit your model results, email this completed form to **2-DSymposium@floodplain.org** and provide FTP instructions for downloading your deliverables in the space below:

FTP Location (example: ftp://ftp.somedomain.com):

User name for FTP access: Password:

**Submitted by:** BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012