BMT

"Where will our knowledge take you?"

TUFLOW

Rapid and Accurate Watershed Assessments Using GPU Technology

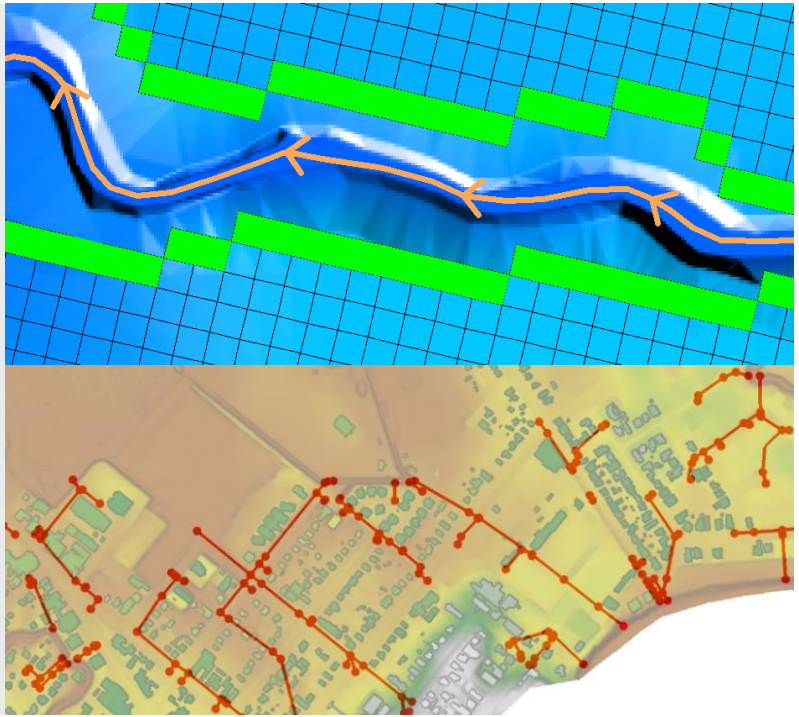
Chris Huxley

Presentation Overview
Urban Direct Rainfall Modelling (1D + 2D)

1. TUFLOW HPC
   - What it is?
2. What is direct rainfall water shed modelling
   - How the modelling is done?
3. Case Study Example
   - Ventura

TUFLOW HPC (Heavily Parallelised Compute)
New to TUFLOW 2017

1. **Fixed grid 2D solver**
2. **TUFLOW GPU Mark II**
   - New 2nd Order solution (the default)
   - Full 1D/2D linking functionality
   - Unconditionally stable
3. **Runs on Nvidia GPU devices**
   - 20 – 100 times faster than CPU!



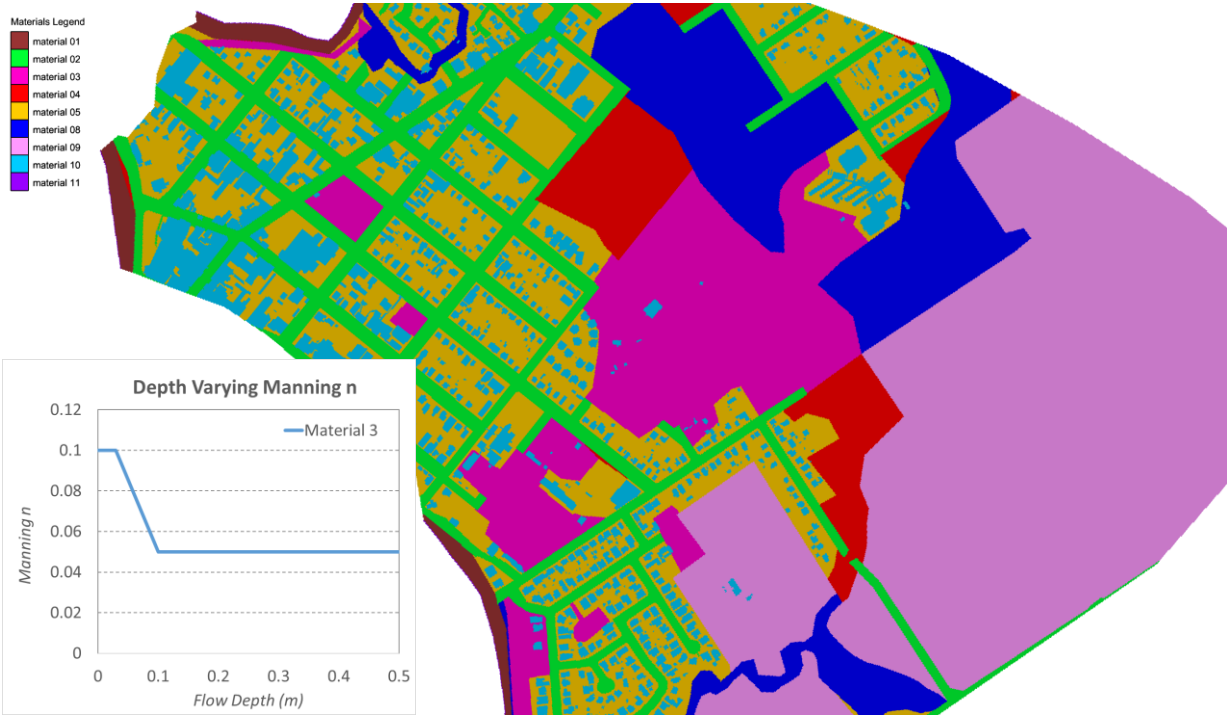
Urban Stormwater Modelling Data Inputs

What inputs go into an urban stormwater 1D / 2D direct rainfall hydraulic model?

Urban Stormwater Modelling Data Inputs

Spatially Varying Landuse and Soil Data

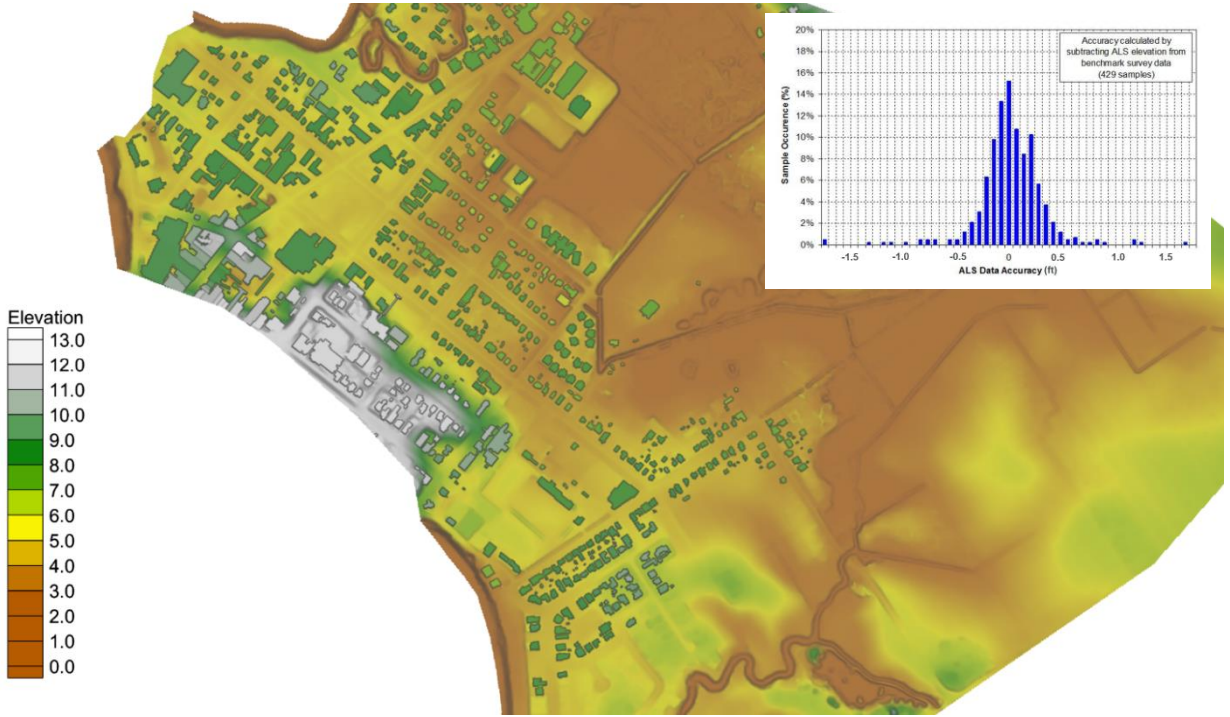
- **Bed resistance**
  - Depth varying
  - Log law
- **Perviousness**
  - %
- **Loss options**
  - Rainfall excess
  - IL / CL infiltration
  - Green Ampt infiltration
  - Horton infiltration



Urban Stormwater Modelling Data Inputs

Topography Data

- LIDAR
- Ground Survey
- Bathymetric survey /cross-sections



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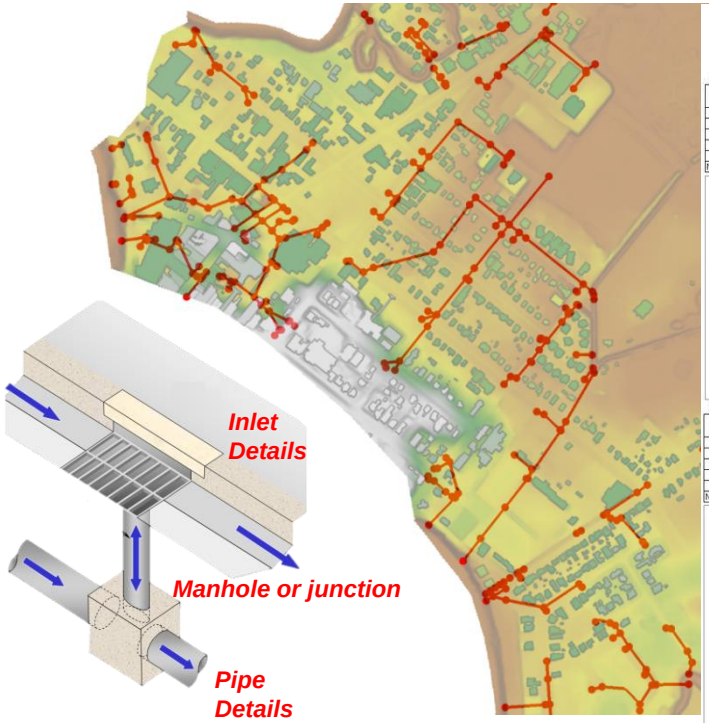
Urban Stormwater Modelling Data Inputs

Stormwater Network

- Inlets
- Manholes or junctions
- Storm water pipes

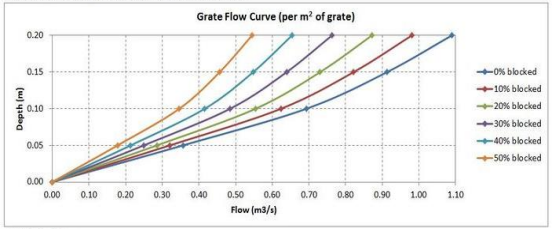


Pit Inlet depth vs flow curves

Grate Flow Curve

Water Depth (m)	Discharge (m^3/s) per m^2 of grate area					
	0% blocked	10% blocked	20% blocked	30% blocked	40% blocked	50% blocked
0.00	0.000	0.000	0.000	0.000	0.000	0.000
0.05	0.357	0.321	0.285	0.250	0.214	0.178
0.10	0.693	0.624	0.554	0.485	0.416	0.347
0.15	0.913	0.822	0.730	0.639	0.548	0.456
0.20	1.089	0.980	0.871	0.763	0.654	0.545

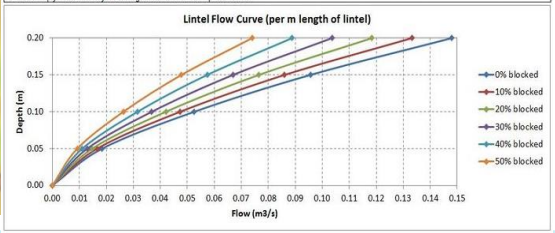
NOTE: Multiply table value by grate area to calculate site specific value



Lintel Flow Curve

Water Depth (m)	Discharge (m^3/s) per m length of lintel					
	0% blocked	10% blocked	20% blocked	30% blocked	40% blocked	50% blocked
0.00	0.000	0.000	0.000	0.000	0.000	0.000
0.05	0.018	0.017	0.015	0.013	0.011	0.009
0.10	0.053	0.047	0.042	0.037	0.032	0.026
0.15	0.096	0.086	0.077	0.067	0.057	0.048
0.20	0.148	0.133	0.118	0.104	0.089	0.074

NOTE: Multiply table value by lintel length to calculate site specific value



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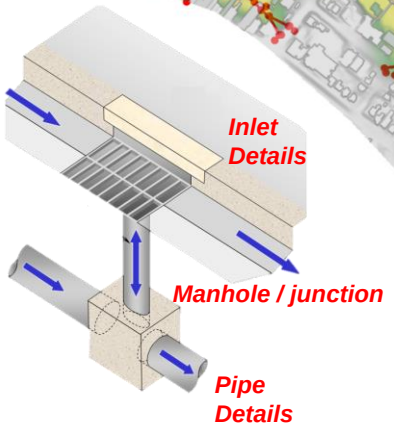
Urban Stormwater Modelling Data Inputs

Stormwater Network

- Inlets
- Manholes or junctions
- Storm water pipes
- Gates, Spillways, Weirs, Backflow control devices



Variety of energy loss options

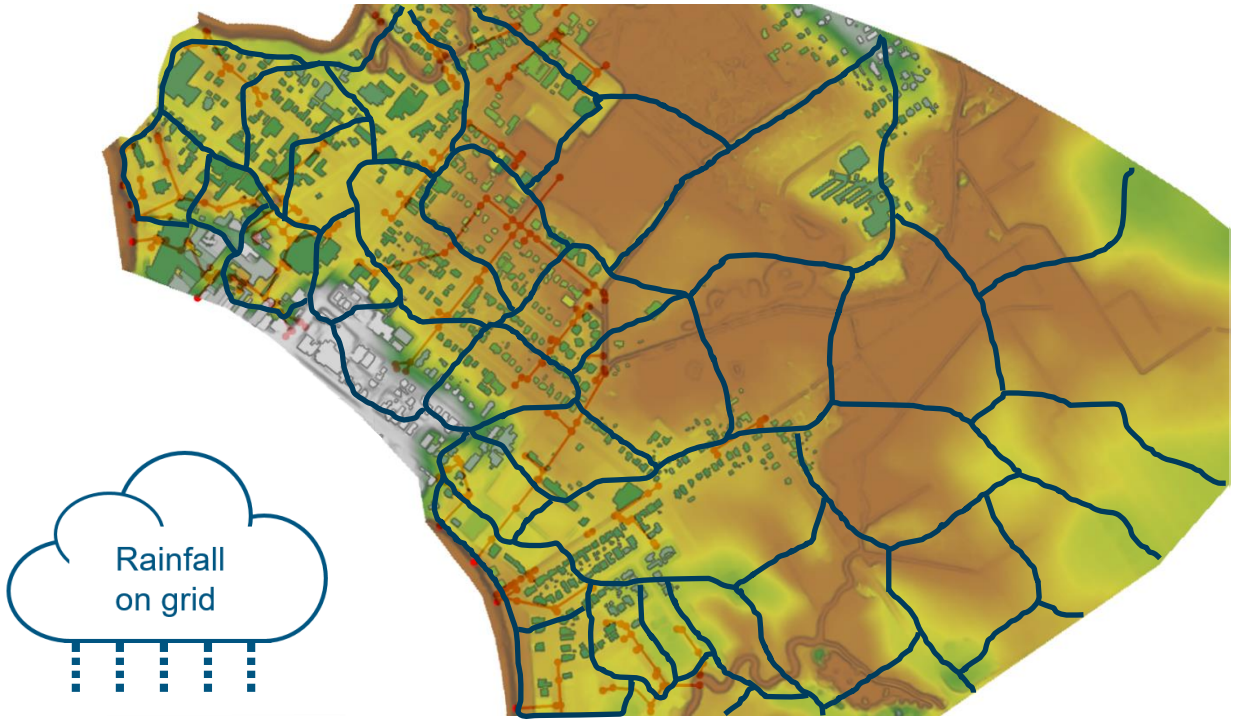
- Fixed (optional)
- Engelund method (default)
  1) Expansion / contraction of flow
  2) Changes in pipe size
  3) Changes in angle at junctions
  4) Change in elevation at junctions

Urban Stormwater Modelling Data Inputs
Hydrologic Input Options

Hydrologic Model Flows

or

Direct Rainfall



Urban Stormwater Modelling Data Inputs
Direct Rainfall Example

What is rainfall on grid?

Rainfall is applied to every 2D cell.

The hydraulic model routes flows (2D SWE)

Avoids potential errors associated with hydrologic sub-catchment delineation

Urban Stormwater Modelling Data Inputs
Direct Rainfall Example

What is rainfall on grid?

Rainfall is applied to every 2D cell

The hydraulic model routes flows (2D SWE)

Avoids potential errors associated with hydrologic sub-catchment delineation

Excellent representation of key physical processes

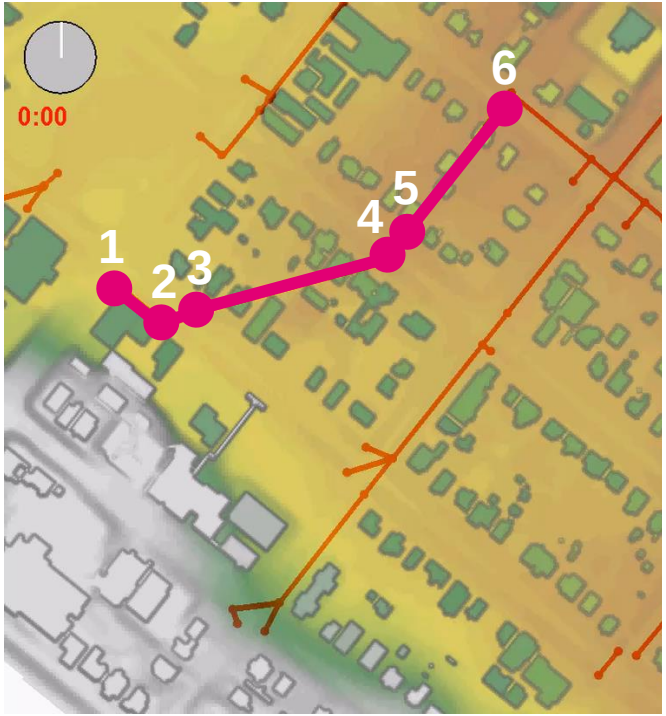
1) Rainfall
2) Hydrologic losses (infiltration)
3) Runoff
4) Flow capture by the stormwater network
5) Energy loss within the underground pipe network
6) Above / below ground stormwater network interactions

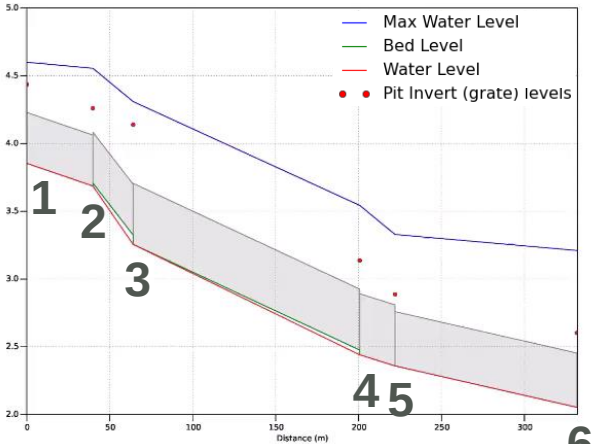
Urban Stormwater Modelling Data Inputs

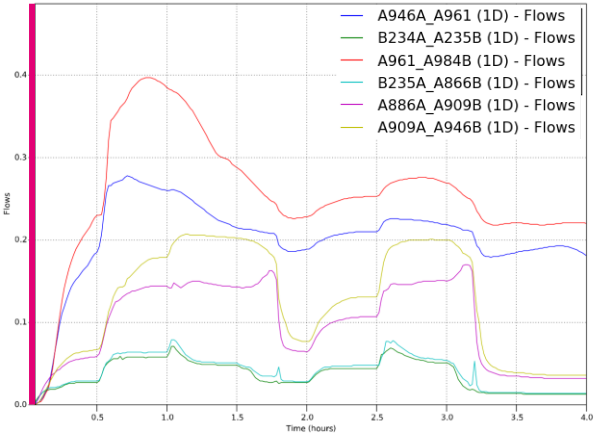
Direct Rainfall – 1D/2D integration

Dynamically linked 1D storm water network and 2d overland flow model

Accurate representation of overflow into neighboring drainage areas if storm water network capacity is exceeded







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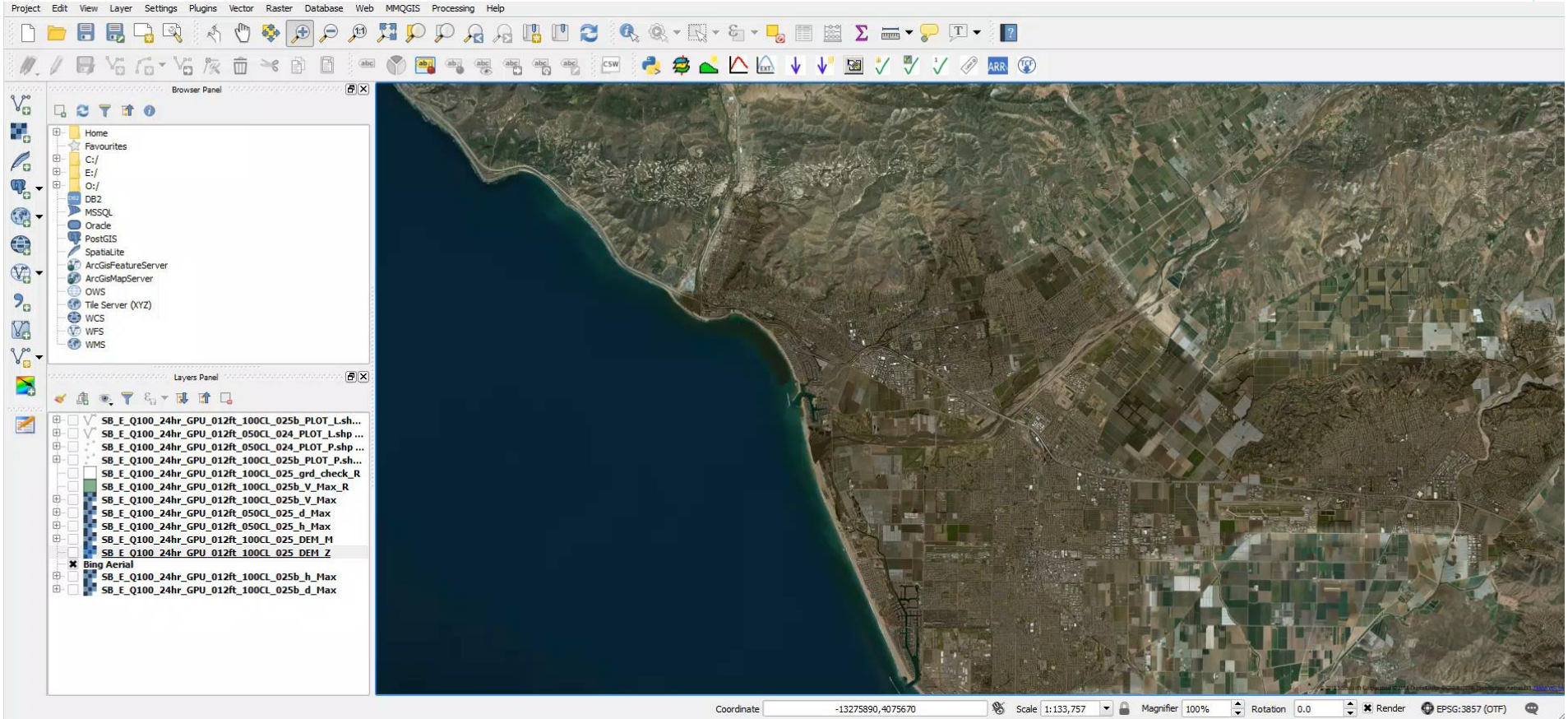
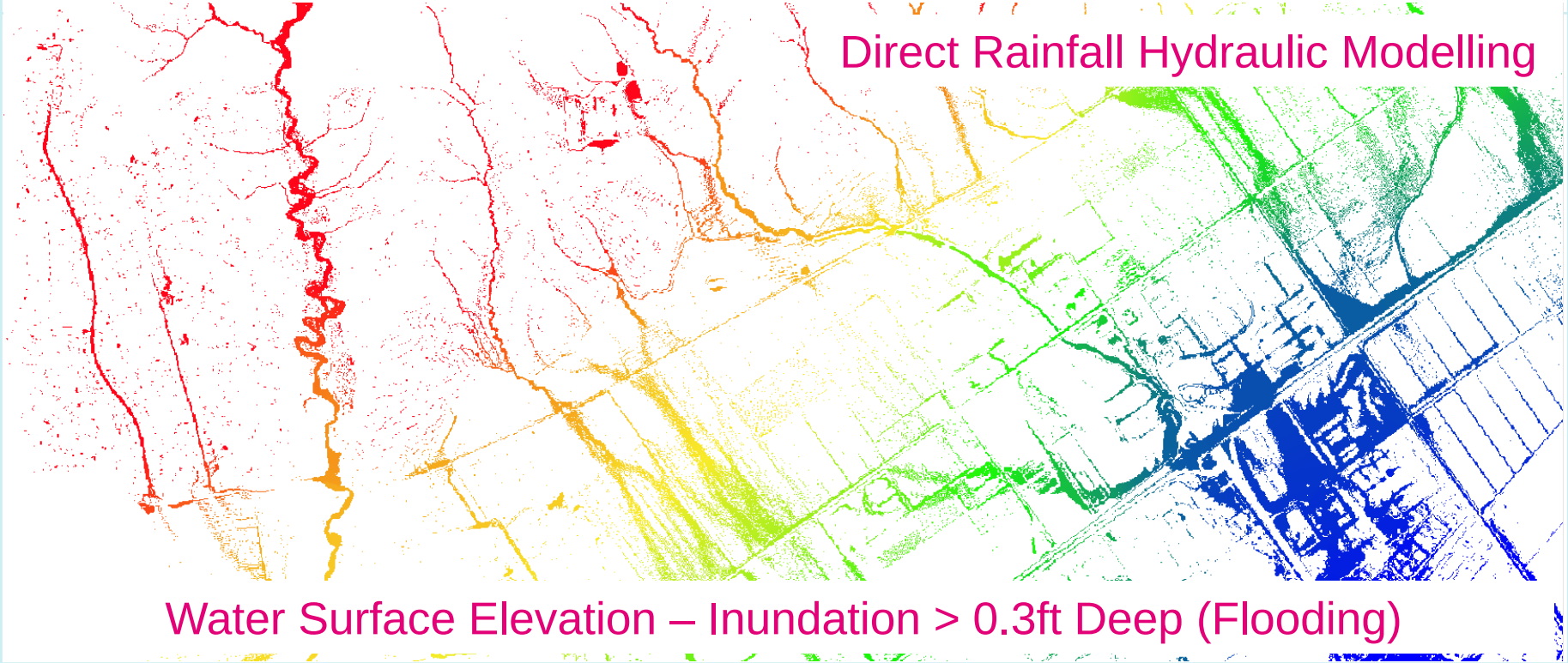
Local Example: Ventura Watershed Model (Eastern Domain)



Local Example: Ventura Watershed Model (Eastern Domain)



Local Example: Ventura Watershed Model (Eastern Domain)

The model uses a 12ft cell resolution (5,000,000 Cells).

What is Cell Size Convergence?

"In well designed modelling software - cell size convergence refers to the tendency for model results to trend towards a common answer as cell size decreases"

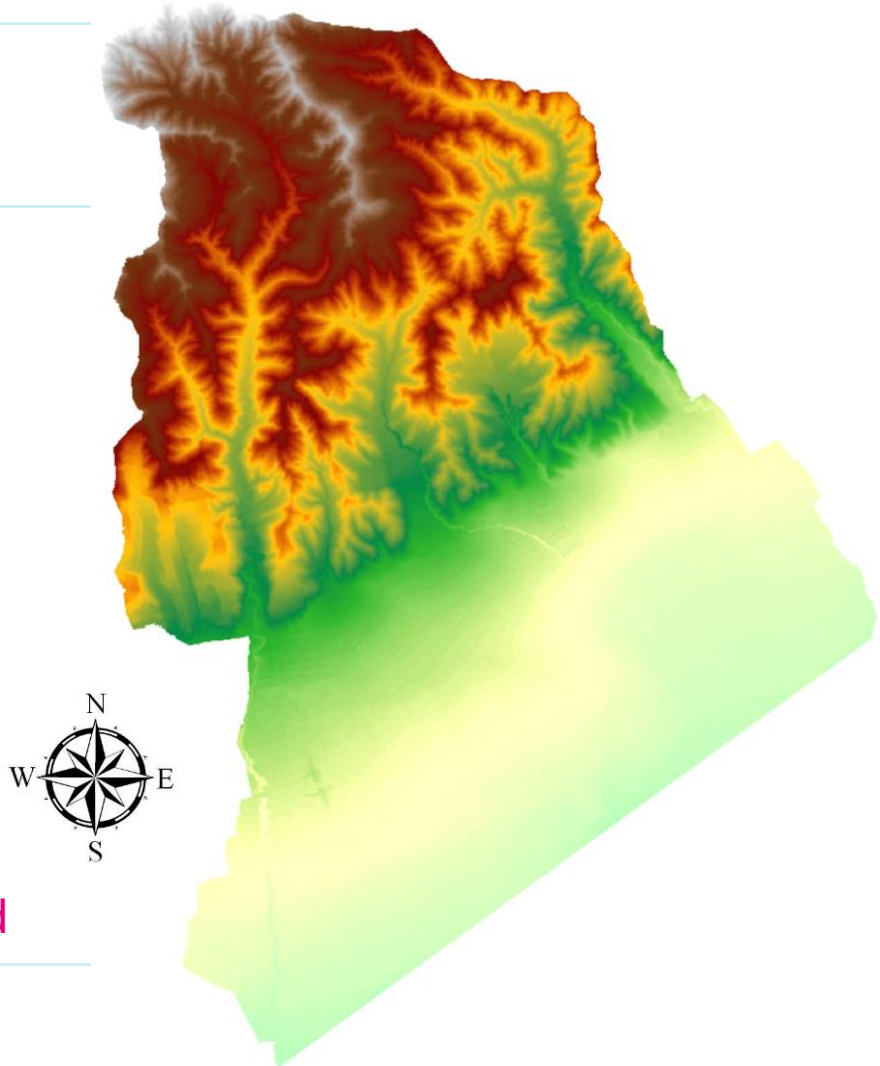
Why is it worth talking about?

Small cell size = lots of cells = long simulations

Ventura Watershed Model

Cell Resolution Test Cases

1. 10ft – 5,800,000 cells
2. 15ft – 2,600,000 cells
3. 20ft – 1,450,000 cells
4. 30ft – 644,000 cells
5. 50ft – 231,000 cells
6. 75ft – 103,000 cells



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2 x NVIDIA GeForce GTX 1080 Ti GPU card

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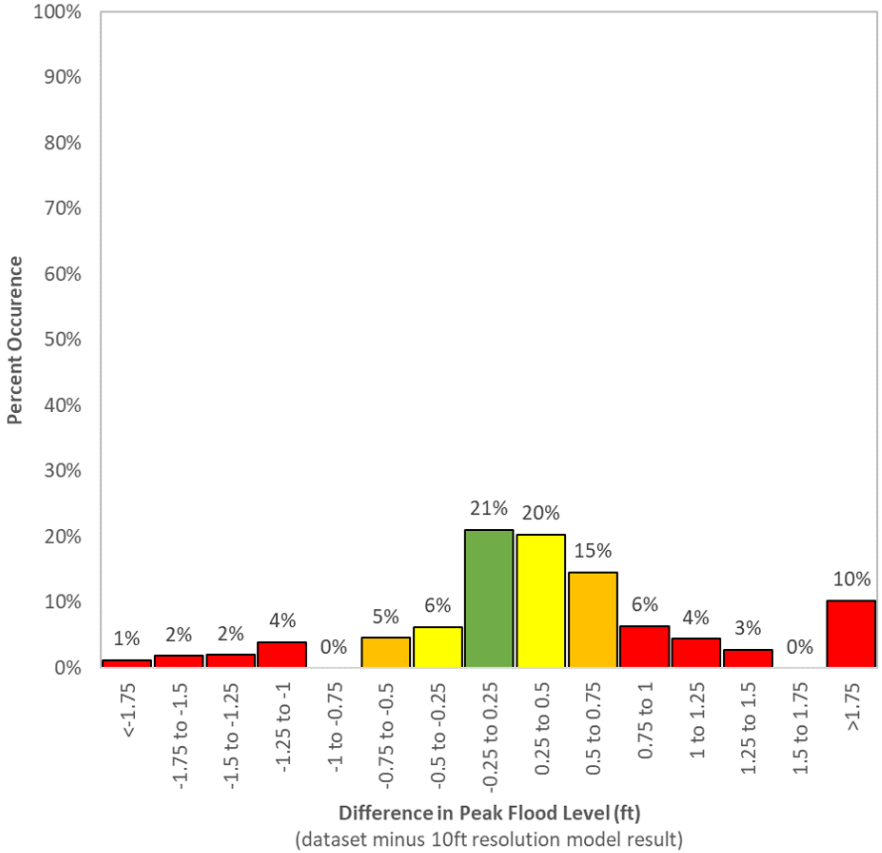
Results

10ft case used as baseline for analysis of coarser resolution results

Sample Size = 3950522 comparison points (all locations where data overlap)



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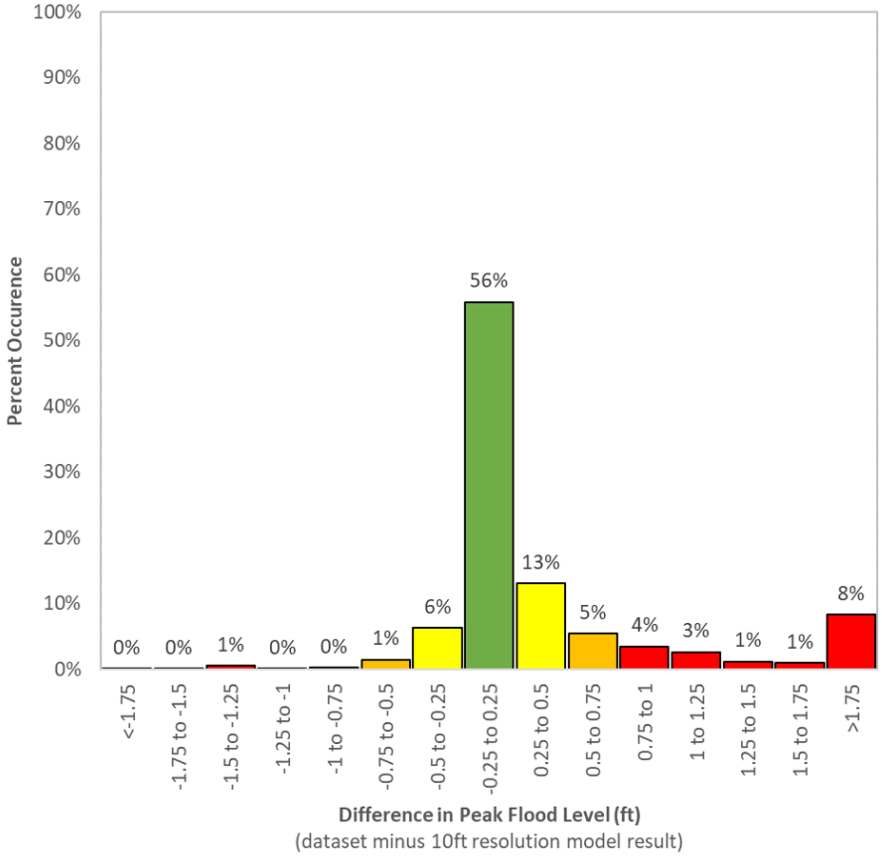
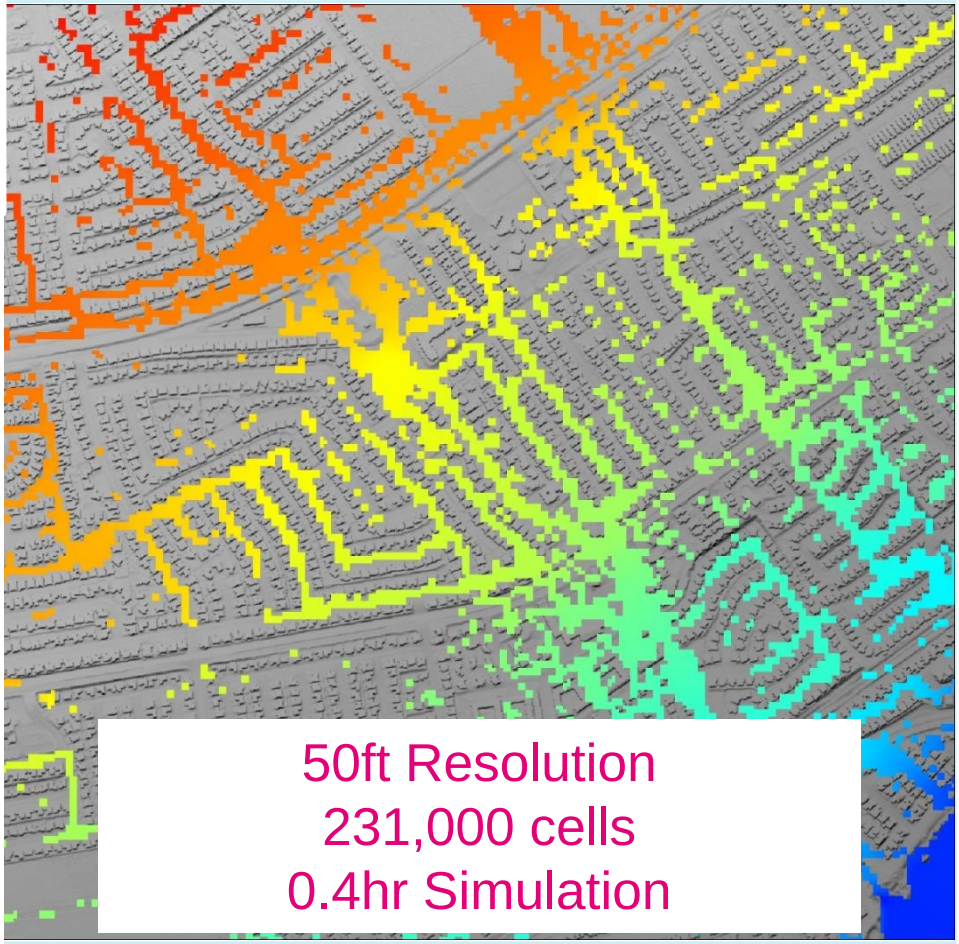
Sample Size = 4677610 comparison points (all locations where data overlap)





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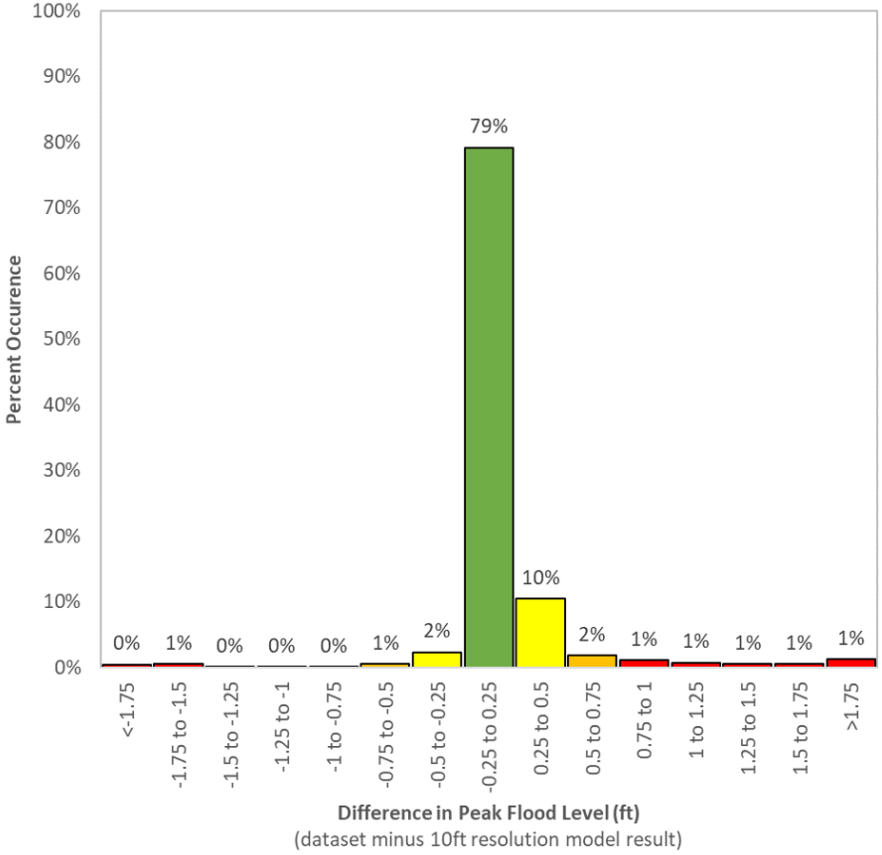
Sample Size = 4811724 comparison points (all locations where data overlap)



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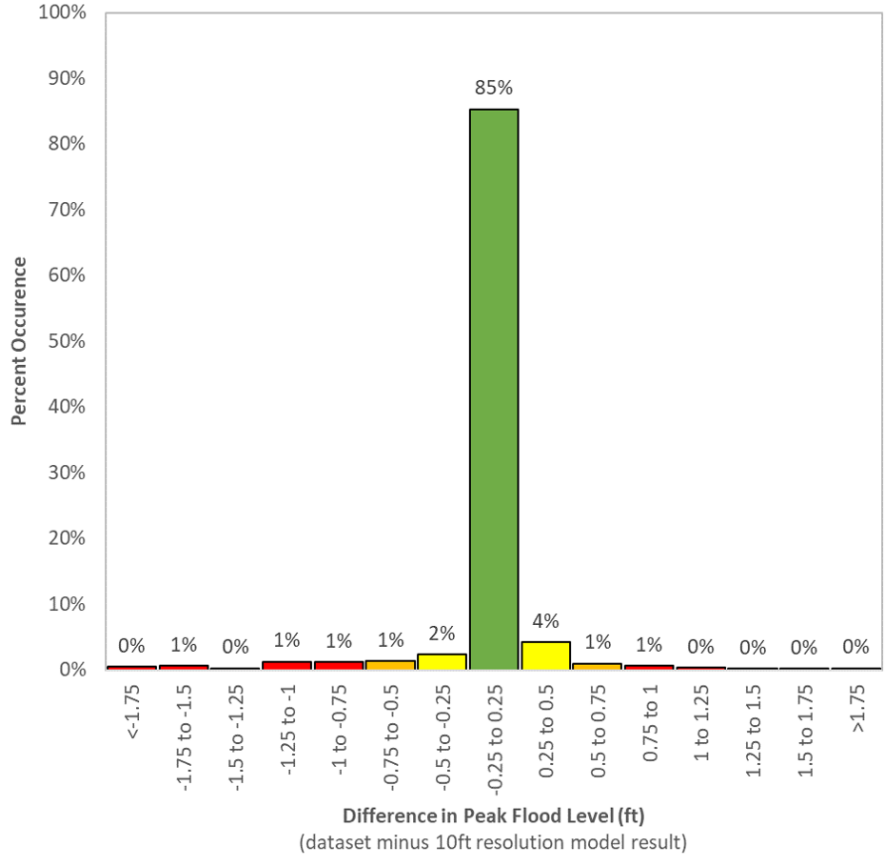
Sample Size = 4891825 comparison points (all locations where data overlap)



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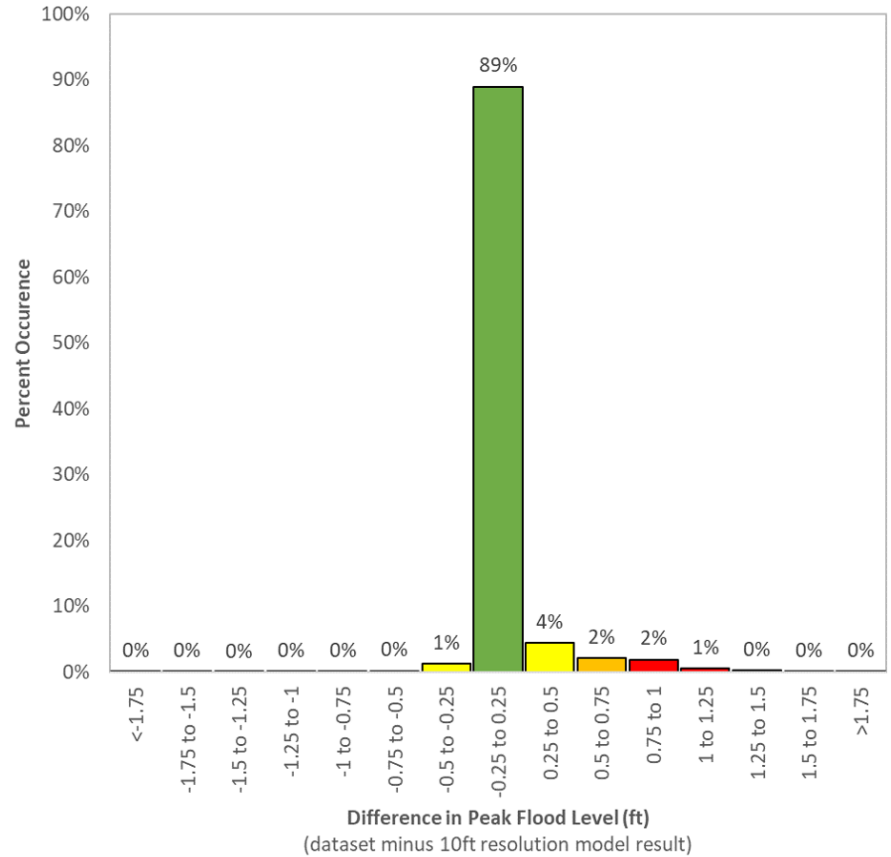
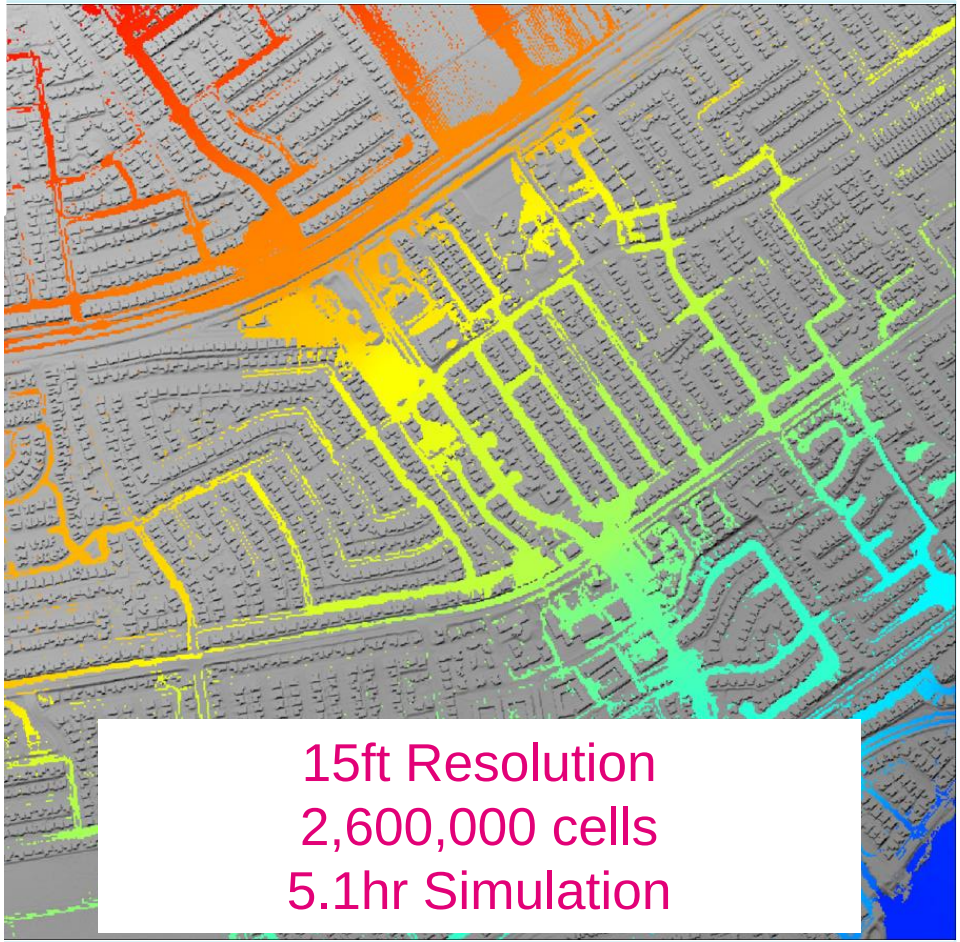
Sample Size = 4941381 comparison points (all locations where data overlap)





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Urban Result Discussion
Guideline Comparison

- **Resolution < 15ft is recommended**
- **Test results agree with guideline recommendations**
- **Why is fine resolution necessary?**

1. Urban areas characteristically have many abrupt obstructions
2. All 2D model only calculate one velocity value per cell face!
3. Fine resolution is required to accurately represent the high variations in flow behavior (level and **velocity**) near obstructions

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Questions?