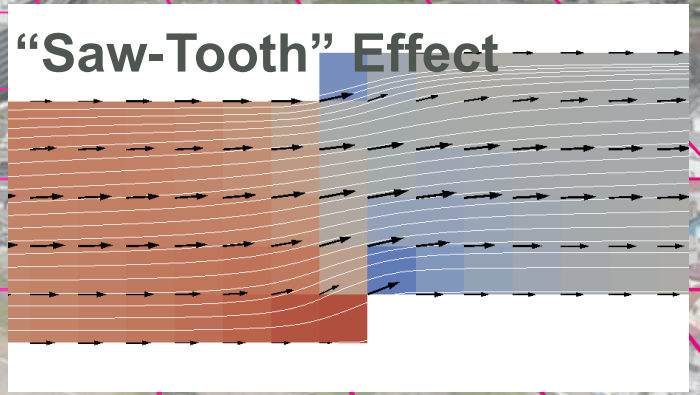
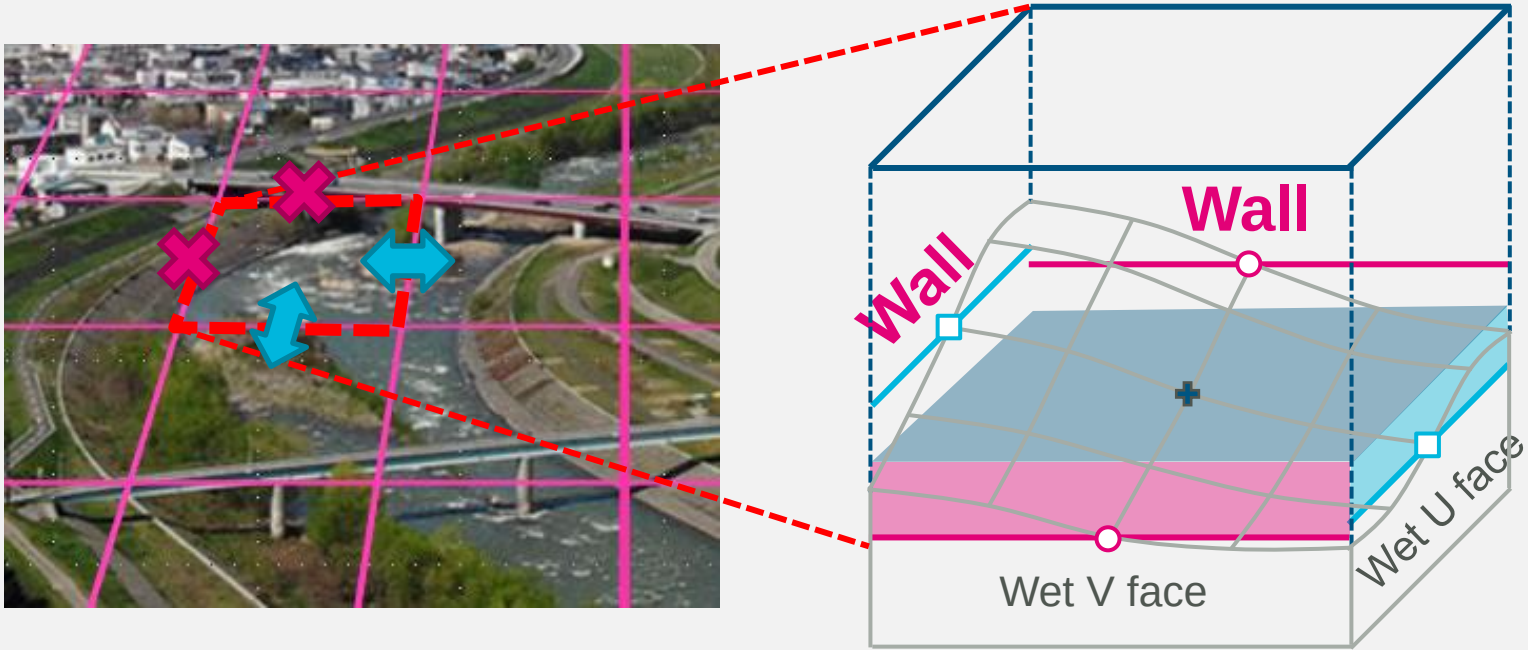
Application of Higher Order Bathymetry Representation in Fixed Grid Shallow Water Solvers

BMT, Brisbane, Australia
Shuang GAO
Greg COLLECUTT
Bill SYME



Why Artificial Loss Happens?
"First order" bathymetry representation

- Flat cell/face



Background
Common Mesh Type Used for River Flood Modelling

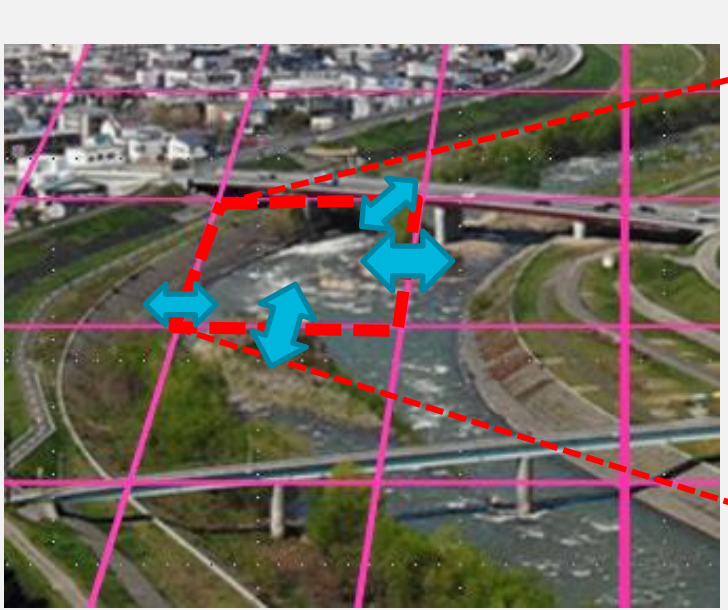
Cylindrical Coordinate
(e.g. Yoshida and Ishikawa, 2007; iRIC)

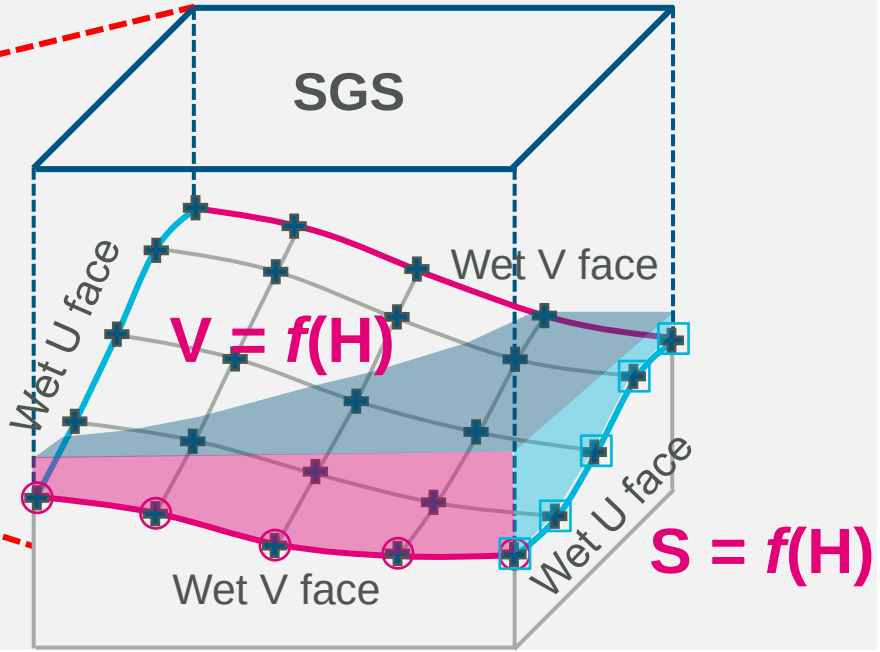
Unstructured Mesh
(e.g. Akoh and Ishikawa, 2012; MIKE)

Structured Mesh
(this study)

Sub-grid Sampling(SGS)
"Second order" bathymetry representation

- Sub-grid Sampling





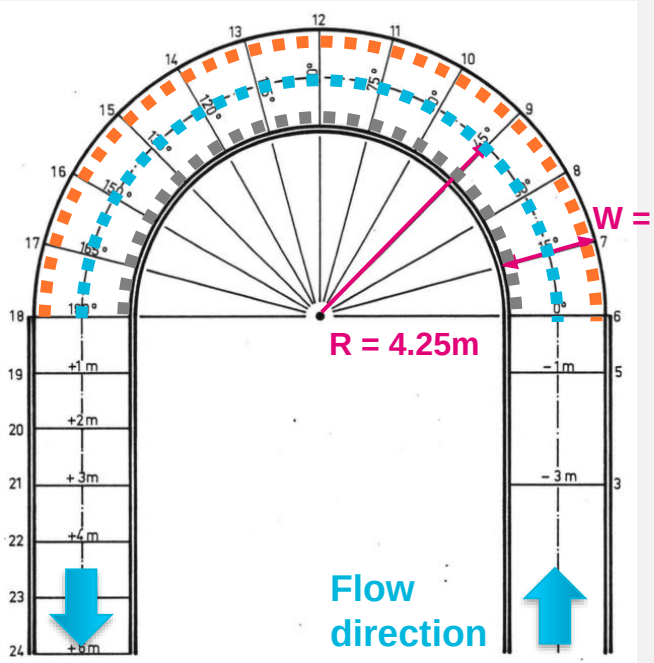
Numerical Solver – TUFLOW HPC + SGS

TUFLOW HPC: Collecutt and Syme (2017)

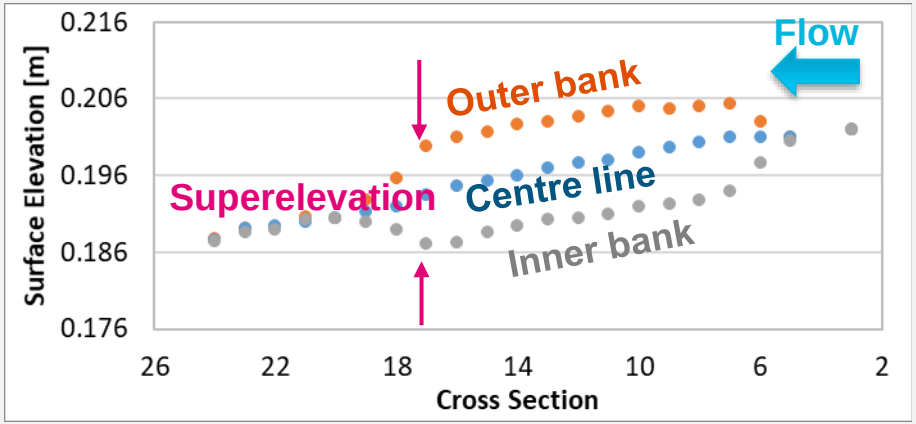
- 2D non linear Shallow Water Equation solver
- *Finite Volume Method*
- *2nd order spatial scheme*
- 4th order explicit scheme in time (Runge-Kutta method) and adaptive time stepping
- Parallelised for CPU and GPU

Model Verification (1)
U-Bend Flume Test

- De Vriend and Koch (1978)



- Q = 0.189 m^3/s
- h = 0.18 m
- Manning's n 0.0115 ~ 0.0125

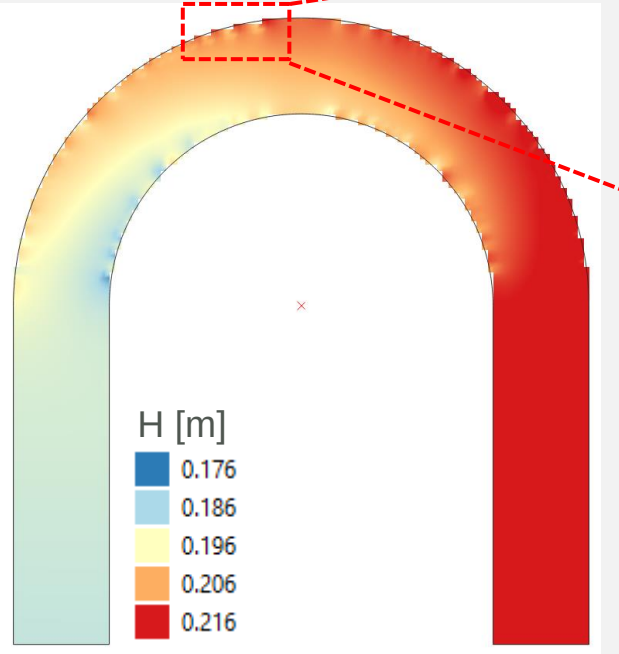


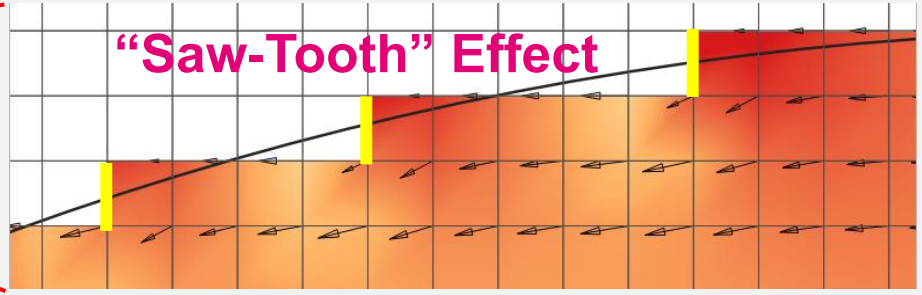
TUFLOW

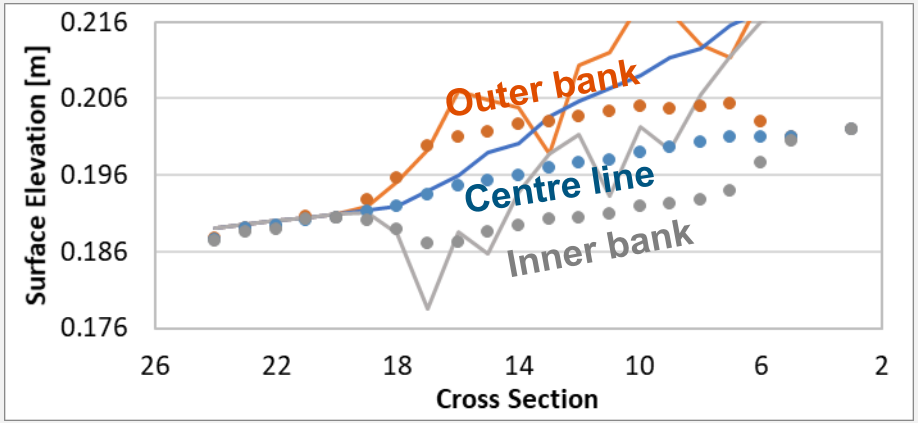
BMT

Model Verification (1)
U-Bend Flume Test

- Structured Mesh

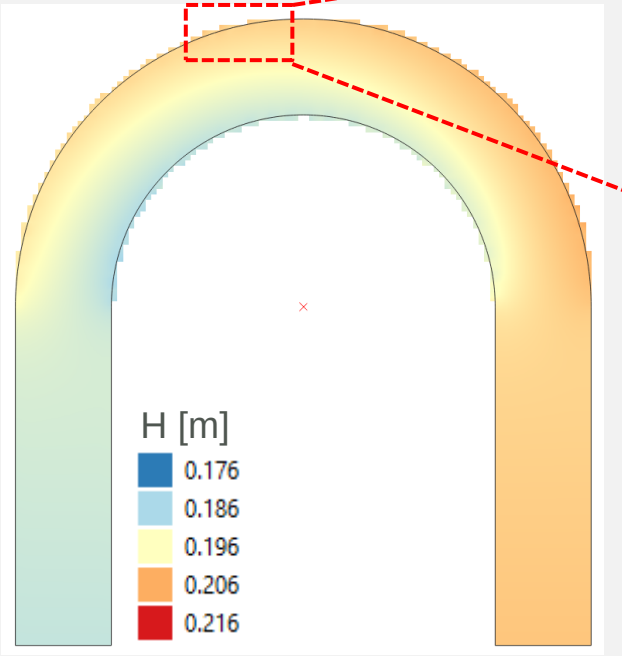


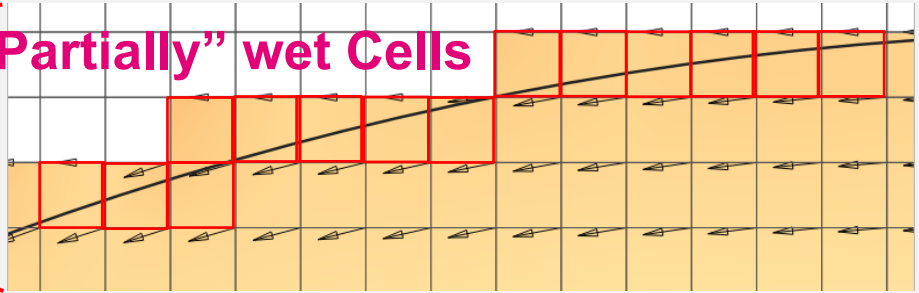


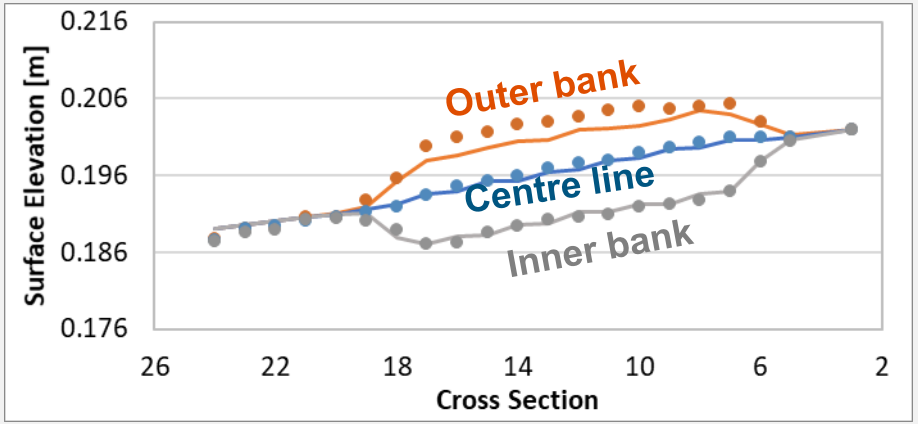


Model Verification (1)
U-Bend Flume Test

- Structured Mesh + SGS

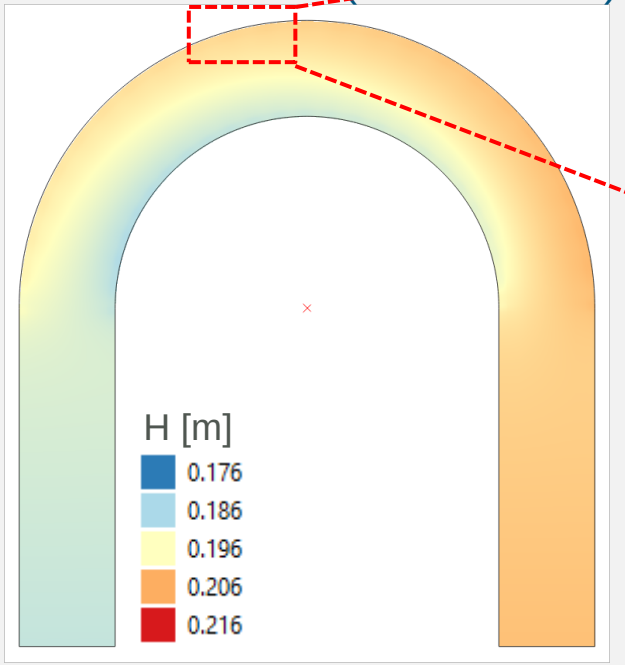


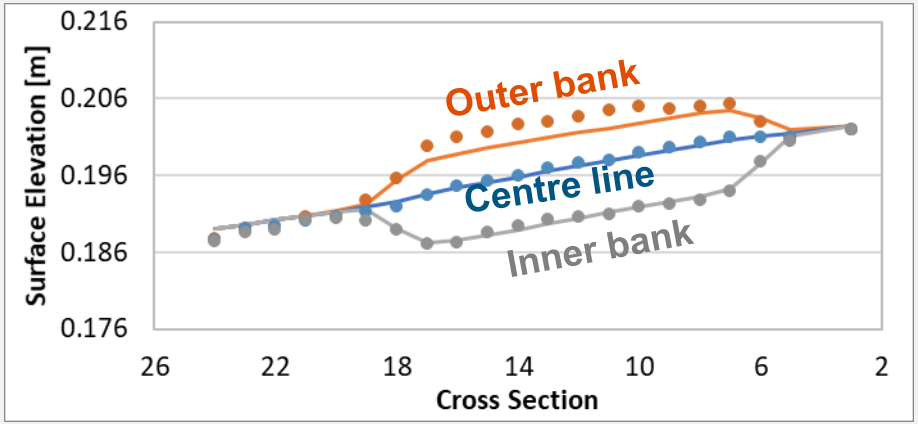




Model Verification (1)
U-Bend Flume Test (bonus)

- Unstructured Mesh (TUFLOW FV)





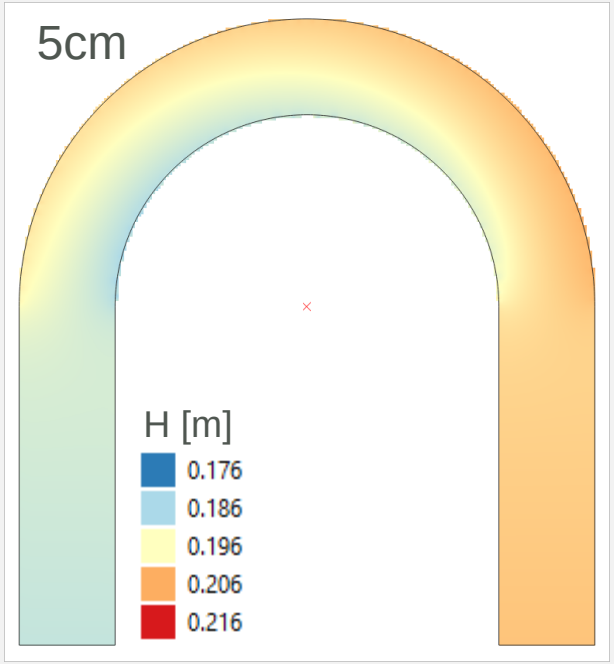
Model Verification (1)
U-Bend Flume Test

Structured Mesh + SGS vs **Unstructured Mesh**

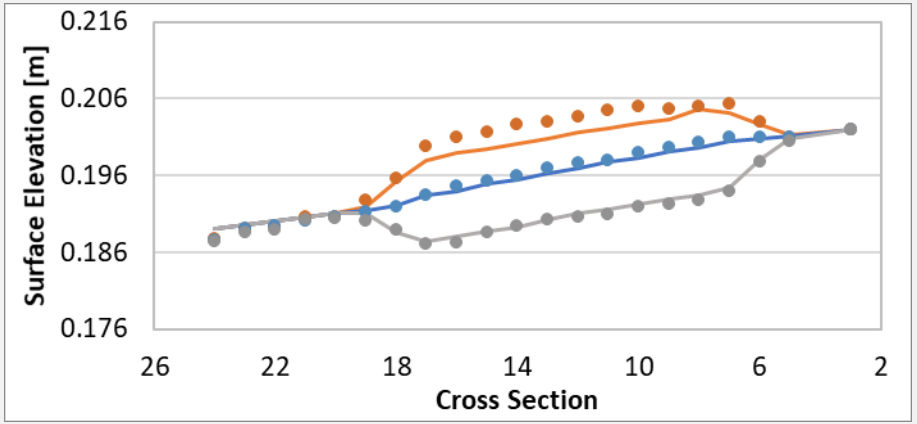
As good as a well designed unstructured mesh model !!

Model Verification (1)
U-Bend Flume Test – Mesh Size Sensitivity

- Structured Mesh + SGS



No artificial head loss even with the coarsest cell size (5 cells across the channel)

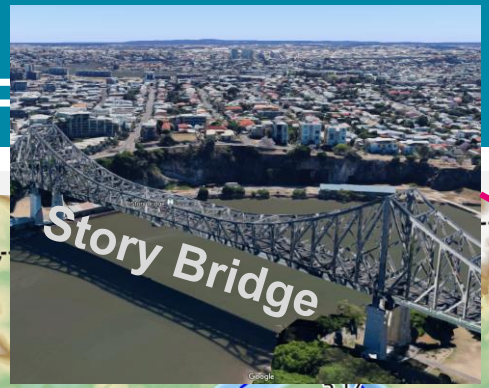


TUFLOW

BMT

Model Verification (2)
2011 Brisbane River F

- Peak Q = 9,000 m^3/s
- Downstream H = 2.7m
- Width = ~200m
- Depth = 20~30m
- **Bends** and **cliffs**
- High quality DEM
- Water level marks of the historical flood

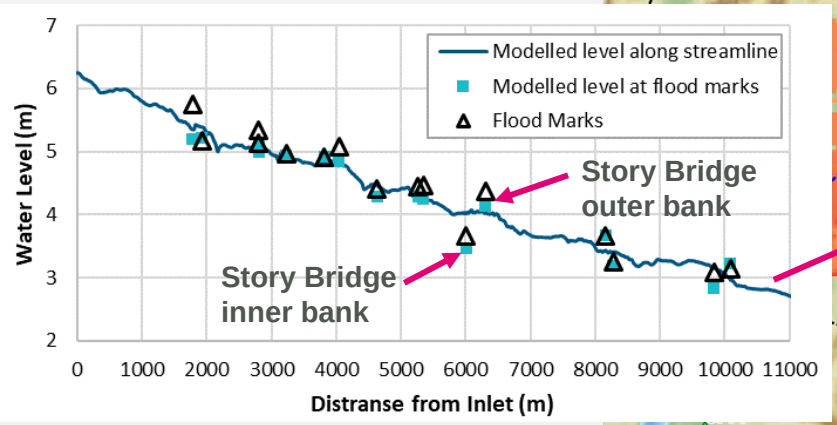


TUFLOW

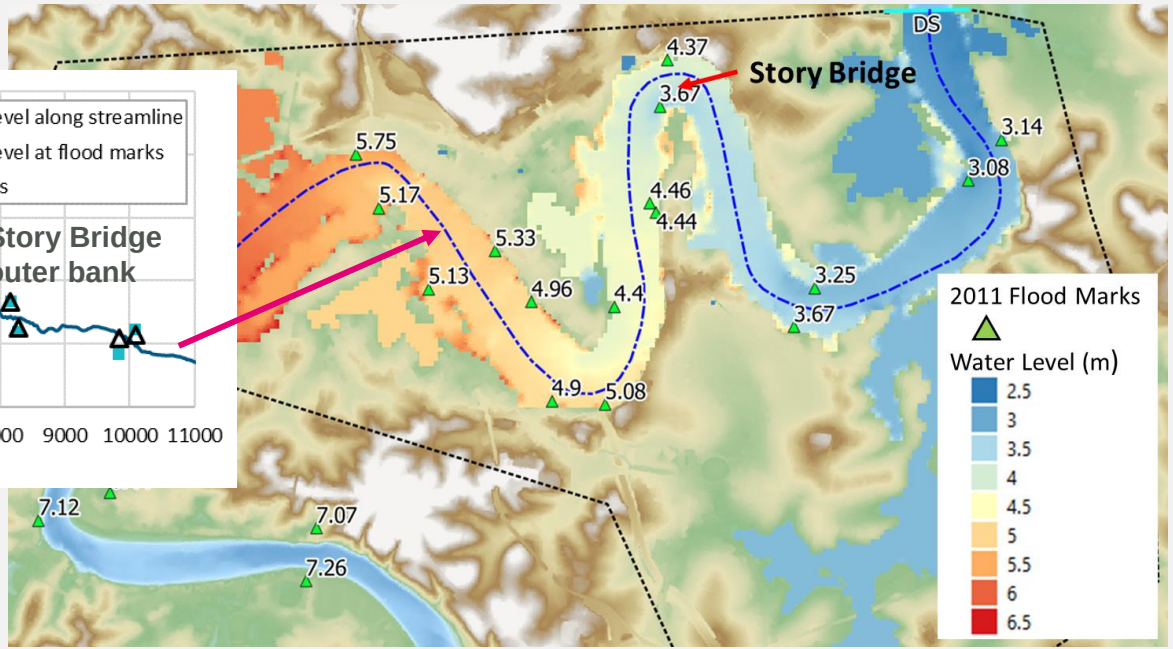
BMT

Model Verification (2)
2011 Brisbane River Flood

- Peak Q = 9,000 m^3/s

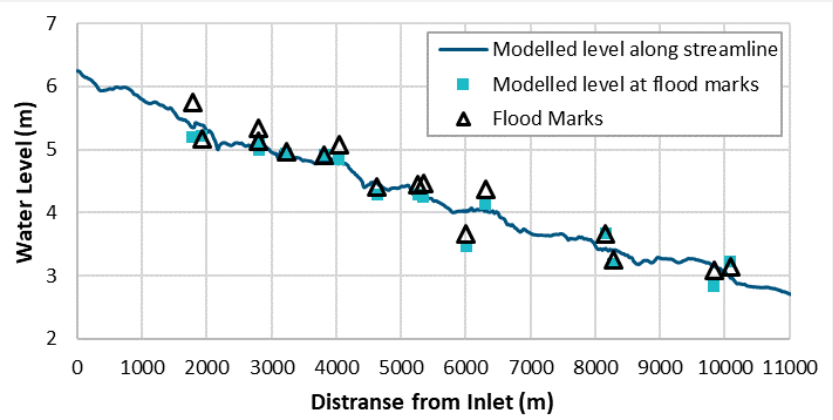


the historical flood

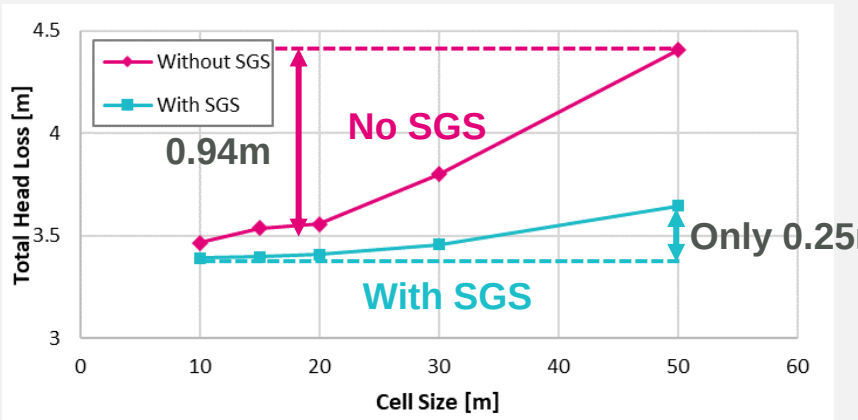


Model Verification (2) and Conclusions
2011 Brisbane River Flood

Modelled water level vs Flood marks



Total head loss vs Mesh size



- Significantly improves mesh **size** and **alignment sensitivities**
- Eliminates artefact energy losses ("**saw tooth affect**") near dry/wet boundary
- Allows larger mesh: improve modelling **speed** and the **efficiency of calibration**

TUFLOW

BMT

Thank you!

ご清聴ありがとうございました