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"Where will our knowledge take you?"

TUFLOW

Rapid and Accurate Stormwater Drainage Assessments Using GPU Technology

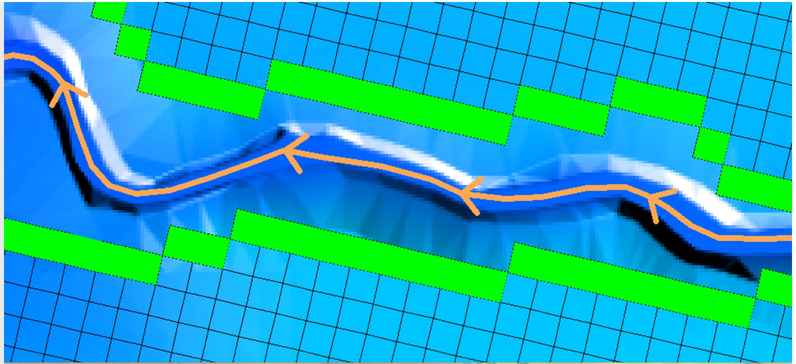
IECA-SQ Conference
Brisbane, Australia
Chris Huxley

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

1. TUFLOW HPC
   - What it is?
2. Case study example
   - Where?
   - How the modelling was done?
3. Modelling advice
   - What matters

TUFLOW HPC (Heavily Parallelised Compute)
New to TUFLOW 2017

1. **Alternative fixed grid 2D solver to TUFLOW Classic**
2. **TUFLOW GPU Mark II**
   - Improved 1st Order solution scheme from TUFLOW GPU
   - New 2nd Order solution (the default)
   - Change in cell schematisation to utilise cell sides
   - All 1D/2D linking functionality (HX and SX)
   - All 1D functionality
   - Unconditionally stable
3. **Runs on CPUs and Nvidia GPU devices**



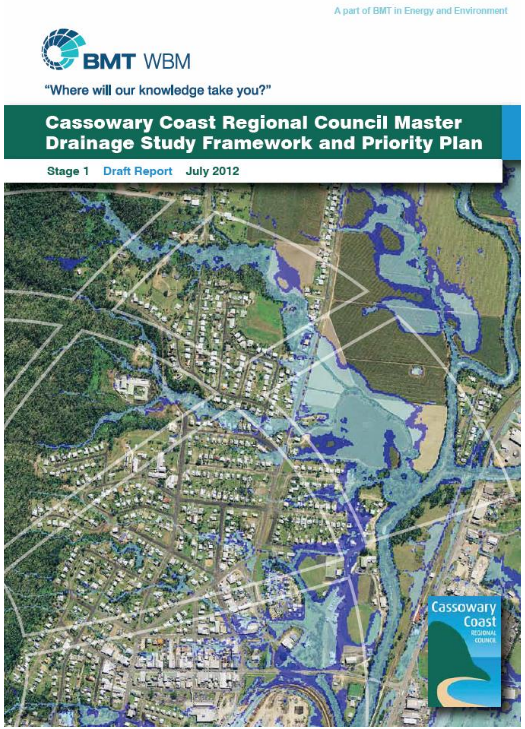
Presentation Case Study Location

Study Overview

- Cassowary Coast Regional Council (CCRC)
- Hydraulic assessment of urban drainage infrastructure for 10 major towns

Study Objectives

- Review of existing network capacity / performance
- Development of a future infrastructure upgrade plan



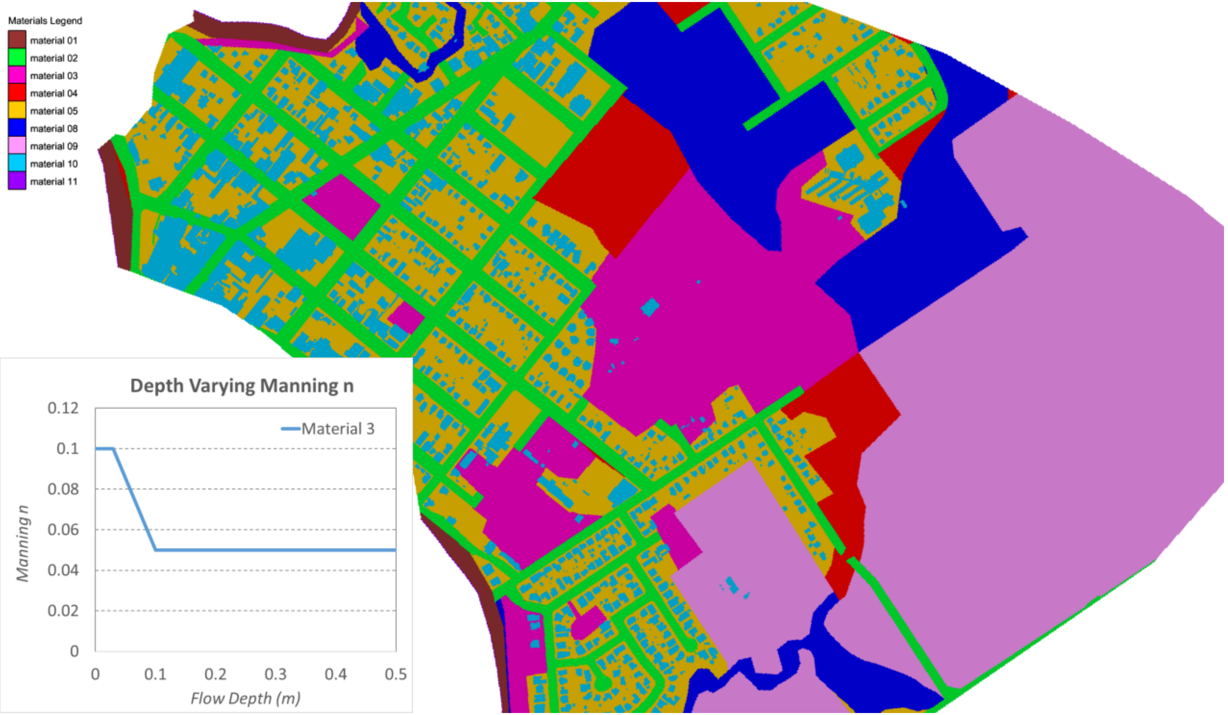
Cardwell
Innisfail CBD
Innisfail East
Innisfail Estate
Mission Beach
Mourilyan
Silkwood
South Johnston
Tully
Tully Heads / Hull Heads

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

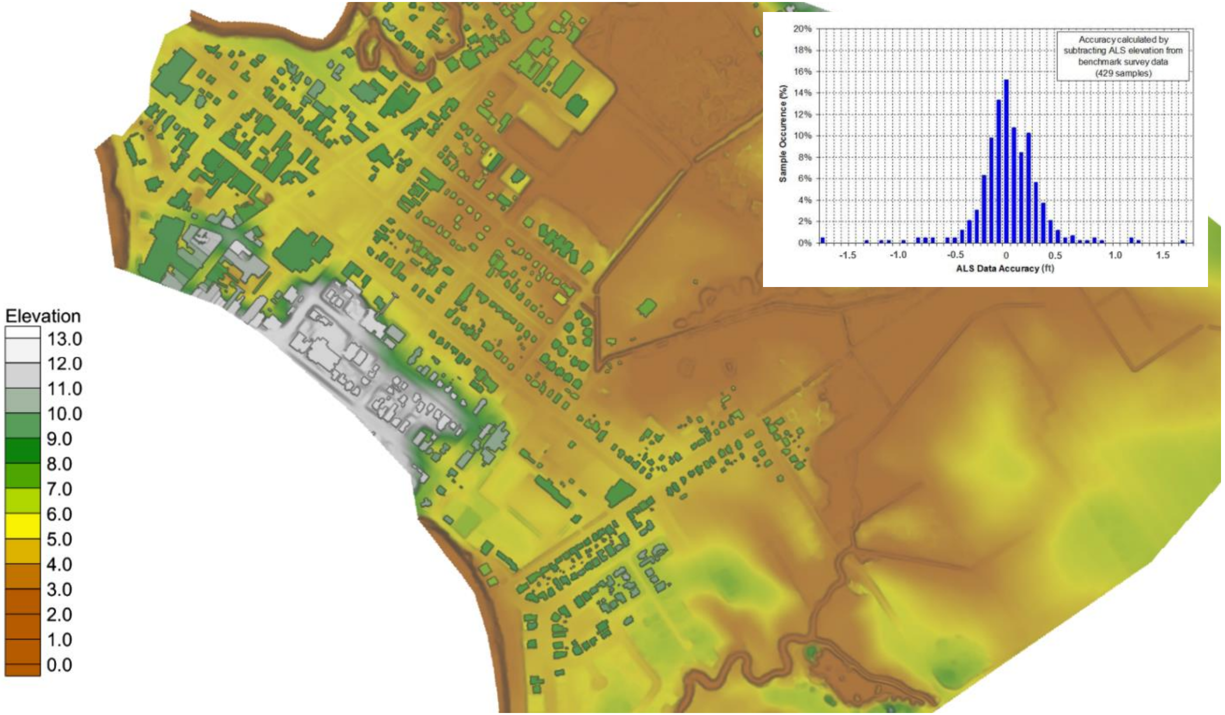
- **Bed resistance**
  - Depth varying
  - Log law
- **Perviousness**
  - %
- **Loss options**
  - Rainfall excess
  - IL / CL infiltration
  - Green Ampt infiltration
  - Horton infiltration



Urban Stormwater Modelling Data Inputs
Topography Data

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

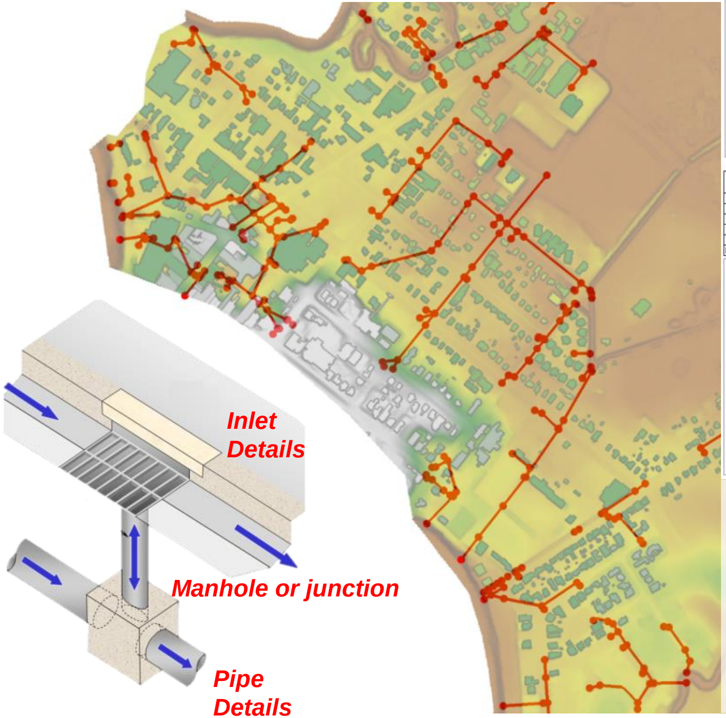
(12D, LandXML)



Urban Stormwater Modelling Data Inputs

Stormwater Network

- Inlets
- Manholes or junctions
- Stormwater pipes

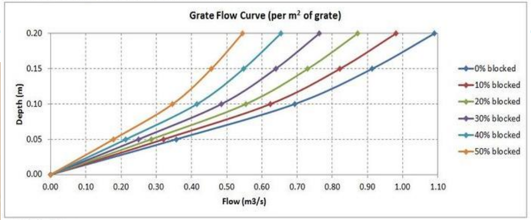


Pit Inlet depth vs flow curves

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

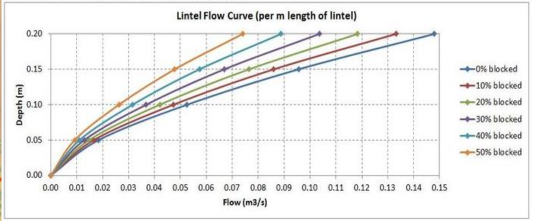
NOTE: Multiply table value by grate area to calculate site specific value



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

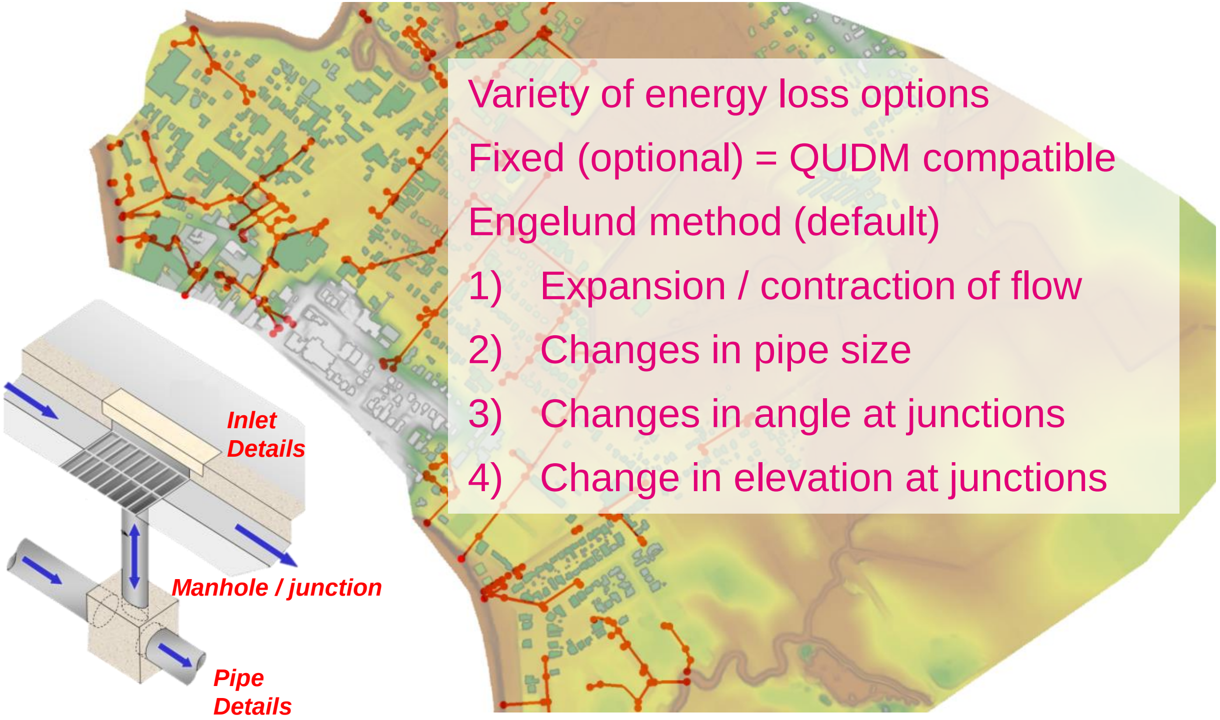


+
New “Road Crossfall” option to improve flow capture at pits

Urban Stormwater Modelling Data Inputs

Stormwater Network

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



Variety of energy loss options

Fixed (optional) = QUDM compatible

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

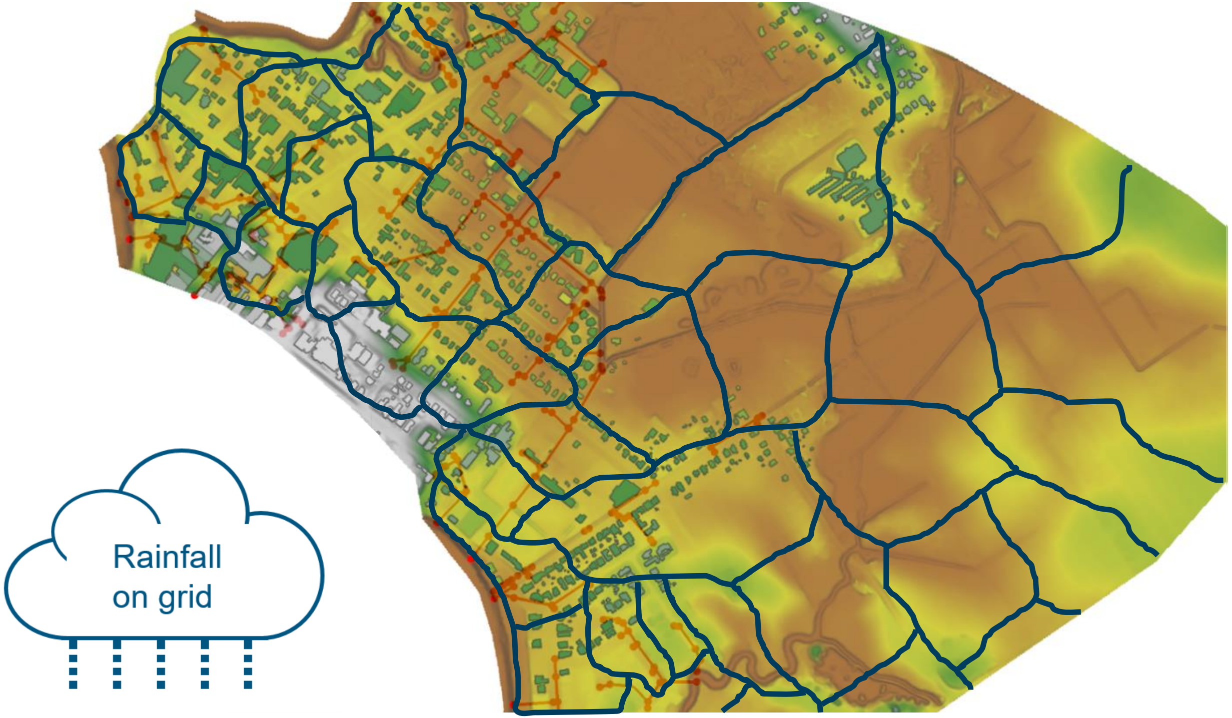
Hydrologic Model inflows

RORB, URBS, WBMN, XPRAFTS or user defined

or

Direct Rainfall

(used in CCRC study)



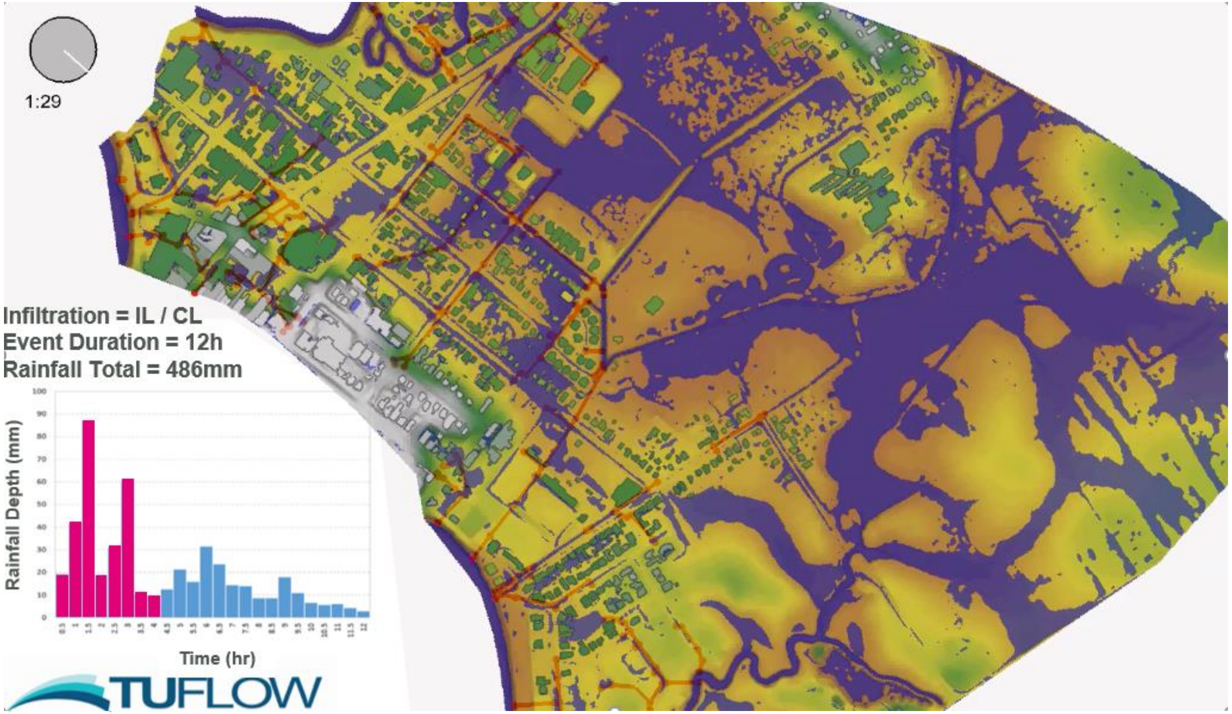
Urban Stormwater Modelling Data Inputs
Direct Rainfall Example

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



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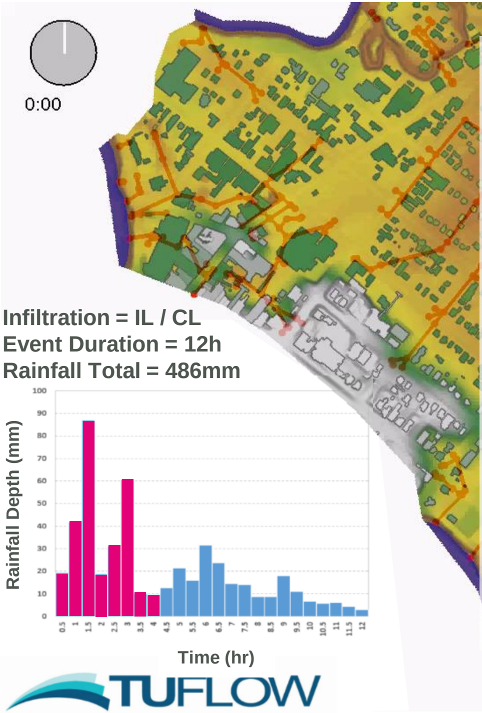


Excellent representation of key physical processes

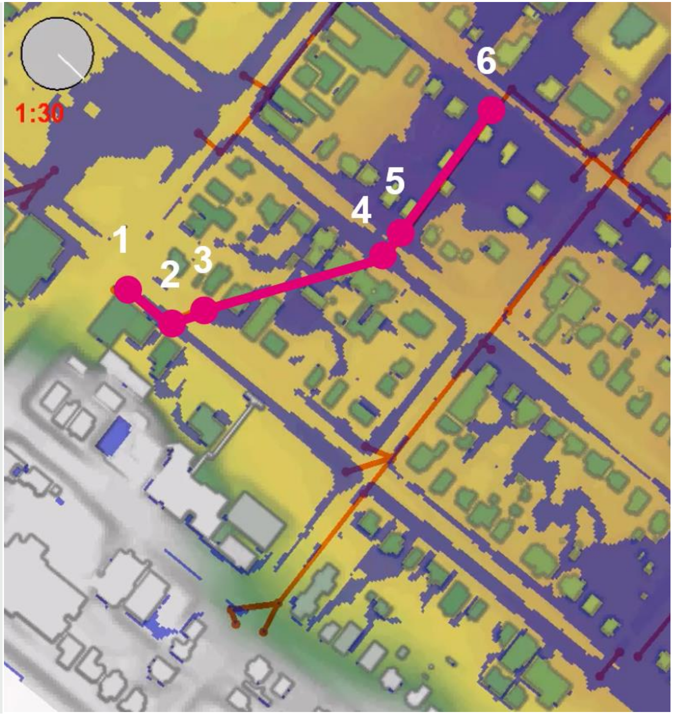
1) Rainfall
2) Hydrologic losses (infiltration)
3) Runoff
4) Flow capture by the stormwater network
5) Energy loss within the underground pipe network
6) Above / below ground stormwater network interactions

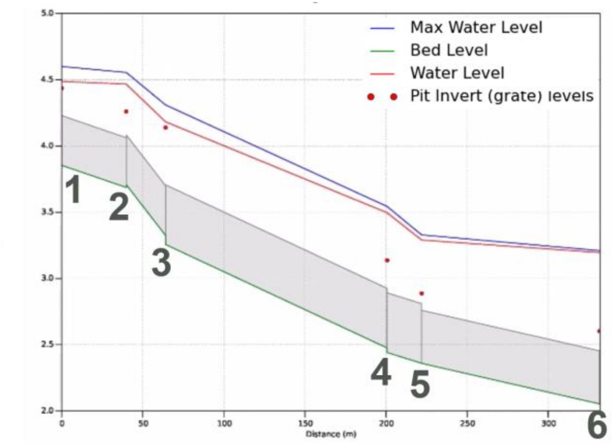
Urban Stormwater Modelling Data Inputs

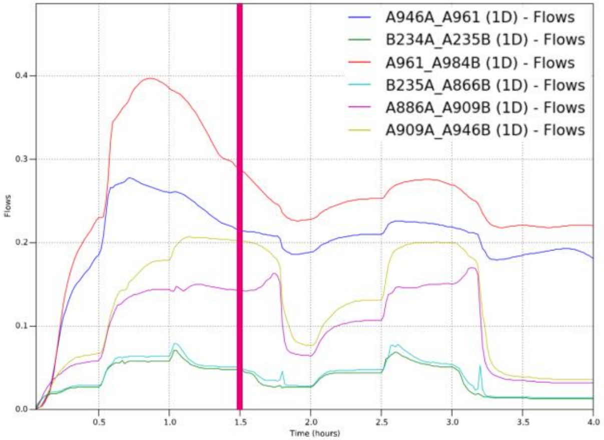
Direct Rainfall – 1D/2D integration

Dynamically linked 1D stormwater network and 2d overland flow model

Accurate representation of overflow into neighbouring drainage areas if stormwater network capacity is exceeded







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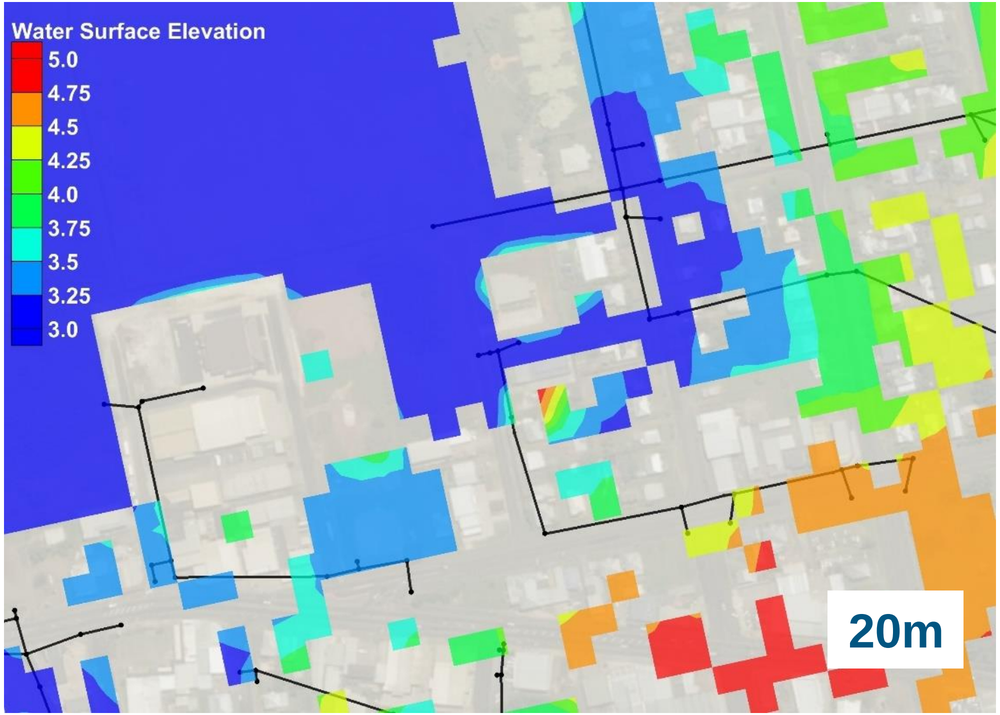
Urban Stormwater Modelling Data
What Matters?

Accurate topography data

What 2D model resolution…

How fine for urban situations?

- 20m 7,500 cells



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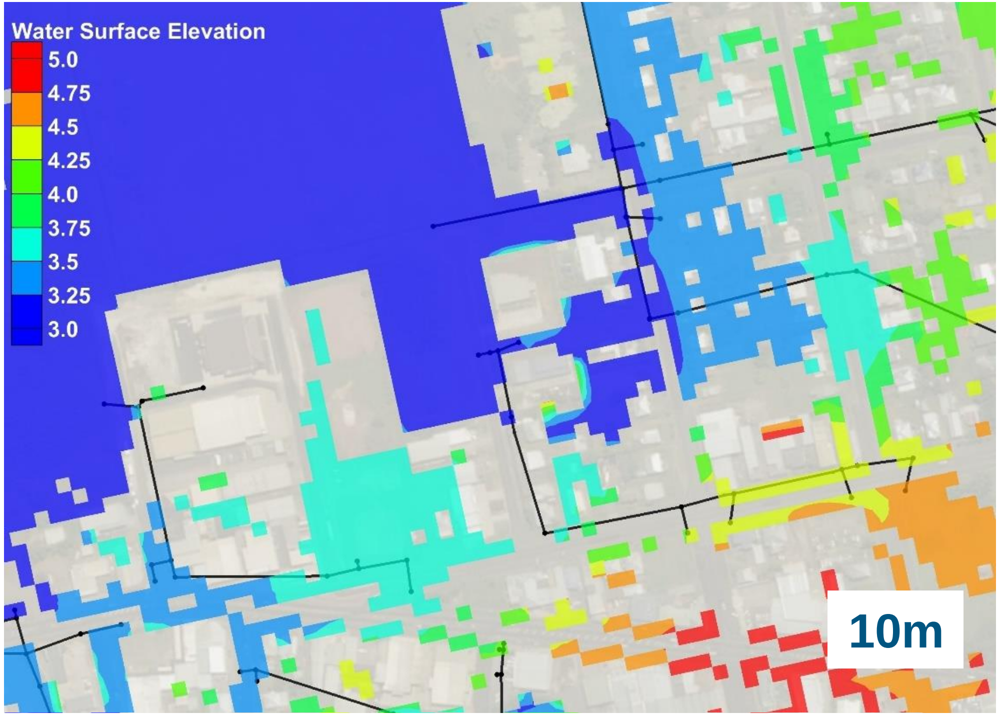

Urban Stormwater Modelling Data
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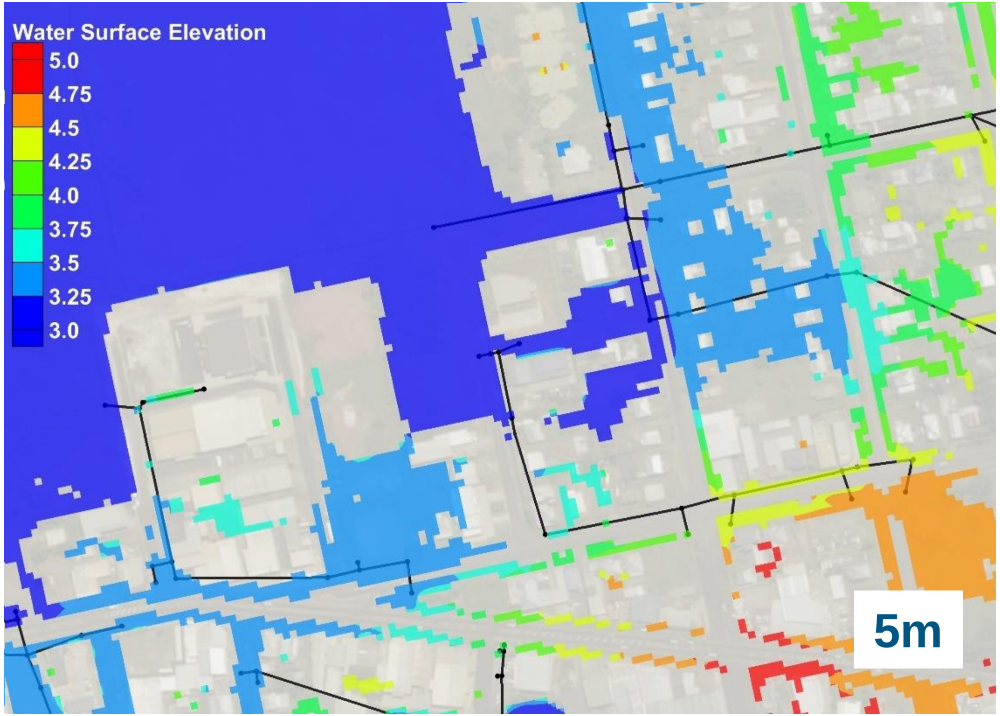
How fine for urban situations?

• 20m	7,500 cells
• 10m	31,000 cells
• 5m	125,000 cells



Urban Stormwater Modelling Data
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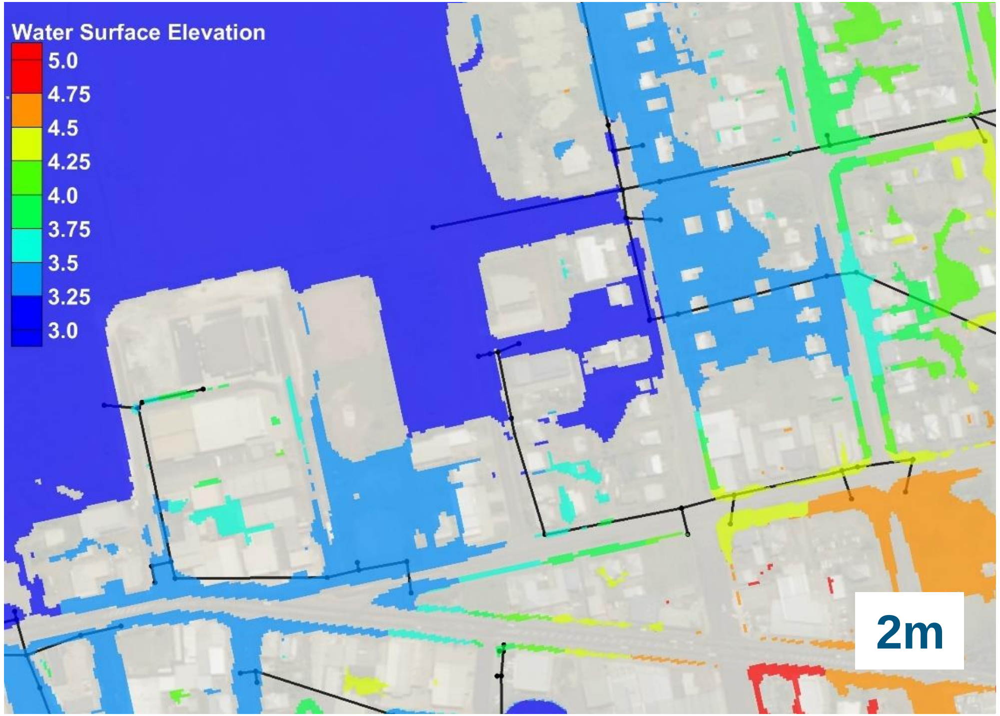
What 2D model resolution…

How fine for urban situations?

• 20m	7,500 cells
• 10m	31,000 cells
• 5m	125,000 cells
• 2m	750,000 cells



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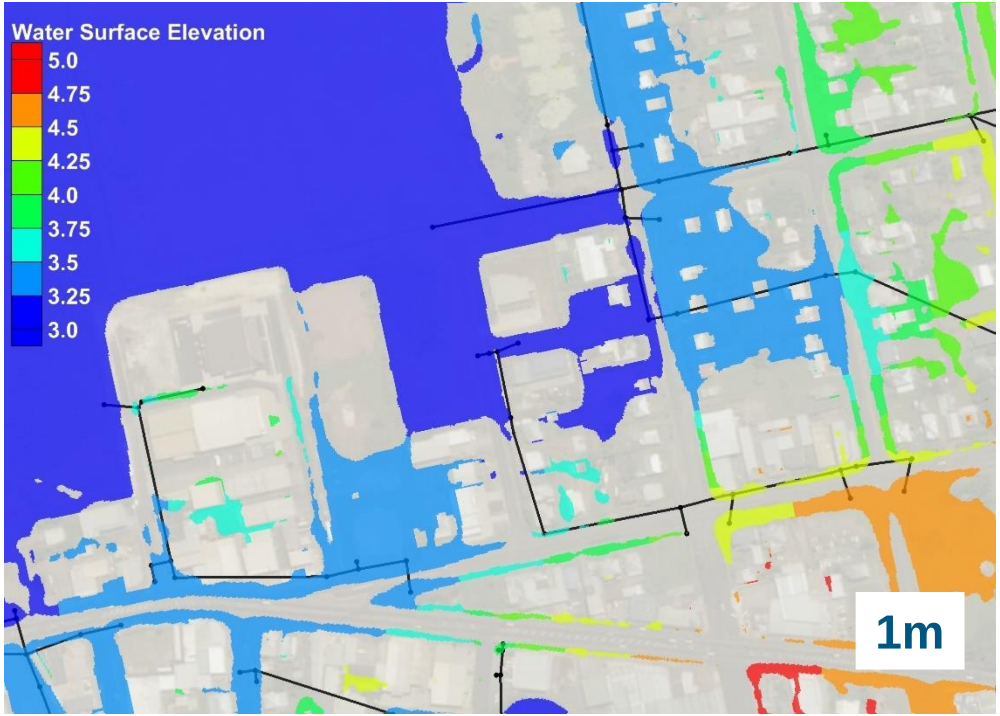
• 1m	3,100,000 cells



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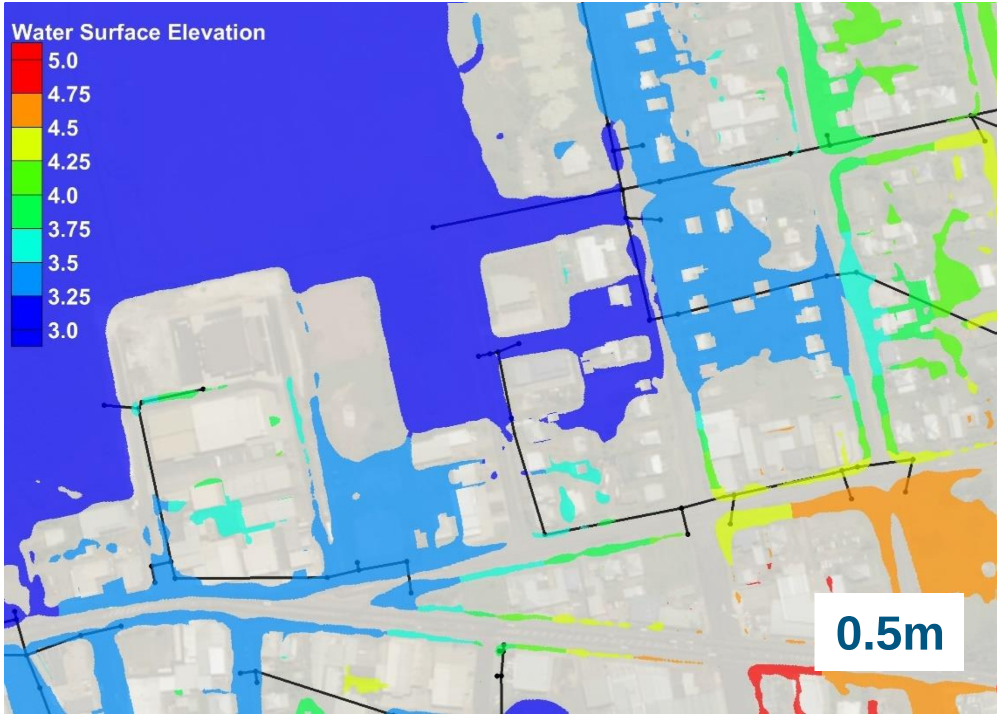
•	2m	750,000 cells
•	1m	3,100,000 cells
•	0.5m	12,500,000 cells



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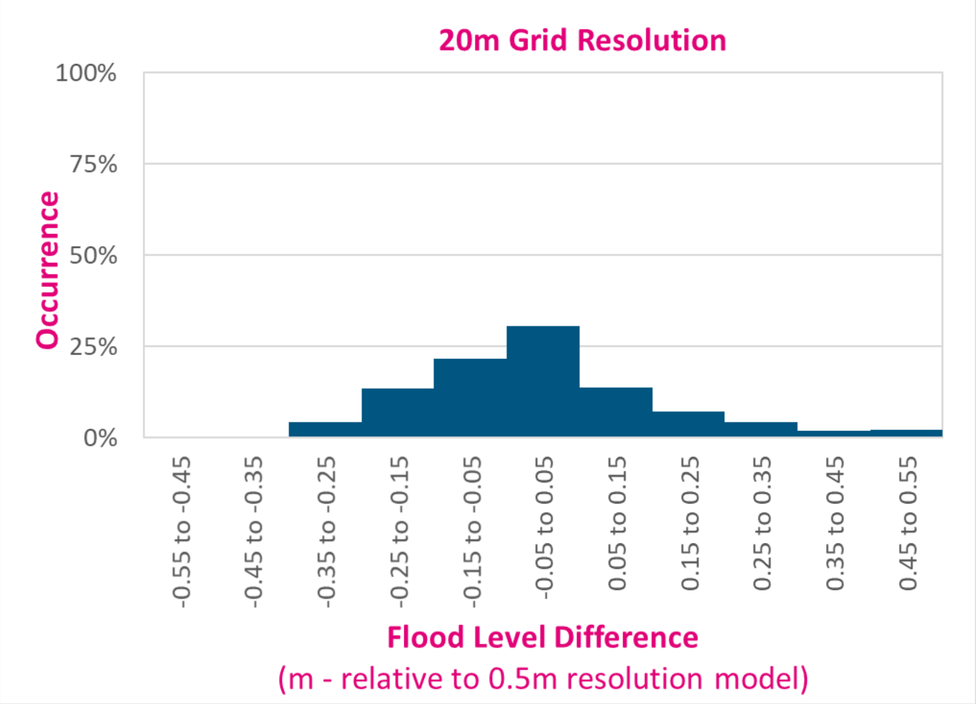

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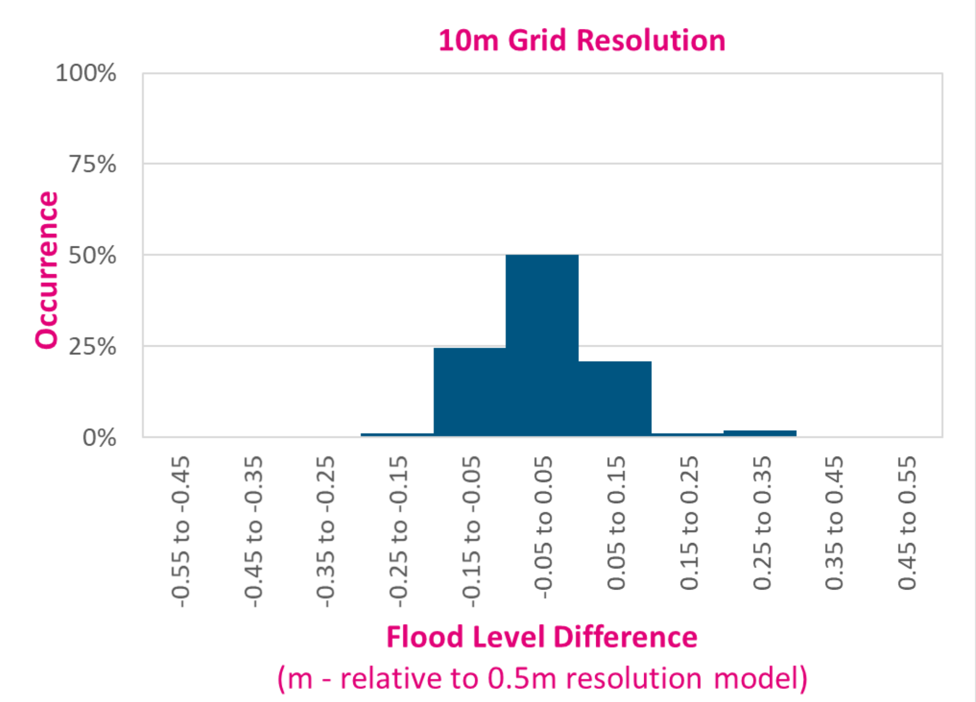

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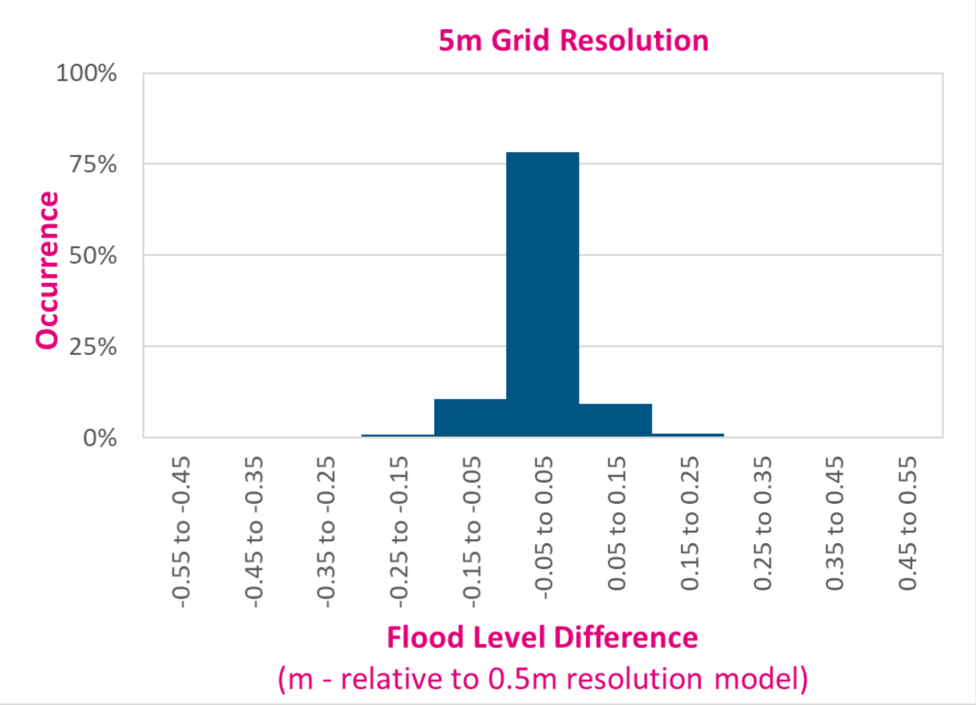

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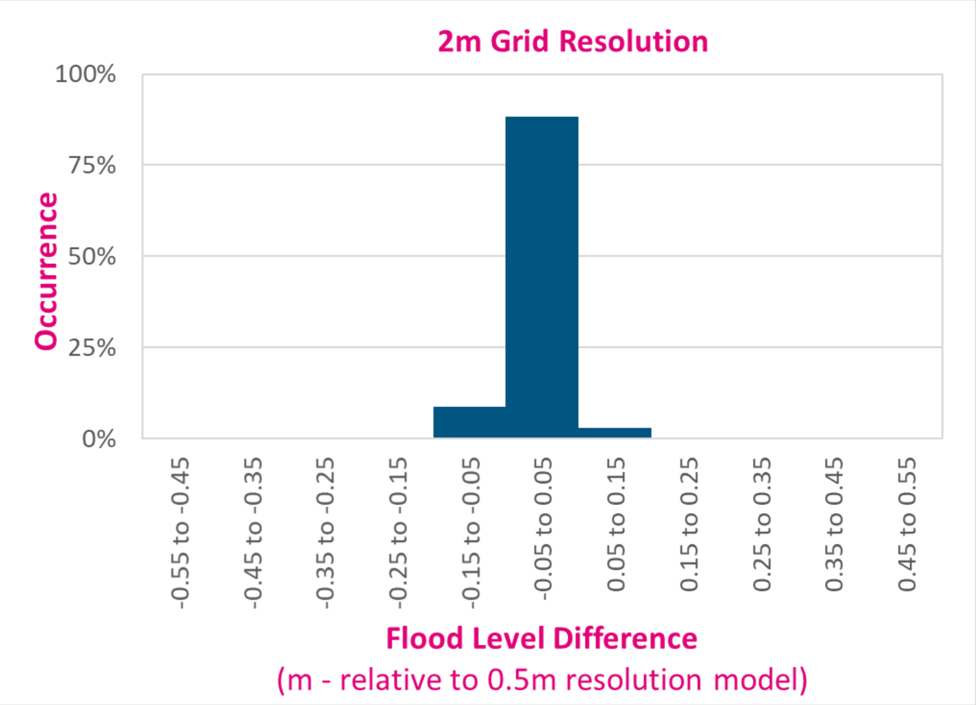
- 5m ✗ 125,000 cells
- 2m ✓ 750,000 cells



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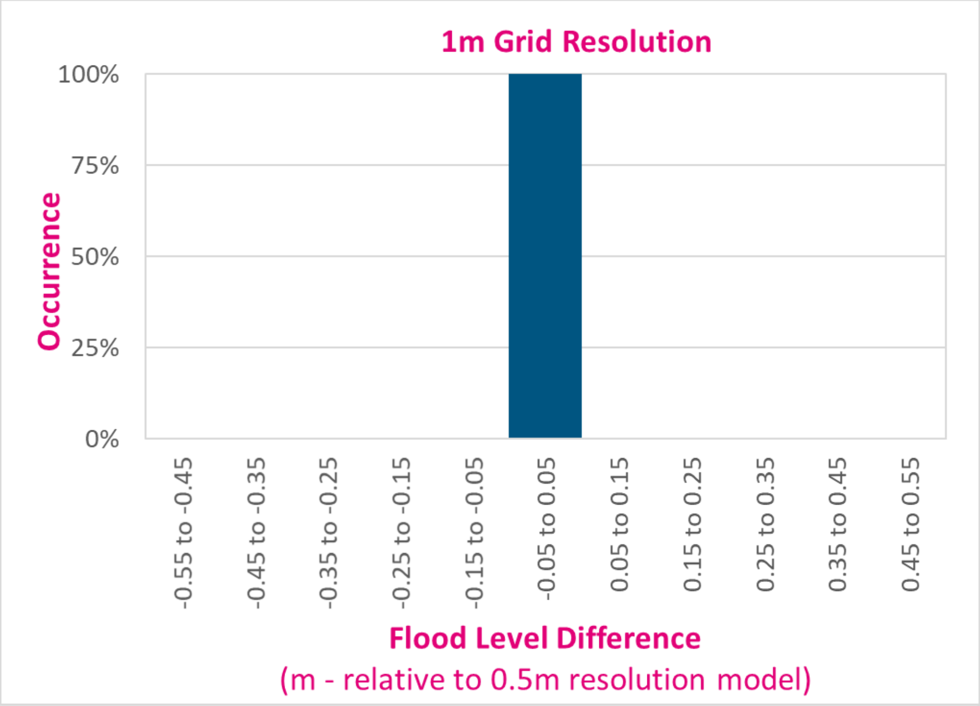
- 5m ✗ 125,000 cells
- 2m ✓ 750,000 cells
- 1m ✓ 3,100,000 cells
- 0.5m ✓ 12,500,000 cells

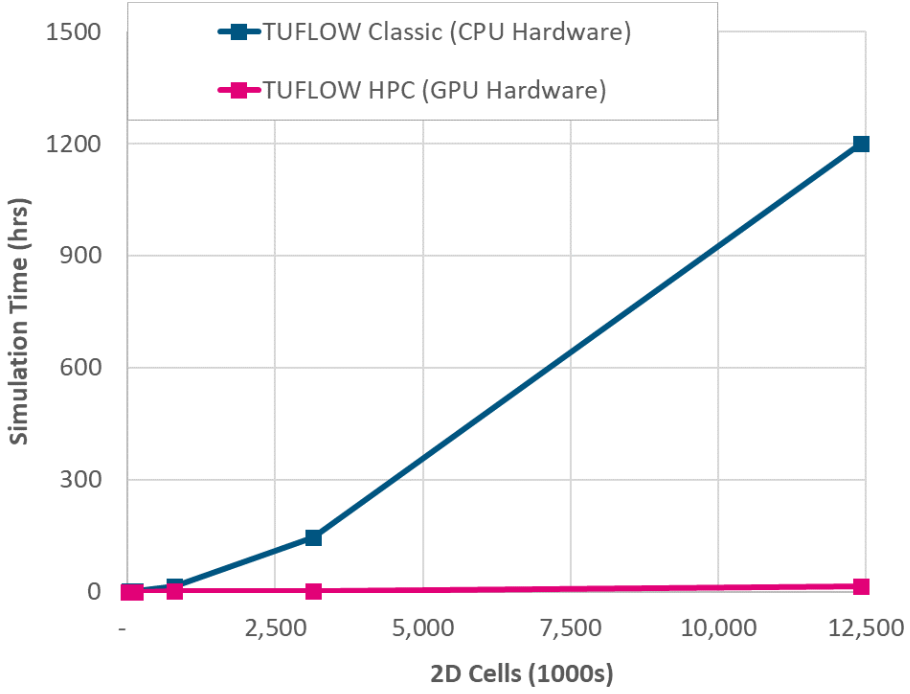


Urban Stormwater Modelling Data
What Matters?

CPU = 17-5960X CPU @3.00GHz
GPU = 2 x GeForce GTX 980

Solver and Hardware Options

	Classic CPU	HPC GPU
• 20m	0:12 hr	0:03 hr
• 10m	0:15 hr	0:03 hr
• 5m	1:32 hr	0:05 hr
• 2m	15:19 hr	0:20 hr
• 1m	146:0 hr	1:55 hr
• 0.5m	≈48 days	18.30 hr



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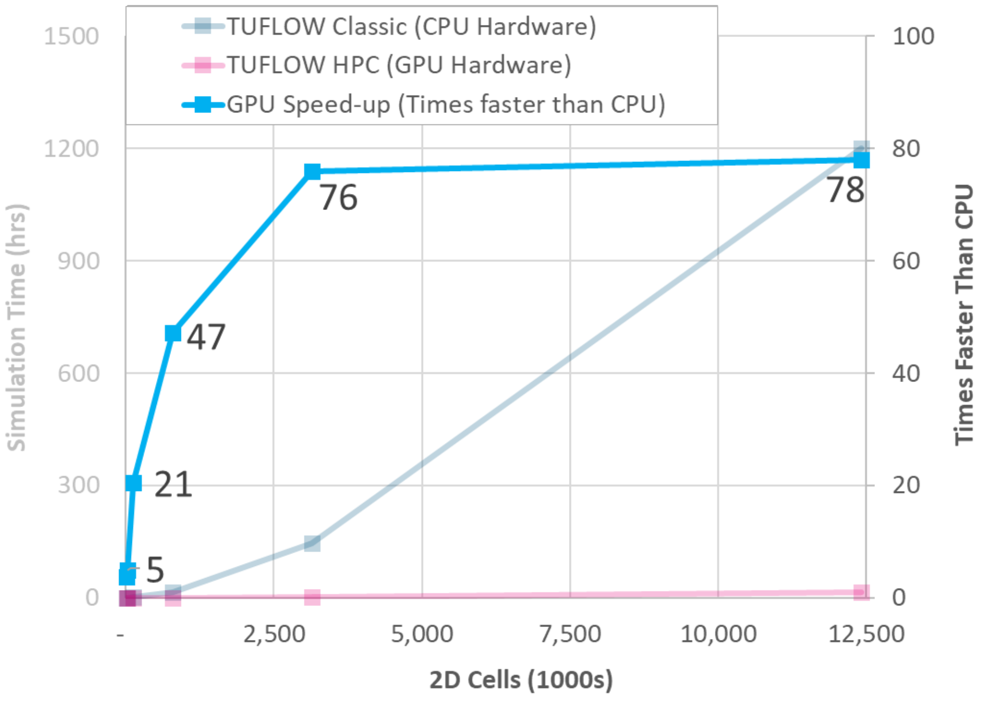
~~5m~~	~~1:32 hr~~	~~0:05 hr~~
2m	15:19 hr	0:20 hr
1m	14[illegible]0 hr	1:55 hr
0.5m	≈48[illegible]days	18.30 hr



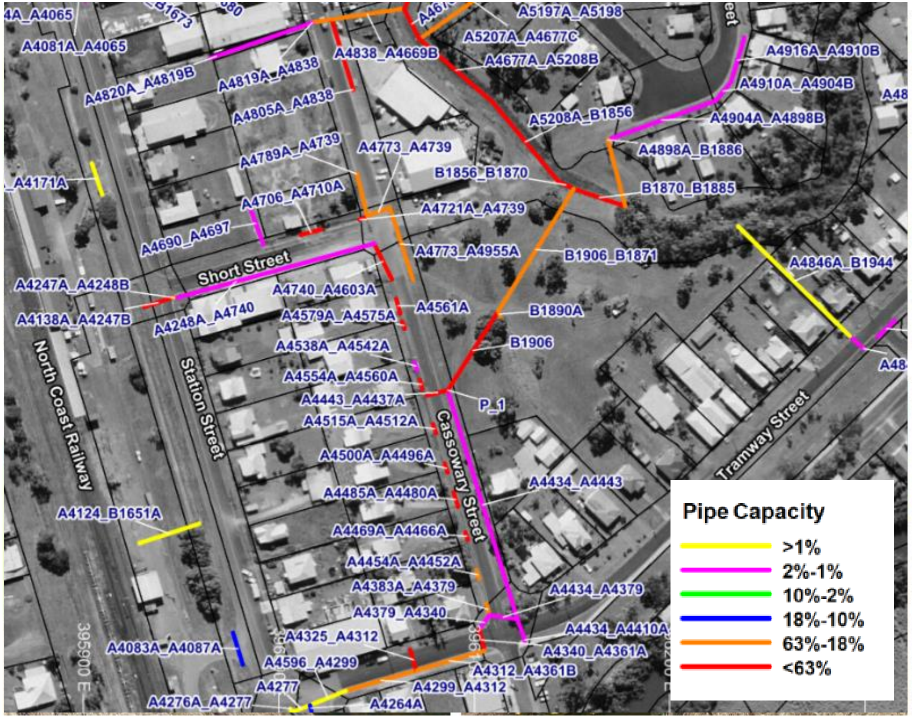
Study Outcomes and Presentation Summary

Study Outcomes

- Physical review of infrastructure condition
- Infrastructure capacity modelling (current and future climate)
- Priority infrastructure upgrade tables

General Modelling Summary

- Urban modelling is now more efficient thanks to HPC and GPU hardware
- Accurate representation of the physical urban drainage processes
- Cell size selection is an important consideration for result accuracy and realistic simulation run time



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ID	Pipe Centroid		Current Size	Current Capacity	Design Capacity	Current Climate AEP Flow (m³/s)					Future Climate AEP Flow (m³/s)					Upgrade Required	
	Easting	Northing				63%	18%	10%	2%	1%	63%	18%	10%	2%	1%	Current Climate	Future Climate
Upstream of Outlet A1046B_A1066A																	
A1367A_A1325	396,760.17	8,061,805.99	1 x 0.9m x 0.31m	<63%	18%	0.17	0.23	0.23	0.24	0.24	0.21	0.23	0.23	0.23	0.23	2xΦ0.9m	2xΦ0.9m
A1325B_B482B	396,764.16	8,061,772.03	1 x 0.95m x 0.31m	<63%	18%	0.15	0.23	0.23	0.24	0.24	0.20	0.20	0.20	0.20	0.20	2xΦ0.95m	2xΦ0.95m
A1368A_B477C	397,150.09	8,062,378.54	1 x 0.91m x 0.3m	<63%	18%	0.17	0.23	0.23	0.23	0.23	0.18	0.23	0.23	0.23	0.23	2xΦ0.91m	2xΦ0.91m
B477A_A1126B	397,159.98	8,062,373.69	1 x 0.6m x 0.35m	<63%	18%	0.24	0.26	0.26	0.26	0.26	0.25	0.25	0.25	0.25	0.25	2xΦ0.6m	2xΦ0.6m
A1111A_A1126	397,165.97	8,062,361.51	1 x 0.6m x 0.3m	<63%	18%	0.15	0.20	0.20	0.20	0.20	0.17	0.17	0.17	0.17	0.17	2xΦ0.6m	2xΦ0.6m
A1075A_A1012	397,171.53	8,062,347.96	3 x Φ0.475m	<63%	18%	0.37	0.39	0.39	0.40	0.41	0.38	0.38	0.38	0.38	0.38	-	-
A1012_A1064A	397,184.84	8,062,342.12	1 x Φ0.475m	2%-1%	18%	0.20	0.22	0.23	0.70	0.70	0.21	0.21	0.21	0.21	0.21	-	-
A1046B_A1066	397,198.69	8,062,345.15	1 x Φ0.375m	<63%	18%	0.09	0.11	0.11	0.13	0.13	0.09	0.09	0.09	0.09	0.09	2xΦ0.375m	2xΦ0.375m
A1010A_A1012	397,208.88	8,062,345.16	2 x Φ0.375m	<63%	18%	0.10	0.12	0.12	0.12	0.12	0.10	0.10	0.10	0.10	0.10	-	-
A1075D_A1076	396,793.05	8,062,952.78	3 x Φ0.475m	2%-1%	18%	0.37	0.42	0.43	0.54	0.54	0.38	0.38	0.38	0.38	0.38	-	-
B482A_B476B	396,316.18	8,062,260.01	1 x 0.955m x 0.31m	<63%	18%	0.16	0.23	0.23	0.24	0.24	0.20	0.20	0.20	0.20	0.20	2xΦ0.955m	2xΦ0.955m
B476A_B477B	396,032.20	8,062,194.79	1 x 0.955m x 0.31m	<63%	18%	0.16	0.23	0.23	0.24	0.24	0.20	0.20	0.20	0.20	0.20	2xΦ0.955m	2xΦ0.955m
A1126A_A1127	396,757.48	8,061,892.79	1 x 0.62m x 0.52m	<63%	18%	0.29	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29	2xΦ0.62m	2xΦ0.62m
A1098A_A1127	396,499.34	8,062,472.37	1 x 0.6m x 0.32m	<63%	18%	0.05	0.06	0.06	0.07	0.07	0.06	0.06	0.06	0.06	0.06	2xΦ0.6m	2xΦ0.6m
A1127_A1076C	396,405.83	8,062,415.60	1 x 0.62m x 0.3m	63%-18%	18%	0.32	0.32	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	-	1xΦ0.75m
Upstream of Outlet A1208A_B957A																	
A1188A_A1188	396,407.80	8,062,365.81	1 x 0.9m x 0.425m	63%-18%	18%	0.18	0.28	0.29	0.29	0.29	0.21	0.30	0.30	0.30	0.30	-	-
A1188AA_A120	396,409.03	8,062,359.64	1 x Φ0.425m	2%-1%	18%	0.18	0.28	0.29	0.30	0.30	0.21	0.30	0.30	0.30	0.30	-	-
A1208A_B957A	396,533.86	8,062,282.74	1 x Φ0.425m	>1%	18%	0.21	0.33	0.34	0.39	0.42	0.25	0.35	0.38	0.42	0.43	-	-
Unknown02	396,559.71	8,062,309.18	1 x Φ0.375m	2%-1%	18%	0.09	0.14	0.15	0.16	0.16	0.11	0.16	0.16	0.16	0.16	-	-
B766A_B401C	396,559.64	8,062,309.35	1 x Φ0.75m	>1%	18%	0.07	0.12	0.13	0.16	0.17	0.09	0.15	0.16	0.19	0.21	-	-
B401A_B387B	396,431.95	8,062,282.05	1 x Φ0.75m	>1%	18%	0.07	0.12	0.13	0.16	0.17	0.09	0.15	0.16	0.19	0.21	-	-
B387A_A1218B	396,756.55	8,061,943.10	1 x Φ0.75m	>1%	18%	0.08	0.14	0.15	0.19	0.21	0.10	0.17	0.19	0.23	0.25	-	-
A1218A_B787A	397,224.60	8,062,106.59	1 x Φ0.75m	>1%	18%	0.08	0.14	0.15	0.19	0.21	0.10	0.17	0.19	0.23	0.25	-	-
B400A_B387C	397,224.76	8,062,098.51	2 x Φ0.375m	>1%	18%	0.02	0.03	0.03	0.03	0.04	0.02	0.03	0.03	0.04	0.04	-	-
Upstream of Outlet A1220_A1213																	
B803A_B792A	396,746.33	8,061,940.83	1 x Φ0.3m	<63%	18%	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	1xΦ0.525m	1xΦ0.525m
B791A_B792B	397,229.75	8,062,075.04	1 x 0.4m x 0.2m	>1%	18%	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	-	-
B792A_A1219	397,319.81	8,062,246.08	1 x Φ0.45m	>1%	18%	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	2xΦ0.45m	2xΦ0.45m
A1220_A1213	397,290.01	8,062,285.36	1 x Φ 0.6m	>1%	18%	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	2xΦ0.6m	2xΦ0.6m
B823_A1264B	397,242.80	8,062,302.38	1 x Φ0.3m	>1%	18%	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-	-
A1264A_A1269	397,242.31	8,062,303.36	1 x Φ0.3m	>1%	18%	0.01	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.04	-	-
A1269_A1259B	397,229.49	8,062,308.63	1 x Φ0.3m	<63%	18%	0.01	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.04	1xΦ0.45m	1xΦ0.45m
A1259A_A1258	397,190.19	8,062,294.45	1 x Φ0.3m	2%-1%	18%	0.01	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.04	-	-
A1258A_A1232	397,212.29	8,062,303.05	1 x 0.6m x 0.2m	63%-18%	18%	0.02	0.13	0.13	0.13	0.13	0.05	0.08	0.08	0.08	0.08	1xΦ0.75m	1xΦ0.75m
A1255A_A1232	397,235.46	8,062,349.82	1 x 0.6m x 0.2m	63%-18%	18%	0.20	0.20	0.21	0.21	0.21	0.24	0.24	0.24	0.24	0.24	1xΦ0.75m	1xΦ0.75m
A1232_A1231	397,228.22	8,062,347.61	1 x Φ0.425m	63%-18%	18%	0.21	0.28	0.28	0.28	0.28	0.29	0.29	0.29	0.29	0.29	2xΦ0.425m	2xΦ0.425m
B1432bb	397,215.89	8,062,344.65	1 x Φ0.3m	>1%	18%	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-	-
B477A_A1126B	397,159.98	8,062,373.69	1 x 0.6m x 0.35m	<63%	18%	0.24	0.26	0.26	0.26	0.26	0.25	0.25	0.25	0.25	0.25	2xΦ0.6m	2xΦ0.6m
A1111A_A1126	397,165.97	8,062,361.51	1 x 0.6m x 0.3m	<63%	18%	0.15	0.20	0.20	0.20	0.20	0.17	0.17	0.17	0.17	0.17	2xΦ0.6m	2xΦ0.6m
A1075A_A1012	397,171.53	8,062,347.96	3 x Φ0.475m	<63%	18%	0.37	0.39	0.39	0.40	0.41	0.38	0.38	0.38	0.38	0.38	-	-
A1012_A1064A	397,184.84	8,062,342.12	1 x Φ0.475m	2%-1%	18%	0.20	0.22	0.23	0.70	0.70	0.21	0.21	0.21	0.21	0.21	-	-
A1046B_A1066	397,198.69	8,062,345.15	1 x Φ0.375m	<63%	18%	0.09	0.11	0.11	0.13	0.13	0.09	0.09	0.09	0.09	0.09	2xΦ0.375m	2xΦ0.375m
A1010A_A1012	397,208.88	8,062,345.16	2 x Φ0.375m	<63%	18%	0.10	0.12	0.12	0.12	0.12	0.10	0.10	0.10	0.10	0.10	-	-
A1075D_A1076	396,793.05	8,062,952.78	3 x Φ0.475m	2%-1%	18%	0.37	0.42	0.43	0.54	0.54	0.38	0.38	0.38	0.38	0.38	-	-
B482A_B476B	396,316.18	8,062,260.01	1 x 0.955m x 0.31m	<63%	18%	0.16	0.23	0.23	0.24	0.24	0.20	0.20	0.20	0.20	0.20	2xΦ0.955m	2xΦ0.955m
B476A_B477B	396,032.20	8,062,194.79	1 x 0.955m x 0.31m	<63%	18%	0.16	0.23	0.23	0.24	0.24	0.20	0.20	0.20	0.20	0.20	2xΦ0.955m	2xΦ0.955m
A1126A_A1127	396,757.48	8,061,892.79	1 x 0.62m x 0.52m	<63%	18%	0.29	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29	2xΦ0.62m	2xΦ0.62m
A1098A_A1127	396,499.34	8,062,472.37	1 x 0.6m x 0.32m	<63%	18%	0.05	0.06	0.06	0.07	0.07	0.06	0.06	0.06	0.06	0.06	2xΦ0.6m	2xΦ0.6m


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