



VARIATION 3 FLOOD MAPS POOKENO UPDATED MAPS - FINAL (NOVEMBER 2023)

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2023 FLOOD MODEL BUILD REPORT Pookeno

This report provides a comprehensive overview and critical analysis of the Pookeno TUFLOW hydraulic model.

The Pookeno hydraulic model focuses on the catchment within and surrounding Pookeno's urban and commercial areas. Pookeno is situated at the base of the Bombay hills and discharges to the Mangatawhiri River which is a tributary of the Waikato River. From a hydrological perspective, Pookeno is known for its high rate of development and its existing and erosion issues.

Modelling Goals & Objectives

The main objective of this rapid flood model is to provide the flood extents for maximum probable development (MPD) to identify areas that additional residential development may be adversely affected by increasing the flood risk. This includes adverse effects to upstream and downstream properties in regards to erosion and flood levels.

The modelling work undertaken includes:

- Acquire and integrate the most recent data and assumptions with regards to topographic, hydrological, and meteorological data into the TUFLOW hydraulic model.
- Identify inaccuracies or deficiencies in the asset data (WDC's GIS stormwater asset information) related to critical infrastructure and revise the hydraulic model to improve the accuracy of the flood risk assessment.
- Utilise the TUFLOW hydraulic model to estimate the flood extents in the study town(s) under Maximum Probable Development (MPD) conditions, considering the anticipated effects of climate change based on the RCP 6.0 scenario (2.3 degree temp. increase) year 2081- 2100.
- Simulate and assess the flood extents for the proposed Maximum Probable Development (MPD) scenario, considering the anticipated effects of climate change based on the RCP 6.0 scenario (2.3 degree temp. increase).
- Evaluate the potential impact of future flooding including flood extents, water depths and velocities (high risk flood hazard D x V as per the district plan hazard criteria).
- Provide insights and data regarding flood extents to inform decision-making processes related to land use planning, infrastructure development and flood risk management.



Model Build Assumptions and Methodology

This hydraulic model incorporates various assumptions crucial to understanding its application, scope, and limitations. These assumptions, inherent in all hydraulic models, aim to reduce the complexity of the natural hydrologic and hydraulic processes to a manageable level while ensuring an acceptable degree of accuracy.

The hydrologic and hydraulic model selection and parameters are outlined in Table 1.

PARAMETERS	DETAILS AND ASSUMPTIONS
SUMMARY	The flood assessment uses a 1D/2D TUFLOW (Version 2020-01-AE) hydraulic model. Design flood hydrographs (applied as both rain on grid and lumped hydrographs) have been developed using HEC-HMS software for the 1% AEP events including Climate Change to 2100.
	 Waikato District Council (WDC) asset data was used for dimensions, length, inverts, and roughness. Where insufficient information was not available to define asset data (i.e., pipes inverts not available), assumptions of invert levels were made based on standard cover to top of pipes (600mm) and existing ground topography for grading assumptions. A Manning's 'n' roughness distribution has been applied to reflect changes in vegetation and land use type within zoned development areas. Roughness values have been determined from the land use coverage from LINZ data in a shapefile format for areas outside of the urban zones. The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the average of the LIDAR points within that cell. Sensitivity check runs have utilised a 3m x 3m grid if the model had a long run time or where multiple runs were required. No soil infiltration was considered in the hydraulic model, as this is accounted for in the hydrologic modeling.
	• The boundary condition downstream consists of a nominal slope, assumed as a 1% in most water body discharge scenarios and 0.5% for land-based discharge scenarios (modified where considered necessary to represent more closely actual topography). For streams discharging into the Waikato River, the tailwater level has not been included as it is considered, as per the WRC flood modelling, that the river levels will not restrict (or significantly affect) the outlet capacity of the network (further refinement of the modelling in the future may include a more detailed representation of the Waikato and other river levels).
MODELLING APP	ROACH
The model incorp	porates 'rain on grid' approach using excess precipitation for Maximum Probable Development (MPD).
MODEL BOUNDARIES/ MAPPED	 The model is made up of three distinct result boundaries that are reflected in the model. These are: 1. Rain on grid areas: These are areas that assign rain fall directly onto the ground model. These areas represent flooding within areas of interest (MDRS and urban zones).
RESULTS	2. 1D catchments : These catchments are represented by a numerical 1D model (Hec-hms) for model efficiency. As such the mapping of flow/water level depths in these areas are not shown. These areas are outside the areas of interest.
	3. 2D Catchments: These areas of 2D terrain show the 1D lumped catchment inflows as well overland flow from the rain on grid areas. These areas are restricted to major flow paths/stream network

Table 1 Hydrologic and Hydraulic Model Parameters



	and do n	ot pick up smaller overland flow	v to the same level as provided within the	Rain-on-grid	
	areas. Th	ere areas are outside the areas	of interest		
HYDROLOGIC AS	SUMPTIONS				
LOSSES	 Hydrological losses for the MPD scenario were Calculated using the SCS method, which uses different curve numbers (CN) based on soil drainage and land use. Because of the variety of soils in the area, the CN values were determined for each sub-catchment. Adopted curve numbers have been sourced from S-Map (soil maps) and as per the Waikato Hydraulic Modelling Runoff Guidelines. The weighted curve numbers for developed areas also incorporated another % of impervious areas in the model. The assumptions are based on the table below 				
		Zone /Area	% Impervious in MPD		
		Rural	Area taken from building layer and 100% impervious applied		
		Existing Residential	70		
		Residential Growth Cells (includes Roads)	80		
		Commercial	90]	
		Industrial	90		
		Existing Roads	Area taken from Road layer and 80% impervious applied		
	Initial Abstraction (IA) and storage: IA is the amount of rain that soaks into the ground before a rainfall event turns into runoff. This was modelled as per the Waikato Stormwater Runoff Modelling Guidelines. The following equation is utilised to calculate IA in the model. $I_a = 0.05 \times S$				
	Storage is calcu	hated as per the walkato Regiona $S = \left(\frac{1000}{cN}\right)$	(-10) 25.4 (mm)		
CATCHMENT DELI	INEATION/ RAINFA	ALL AREAS			
NET RAINFALL ZONES	Zones and soil	Zones and soil classes form the 2d areas that are used for the 2D rainfall areas.			
EXTERNAL AND INTERNAL 1D CATCHMENTS	Hydrologic sub- within the GIS of data (LIDAR) ar	-catchment delineation is initial environment. This tool defines s nalysis and the identification of t	ly developed using the watershed definitions sub-catchment boundaries based on the d flow paths based on topography.	on algorithm igital terrain	
AND ZONES.	The 1D Catchm model input an but contribute	nents that drain into the areas o d shows no overland flow paths (inflows) to areas of interest.	f interest of this model are represented b s or flooding (as these are outside of the a	y a HEC-HMS rea of interest),	



DESIGN RAINFALL	Rainfall data was tak on the October 2023 Guidelines for infras	aken from the existing model which was sourced from the NIWA HIRDS v4 website 23 and is outlined below. As per the Waikato Stormwater Runoff Modelling astructure an RCP 6 year 2081-2100 (as a minimum) has been adopted.				osite	
		Town	Duration / AE	P event 1	% AEP		
		Pookeno	24h - Duration	1	90mm		
LAND USE / ROUGHNESS	The model uses Ma roughness. These c handled by using di in QGIS. The remain consistent with the	nning's coefficie oefficients are a fferent values ir ing areas of the Waikato Storm	ents to represent er ssumed to be const a different cells. The e catchment were as water Management	ergy losses due to ant across each ce area was separate ssumed to be gras Guideline.	o channel ell, and sp ed into la s cover. N	and floodplain patial variability nd cover classif Aanning's value	i is fications es are
	Houses Gra	ss Roads	Water bodies (Low Vegetation)	Bush (Dense Vegetation)	Cultivat (Mediu Vegetat	ted Areas m tion)	
	0.5 0.	0.015	0.025	0.06		0.04	
1D Hydraulic Mo	del Assumptions						
PIPES	 The pipes with missing or '0' diameter in the asset were assumed to have the same diameter as the pipe on the immediate downstream. Pipes with missing inverts were assigned the invert levels from the surrounding manholes or pipes. In case none of the connected manholes and pipes have any invert information, then the inverts were interpolated from the ground network as Invert = Ground level - 0.6m - Diameter of the largest connected pipe 					iter as les or nverts	
MANHOLES	 Diameters for manholes with missing diameters were assumed to be 1050mm dia unless connected pipe(s) sizes warranted an increased diameter. Missing manhole inverts were taken from the invert of the lowest connected pipe. 						
CULVERT	 Culverts are incorporated in the model where a significant waterway occurs. Culvert information has been extracted from WDC's GIS database. Where information was not available/missing the following assumptions have been applied: The culvert inverts have been determined from the existing channel terrain data. The pipe diameters and number of culverts have been determined from the stream cross-sections and upstream and downstream pipe diameters. In some cases where the culvert is unable to determined, the crossings have been "burnt in" (embedded into the ground model) to reflect a continuation of flow. 						
HYDRAULIC LOSSES	Hydraulic losses have been applied to inlet and outlet of culverts and pipes – losses have not been applied to the manholes.						
LIDAR	The DEM provided model. This data wa	had a resolution is assumed to b	of 1m x 1m that fo e accurate.	rms the base infor	mation fo	or the hydraulio	С



	Where it was observed that water levels and vegetation have not been accurately removed within the
	LIDAR ground model or there where observed connectivity issues – modification (Z lines) were added to
	the LIDAR.
GRID SIZE	The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the
	average of the LIDAR points.
	The SGS approach samples the bathymetric data at a finer resolution than the 2D grid (0.5m x 0.5m),
	generating depth-varying hydraulic properties for each cell.
BOUNDARIES	Downstream boundaries that discharge from the network are set as a normal slope of 0.5%, consistent
	with the gradient of the land.
RIVERS AND	Rivers were excluded from the modeling. A normal depth boundary condition with a slope of 1% was
STOP BANKS	assumed along the river stop banks. No abnormal ponding or glass wall effect were seen in the final
	results.
SENSITIVITY	Sensitivity analysis has been undertaken using different scenarios. This is outlined in the below Quality
RUNS	Assurance and Sensitivity Checking section.
ASSUMPTION	The modelling undertaken aligns, as much as practicable within the project scope, with the Waikato
AND	Stormwater Runoff Modelling Guidelines (June 2018).
LIMITATIONS	
CALIBRATION	Calibration has not been undertaken on the model as data is unavailable. Calibration and or
	validation could be undertaken within the stream network if monitoring stations are utilised in the
	future and survey of debris levels are taken post extreme events.



Quality Assurance and Sensitivity Checking

This section addresses the additional checking and quality assurance outlined in the TMW evidence prepared for the MDRS Variation 3 hearing. This also aligns with the discussions at the hearing in regard to model confidence and standard practice for urban scale hydraulic models.

Additional model runs were undertaken to test the model's sensitivity to certain parameters. This was to provide an indication of how each model is affected by certain key parameters. Although these parameters are selected by following guidance there is an envelope of interpretation required. This methodology enables confidence in the flood maps if the results are similar to the base run as this shows the factors are less critical. If the results are significantly different this highlights the parameter maybe more critical in which case the parameter is re-considered in more detail to confirm it is correct.

Modelling QA Summary:

1. Base model:

- 1. Manual removal of small, isolated ponding areas that were considered to represent errors in topography from LIDAR processing or not relevant to the flooding assessment scope (identification of properties with flooding that requires assessment if developed).
- 2. Manual removal of small, isolated ponding areas that were considered unlikely to occur due to potential LIDAR processing areas from vegetation.
- 3. Checking of connectivity between large flooding area split by roads or embankments.
- 4. Cutting in of channels to represent connection under bridges or channels not considered to be accurately represented by LIDAR.
- 5. Checking and inclusion of pipes and culverts in areas considered likely to contain pipes and culverts based on knowledge of areas and surrounding topography.

2. Blockage Scenarios

- Base Blockage Scenario (as included in finalised flood maps): Critical pipes only included in model: If pipes are included in model (refer pipes modelled maps) then these are considered to be at 100% capacity (0% blocked). Initially all pipes below 300mm were excluded, however during the QA stage some pipes 300mm dia and smaller were included if they had potential to impact ponding areas.
- 2. Blockage Scenario 1: 100% blockage on all pipes within model (Bridges and Z channels = 0% blockage).
- 3. Blockage scenario for critical pipes (all pipes included in model) are outlined in the table below:

Pipe size(s)	<300mm	300-600mm	600-900mm	>900mm	Bridges/open channels (Z Cuts)
% blockage	100%	75%	50%	25%	0%



3. Runoff factors:

Current CN Values as included in finalised flood maps

Soil Type	Cover type / Soil Description	CN values				
		Forest	Grass	Dirt	Cropland	Impervious
А	Moderately Well	30	39	72	67	98
	Draining & Well					
	Draining					
В	Imperfectly Well	55	61	82	78	98
	Draining					
С	Poorly Drained	70	74	87	85	98
D	Very Poorly Drained	77	80	89	89	98
Impervious		98	98	98	98	98

Sensitivity check CN Values: 25% added to existing (Existing CN * 1.25 + rounded to nearest whole number to a max of 98). Increased values are underlined.

Soil Type	Cover type / Soil Description	CN values				
		Forest	Grass	Dirt	Cropland	Impervious
А	Moderately Well	<u>38</u>	<u>49</u>	<u>90</u>	<u>84</u>	98
	Draining & Well					
	Draining					
В	Imperfectly Well	<u>69</u>	<u>76</u>	<u>98</u>	<u>98</u>	98
	Draining					
С	Poorly Drained	<u>88</u>	<u>93</u>	<u>98</u>	<u>98</u>	98
D	Very Poorly Drained	<u>96</u>	<u>98</u>	<u>98</u>	<u>98</u>	98
Impervious		98	98	98	98	98

4. Hydrology:

- 1. Existing = 24 hour rainfall event + 6 RCP climate change scenario (as included in finalised flood maps) for years 2081-2100.
- 2. Check = 24 hour event + 8.5 RCP climate change scenario for years 2081-2100.

5. Comparison to existing models

- 1. WRC flood model This comparison showed that the WRC flood maps/modelling does not intersect the urban area and therefore no useful comparison was able to be undertaken.
- 2. Previous WSP rapid flood hazard modelling. This mapping was based on previous LIDAR which is less accurate than the 2022 LIDAR. This also excluded all pipes. This quick method for flood area identification showed good correlation in the gully areas.



6. Sensitivity results comparison:

The following compares the results from each sensitivity run to the base model. Each run utilises a 3m x 3m grid and hasn't been cleaned (removal of small isolated ponding areas). Refer to summary table below for results.



Figure 1: Base map (Flood depths)



Figure 2: Blockage Scenario 1 – Shows increased flooding by the 100% blockage scenario. This shows an increase in flood levels but not significantly increasing the flood footprint. This blockage scenario is unlikely to occur as large culverts are less likely to completely block. As expected there is no difference in areas that are not constrained by culverts. Result: Not considered a critical factor.





Figure 3: Blockage Scenario 2 – Shows a slight increase in flooding from the base model and a reduction in flood level from the 100% blockage scenario as would be expected. Result: Not considered a critical factor in the flood model as very similar to base model.



Figure 4: CN Increased Scenario: Shows slight increase from base model (small isolated flooding areas not cleaned). Result: Not a critical factor in the flood model as very similar to base model.





Figure 5: Increased Climate Change Scenario (RCP8.5): Shows slight increase from base model (small isolated flooding areas not cleaned). Very similar to the CN increase scenario. Result: Not a critical factor in the flood model as very similar to base model.

Scenario	Critical	Comment
Blockage 1	Yes in areas directly affected by	Blockage of large culverts is unlikely so not
	culverts.	considered a critical issue requiring further
	No in areas not affected by culverts	testing. Consideration of catchment
	(as expected).	characteristics in terms of blockage risk could be
		considered in the future if further refinements are
		undertaken.
Blockage 2	No	Slight increase only – no additional properties
		inside flood extent
CN factor	No	Slight increase only – no additional properties
increase		inside flood extent
Climate change	No	Slight increase only – no additional properties
increase		inside flood extent

Sensitivity Checking Results summary:

No additional sensitivity checking or changes to the base model parameters are required due to the results above showing that the parameters tested are not critical enough to warrant further testing or adjustments. Any adjustments within the guidance parameters are unlikely to show substantial changes in the flood extent.

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Saeed Ashouri and Andrew Boldero	Britta Jensen
24/11/2023	24/11/2023







VARIATION 3 FLOOD MAPS POOKENO UPDATED MAPS - FINAL (NOVEMBER 2023)

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Client:



Project: Variation 3 Pookeno Flood Model

 Document: TMW-CSW
 Sht 1

 Date:28/11/2023
 Rev

 0
 120
 240
 480 m

 L
 L
 L
 L
 L

N

LEGEND

 MPD Flood Model 1% AEP + CC

 Maximum Depth (m)

 <0.1</td>

 0.10-0.20

 0.20-0.40

 0.40-0.60

 0.40-0.60

 0.80-1.0

 1.0-2.0

 >2.0

 2.0

 2.0 Hydraulic Model Boundary



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	Client: Waikato
	Project: Variation 3 Pookeno Flood Risk
	Document: TMW-CSW Sht 1 N Date:28/11/2023 Rev Image: Non-state state st
	2D Hydraulic Model Boundary High Risk Flood Hazard MPD 1% AEP + CC Flood Extent Plan Zones Village Business Business Town Centre
	Industrial Heavy Industrial Variation 3

Kellyville