MEMORANDUM

Project:	Byron Bay Drainage Upgrade Design	Date:	7 November 2023
To:	Byron Shire Council	From:	Tim Randell
ATT:	Peter Brown	CC:	
Subject:	Basis of Hydrology and Hydraulic Modelling – CONCEPT DESIGN UPDATE – Byron Bay Drainage project.		

INTRODUCTION

This basis of modelling summary has been prepared for Byron Shire Council (BSC) for the proposed Byron Bay Drainage Upgrade. The purpose of the basis of modelling document is to provide an outline of the parameters and approach for the hydrological model and hydraulic model revision and update to be used as the basis for the project. These models are critical to the project as they will define the performance and impact of the drainage and flooding changes proposed in the project.

This document pertains to existing case and developed models planned to be revised for the concept design in July 2023.

GENERAL

Key requirements and documentation that guide the modelling are:

- Australian Rainfall and Runoff 2019.
- NSW DPE – Flood risk management manual (DPE, 2023).
- Byron Bay Local Environment plan (2014).
- Northern Rivers Drainage Manual.

Another key consideration is Councils desired 80 year design life, which influences the developed scenario modelling around what assumptions should be made for a developed case in the near term (i.e., 5-10 year horizon for say year 2030) vs long term (say year 2100).

HYDROLOGY

Hydrologic modelling has adopted the WBNM model software for the analysis. A detailed basis of hydrology modelling list is shown in Table 1. The model is focussed on local catchments in the Byron bay township study area and does not assess regional flooding of Belongil Creek.

Fraction Impervious

The model is to be developed for current day catchments, and future land use assuming full development. This assumes a fraction impervious based on the zoning defined in the Byron Bay LEP (2014). The impervious fractions adopted are as provided in Table 1. This has been completed in line with council's current guidelines with reference the Queensland Urban Drainage Manual (IPWEAQ, 2016) for impervious fractions suggestions.

TABLE 1: FRACTION IMPERVIOUS ADOPTED FOR MODEL CONDITIONS

Land Use	Existing Case (for February 2022 event model run)	Ultimate Case
Recreation and Open Space	Completed using aerial imagery	0%
Intensive agriculture / livestock		30%
Rural Residential		20%
Urban Residential		70%
Industrial		80%
Commercial		90%
Waterbodies		100%

Review of the variation in catchment impervious between using either existing aerial photography compared to ultimate land use values are provided for a few select catchments at Shirley Street and the Town Centre, as shown in Figure 1 and Figure 2. The differences are provided in Table 2. As anticipated, the aerial inspection fraction impervious values are typically lower than that of the land use, especially in the urban residential zones. Within the town centre, the variance is far less significant.

TABLE 2: VARIATION IN AERIAL INSPECTION VS LAND USE FRACTION IMPERVIOUS

Catchment	Aerial Inspection Fraction Impervious	Ultimate Development Fraction Impervious
7A (Shirley Street)	45%	64%
7C (Shirley Street)	48%	67%
9B (Town Centre)	89%	89%
9L (Town Centre)	76%	87%

Figure 1: Shirley Street Representative Catchment

Figure 2: Town Centre Representative Catchment

Rainfall Data Adopted for Design

The latest rainfall data appropriate for the study is the ARR2016 design rainfall available form the Bureau of Meteorology.

Based on review of this available rainfall data sets in the Strategy Report (Engeny, 2023) ARR2016 both on face value and following application of ARR pre burst and losses the ARR2016 rainfall data has generally lower values than the historic ARR1987 values (used by SMEC in the development of the original strategy). This is shown in the table below for the relevant durations up to approximately 3 hours.

TABLE 3: PERCENTAGE DIFFERENCE IN ARR 2019 AND ARR 1987 IFD VALUES (NEGATIVE VALUE INDICATES LOWER ARR 2019 VALUE)

Duration - AEP	63%	39%	18%	10%	5%	2%	1%	1:1000	1:2000
15 min	-9%	-10%	-11%	-8%	-8%	-8%	-8%	4%	0%
20 min	-9%	-11%	-12%	-9%	-9%	-9%	-9%	6%	3%
25 min	-10%	-12%	-13%	-10%	-10%	-10%	-9%	6%	3%
30 min	-11%	-13%	-14%	-11%	-11%	-10%	-10%	5%	2%
45 min	-12%	-14%	-15%	-12%	-12%	-11%	-10%	-1%	-3%
1 hour	-13%	-15%	-16%	-13%	-12%	-11%	-9%	-7%	-10%
1.5 hour	-13%	-15%	-16%	-12%	-11%	-9%	-7%	-2%	-5%
2 hour	-13%	-15%	-15%	-11%	-10%	-7%	-5%	-1%	-4%
3 hour	-12%	-13%	-13%	-9%	-6%	-4%	-1%	-3%	-6%

It is understood further work may be pending on design rainfalls for the region based on the March 2022 flood post event analysis, which may result in increases to the Byron Bay design rainfall IFD similar to those determined for other Northern Rivers locations (such as Lismore). Based on uncertainty of the outcome of this future work and in discussion with Council, a 10% IFD uplift factor has been applied to the point rainfall depths for concept design. This will initially adopt a design rainfall data set closer to the ARR1987; however, these may require revision as future work is completed.

The adoption 10% rainfall uplift factor roughly aligns with:

- The original ARR87 data set used in the scheme development both before and after consideration of losses (SMEC, 2010).
- An IPCC RCP4.5 intermediate climate change scenario based on ARR guidance. (http://www.bom.gov.au/water/designRainfalls/document/Bates-et-al-2015b.pdf).
- The sensitivity 1 climate change scenario per the Byron Bay LEP.

The adopted IFD values ranging from the 63.2% (1 year ARI) up to the 1 in 2000 AEP (2000 year ARI) have been provided in TABLE 4.

TABLE 4: ADOPTED IFD VALUES (ARR2019 *10%)

Duration - AEP	63.20%	39%	18%	10%	5%	2%	1%	1 in 200	1 in 500	1 in 1000	1 in 2000
15 min	20.7	25.6	31.0	35.3	39.8	45.7	49.8	53.6	59.8	64.5	69.1
20 min	24.0	29.7	36.0	40.9	46.2	53.0	58.0	62.3	69.6	75.1	80.5
25 min	26.6	33.0	40.0	45.5	51.5	59.2	64.9	69.9	78.1	84.2	90.2
30 min	28.8	35.8	43.5	49.5	56.1	64.7	71.1	76.6	85.6	92.3	98.9
45 min	34.1	42.4	51.7	59.1	67.3	78.2	86.6	93.3	104.3	112.2	121.0
1 hour	38.1	47.3	58.1	66.7	76.3	89.2	99.3	107.1	119.9	129.8	138.6
1.5 hour	44.2	55.1	68.3	79.0	91.0	107.5	121.0	129.8	145.2	157.3	168.3
2 hour	49.2	61.4	76.7	89.2	103.2	123.2	138.6	148.5	166.1	179.3	192.5
3 hour	57.2	71.7	90.6	106.3	124.3	148.5	168.3	180.4	201.3	217.8	233.2

Additional climate change sensitivities required under the Byron Bay LEP require a 30% uplift in rainfall intensity on the 1:100 AEP event. This will be done on the base case ARR2016 rainfall set (without the 10% uplift). The (LEP 2014) climate change scenarios 2 and 3 are required assess impacts and performance, however, not to size infrastructure.

Losses

Model losses will be adopted as per the strategy report discussion, with the pervious initial losses being as provided in Table 5 and a continuous loss of 0.84 mm/hr. The impervious losses have been adopted as 1 mm and 0 mm/hr respectively.

Table 5: APOPTED PERVIOUS INITIAL LOSSES

Duration	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1:200 AEP	1:500 AEP	1: 1000 AEP	1:2000 AEP
1 hour	24.2	13.2	12.3	12	10.8	7.7	3.8	1.5	0.8	0.4
1.5 hour	25.1	14.7	13.3	12	10.2	8.3	4.1	1.7	0.8	0.4
2 hours	22.4	13.4	13	11.1	10.3	6.1	3.0	1.2	0.6	0.3
3 hours	21.9	13.7	12.6	10.2	9.6	5.2	2.6	1.0	0.5	0.3
6 hours	19.9	12.8	12.2	10.9	11.1	3.5	1.7	0.7	0.3	0.2
12 hours	21.9	15.3	15	12.2	13.8	4.5	2.2	0.9	0.4	0.2
18 hours	25.8	19.1	19.6	14.9	16.7	5.4	2.7	1.1	0.5	0.3
24 hours	29.9	21.7	21.4	16.5	14.3	5.9	2.9	1.2	0.6	0.3
36 hours	35.3	26.4	24.8	19.6	17.9	6.2	3.1	1.2	0.6	0.3
48 hours	37.4	27.7	26.6	23.7	23.2	7	3.5	1.4	0.7	0.3
72 hours	42.3	32.6	32.1	29.6	27.3	11.7	5.8	2.3	1.2	0.6

Extreme Events (0.1%, 0.05% AEP and PMF)

The addition of extreme events in the analysis is required to assess impacts to inform flood damages calculations and cost benefit analysis. Extreme events will not be used for design purposes. Therefore, standard ARR2016 rainfall and methodology will be adopted up to the 0.05% AEP (including the nominated 10% intensity uplift for consistency). No uplift of rainfall depths will be adopted for PMF.

The adopted initial losses have been provided in Table 5, which interpolate from the 1% AEP event to the PMF event (which applies 0 mm), whilst the continuing losses remains consistent with the intermediate and rare events. The rare GSDM temporal patterns have been utilised for the assessment of all extreme events.

Sub Catchments Delineation

Further delineation of the sub catchments in the hydrologic model will be undertaken in concept design to enable the use of the model results for trunk drainage design. Adoption of streamlines in TUFLOW will be used to improve flow representation along kerb lines and through road corridors in the 2D domain.

HYDRAULIC MODELLING

Hydraulic modelling will be per the strategy report model with extensions required to capture the Massinger street area and include available surveyed information of the stormwater network in this catchment.

Consideration of several concurrent projects will be made in the ‘base case ‘model for assessing impacts as follows:

Base Case (current day hydrology for 2022 validation run only)

Topographic basis for the concept design hydraulic model is as follows (in order of precedence):

- 2023 Topographic Survey (Engeny/Bennett and Bennett Surveyors).
- As constructed projects since 2010: (Butler St Bypass work as executed, Lighthouse Road work as executed).
- 2010 Elvis LiDAR.
- Existing Hydrology.

Design Baseline Case (immediate future 3-5 years)

Topographic basis is the same for the future scenario, with the addition of the following:

- Sandhills wetland (IFC Design).
- Road Reserve upgrades in Carlyle Street and Wordsworth Street (as designed).
- No other amendments to topography due infill development or other possible projects are included at this stage.
- Ultimate Hydrology.

Design Upgrade Developed Case (Ultimate Drainage 50 years +)

Topographic basis is the same for the ultimate scenario, with the addition of the following:

- Installation of all proposed drainage mitigation works including flood levees, pump stations and underground pipe networks.
- No other amendments to topography due infill development or other possible projects are included at this stage.
- Ultimate hydrology.

Pit and Pipe Data Base

The existing pit and pipe networks in the model are to be updated based on the latest database from detailed survey. Note that some invert and diameters are still to be inferred based on inaccessible areas in the survey, and some engineering assumptions / judgement will remain in the network analysis.

Blockage

Hydraulic modelling of blockage factors proposed is as follows:

- Bottom-up blockage factor applied to all box culverts per QUDM guideline (20% blockage factor modelled as area reduction). This will be applied in both existing and developed case.
- Design blockage to be applied to new pits in line with northern rivers development manual table D5.10.2 below. Where this is not feasible due to geometric constraints blockage factors will be reviewed.

Table D5.10.2 Allowable Pit Capacities

Condition	Inlet Type	Percentage of Theoretical Capacity Allowed
Sag	Side entry	80%
Sag	Grated	50%
Sag	Combination	Side inlet capacity only Grate assumed completely blocked
Sag	"Letterbox"	50%
Continuous Grade	Side entry	80%
Continuous Grade	Grated	50%
Continuous Grade	Combination	90%

A scenario for worst case blockage of Clarkes beach outlet will also be analysed.

Ocean and Flood Plain Tailwater Scenarios

As per strategy report, with updates for Belongil creek based on interpretation from gauge data at Ewingsdale Bridge, and consideration of storm tide levels per Belongil CreekFlood Study (BMT WBM 2015). Tail water levels in both Belongil Creek and at Clarkes Beach are proposed to be set in accordance with Table 6.

Additionally, it is noted that Belongil Creek can operate at levels in the order of 0.2m- 0.3m AHD at low tide when the creek is flowing to the ocean. Appropriate checks of gravity drainage and pumping components on the system will be undertaken for this scenario to determine that the drainage system can operate effectively within the full envelope of tail water conditions.

No consideration of wave influences on ocean outfalls is considered in the modelling.

Table 6: DESIGN TAILWATER ASSUMPTIONS BASED ON CURRENT STORM SURGE OCEAN LEVEL ESTIMATES

AEP	Design Tailwater Level	Tailwater Relevance	Comment
50%	2.04m AHD	10% AEP storm surge (estimated)	HAT is approximately 1.1m AHD. NSW guideline reference HHWS which is approximately 1.25m AHD
20%	2.04m AHD	10% AEP storm surge (estimated)	
10%	2.12mAHD	10% AEP storm surge (estimated)	Key Design event
5%	2.12m AHD	10% AEP storm surge (estimated)	
	2.29 m AHD	1% AEP storm surge (run to check envelope approach for 1% AEP only)	
2%	2.19m AHD	5% AEP Storm Surge level	
1%	2.2.19m AHD	5% AEP Storm Surge level	
0.1%	2.29m AHD	1:100 AEP storm surge	For relative impacts only to inform flood damages
0.05%	2.29 m AHD	1:100 AEP storm surge	
PMF	**2.29m AHD**	1:100 AEP storm surge	

Concept Design Approach

An iterative TUFLOW /12d design approach will be adopted to assess hydraulic performance of the pipe networks and levees arranged in 12d.

To enhance the detail and suitability of the TUFLOW model for pit design the use of TUFLOW streamlines (2d_SA Streams) will be implemented for kerb and road flows within the study area, flows external to study areas will be applied using typical SA inflow approaches. This will provide a more representative inflow distribution in the model and is a more robust method for assessing approach and bypass flow consistently in the 2d domain.

Levee levels will be set initially for the 1% AEP Belongil creek level of 2.6m AHD. An alternate scenario of levees at 2.26m AHD will also be assessed based on the 10% AEP Belongil Creek flood level.

Pump stations will be represented with the following detail in the hydraulic model:

- Wet well storage included and flood plain storage per the 2d terrain (initial sizing per the strategy report and storage characteristics available behind levees at each site). This will typically be input as a 1d nodal area which allows a storage curve to be input.

- Based on further discussion with suppliers experienced with stormwater pumping and start-stop requirements, the number of starts per hour can possibly be relaxed to as many as 20.
- Number of pump units initially per the strategy report (minimum 2 pumps) and approximate space constraints.
- Pump curves will be input into the model to ensure realistic flow rates based on available head, suction and delivery conditions.
- Pump alarms and start-stop will be set initially at realistic levels based on wet well depths and incoming pipe network levels.
- Outlet conditions checked for pumps to ensure operating ranges for discharge lines are suitable between RL 0.0m AHD and 3.0m AHD.

Idealised backflow devices will be adopted initially, with separate consideration on practical limitations of backflow prevention made (not in flood model).

Attachments

A summary of the documentation appended to this memorandum for council review and endorsement is as follows:

- Attachment 1 - Hydrological basis of modelling (using WNBM Software and ARR19).
- Attachment 2 - Hydraulic basis of modelling (TUFLOW software).
- Attachment 3 - Model Run Register.

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Hydrology Basis of Modelling

Date	**7/11/2023**	**Revision**	B		
Project Number	QC2003_002	**Project Manager**	TR	**Client**	Byron Shire Council
Project Name	BB Drainage	**Project Director**	MP	**Client Contact**	Peter Brown
		Author	SW		

Item No.	Parameter	Value	Comment
1	**Catchments**		
1.1	Topography Data	-	Completed using ELVIS 1m 2010 LiDAR
1.2	Catchment Extent	-	Extent provided in *Hydrology BOM Supporting Doc - **1.2 Catchment Extent***
1.3	Catchment History	-	The catchment configuration is based of the initial catchment extent used for the Belongil Creek XPRAFTS model developed by SMEC, but has been reduced to only catchments relevant to the study area, and further refined in the township. Refer to *Hydrology BOM Supporting Doc - **1.3 Catchment History - SMEC Catchment Extent***
2	**Impervious Fraction**		
2.1	Existing Case	Aerial Inspection	The impervious fraction value applied to each catchment is based of a visual inspection of the latest available aerial photography. This is inline with the approach of the original Belongil Creek Flood Study. This does not consider future land use value (i.e. significant increases in urban density).
2.2	Ultimate Case	Recreation and Open Space: 0% Intensive agriculture / livestock: 30% Rural Residential: 20% Urban Residential: 70% Industrial: 80% Commercial: 90% Waterbodies: 100%	Councils 2014 Land Use layer has been used to determine to average the potential ultimate impervious fraction. The impervious fraction applied to each landuse type is derived from QUDM, as per councils guideline.
3	**AR&R Inputs**		
3.1	Coordinates	-28.6581, 153.6048	
3.1	AR&R Approach & NSW Specific Info	-	AR&R 2016 Guidelines have been utilised for the purposes of this assessment which is the latest industry standard for hydrological studies. It is noted that NSW Office of Environment and Heritage has developed an independent guide to assists undertaking of studies within NSW in relation to AR&R 2016. It was observed during review of the AR&R 2016 update the a serious under-estimation of peak flow was occurring when using default AR&R data hub information, with CL being observed to be over-estimating losses. The specifics of NSW guideline is provided in *Hydrology BOM Supporting Doc **3.1 NSW Specific Info***, but the key output is the multiplication of the Datahub provided CL by 0.4, and the replacing of the IL and pre-burst with the Probability Neutral Burst Loss.
3.2	General Metadata	-	The relevant metadata is provided in *Hydrology BOM Supporting Doc **3.2 AR&R 2016 Datahub MetaData***.
3.3	ARR2016 IL, CL	27mm, 2.10mm/hr	Datahub output, as discussed above. Both IL and CL have been factored according to the relevant guidelines
3.4	Pervious IL, CL	Variable	Initial losses applied to the model vary, and have been completed in line with the NSW guidelines
3.5	Design Events	63pct, 39pct, 18pct, 10pct, 5pct, 2pct, 1pct, 1:1000, 1:2000 and PMF	Events have been selected to cover a wide range of options. Rainfall has been increased by 10%.
3.6	Modelled Durations	10min - 12hr	
3.7	Temporal Pattern - Frequenct, Intermediate and Rare	East Coast South	All temporal patterns for selected durations are to be assessed.
3.8	Temporal Pattern - Extreme	GSDM	All temporal patterns for selected durations are to be assessed.
4	**Other Hydrological Inputs**		
4.1	Areal Reduction Factors	N.A.	Areal reduction factor has not been applied due to the smallest catchment areas of interest not satisfying conditions as per ARR 2019 guidelines.
4.2	Impervious IL, CL	1 mm, 0 mm/hr	
4.3	Pre-Burst Conditions	Variable	As per the NSW guidelines, the pre-burst depths have been used to subtracted off the applied initial losses.
4.4	Historical Events	March 2022	The March 2022 rainfall event will be run through WBNM for input into the hydraulic model. The rainfall for this assessment will be sampled from gauge *H058216* - Cape Byron. This gauge has 1 minute interval rainfall data from the 14 of February to the 11 of April.
5	**Modelling Software**		
5.1	Software	-	Watershed Bounded Network Model (WBNM) & Storm Injector have been selected for the purposes of this assessment. WBNM is a software package designed for flood hydrograph studies on natural or urban catchments.
5.2	Pervious Lag	1.6	WBNM recommended value
5.3	Impervious Lag	0.1	WBNM recommended value
5.4	Routing Parameter	1	WBNM recommended value

Hydraulic Basis of Modelling

Date		**Revision**	1		
Project Number	QC2003_002	**Project Manager**	TR	**Client**	Byron Shire Council
Project Name	BB Drainage	**Project Director**	MP	**Client Contact**	Peter Brown / James Moffatt
		Author	JH		

Item No.	Parameter	Value	Comment
1	**Model Inflows & Boundaries**		
1.1	Inflow Boundary Conditions	Per Engeny validated WNBM hydrology model subcatchments	Urban catchments applied as 2d_sa regions with 2d_sa streamlines to apply catchment flow along kerb lines wherever possible. Where kerb application is not possible, streamlines will be used to apply flows either upstream of pits within the sub-catchment or at an alternative appropriate location. Upstream urban catchments (external to model code) and rural catchments applied as 2d_sa regions to 2d domain.
1.2	Outflow Boundary Conditions	Varying	See model run register for a breakdown of the proposed model scenarios and associated tailwater conditions.
2	**2D Domain**		
2.1	Model Extents	-	2d_code to cover all study areas (Town Centre, Shirley St, Cowper St & Massinger St) and upstream contributing catchments. Catchments for the greater Belongil Creek included as necessary to represent tailwater impacts only.
2.2	Cell Size	1m	
2.3	Z-Shapes	-	Apply 2d_zsh thin lines to road centrelines and creek banks, extracted elevations from DEM. Inspect DEM, apply crest line if DEM "broken through" over culverts.
2.4	Initial Water Levels	-	Apply IWL based on outlet tailwater levels. Under some sccenarios there levels may be different at Clarkes Beachcompared to Belongil Creek
2.5	Plot Output	-	2d_po applied at all cross drainage locations and key drainage locations to inform design
3	**Hydraulic Roughness**		
3.1	Road Reserve	0.025	Based on road reserve cadastre
3.2	Open Water Bodies & Ocean Outfall	0.03	Visual
3.3	Low-Density Residential	0.15	Ultimate land use mapping as per the hydrology assumptions
3.4	Medium-Density Residential	0.2	Ultimate land use mapping as per the hydrology assumptions
3.5	Commercial	0.25	Ultimate land use mapping as per the hydrology assumptions
3.6	Open Space	0.04	Visual - Sports field, maintained grass, residential lots with no dwelling
3.7	Light or Scrubby Vegetation	0.06	Visual - sparse trees and veg cover
3.8	Medium Dense Vegetation	0.08	Visual - moderate tree cover and thick shrubbery
3.9	Swamp/Wetland	0.05	Visual - veg with standing water, mossy
3.10	Community Facilities	0.1	Ultimate land use mapping as per the hydrology assumptions
4	**1D Domain**		
4.3	Pits	-	Design Baseline Scenario: Kerb inlets represented as Q-type (specified depth-flow curve) based on survey data, standard 2.4m kerb inlet adopted otherwise. Design Upgrade Scenario: Kerb inlets represented as Q-type (specified depth-flow curve) based on target flow capture. Existing pits not upgraded as per Design Baseline Scenario. Design blockage at kerb inlets to assumed grate is fully blocked, as per QUDM Table 7.5.1 recommendations.
4.4	Pipes	-	All pipe sizes included based on detail survey, Council data and BMT model. C and R type, standard height and width contraction coefficients and entrance and exit loss.
4.5	Culverts	-	20% design blockage for circular pipes, 25% bottom-up blockage for box culverts, as per QUDM Table 10.4.1. C and R type, standard height and width contraction coefficients and entrance and exit loss.
4.6	Initial Water Levels	-	Apply IWL directly to all pits hydraulically connected to the 2d IWL conditions, based on outlet tailwater levels.
5	**Model Validation**		
5.1	Historical Event Validation	March 2022	Modelled flood levels will be compared to the 14 flood debris survey markers collected throughout the Byron Township following the March 2022 event.
6	**Output**		
6.1	Grids	Max	Produce for maximum only, utilising these commands: Store Maximums and Minimums == ON MAXIMUMS ONLY Maximums and Minimums Only For Grids == ON
6.2	Map Output Format	TIFF	Raw and processed TUFLOW model outputs stored as GeoTIFF
6.3	Map Output Interval	3600s	
6.4	Output Types	d, h, V, Z0, ZQRA, ZAEM1, TMax (0.0m, 0.3m & 0.5m), TDur (0.0m, 0.3m & 0.5m)	
6.5	Design Events	Varying	Refer to model run register for full breakdown of proposed model simulations.
6.6	Historical Events	March 2022	
6.7	Sensitivities	Varying	Refer to model run register for full breakdown of proposed model simulations.
6.8	TUFLOW Engine	2023-03-AB	
6.9	Solution Scheme/Solver	HPC GPU	

Byron Bay Drainage Model Run Register

Total Runs	106
Average Event Simulation Time	1 hour
Total Model Simulation Time	106 hours (approx 2 days on 2x GPUs)

Design Assessment					
Design Scenario	**Model Scenario**	**Storm AEP**	**Tailwater Conditions**	**Storm Duration**	**Storm Temporal Pattern**
Design Baseline Scenario	Design Baseline Scenario (Ultimate Landuse Hydrology & Existing Network)	1% AEP	Envelope Approach: 1% AEP with 2.19mAHD OR 5% AEP with 2.29mAHD	30-minute	9
				60-minute	6
				120-minute	1
				180-minute	10
		2% AEP	2.19m AHD (5% AEP Storm Surge /regional flood)	30-minute	9
				60-minute	6
				120-minute	1
				180-minute	10
		5% AEP	2.12m AHD (10% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4
			2.29mAHD (1% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4
		10% AEP	2.12m AHD (10% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4
		20% AEP	2.04m AHD (10% AEP Storm Surge)	30-minute	10
				60-minute	5
				120-minute	4
				180-minute	5
		50% AEP	2.04m AHD (10% AEP Storm Surge)	30-minute	7
				60-minute	5
				120-minute	4
				180-minute	5
Validation Case	Existing (Current Day) - Actual Event Rainfall	2022 March	Time-Varying	1440-minute	NA
Design Upgrade Scenario	Design Upgrade Scenario (Ultimate Landuse Hydrology & Ultimate Network)	1% AEP	Envelope Approach: 1% AEP with 2.19mAHD OR 5% AEP with 2.29mAHD	30-minute	9
				60-minute	6
				120-minute	1
				180-minute	10
		2% AEP	2.19m AHD (5% AEP Storm Surge /regional flood)	30-minute	9
				60-minute	6
				120-minute	1
				180-minute	10
		5% AEP	2.12m AHD (10% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4
			2.29mAHD (1% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4
		10% AEP	2.12m AHD (10% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4
		20% AEP	2.04m AHD (10% AEP Storm Surge)	30-minute	7
				60-minute	5
				120-minute	4
				180-minute	5
		50% AEP	2.04m AHD (10% AEP Storm Surge)	30-minute	7
				60-minute	5
				120-minute	4
				180-minute	5
Validation Case	Existing (Current Day) -Actual Event Rainfall with design infrastructure	2022 March	Time-Varying	1440-minute	NA
Shirley Street Levee Trade-off	As per Design Upgrade Scenario with lower levee height	1% AEP	Envelope Approach: 1% AEP with 2.19mAHD OR 5% AEP with 2.29mAHD	30-minute	9
				60-minute	6
				120-minute	1
				180-minute	10
		10% AEP	2.12m AHD (10% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4

Design Impact Sensitivity Assessment					
Design Scenario	**Model Scenario**	**Storm AEP**	**Tailwater Conditions**	**Storm Duration**	**Storm Temporal Pattern**
Outlet Full Blockage	As per Design Upgrade Scenario with outlet full blockage	1% AEP	Envelope Approach: 1% AEP with 2.2mAHD OR 5% AEP with 2.6mAHD	30-minute	9
				60-minute	6
				120-minute	1
				180-minute	10
		10% AEP	2.04m AHD (10% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4
Pump Failure	As per Design Upgrade Scenario with no pumps	1% AEP	Envelope Approach: 1% AEP with 2.2mAHD OR 5% AEP with 2.6mAHD	30-minute	9
				60-minute	6
				120-minute	1
				180-minute	10
		10% AEP	2.04m AHD (10% AEP Storm Surge)	30-minute	8
				60-minute	7
				120-minute	6
				180-minute	4

Extreme Events for Flood Damages					
Design Scenario	**Model Scenario**	**Storm AEP**	**Tailwater Conditions**	**Storm Duration**	**Storm Temporal Pattern**
Flood Damages Assessment	Design Baseline Scenario (Ultimate Landuse Hydrology & Existing Network)	PMF	2.29mAHD (1% AEP Storm Surge)	30-minute	TBC- GSTM
				60-minute	TBC- GSTM
				120-minute	TBC- GSTM
				180-minute	TBC- GSTM
		0.05% AEP	2.29mAHD (1% AEP Storm Surge)	30-minute	TBC- GSTM
				60-minute	TBC- GSTM
				120-minute	TBC- GSTM
				180-minute	TBC- GSTM
		0.1% AEP	2.29mAHD (1% AEP Storm Surge)	30-minute	TBC- GSTM
				60-minute	TBC- GSTM
				120-minute	TBC- GSTM
				180-minute	TBC- GSTM
	Design Upgrade Scenario (Ultimate Landuse Hydrology & Ultimate Network)	PMF	2.29mAHD (1% AEP Storm Surge)	30-minute	TBC- GSTM
				60-minute	TBC- GSTM
				120-minute	TBC- GSTM
				180-minute	TBC- GSTM
		0.05% AEP	2.29mAHD (1% AEP Storm Surge)	30-minute	TBC- GSTM
				60-minute	TBC- GSTM
				120-minute	TBC- GSTM
				180-minute	TBC- GSTM
		0.1% AEP	2.29mAHD (1% AEP Storm Surge)	30-minute	TBC- GSTM
				60-minute	TBC- GSTM
				120-minute	TBC- GSTM
				180-minute	TBC- GSTM

NSW Floodplain Manual Guidance

- Coincidence of ISLW in indicative spring and neap tide cycle (Appendix C) with one per cent AEP catchment flooding to test peak velocities.

Table 8.1: Combinations of Catchment Flooding and Oceanic Inundation Scenarios

Design AEP for peak levels/velocities	Catchment Flood Scenario	Ocean Water Level Boundary Scenario	Comment/ Reference
50% AEP	50% AEP	HHWS(SS)	Dynamic hydrograph can be taken from Appendix C with peak flood to coincide with HHWS(SS) highest peak for highest water levels Peak HHWS(SS) 1.25m AHD
20%	20% AEP	HHWS(SS)	
10%	10% AEP	HHWS(SS)	
5%	5% AEP	HHWS(SS)	
2%	2% AEP	5% AEP	Dynamic ocean water level boundary hydrograph Appendices A or B for relevant waterway type
1% Envelope level	5% AEP	1% AEP	Envelope provides 1% AEP design flood estimate Dynamic ocean water level boundary hydrograph Appendices A or B for relevant waterway type
1% Envelope level	1% AEP	5% AEP	
1% Envelope velocity	1% AEP	ISLW	Dynamic hydrograph can be taken from Appendix C with peak flood to coincide with ISLW lowest trough for peak velocities in entrance. Fixed ISLW approx. -0.95m AHD
0.5%	0.5% AEP	1% AEP	Dynamic ocean water level boundary hydrograph Appendices A or B for relevant waterway type
0.2%	0.2% AEP	1% AEP	
PMF	PMF	1% AEP	
1% Catchment	1%	HHWS(SS)	Suggested envelopes for analysis of catchment flooding only
PMF Catchment	PMF	HHWS(SS)	

***Note:** Individual projects are likely to specify the use of only a select number of AEPs outlined in the table.*