FIGURE 5

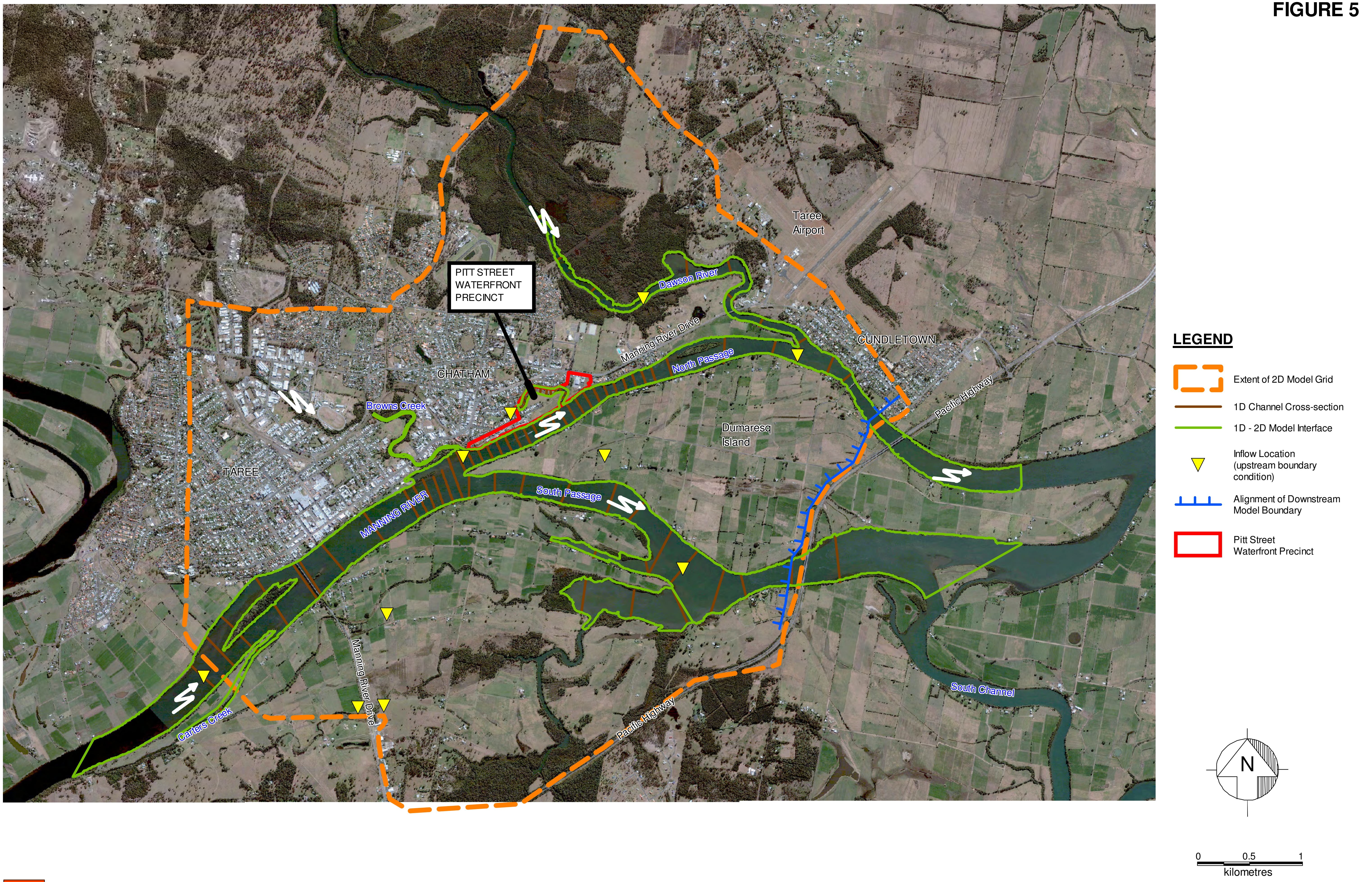

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Figure 5 - Tuflow Model.wor

TUFLOW MODEL LAYOUT

- Upstream limits:
  - ⇒ Manning River – 3.3 kilometres upstream of Dumaresq Island.
  - ⇒ Dawson River – 2.4 kilometres upstream from confluence with Manning River North Passage

The grid size adopted for the 2D model network was 10 metres at areas across the Manning River floodplain and the Pitt Street Waterfront Precinct. In other words, the model grid nodes were spaced every 10 metres. This mesh size was considered appropriate to adequately represent changes in topography across the floodplain and the precinct for existing conditions. It was also considered adequate for representation of the proposed topography for post-development development conditions (*see sections below*).

The TUFLOW model also incorporates a total of eight 1D channels that are embedded within the 2D model network, representing the following channels (*refer* **Figure 5**):

- Manning River North Passage;
- Manning River South Passage;
- Dawson River;
- Browns Creek;
- the unnamed creek through the precinct;
- Carters Creek; and,
- minor floodways across the southern floodplain.

2.6.1 Channel and Floodplain Roughness

As discussed, overbank roughness parameters were determined based on the analysis of aerial photography of the study area. The adopted roughness parameters were determined by comparing vegetation density and site characteristics with standard values for stream and floodplain conditions for which Manning's "n" values are documented in the TUFLOW software manual.

The roughness parameters that were adopted in the TUFLOW model for the 2D network grid and 1D channels are listed in **Table 2**. The spatial variation in roughness parameters is shown in **Figure 6**.

As shown in the figure, existing structures and dwellings in the immediate vicinity of the precinct have been incorporated into the model network as "blocked-out" areas, through which flow cannot pass. Model roughness has also been increased across this area to account for additional impediment to flow, such that would result from fences and backyard items.

FIGURE 6

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Figure 6 - existing materials.wor

ADOPTED TUFLOW MODEL ROUGHNESS FOR EXISTING CONDITIONS

Wider urban areas have been incorporated into the TUFLOW model as areas of significantly increased roughness (*refer* **Figure 6**). It should also be noted that much of the urban area to the north-west of the precinct will not be subject to inundation due to its higher elevation.

Table 2 TUFLOW MODEL ROUGHNESS PARAMETERS

DESCRIPTION	ROUGHNESS VALUE
Roads	0.02
Short Grass	0.03
Thick Grass / Urban area	0.04
Grass, some trees/shrubs	0.05
Vegetated Channel / Shrubbery	0.06
Forested / Wider urban area	0.07-0.08
Buildings	0.10

2.6.2 Model Boundary Conditions

Model boundary conditions simulate the physical boundaries at the limits of the modelled area. A majority of the boundary condition data used in 2D modelling for this study was derived from the results of previous ESTRY modelling undertaken in 1991. As a result, the TUFLOW model can be seen as effectively being “embedded” within the larger ESTRY model for the Manning River.

Upstream Boundary Conditions

For a 2D flood model, upstream boundary conditions are typically defined by the catchment runoff that enters the modelled area. Upstream boundary conditions are typically represented by flow hydrographs which are specified at the upstream limit of the hydraulic model. These hydrographs represent a varying rate of flow over time.

The location of hydrograph inflow points to the TUFLOW model are shown in **Figure 5**. Three inflow hydrographs were extracted from the results of ESTRY modelling for the Manning River (*refer* **Table 3**). As shown, a majority of the flow across the Manning River floodplain is fed into the model within the river channel geometry at the upstream model boundary.

Table 3 HYDRAULIC MODEL INFLOWS

LOCATION OF MODEL INFLOW	PEAK 100 YEAR RECURRENCE FLOOD DISCHARGE (*m^3/s*)
Manning River (*ESTRY Node 14*)	~ 12,300
Southern Floodplain of Manning River (*2 inflow points – ESTRY Nodes 121 and 123*)	~ 200

Additional inflow points are located at Dawson River and other locations to "boost" river flows along the model reach, as was incorporated into the original ESTRY model (*refer* **Figure 5**).

The DRAINS model developed by GTCC for the catchment draining to the precinct was also interrogated to extract discharge hydrographs that feed into the unnamed creek that passes through the precinct. It should be noted that storm events over the local catchment will have a relatively short duration and therefore flow along the unnamed creek is expected to pass through the site prior to the rise of floodwaters in the Manning River.

Downstream Boundary Conditions

Downstream boundary conditions for flood modelling are typically defined by water level, in the form of a stage hydrograph. Stage hydrographs represent the variation in water level over time.

Stage hydrographs for TUFLOW modelling were extracted from the results of the existing ESTRY model at river channel and floodplain nodes located immediately upstream from the Pacific Highway (*refer* **Figure 5**). Specifically, the downstream boundary incorporates stage hydrographs at ESTRY Nodes 309, 316, 315, 307, 907 and 926. The resultant boundary condition effectively represents a continuous line of time-varying water levels.

The peak flood levels adopted at the downstream model boundary are summarised in **Table 4**.

Table 4 PEAK DESIGN FLOOD LEVELS AT PACIFIC HIGHWAY

AVERAGE RECURRENCE INTERVAL (*Years*)	PREDICTED PEAK FLOOD LEVEL (*m AHD*)
20	3.4 - 3.7
100	4.3 - 4.6

2.6.3 Waterway Crossings

The incorporation of existing bridge crossings into the TULFOW model geometry was investigated. It was determined that inclusion of the bridge crossings was not warranted, based on the following:

- The original ESTRY model of the Manning River (*developed for the 1991 Flood Study*) does not include any bridge crossings for the Manning River, Browns Creek or Dawson River. To effectively reproduce flood behaviour simulated by the ESTRY model, it was considered necessary to adopt the same approach employed in the ESTRY model.
- Engineering plans or survey for the bridges have not been made available for this investigation. Based on a visual assessment of the geometry of the bridges along the Manning River and their significant distance from the Pitt Street Waterfront Precinct (*i.e., at Taree and Cundletown*), it is considered that the bridges will have minimal impact on flood behaviour, particularly within the vicinity of the precinct. The same is considered to apply for bridge crossings at Browns Creek and Dawson River.
- The downstream boundary for the TUFLOW model has been established immediately upstream from the Pacific Highway crossing of the Manning River channels, thereby avoiding the need for incorporation of these bridges into the TUFLOW model.

It should be noted that the topography of the Pioneer Street crossing of the unnamed creek, immediately upstream from the precinct, has been incorporated into the TUFLOW model geometry.

2.6.4 Initial Conditions, Time Step and Simulation Time

Initial conditions and time step duration for the TUFLOW model were naturally governed by the initial conditions and time step duration adopted in the existing ESTRY model for the Manning River. This is because all upstream and downstream boundary condition data for the TUFLOW model were extracted from ESTRY model results files.

Accordingly, a time step duration of 30 minutes (*half-hour*) was adopted for the input of boundary condition hydrographs and for the extraction of TUFLOW model results.

TUFLOW simulations were run for up to 70 hours duration, which represents the bulk of the full hydrographs extracted from the original ESTRY model. The ESTRY model was originally run for 90 hours. However, the “tail-end” of the hydrographs was not considered necessary for inclusion in simulations. The peak flood level was typically reached around 36 hours into each simulation.

2.6.5 Pseudo-Calibration of TUFLOW Model

A pseudo-calibration of the TUFLOW model was undertaken through the comparison of flood levels extracted from design flood simulations with flood levels extracted from the results of previous ESTRY modelling. Greatest focus was on achieving a decent "fit" for design flood levels in the direct vicinity of the precinct for the 100 year recurrence event.

Adjustments to floodplain and channel roughness parameters were made to achieve the best reproduction of ESTRY model results.

Further discussion of the pseudo-calibration results is presented in the following sections.

2.7 FLOOD MODELLING RESULTS

The TUFLOW model was used to simulate the following design flood events for existing conditions:

- 100 year recurrence flood;
- 100 year recurrence flood with a 20 year recurrence tailwater level; and,
- 20 year recurrence flood.

A discussion of the results of the modelling for each scenario is outlined in the following.

2.7.1 Design 100 Year Recurrence Flood

Peak flood levels and flow velocities for the 100 year recurrence event are presented in **Figure 7**. Increased detail in the vicinity of the Pitt Street Precinct is provided in **Figure 8**.

As shown, the 100 year recurrence flood level varies across the precinct from 5.2 to 4.9 mAHD. This provides a close representation of the ESTRY model results at the upstream limit of the precinct and is within 50 to 100 mm of previously determined design flood levels at the downstream limit.

Further comparison between peak flood levels extracted from the TUFLOW and ESTRY models is presented in **Figure 9** for the 100 and 20 year recurrence floods. As shown, the peak flood levels extracted from the TUFLOW model results are generally consistent with the previously modelled levels, particularly in the vicinity of the Pitt Street Waterfront Precinct.

There are some larger differences in flood levels across overbank areas to the south of the Manning River. However, these are likely attributable to the inherent difference in modelling techniques associated with the 2D versus 1D approach. For instance, it is considered that the TUFLOW model more reliably models the 2D distribution of flow (*or lack thereof*) from the river channels to the overbank areas. Whereas, the capacity of the previous ESTRY model to reliably simulate this flow distribution would have been limited.

It should also be noted that most locations where flood level differences are greater than 100 mm are near the upstream limit of the TUFLOW model. Accordingly, the TUFLOW model results could be influenced by upstream boundary effects, which deteriorate with distance downstream from the boundary.

FIGURE 7

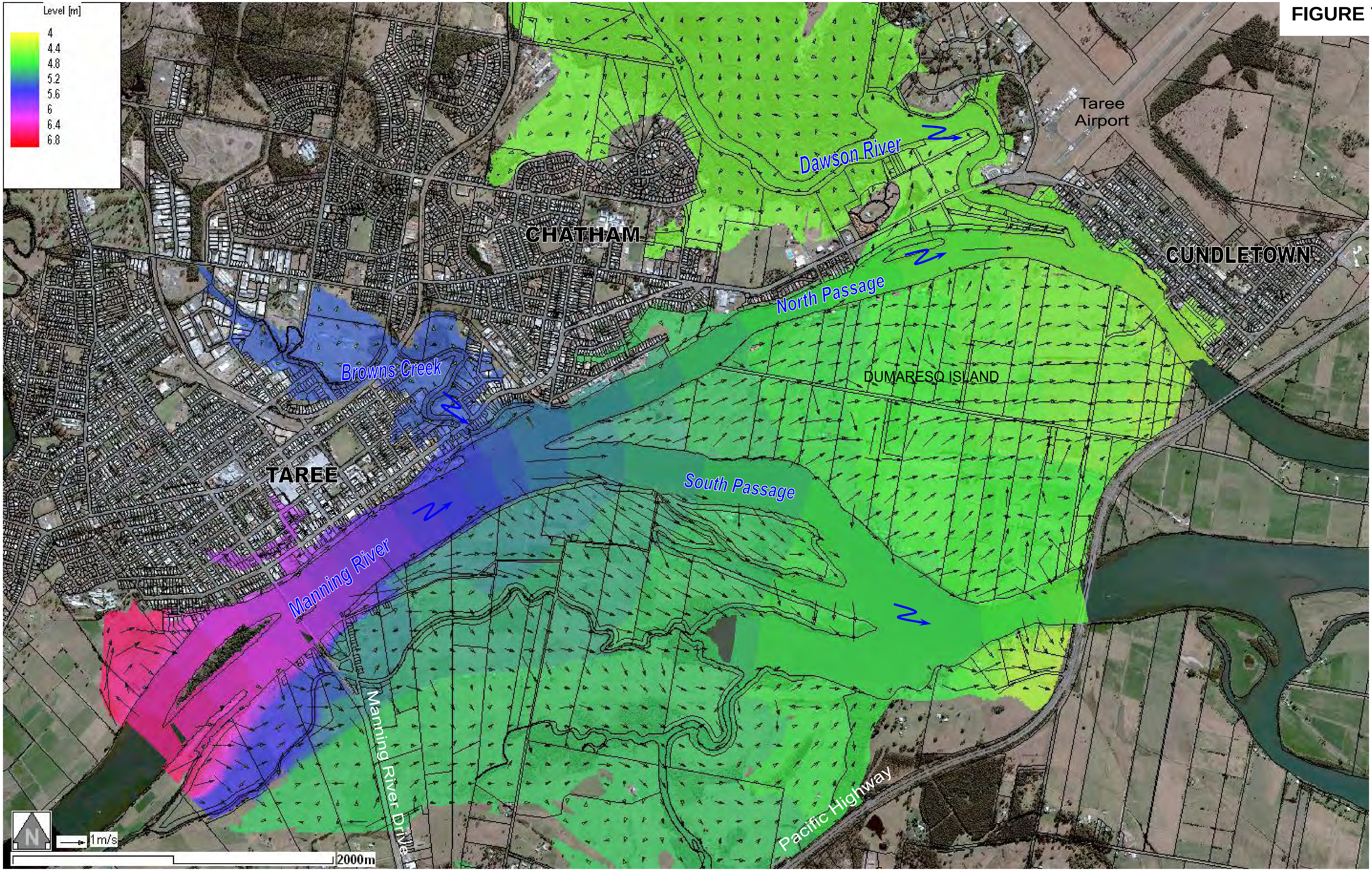

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Figure 7 – 100 year flood levels.doc

PEAK 100 YEAR RECURRENCE FLOOD LEVELS AND FLOW VELOCITIES

FIGURE 8

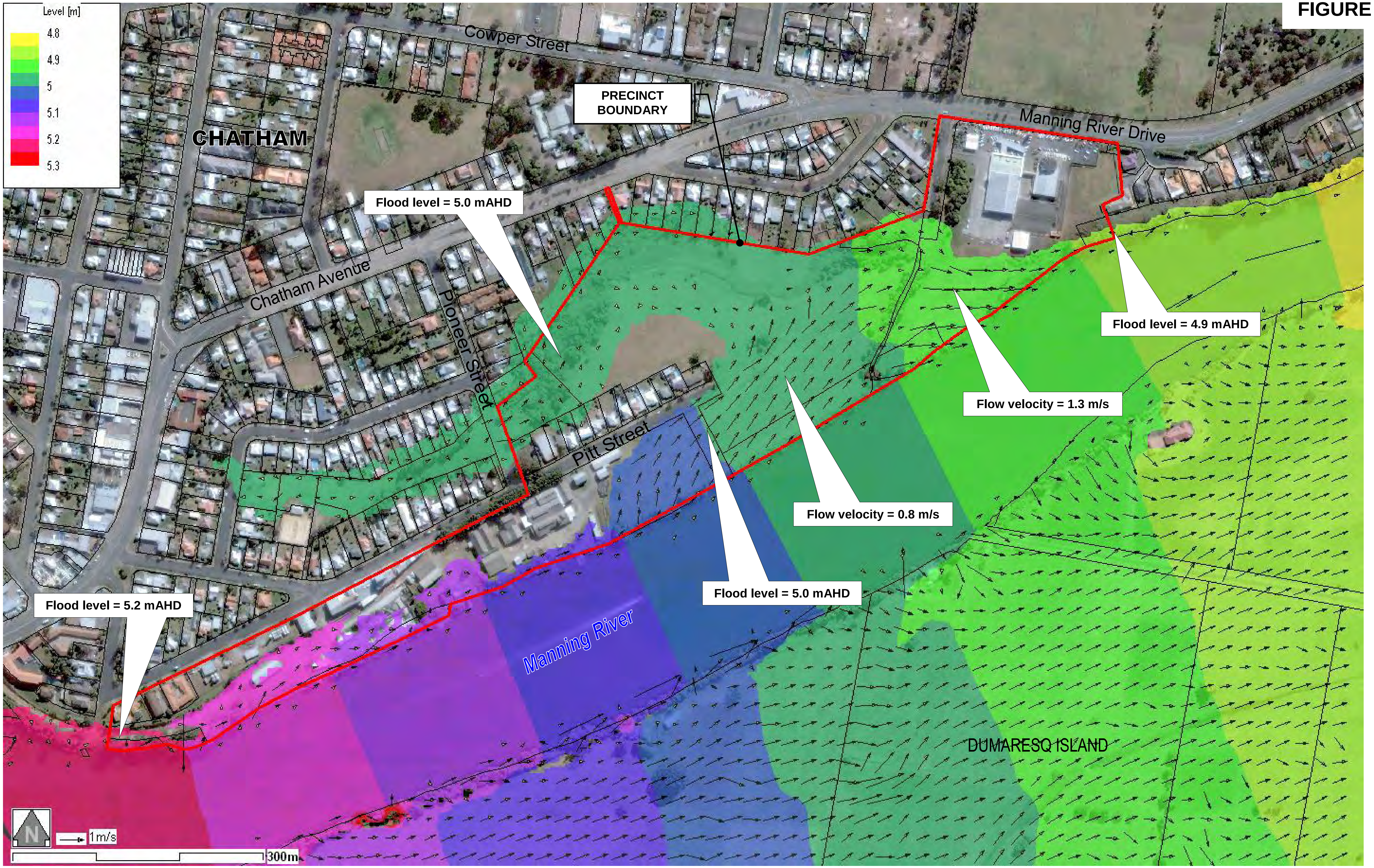

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Figure 8 – 100 year flood levels zoom.doc

PEAK 100 YEAR RECURRENCE FLOOD LEVELS AND FLOW VELOCITIES AT THE PITT STREET WATERFRONT PRECINCT