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FLOOD IMPACT ASSESSMENT

HOTEL AND WATER PARK DEVELOPMENT
TOWNSVILLE TURF CLUB SITE

FOR
TOWNSVILLE TURF CLUB

JOB No:	BNC0084
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EXECUTIVE SUMMARY

MCK Pty Ltd is proposing the Townsville Water Park and Hotel development at the Townsville Turf Club (TTC) site. The land parcels include Lot 1 on SP101275, Lot 2 on RP748152 and Lot 1 on EP1477. The site is proposed to be developed as depicted on the CA Architects layout plan and involves a bulk earthworks application.

This flood impact assessment report is prepared in support of the proposed development and outlines the proposal including the flood mitigation arrangements and demonstrating the site is suitable for the proposed uses.

An extensive flood impact assessment has been carried out using a fine scale mini TUFLOW model based on inputs and boundary conditions derived from Townsville City Council's new Ross River Flood Study. This has involved an extensive assessment based on updating the fine scale mini model with inputs that were updated from the previous model which was based on different critical duration and higher flood levels. The assessment involved the additional of a series of low maintenance, free draining flood mitigation measures and has demonstrated that the proposed development footprint can comply with the flood hazard overlay code.

The assessment included an impact assessment which demonstrates that the development proposal can proceed without any actionable impacts to the surrounding properties or the adjacent state controlled road. The most critical areas adjacent to the Racecourse Road demonstrate a small improvement during the flood events assessed. It also ensured that no additional flooding occurred in the vicinity of the existing buildings and infrastructure and where possible, reduces the potential for / extent of flooding.

The details of this assessment are outlined herein.

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1.0 INTRODUCTION

1.1 Overview

The Townsville Turf Club (TTC) currently controls the land and infrastructure that make up the Townsville Racecourse inclusive of a number of land parcels within the immediate surrounds of the racecourse. These parcels are depicted in Figure 1-1 and include Lot 1 on SP101275, Lot 2 on RP748152 and Lot 1 on EP1477.

The proposal involves the water park, hotel as well as other retail, commercial and residential uses complementary with the overall master planning concept. NCE have been engaged by MCK TSV Pty Ltd to conduct an assessment which is based on inputs from the Townsville City Council (TCC) Ross River Flood Study (2021), TUFLOW baseline model in order to assess the proposed development. MCK TSV Pty Ltd will be herein referred to as “the client” for the purpose of this report.

NCE have developed a small fine scale TUFLOW model that incorporates the Australian Rainfall & Run-off 2019 (ARR2019) hydrology to ensure the assessment accurately depicts the flood conditions provided in the new TCC Ross River model.

1.2 Study Area

The site is located in the suburb of Cluden and bounded by the Bruce Highway (north), Stuart Drive (west), Dommett Street (south) and North Coast Rail Line (east). The site is influenced by the Stuart Creek and Gordon Creek catchments, however, is represented in its entirety within the TCC Ross River (2021) TUFLOW baseline model.

The race track is generally located in the centre of Lot 2 on RP748152 which includes a large storage lake within the centre of the track. The north-eastern portion of the site (Lot 1 on EP1477) houses the holding yards and administration buildings with grand stands, betting ring and dwellings located immediately west. Access to the site is via the southern leg of the Lakeside Drive / Bruce Highway intersection located at the common boundary of Lot 1 on SP101275 and Lot 2 on RP748152.

Lot 1 on SP101275 contains a drainage easement and existing open channel adjacent to the Lot 2 on RP748152 common boundary. The remainder of the site is vacant, however current baseline flood mapping shows significant inundation in the northern half of the site.

1.3 Scope of Works and Purpose of the Report

The purpose of this report is to assess if the proposed development layout is able to be filled and developed to achieve an appropriate level of flood immunity without generating actionable impacts to the surrounding flood characteristics. To achieve this, the scope of works incorporates:

- Develop a fine-scale 2D TUFLOW flood mini-model based on the provided TCC Ross River (2021) flood model;
- Adopt the hydrology and critical duration as provided in the Ross River Flood Report mapping;
- Model the 1% and 20% Annual Exceedance Probability (AEP) critical duration design event to compare the mini-model baseline to the Ross River (2021) model;
- Model the 1% and 20% AEP critical duration design events to determine the extent and magnitude of impacts to the existing flood characteristics;

- Identify mitigation measures necessary to reduce impacts to acceptable levels whilst maintaining as much of the proposed development;

- Delivery of report and associated flood mapping.

Figure 1-1 Study area locality

1.4 Limitations

In order to assess the implications of the proposed development extent, NCE has acquired TCC's Ross River (2021) TUFLOW model under a Confidentiality Deed. Details regarding the development of this model are provided in the 2021 Ross River Flood Study report, which was provided in conjunction with the model. A detailed audit of this model has not been undertaken, however, as the model has been calibrated, approved for use by TCC and promoted for use to inform planning and development decisions, it is reasonable to expect that industry standard modelling practices have been incorporated in both the hydrological and hydrodynamic components and is therefore suitable for this type of assessment.

Development or modification of the models necessary to undertake this assessment have been conducted in accordance with good engineering practices however, is bound by the practical limitations of the accuracy of information and data used for the modelling, and the software. The information produced in this report is accurate at the time of issue and is based on the information available at the time of the analysis. The report has been prepared by NCE for the client and may only be used and relied on by the client for the purpose agreed between NCE and the client as set out in Section 1.3 of this report. All information contained herein is considered to align with the content and intent of the Confidentiality Deed. However, this report is issued for the express purposes and for the recipients noted. Any distribution or use other than that nominated, is considered to fall outside the bounds of the report intent and NCE take no responsibility for its use.

NCE otherwise disclaims responsibility to any person other than the client arising in connection with this report. NCE also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by NCE in connection with preparing this report were limited to those specifically detailed in the scope and limitations of the report.

The opinions, conclusions and any recommendations in this report are based on assumptions made by NCE described in this report. NCE disclaims liability arising from any of the assumptions being incorrect.

NCE has prepared this assessment on the basis of information provided by 3rd parties, which NCE has not independently verified or checked beyond the agreed scope of work. NCE does not accept liability in connection with such unverified information, including errors and omissions in the supplied information.

1.5 Proposed Development

In accordance with the scope of works, the proposed development is associated with the proposed water park and hotel. The preliminary layout is depicted in Figure 1-2 below with the full set of architectural plans provided in Appendix J. For the purpose of the flooding assessment, NCE have excluded any inherent internal storage and drainage from the water park and have treated the whole area as to be filled above the defined flood event (DFE) (1% AEP) with runoff and imperviousness similar to general commercial developments in accordance with the TCC development manual.

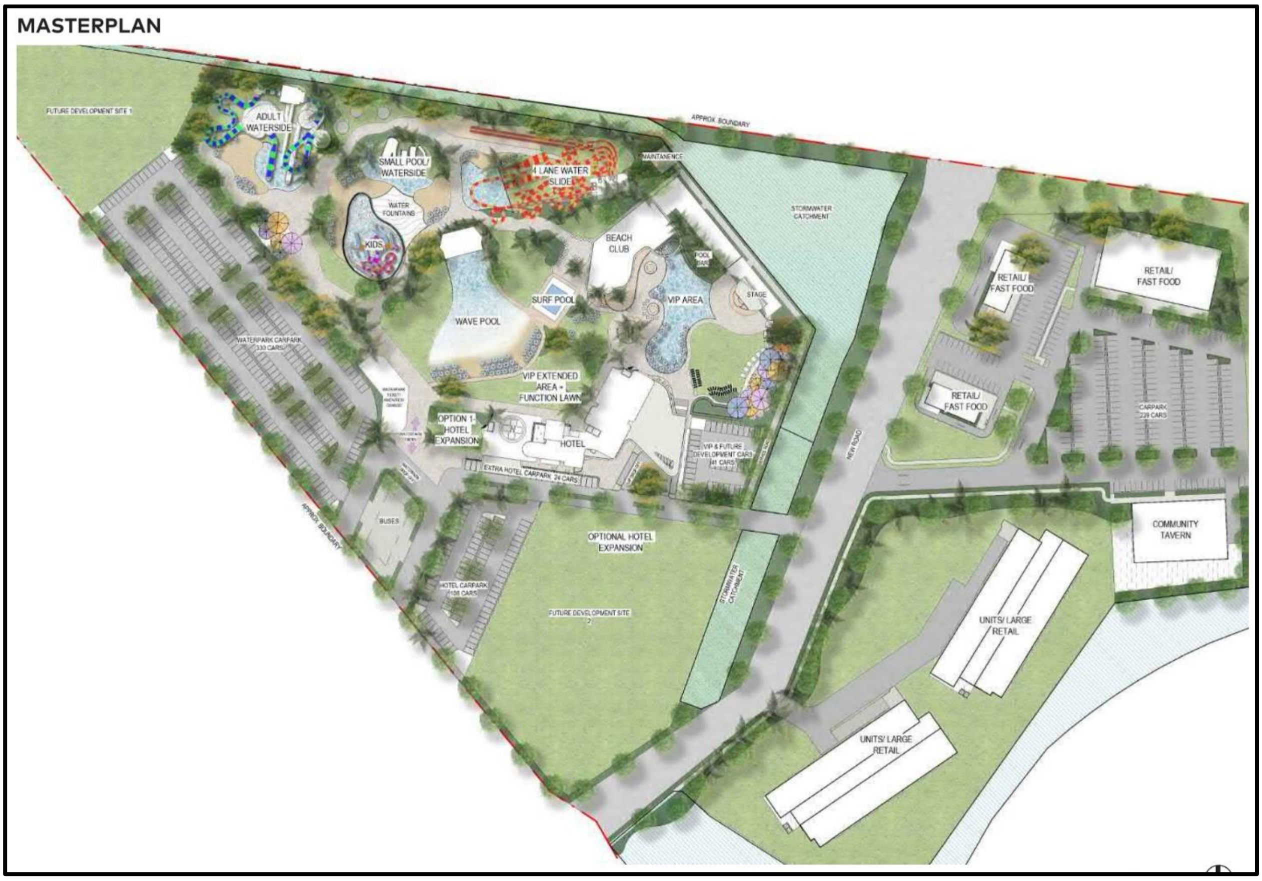


Figure 1-2 Proposed development – preliminary architectural plans

2.0 AVAILABLE DATA

This report and the associated hydrologic and hydraulic models have been largely prepared based directly or indirectly on the information contained in reports from previous studies, including but not limited to the 2021 Ross River Flood Study.

2.1 Topographic Information

Figure 2-1 shows the extent of the topographic survey that was prepared by Rowlands Surveys and used to update the Digital Elevation Model (DEM) of the hydraulic component of the TUFLOW model. This data was stamped into the existing DEM to ensure the most current representation of the terrain was reflected within the TUFLOW model.

For the TUFLOW model, the DEM is based on LiDAR survey data over the entire hydraulic model extent that was captured as part of the Townsville City Council 2016 LiDAR project and sourced from the Open Data portal. NCE note that the 2016 LiDAR was utilised in place of the 2019 LiDAR as this was adopted by the 2021 Ross River flood model. As per the TUFLOW DEM, the Rowlands survey was stamped over the LiDAR data to form the baseline terrain for the TUFLOW model.

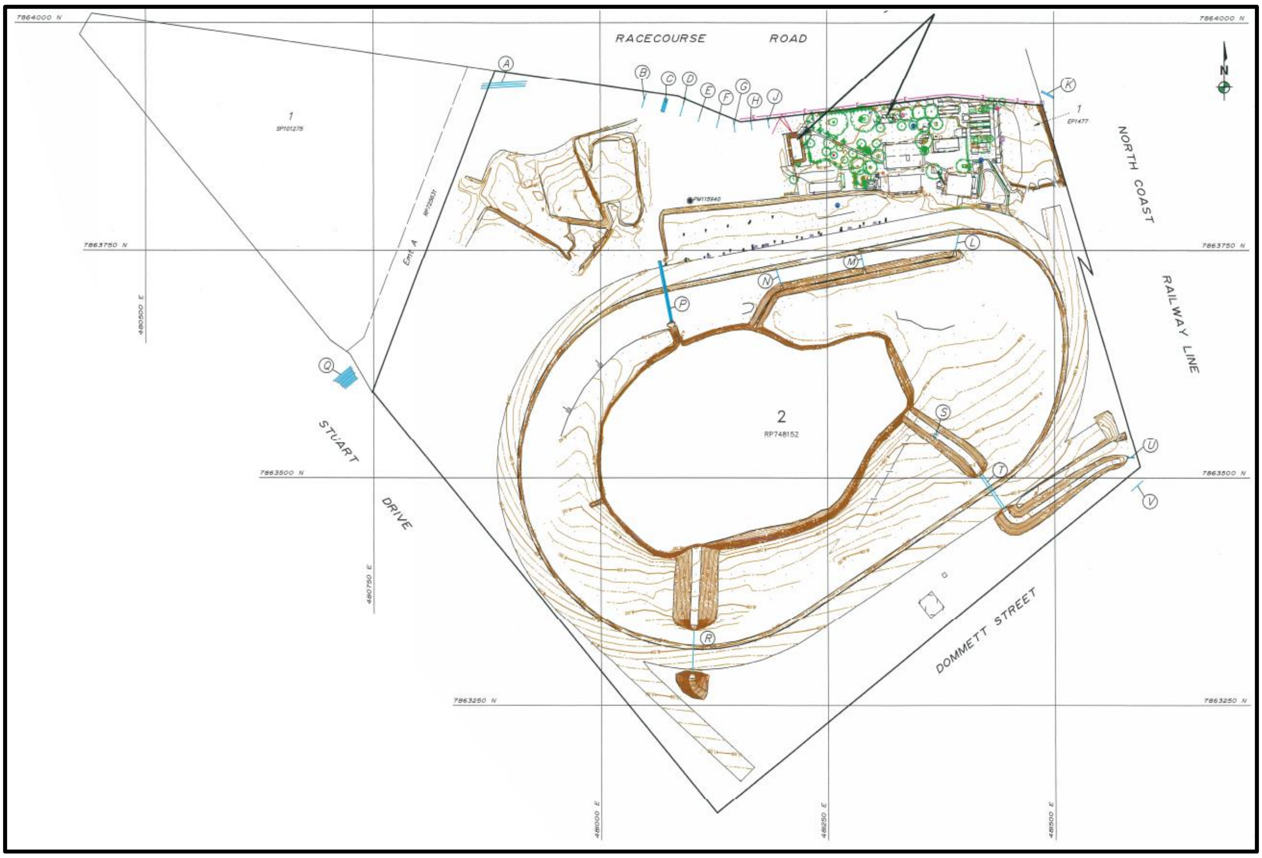


Figure 2-1 Topographic survey data extents

2.2 Spatial Data

The following data was acquired to undertake this assessment:

- Cadastral data and other various data sources (i.e. watercourses, broad catchments, etc) of the site and surrounding area, sourced from the Queensland Government's QSpatial catalogue and TCC.

2.3 Aerial Imagery

Aerial imagery has been sourced from Google satellite sources and TCC's 2019 aerial photogrammetry, sourced from the TCC Open Data portal. This imagery has been utilised for roughness / land use mapping and flood results mapping.

2.4 Previous Reports

2.4.1 2021 Ross River Flood Study – Baseline Flooding Assessment

The report details the technical setup and calibration of the TUFLOW model which includes:

- a DEM resolved to a 5 m grid, utilising sub-grid sampling (SGS);
- underground drainage network including everything captured in the TCC Open Data Portal and additional surveyed network items;
- bridges applied as layered flow constrictions within the model;
- application of direct rainfall on the grid model (rain-on-grid (ROG));
- additional inflows derived from XP-RAFTS hydrologic models for the:
    - Ross Creek catchment,
    - Lower Ross River catchment, and
    - Mundy Creek catchment;
- Storm tide inundation applied at the downstream end of the model.

The calibrated and verified model was used to assess design storm flood events with the results used to:

- quantify the floodplain hydraulic response;
- evaluate potential impacts on properties;
- identify flood hazard zones;
- inform planning and development works within the catchment;
- identify emergency management considerations.

The results of this model were used to validate / compare the results from the new fine scale TUFLOW model.

3.0 MODELLING METHODOLOGY

Given the nature of the assessment, the modelling to identify the required mitigation measures was an iterative process, where one set of results was used to inform or refine the subsequent simulation. With this in mind, the following approach was used:

TUFLOW

For this assessment, a site specific 1D / 2D TUFLOW model has been developed which has adopted the HPC solver, SGS and the following methodology:

- Development of a fine scale model, adopting similar or updated parameters as the calibrated Ross River (2021) TUFLOW model.
- Simulate the 1% and 20% AEP event for the critical duration event outlined in the Ross River flood report to validate / compare the model results.
- Update hydrology and other model parameters to better correlate with the provided Ross River (2021) flood results.
- Confirm the critical duration and pattern against the provided flood model results for the Ross River (2021) model and modify the adopted hydrology if necessary.
- Incorporate the proposed development and mitigation measures identified in the architectural plans and adjust as necessary to obtain an acceptable outcome.

In accordance with TCC CityPlan, the appropriate level of flood immunity is defined as the 1% AEP event for the critical duration. The 20% AEP event was simulated in order to understand the potential impacts associated with a more frequent event. The 20% AEP was selected as the specific minor event as more frequent “minor” flooding is of particular interest to the adjacent road corridors controlled by the Department of Transport and Main Road (DTMR). The proposed development is expected to generally maintain a commercial land use and therefore the minor system is expected to be designed to the 20% AEP in accordance with the TCC development manual.

All modelling works were undertaken with a Mean High Water Springs (MHWS) boundary condition, i.e. initial water level of 1.314 m AHD, stage-discharge or stage-time curves.

3.1 Hydrologic Modelling

The hydrological response of the local catchment has been derived using source area inflows and a rain-on-grid approach. Technical details of the model set-ups are described in the Ross River (2021) Flood Study report with technical changes discussed in Appendix H.

In the initial stages of modelling, no changes were proposed / required to the existing hydrologic model as the mini model showed good correlation to the Ross River (2021) model, particularly around the site. Furthermore, the rainfall applied to the Ross River (2021) model has been calibrated to multiple past events.

3.1.1 Critical Duration Assessment

Given the Ross River (2021) flood model has been previously calibrated to past events, the mapping provided within the Ross River (2021) flood study report has been assumed to accurately depict the critical duration over the development site. The mapping provided in the flood study report indicates the critical durations for each flood frequency from 50% AEP to 0.1% AEP. The ARR2019 approach as adopted by the flood study is to simulate the rainfall depth for a given duration under the ensemble of ten (10) temporal patterns to determine the median flood characteristics for the site. This means that for every flood event of a given durations, there are ten (10) design storms that require assessment in order to identify the median temporal pattern. The critical duration for the 1% AEP event as per the provided mapping is the 1.5-hour storm.

In progressing the development assessment, the initial results provided suitable results without significant impacts off site. However, through a series of further and final verifications and comparison with the report maps, it was found that there were anomalies with the results.

As NCE were supplied the flood results as part of the flood model agreement with TCC, a critical duration raster was also supplied for the 1% AEP event. The provided raster is generated by compiling all the flood model results and comparing the peak water surface levels (WSLs). The resultant raster indicates that the majority of the development site has a peak water surface level in the 9-hour storm. The comparison of the flood report mapping and the raster mapping is provided in map A04 in Appendix A. NCE have utilised the provided results and confirmed that the critical duration raster is accurate and the 9-hour peak WSLs were significantly higher than the 1.5-hour duration. Therefore, NCE have adopted the 9-hour critical duration for the 1% AEP event modelling and revised the development assessment accordingly. This initially showed impacts off site which required addressing in accordance with the TCC flood hazard overlay code. This is discussed herein.

NCE have not been provided a critical duration raster for the other event flood frequencies and thus have been forced to adopt the critical duration from the flood study mapping for the 20% AEP event. The provided mapping shows the 2-hour and 3-hour storm durations as critical over the development site. NCE have adopted the 2-hour duration for the 20% AEP event as it is critical over the more integral parts of the proposed development. NCE note that the downstream impacts of a significantly longer duration event are much less likely to impact the development site within the 20% AEP event and therefore, the shorter duration may be more applicable.

NCE have not conducted any further assessment on the median temporal patterns and have instead adopted the patterns presented in Appendix D of the Ross River (2021) flood study report. The adopted critical duration events are indicated in Table 3-1.

It is noted that the 9-hour peak WSLs are controlled by tailwater levels from the downstream lakes area and thus the flood characteristics are significantly different from the shorter duration event. This resultants in less available flood storage downstream at the peak of the storm and less capacity for flows downstream.

3.2 Hydraulic Modelling

The original hydraulic modelling has been undertaken using the Ross River (2021) TUFLOW model, which is a dynamically linked hydrodynamic model that couples 1D structure (culverts, bridges, etc) hydraulics and 1D subsurface drainage networks with a 2D terrain model. Technical details of the model set-up are described in the Ross River (2021) Flood Study report with technical changes to the model discussed in Appendix I.

The TUFLOW mini-model was used to determine flood levels for the events and durations listed in Table 3-1. These results were then post-processed to create flood extents, water surface levels (WSL), depth, velocity and afflux plots.

Table 3-1 Flood events assessed

Flood event	1% AEP		20% AEP
Duration (hour)	1.5	9	2
Baseline	✓	✓	✓
Developed	x	✓	✓

4.0 FINDINGS, RESULTS AND DISCUSSION

Observations during the assessment indicated that there was a balancing act between allowing initial flows from the longer duration storm critical in the 1% AEP event out early to increase the amount of flood storage in the peak flow condition and detaining flows from the shorter duration storm critical in the 20% AEP event. The areas downstream of the Lakeside Drive intersection are particularly sensitive to the inclusion of additional flows at the peak of the event with additional flows resulting in broad increases in WSLs which impacts on the rail corridor and Cluden/Abbott Street to the east. These areas are particularly sensitive as flood levels are downstream controlled so significant increases in discharge result in increases in the volume of water and raised flood levels.

As the peak water surface levels in the 1% AEP event are controlled by the tailwater levels, the flood storage within the TTC lake is a significant controlling device for mitigating flood impacts to the north east downstream of the Lakeside Drive intersection. To mitigate the flood impacts in the 1% AEP event the TTC lake will be required to be updated with a new high flow diversion pipe to divert flows at the peak of the event.

The peak water surface levels in the 20% AEP event are controlled by immediate runoff and the capacity of existing drains and culverts. Additional flow diversions to divert the early portions of the 1% AEP storm have enough capacity for the majority of the 20% AEP event and therefore, result in increased outflows downstream. To resolve this, low-flow storage is required within the site itself to detain flood water in lower events but not impact on the storage and flow requirements of the major events. Additional basins and weirs with low flow pipes have been sized, levelled, and positioned to detain the peak flow of the 20% AEP event.

All development runs have been modelled to include the preliminary design surface based on the architectural plans provided for the proposed development extent and layout. This includes the broad filling of Lot 1 on SP101275 and the filling of the western section of Lot 2 on RP748152.

Due to the nature of rain-on-grid, fine scale model results and to provide some clarity, the final maps have been filtered such that areas predicted to experience water depths less than 0.05 m and water velocities less than 0.5 m/s are shown free from flooding. This varies from Council's historic standard of 0.1m and 0.8m/s but is adopted in this instance due to the restricted model area of interest and to highlight all areas with minor flooding. As a result, there may be slight discrepancies in flood extents, when comparing TCC baseline extents against the baseline results of this assessment due to the reduction in the depth parameter and the use of a finer scale hydraulic model (TUFLOW).

Table 4-1 lists the results that have been mapped and presented in the following appendices:

- Appendix B – Afflux plots
- Appendix C – Depth plots
- Appendix D – Velocity plots
- Appendix E – WSL plots
- Appendix F – Safety Hazard (Vd Product) plots

Table 4-1 Result map plots

Scenario	Event (AEP)	Flood Characteristic and Event Duration			
		WSL	Depth	Velocity	Vd
Baseline	1%	✓	✓	✓	✓
	20%	✓	✓	✓	✓
Developed	1%	✓	✓	✓	✓
	20%	✓	✓	✓	✓
Afflux	1%	✓	x	✓	x
	20%	✓	x	✓	x

The following sections discuss specific model modifications, in addition to those outlined in Sections 4.2.2, and results of the assessment.

4.1 Baseline Scenario

4.1.1 Digital Elevation Model (DEM) Modifications – TUFLOW

At the time of preparing the TUFLOW model, 2019 LiDAR data was available, however, given the Ross River (2021) considered the 2016 LiDAR data more appropriate NCE have also adopted this. The2016 LiDAR was transposed onto a 2 m grid to define the baseline topography of the hydraulic model. Detailed site survey was completed over the TCC site and was also stamped into the LiDAR base. It is noted that a number of locations were also altered slightly to better match the existing levels / conditions. These minor DEM alterations are outlined below:

- Dirt track through the drain at the south-east corner of the TTC site. There is a culvert under this location which is not picked up in the 2016 LiDAR.
- At the Stuart Drive / Edison Street roundabout the full roadway width of Stuart Drive over the bank of culverts is not depicted and has been bridged over.
- The full roadway width over Stuart Drive at the Gordon Creek bank of culverts is not depicted and has been bridged over.
- The full roadway width over Lakeside Drive at the Lakes overflow is not depicted and has been bridged over.
- The minor drain from the Lakes parallel to Abbott Street that extends all the way to the site is depicted as considerably higher than the actual levels. Culvert invert levels are recorded as lower than the DEM indicating that the LiDAR has picked up on levels obscured by thick vegetation. NCE have cut the invert of the drains based on the invert levels recorded at the culverts.
- Existing surveyed buildings on the TTC site have been included into the DEM to ensure they are not included in the flood plain storage.
- The bottom of the TTC lake has been set at a DEM level of 2.55 within the Ross River (2021) model and NCE have copied this into the mini-model to maintain DEM similarities where possible.

NCE note that some DEM modifications utilised in the Ross River (2021) flood model have not be adopted for the mini-model if they have not been considered critical to the development site.

A comparison of the depth and water surface level results showed suitable agreement between the Ross River (2021) model and the developed fine-scale mini-model. The comparison of the flood depths which show good correlation in magnitude and extent is shown in Map A05 in Appendix A. NCE note that the depths of the TTC site are slightly different due to the applied survey surface. The results demonstrated that the fine-scale mini-model is fit for purpose.

4.1.2 Critical Duration – TUFLOW

As discussed in Section 3.1.1 the hydrology has been updated to the current ARR2019 guideline and as such the 9-hour pattern 2 was found to be critical for the 1 AEP event and the 2-hour temporal pattern 7 was found to be critical for the 20% AEP event. The peak WSL of 9-hour duration was found to be significantly higher than the 1.5-hour duration, therefore no further assessment of the 1.5-hour was completed.

4.1.3 Existing Culverts

There were a number of culverts within the site that weren't included in the TCC Ross River (2021) model. Details of the culverts were picked up as part of the detailed survey and those that were equivalent to or greater than a 600 dia RCP were incorporated into the baseline model. Table 4-2 lists the culverts added TUFLOW model.

Table 4-2 Culverts added to the baseline model

ID	US IL (m AHD)	DS IL (m AHD)	Length (m)	Configuration	**Manning's** n value
RC001	2.00	1.97	14.5	4/900x450 RCBC	0.015
RC002	2.95	2.95	14.5	2/1200x450 RCBC	0.015
RC003	5.66	5.64	6.2	2/450x450 RCBC	0.015
RC004	5.79	5.71	15.6	1/900x300 RCBC	0.015
RC005	4.75	4.52	45.6	2/2500x1500 RCBC	0.015
RC006	4.33	4.22	4.0	3/1500 dia RCP	0.015
RC007	4.39	4.17	48.0	1/3200x3800 RCBC	0.025
RC008	2.96	2.55	66.6	4/600 dia RCP	0.015

4.2 Developed Scenario

4.2.1 Digital Elevation Model (DEM) Modifications – TUFLOW

In the TUFLOW model, the fill pads north and west of the race track have been raised to provide immunity to the 1% AEP event and levelled / graded in a preliminary manner that directs run-off to the preferred discharge location. The fill pads have been developed as a preliminary bulk earthworks design surface undertaken in 12d and stamped over the baseline model. Other works include the eastern carpark portion (20% AEP immune). Any mitigation measures and/or alterations to the preliminary earthworks surface have been incorporated into the model using z-shapes and level points.

Appendix A contain maps of the 2D terrain adopted for each scenario.

4.2.2 Critical Duration – TUFLOW

Refer to Section 4.1.2. An assessment of the provided critical duration raster resulted in the critical duration changing from 1.5-hour to 9-hour.

4.2.3 Rain-on-grid Design Discharge

Technical details of the rain-on-grid (ROG) setup, rainfall depths and Ross River (2021) flood report references, are provided in Appendix H with a summary of the design ROG methodology provided below.

In the TUFLOW model, the total rainfall depth is applied directly to the 2D grid with losses removed via soil infiltration, subject to the fraction impervious defined in the materials / land use mapping.

In order to account for changes in impervious areas for the proposed development, the land use for entire extent of each fill pad was modified to reflect a 90% impervious, representing a 'design' discharge from the future potential development.

4.2.4 Initial Water Levels

Initial water levels have been adopted directly from the TCC Ross River (2021) flood model. Where extracted initial water levels differ from the Mean High Water Springs (MHWS) level of 1.314m AHD alternative water levels have been applied:

- Gordon Creek to the west of the Fairfield Lakes have been set at initial water levels within the stage-time boundary.
- Initial water levels through the Fairfield Lakes and associated drains have been extracted directly from the Ross River (2021) model with levels also applied within the stage-time boundary.
- The TTC lake initial water level has been extracted directly from the Ross River (2021) model.

4.2.5 Fill Extents

The preliminary development layout outlines the extent of fill expected. The extent of earthworks involved with the development of the site is generally depicted in the maps provided in Appendix G.

4.2.6 Mitigation Measures

Various mitigation controls and devices have been explored in order to find a balance and include:

- culvert under future / existing roads and race track;
- flow diversions via open channels and culverts;
- flow restrictions via levees;
- detention storage basins; and
- reduction of fill extents from natural flow paths and flood inundation areas.

4.2.6.1 Culverts

Culverts were utilised to help divert, detain and increase flows to different portions of the development. As outlined in Section 3.1.1 to resolve the different critical durations differing methodologies were required which necessitated the inclusion of multiple different set ups. The development culverts along with their use are outlined in the maps provided in Appendix G. The culvert ID's are also presented in Map G06 provided in Appendix G. Table 4-3 lists the proposed culverts parameters as included in the assessment.

Table 4-3 Development culverts

ID	Type	US IL (m AHD)	DS IL (m AHD)	Configuration	Manning's n value
C01	Rectangular Culvert	3.57	3.44	3/1200x750	0.015
C02	Rectangular Culvert	3.15	3.05	3/1200x750	0.015
C03	Rectangular Culvert	2.369	2.351	3/2100x600	0.015
C04	Rectangular Culvert	3.71	3.65	3/1500x600	0.015
C05	Rectangular Unidirectional Culvert	3.51	3.27	2/2700x1200	0.015
C06	Rectangular Culvert	3.3	3.29	3/1500x600	0.015
C07	Rectangular Culvert	3.39	3.37	3/1200x450	0.015
C08	Rectangular Culvert	3.35	3.21	3/1500x600	0.015
C09A	Rectangular Culvert	3.75	3.7	5/1200x600	0.015
C09B	Rectangular Culvert	2.4	2.3	2/1200x900	0.015
C10A	Rectangular Culvert	3.5	3.45	5/1200x600	0.015
C10B	Rectangular Culvert	2.25	2.15	2/1200x900	0.015
C11	Circular Unidirectional Culvert	2.29	2.26	2/450	0.015

4.2.6.2 Open / Diversion Channels

The proposed open and diversion channels aim to maintain the existing flow paths or divert flows to additional storage areas. The profile of each drain is provided in Table 4-4 below including the average grade and length. All batters are proposed to be at a maximum of 1 in 4. Channels are named as per the maps in Appendix G. Open drain 1 is designed to maintain the same purpose of the existing drainage easement on site. Whereas open drain 2 is designed as a bypass for flows around the existing TTC lake, this helps to reduce the flows into the lake outside of the peak flow period. Open drain 3 is the outlet for the TTC lake and open drain 2.

Table 4-4 Open / Diversion channel details

ID	Top Width	Bottom Width	Length (m)	Grade
Open Drain 1	30.0m	16.4m	270m	1 in 255
Open Drain 2	24.0m[1]	4.0m	260m	1 in 190
Open Drain 3	24.0m	5.0m	170m	1 in 415

[1] This is the average top width the actual top widths vary over the length

4.2.6.3 Levees / Weirs

All levees and weirs are displayed in the maps provided in Appendix G. Nine (9) levees/weirs are required;

- Levee 1 (L1) – Levee formed by the access from the Stuart Drive roundabout. This levee forces flows into the culverts C01 and C04 and over the high flow weir W1 into detention basin south in peak flow events.

- Levee 2 (L2) – Levee formed by the internal roads, required to access the waterpark from the central internal road. This levee forces flows into culvert C02 and creates flood storage through open drain 1. This levee is not required of the mitigation measures but is necessary to the function of the development.

- Levee 3 (L3) – Levee formed by the access to and from the proposed TTC car park area. This levee forces flows into the culverts C09A and C09B. This levee acts as a flow restriction where culverts C09A and C09B act as low and high flow diversions respectively.

- Levee 4 (L4) – Levee formed by the access to and from the proposed TTC car park area. This levee forces flows into the culverts C10A and C10B. This levee acts as a flow restriction where culverts C10A and C10B act as low and high flow diversions respectively.

- Weir 1 (W1) – High flow bypass weir for rare events which diverts significant flows towards detention basin south just prior to the flood peak and also into the TTC lake via pipe C05.

- Weir 2 (W2) – Detention weir with low flow bypass pipe C03. The weir allows for additional flood storage within the detention basin west without the need to alter the culverts under the existing road.

- Weir 3 (W3) – Detention weir with low flow bypass pipe C06. The weir allows for additional flood storage within the detention basin south before flows are diverted through C05.

- Weir 4 (W4) – Detention weir with low flow bypass pipe C07. The weir and low flow combination allows for maximum storage at the peak of the minor event whilst still allowing early flows out during the major event.

- Weir 5 (W5) – High flow weir to allow the peak flows of the minor event into the detention basin north. Allows for maximum storage at the peak of the minor event.

- Key details of each levee / weir for each option are provided in Table 4-5.

Table 4-5 Levee key details

ID	Top RL (m AHD)	Weir RL (m AHD)	Weir Length (m)
L1	5.00[1]	-	-
L2	4.54[1]	-	-
L3	4.70	-	-
L4	4.50	-	-
W1	4.90	4.55	19
W2	3.35	3.35	50[2]
W3	4.70	4.51	22
W4	4.30	4.30	25[2]
W5	4.10	3.11	30

[1] The top levee level is on grade so the lowest level is indicated.
[2] Weirs are to retain low flows only and are intended to be under flooded conditions in major events.

4.2.6.4 Detention Storage

Detention storage was required to offset some of the natural storage occurring on the site, particularly in the areas adjacent to the highway. All detention areas are provided in shown in Appendix G. Four (4) detention storage areas were identified for both scenarios:

- Detention Basin South – located to the south east of the proposed development directly to the west of the existing Turf Club Lake. This detention storage area is positioned to detain the overtopping of Weir 1 in the significant events. This detention basin drains to the north through Open Drain 2 and Weir 3 with a high flow bypass culvert (C05) diverting flows into the Turf Club Lake. The basin acts as preliminary storage to delay the flows through the high flow bypass culvert (C05) to ensure the storage within the Turf Club Lake is not filled earlier within the critical duration event.

- Detention Basin Central – located directly to the north of Detention Basin South and west of the southern portion of Open Drain 2. The basin acts as low flow offline storage for more frequent events where Weir 4 and low flow pipe C07 are sized and positioned to ensure peak storage is contained at the peak of the 20% AEP event. Culverts C07 and C08 outlet the basin into Open Drain 2 while the inflow to the basin is controlled by culvert C04.

- Detention Basin West – located to the west of the northern end of the central road. This basin acts as low flow and high flow storage before flowing into the table drain to the east. Weir 2 allows the storage of low flows with the culvert C03 sized to ensure maximum available detention at the peak of the event. The existing culverts detain the higher flows through the detention basin and table drain to the west.

- Detention Basin North – located to the west of the downstream end of Open Drain 3. This basin acts as peak flow detention basin for the 20% AEP event which otherwise causes afflux. Weir 5 is levelled and positioned to allow in the peak flow only and reduce the amount of afflux downstream of Open Drain 3. Culvert C11 acts as a outflow for the basin outside of peak events whilst ensuring no back flow occurs into the basin.

- Table 4-6 lists the key detention storage area details.

Table 4-6 Detention storage area summary

ID	Storage Area[1] (m^2)	Average Basin Depth (m)
Detention Basin South	4,800	1.39
Detention Basin Central	3,200	1.27
Detention Basin West	4,200	1.75
Detention Basin North	2,000	1.80

[1] Storage area is taken from the toe of the batters.

The combination of all the above mitigation and flow control devices are required in order to achieve no actionable impacts off site in both the major and minor events.

4.3 Results

Results associated with the maps provided in Appendix B to Appendix F are discussed in detail in the following sections.

4.3.1 Afflux

The scope of works required the assessment of the proposed development layout which is undertaken by assessing the potential changes and impacts on the flood characteristics, and best analysed by assessing the afflux. Afflux is defined as the relative change in a flooding characteristic, namely WSL or velocity, between the baseline and developed situation. This is determined by subtracting the baseline peak results from the developed peak results, where a positive value represents an increase in the flood characteristic and a negative value is a decrease.

Afflux has been determined for two (2) flooding characteristics, WSL and velocity, which as discussed in detail in the following section.

4.3.1.1 WSL Afflux

WSL afflux has been assessed for both the 1% and 20% AEP events for both options. In reference to the afflux maps in Appendix B the TCC parameters for acceptable development is +/- 10 mm change in WSL (shown in white). Depending on the circumstances, in areas that are not sensitive to flooding, do not impact the function of infrastructure or properties, NCE are of the opinion that increases in excess of this (light green/aqua) is also acceptable in some instances and isn't of concern. With this in mind, the following commentary is provided.

- 1% AEP
  - North of the Lot 1 on SP101275 (within the highway corridor table drain) there is a slight, highly localised, increase in levels (yellow) to a maximum of 24mm. NCE also note that the rest of the table drain to the north of the Lot 1 on SP101275 sees a general decrease of 7-8mm. The resulting levels which are localised and generated due to the inclusion of Weir 2 are well clear of any carriageway and does not impact the function of the roadway. NCE consider due to the localised nature and positioning of the afflux as well as the general minor decrease along the majority of this stretch, that it is an acceptable, non-actionable impact.
  - Immediately downstream of existing culvert WPB26A there is a minor increase of a maximum of 16 mm within the highway corridor, however this is within the existing drain that was constructed as part of the V2C works and the WSL is still well below the carriageway level (over 1m below).
  - Upstream of the development, at both the upstream and downstream ends of the existing 11/1200x600 culverts underneath Stuart Drive, there is a negative afflux (decrease in levels post-development). The improvement reaches up to ~50mm at the upstream end and up to ~20mm at the downstream end.
- 20% AEP
  - North of Open Drain 3 (within the road corridor) there is a slight increase in levels up to 26mm, the afflux spreads further to the east decreasing as it goes. NCE note that upstream in the table drain to the west there is a significant decrease in afflux up to 56mm which is considered to be a positive outcome during frequent events. The resulting levels which are localised and generated due to the Open Drain 3 and are well clear of any carriageway. NCE consider due to the localised nature and positioning of the afflux that it is acceptable.
  - To the north east of Lot 2 on RP748152 at the common boundary with Lot 1 on EP1477 there is a minor, highly localised increase in water surface levels of up to 22mm. To the north of the localised increase is a decrease in levels directly upstream of the existing culverts under the Bruce Highway. The decrease indicated is to a maximum of 15mm and is localised to the areas directly upstream of the culvert.
  - There are broad spread significant decreases in levels to the north of Lot 1 on SP101275. Level decreases spread from ~150mm within Detention Basin West to ~70mm through the table drain. Significant decreases are due to the new levees 1 and 2 and the bypass culvert C04.
  - Upstream of the development, at both the upstream and downstream ends of the existing 11/1200x600 culverts underneath Stuart Drive there is a decrease in afflux. The improvement reaches up to ~50mm at the upstream end and up to ~20mm at the downstream end.

Overall, any impact associated with this development is contained within the development site, other than those areas noted above. It is our opinion that the increase observed in the road corridors are non-worsening as there is no fundamental impact on the carriageway, i.e. the flood levels are below the carriageway or maintain the same functionality as previously observed.

4.3.1.2 Velocity Afflux

Any changes in flow velocities should be shown to have minimal impact on erosion potential which leads to an in-depth assessment of various characteristics. Some of these characteristics include the soil type, vegetation, energy dissipation measures and pre and post velocities.

When undertaking this assessment many of these characteristics were unknown which has led to a broader assessment of the potential impacts associated with a change in velocity. Subsequently the criteria adopted for changes beyond the extents of the proposed development for this assessment is as follows:

- Any change below 0.1 m/s has no cause for concern and is an acceptable outcome;
- 0.1 m/s to 0.3 m/s is of minor concern which may be considered acceptable following a review of the pre and post velocities;
- 0.3 m/s to 0.5 m/s raises concern and requires further investigation to determine if additional mitigation measures are required;
- Above 0.5 m/s is of greater concern and requires an in-depth investigation into the potential erosion impacts as well identifying mitigation measures.

In reference to the maps provided in Appendix B, it is evident that changes in velocity that raises concern are generally contained within the extents of the development and isolated to new diversion channels and weirs. Consequently, appropriate detail design of these channels will be required to ensure potential scouring is minimised.

It is noted that there are a number of isolated areas of velocity increases particularly through the table drains to the north of Lot 1 on SP101275 and Lot 2 on RP748152 in the 1% AEP and 20% AEP events. These locations are generally increases less than 0.2m/s and do not correlate with significant velocities (greater than 1m/s). In accordance with the Queensland Urban Drainage Manual (QUDM) the maximum velocity for an open channel of easily eroded soils with a vegetation cover of 70% is 1.5 m/s. Therefore, this increase in not expected to increase the risk of scour or erodibility of these areas. The indicated increases in afflux also do not correlate with any significant increase in the safety hazard (Vd product), therefore NCE consider these localised increases to be acceptable.

4.3.2 <u>Peak Flood Levels and Depths</u>

Peak depths and WSL are shown in Appendix C and Appendix E respectively. On the WSL plots, 0.1m contours have been provided to help determine the minimum height of fill in order to achieve flood immunity, NCE note however that there isn't significant hydraulic grade through the development site in either of the modelled events. In addition to the information shown on the maps, the following items are noted:

- The bike lane of the west bound legs of the highway, from Lakeside Drive to Stuart Drive, are shown to be inundated in the baseline scenario as flood levels are observed to reach 4.230 m AHD and levels across the carriageway (in this section) vary from 4.11 m AHD on the southern side to 4.43 m AHD on the northern edge of the west bound lanes. NCE note that no increase in water surface levels or velocity is noted over these areas.

- The flood water surface levels north of Lot 2 RP748152 are now reading at ~4.2m AHD which roughly aligns with the provided council data of the Ross River (2021) flood model for the 1% AEP. The flood data extracted from the TCC online mapping indicates the previous calculated peak water surface level was 3.84m AHD in the same location.

- The flood water surface levels north of Lot 1 on SP101275 are now reading at ~4.22m AHD which roughly aligns with the provided council data of the Ross River (2021) flood model for the 1% AEP. The flood data extracted from the TCC online mapping indicates the previous calculated peak water surface level was 4.14m AHD in the same location.

- The existing buildings remain free from inundation during the 20% AEP event in the proposed development case.

4.3.3 Peak Velocity

Appendix D contains the peak velocity maps. It is evident that the velocity is generally <0.5 m/s across the site and surrounding areas in both the 1% and 20% AEP events with the exception of channels. The typical peak velocity in the channels is ~1.2 m/s where appropriate vegetation, i.e. 70% coverage, will minimise the risk of scour and erosion. Portions of the channels particularly around culvert outlets and weirs are in excess of 1.2m/s and may require rock cover or other forms of scour treatment.

4.3.4 Safety Hazard (Vd Product)

In accordance with QUDM, the maximum vehicle safety criteria require a Vd product ≤0.4 m/s where depth is ≤250 mm and Vd product ≤0.3 m/s where depth is ≤200 mm for longitudinal and transverse flow respectively. In reference to the maps in Appendix F, it can be seen that the maximum Vd product for any of the events is no greater than 0.3 m/s on roads.

As expected, the Vd product increases in channels and areas of significant inundation depth. It is therefore recommended that safety for the public is considered in these areas during the detailed design phase. It is noted that the Vd product mapping in Appendix F is based on the peak velocity and peak depth, whereas in reality these peak parameters may not actually coincide, therefore the mapping provided is considered to be conservative.

5.0 SUMMARY AND CONCLUSION

MCK Pty Ltd is proposing the Townsville Water Park and Hotel development at the Townsville Turf Club (TTC) site. The proposal involves the water park, hotel as well as other retail, commercial and residential uses complementary with the overall master planning concept.

NCE have been engaged by MCK TSV Pty Ltd to conduct an assessment which is based on inputs from the new Townsville City Council (TCC) Ross River (2021) TUFLOW baseline model.

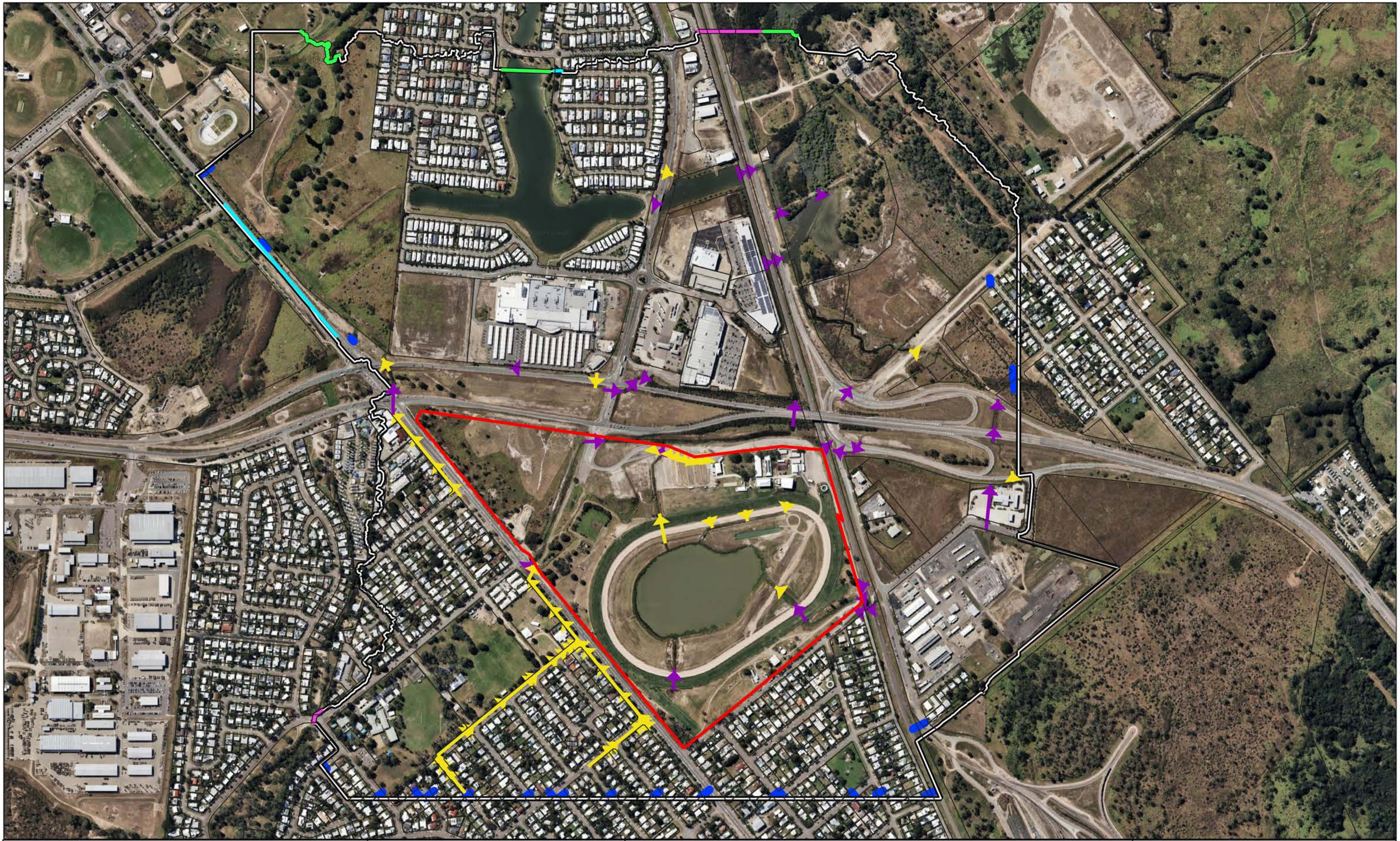
NCE have developed a fine-scale TUFLOW mini-model in order to assess the proposed development of a hotel and water park that can be further developed in line with TTC's vision. The fine-scale mini-model has been developed using the Australian Rainfall & Run-off 2019 (ARR2019) hydrology.

As a result of the extensive investigation undertaken during the assessment, a solution has been identified. The mitigation measures for the proposed development as depicted in Appendix G consist of a combination of open channels, culverts, detention basins and weirs.

The investigation included an impact assessment which demonstrated that the development does not cause any actionable impacts to the existing flooding conditions experienced at the site or surrounding areas. The assessment also demonstrated some improvement in flood conditions in the western end of Racecourse Road.

APPENDIX A

Model Setup Maps – Developed by NCE



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0 100 200 300 400 m

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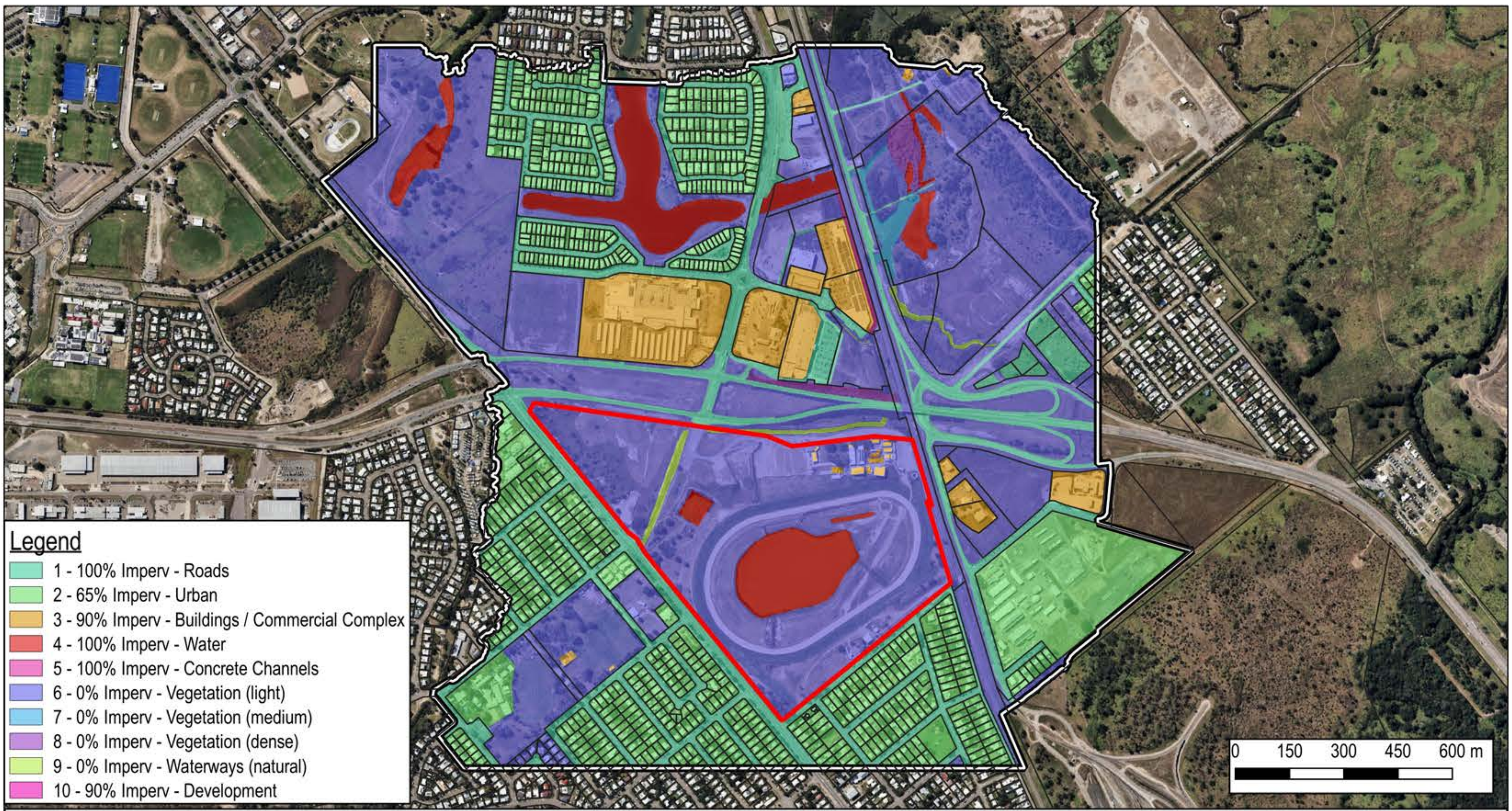
Legend

Development Site	TCC Circular Culverts
Flood Model Boundary	TCC Rectangular Culverts
TCC Land Parcels	Inflow Locations
Stage-time Boundary	Flow-time Boundary
Stage-flow Boundary	

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

FLOOD MODEL SETUP

Prepared By: BB	Date: 08/08/2024	Size	Sheet
Reviewed by: AW	Revision: A	A3	A01
	NCE Ref: BNC0084		



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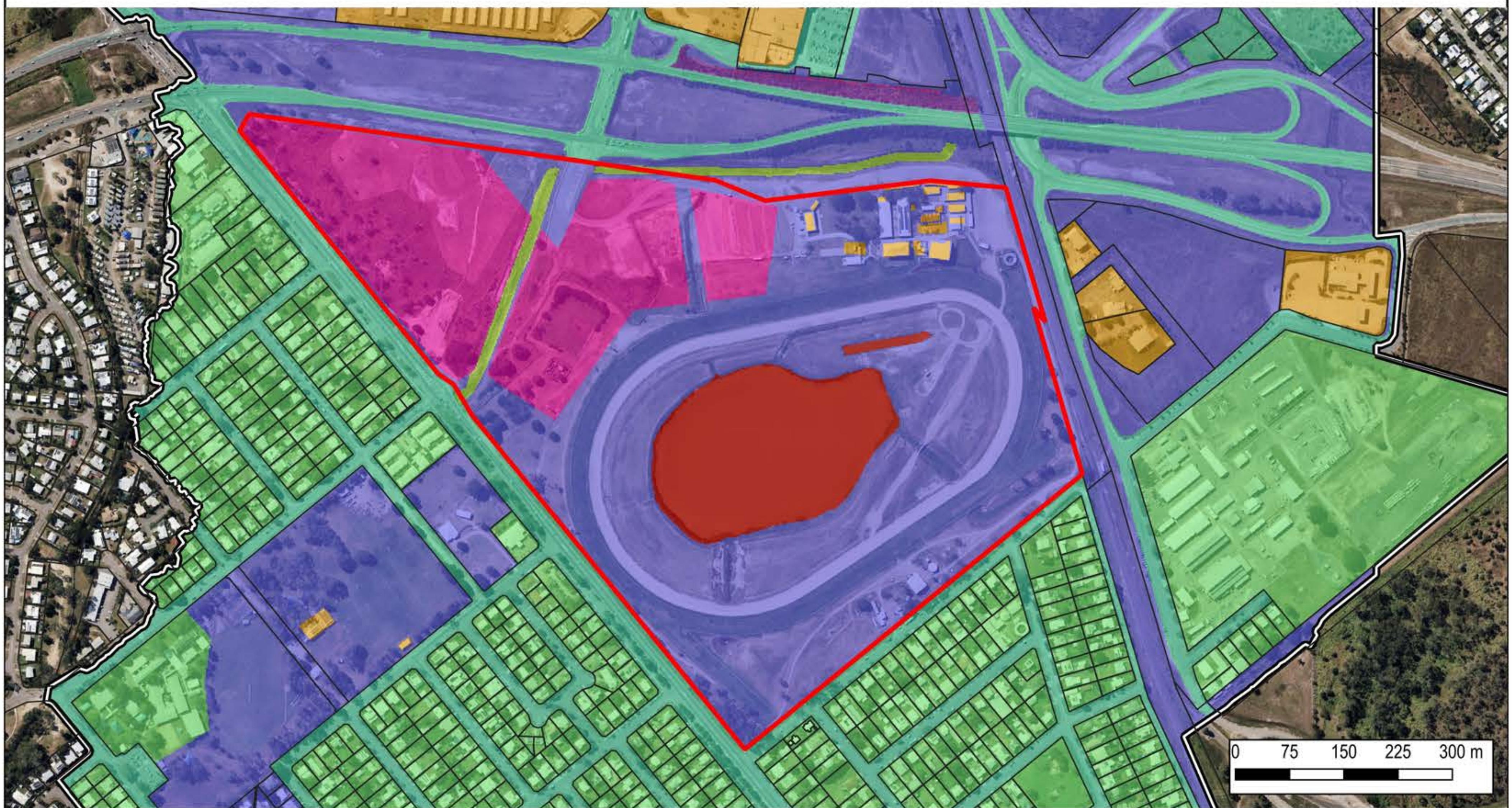

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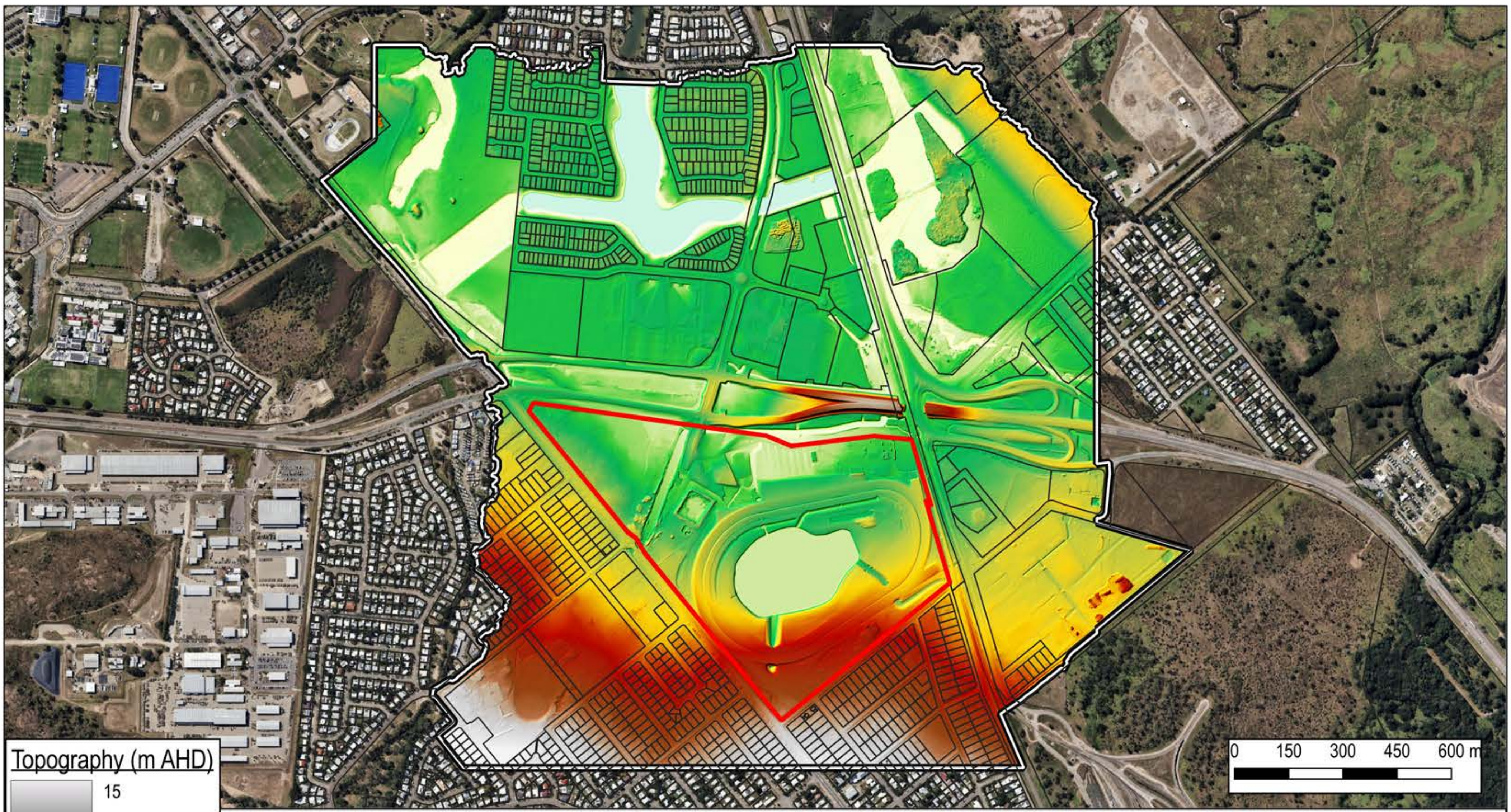
TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

TUFLOW MATERIALS BASELINE VS DEVELOPED

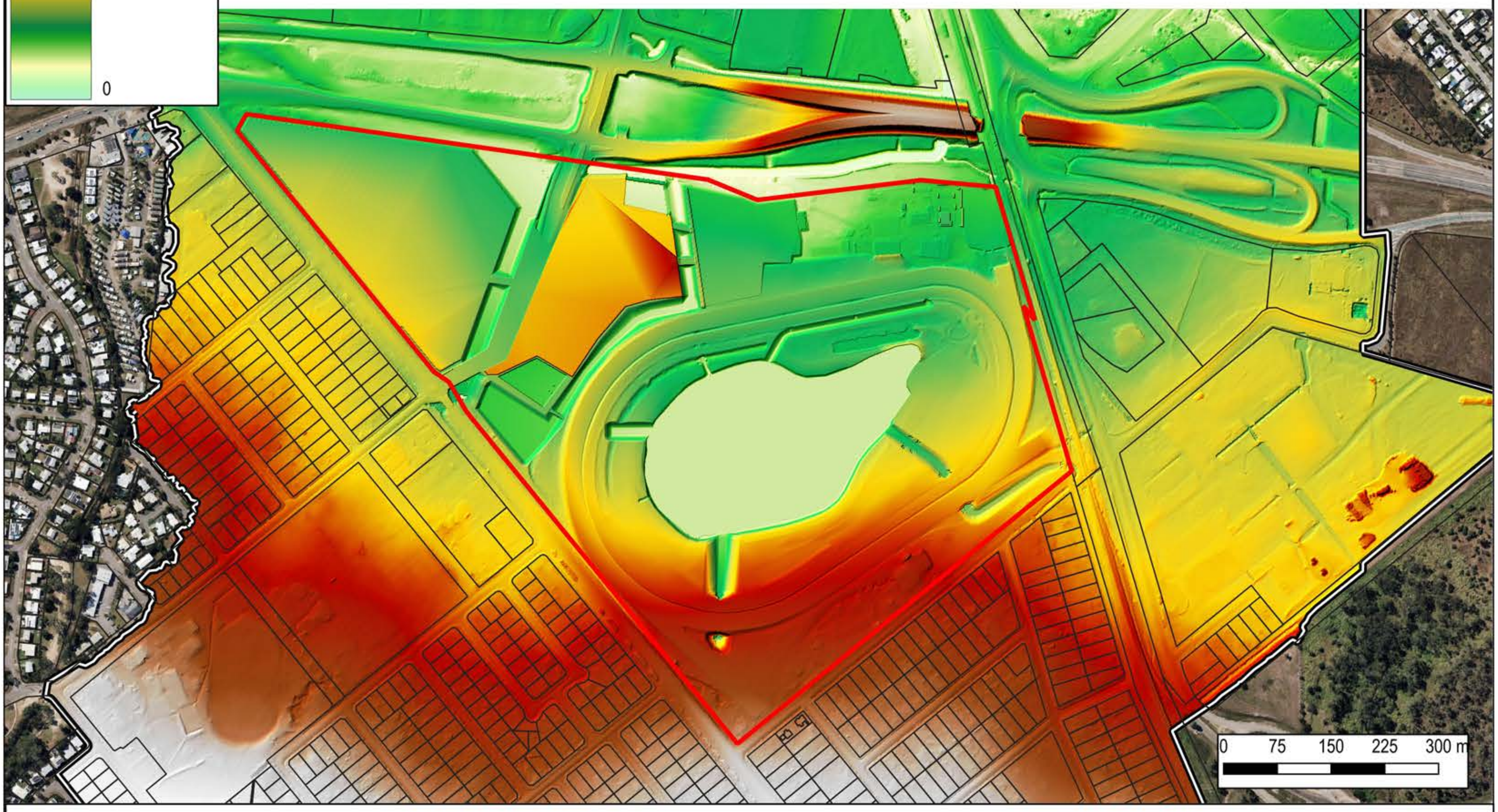
Date: **08/08/2024**
Revision: **A**
NCE Ref: **BNC0084**

Size **A3**

Map **A02**



BASELINE



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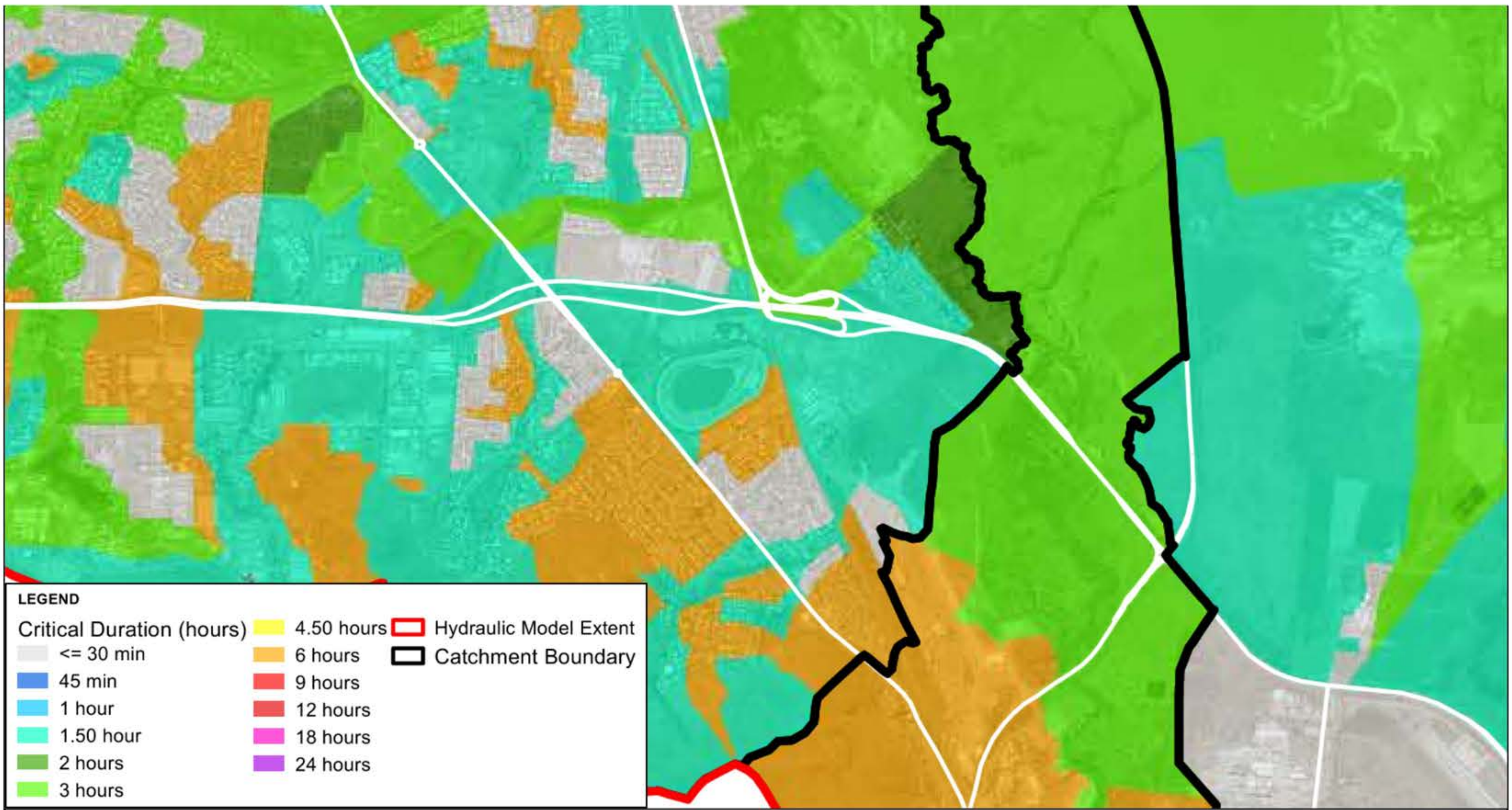
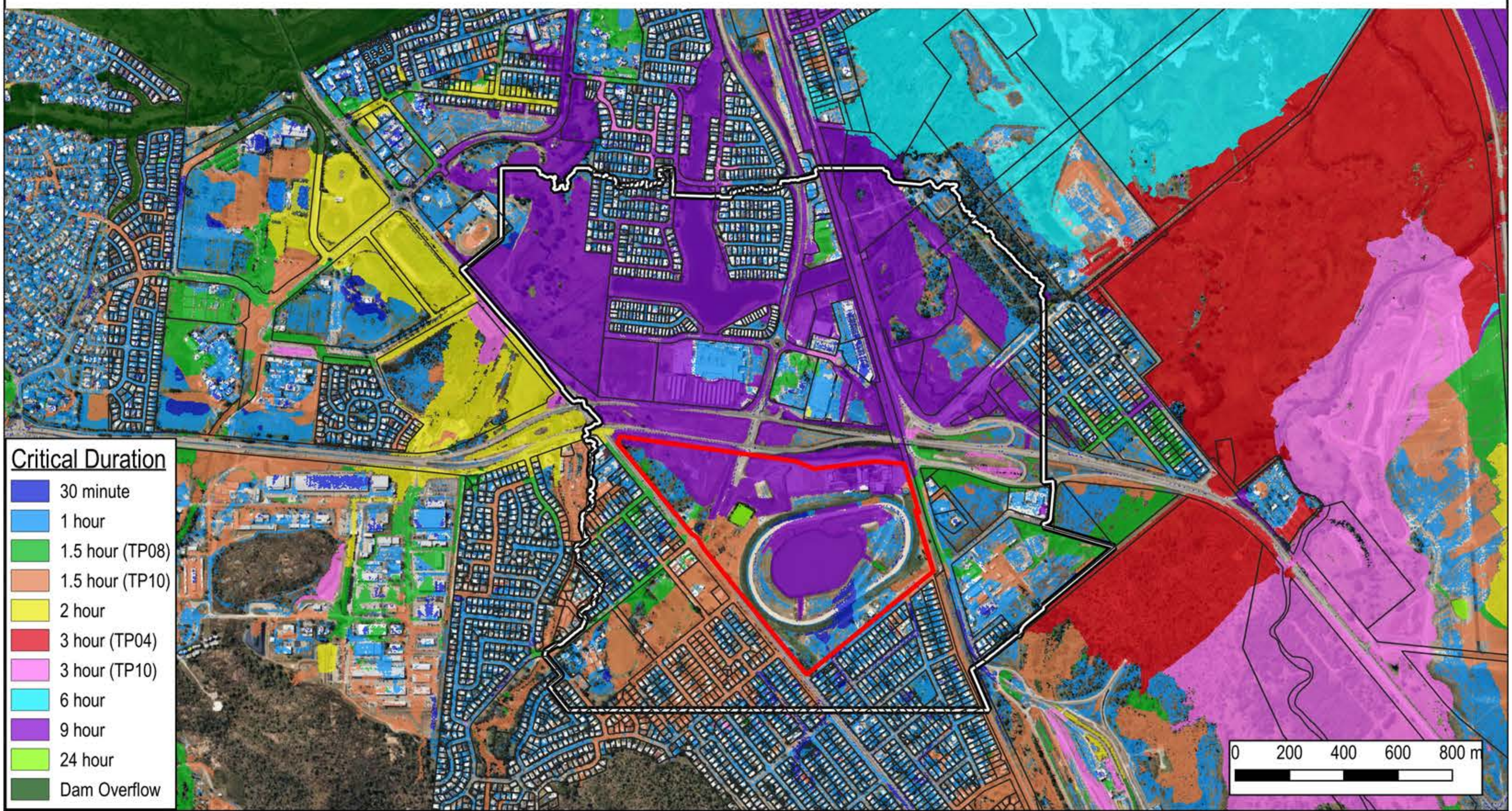
TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

TUFLOW TOPOGRAPHY BASELINE VS DEVELOPED

Date: **08/08/2024** Revision: **A** NCE Ref: **BNC0084**	Size **A3**	Map **A03**



ROSS RIVER (2021) FLOOD REPORT MAPPING



PROVIDED CRITICAL DURATION RASTER

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Legend
Development Site | Flood Model Boundary | TCC Land Parcels

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TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

TUFLOW CRITICAL DURATION MAPPING COMPARISON

Date: 14/08/2024
Revision: A
NCE Ref: BNC0084

Size: A3
Map: A04

ROSS RIVER (2021) FLOOD MODEL

BASELINE MINI-MODEL

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Legend

Development Site | Flood Model Boundary | TCC Land Parcels

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TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

TUFLOW BASELINE DEPTH COMPARISON

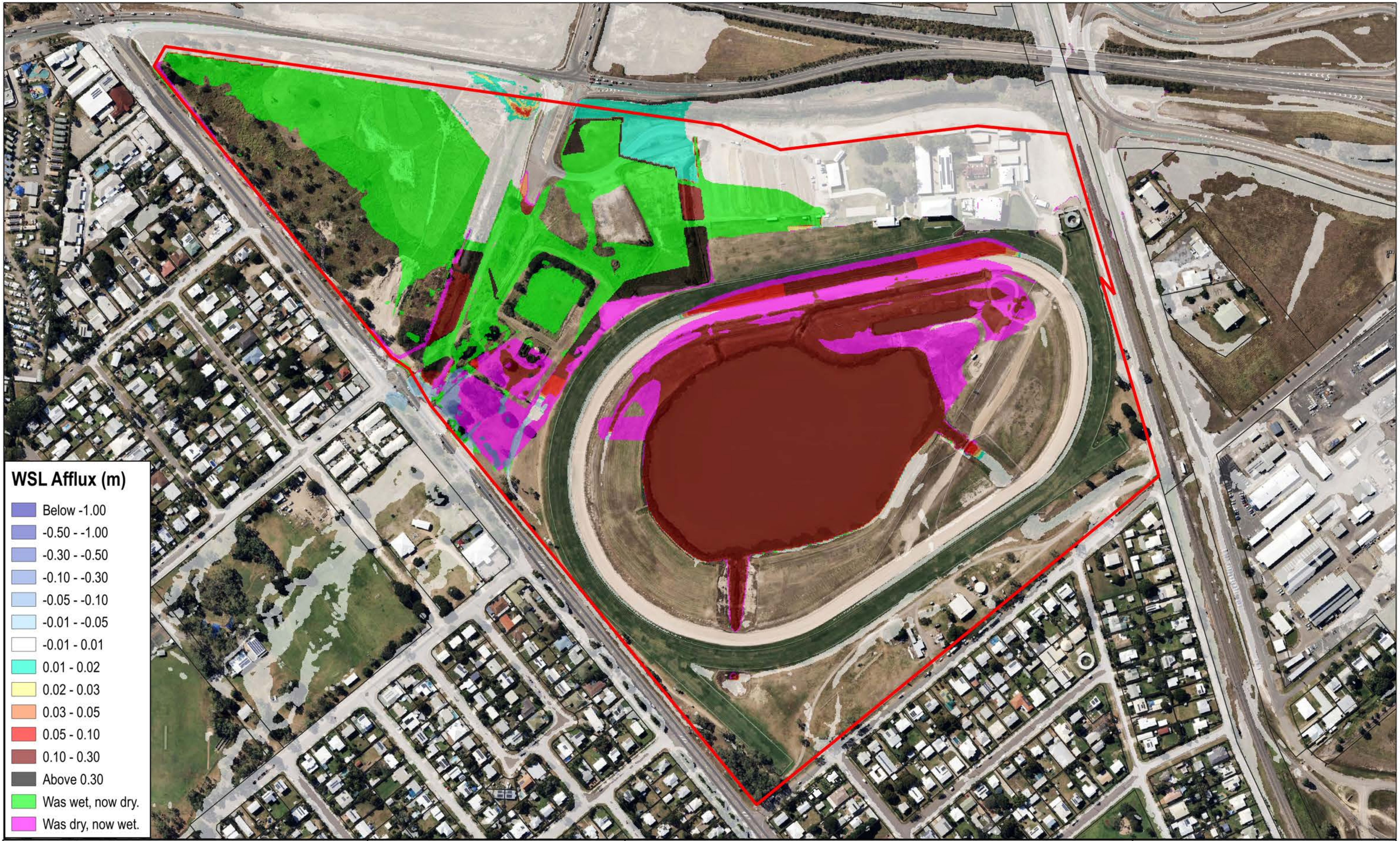
Date: 14/08/2024
Revision: A
NCE Ref: BNC0084

Size: A3

Map: A05

APPENDIX B

Flood Afflux Results (WSL & Velocity Afflux) – Developed by NCE



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0 50 100 150 200 m

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Legend

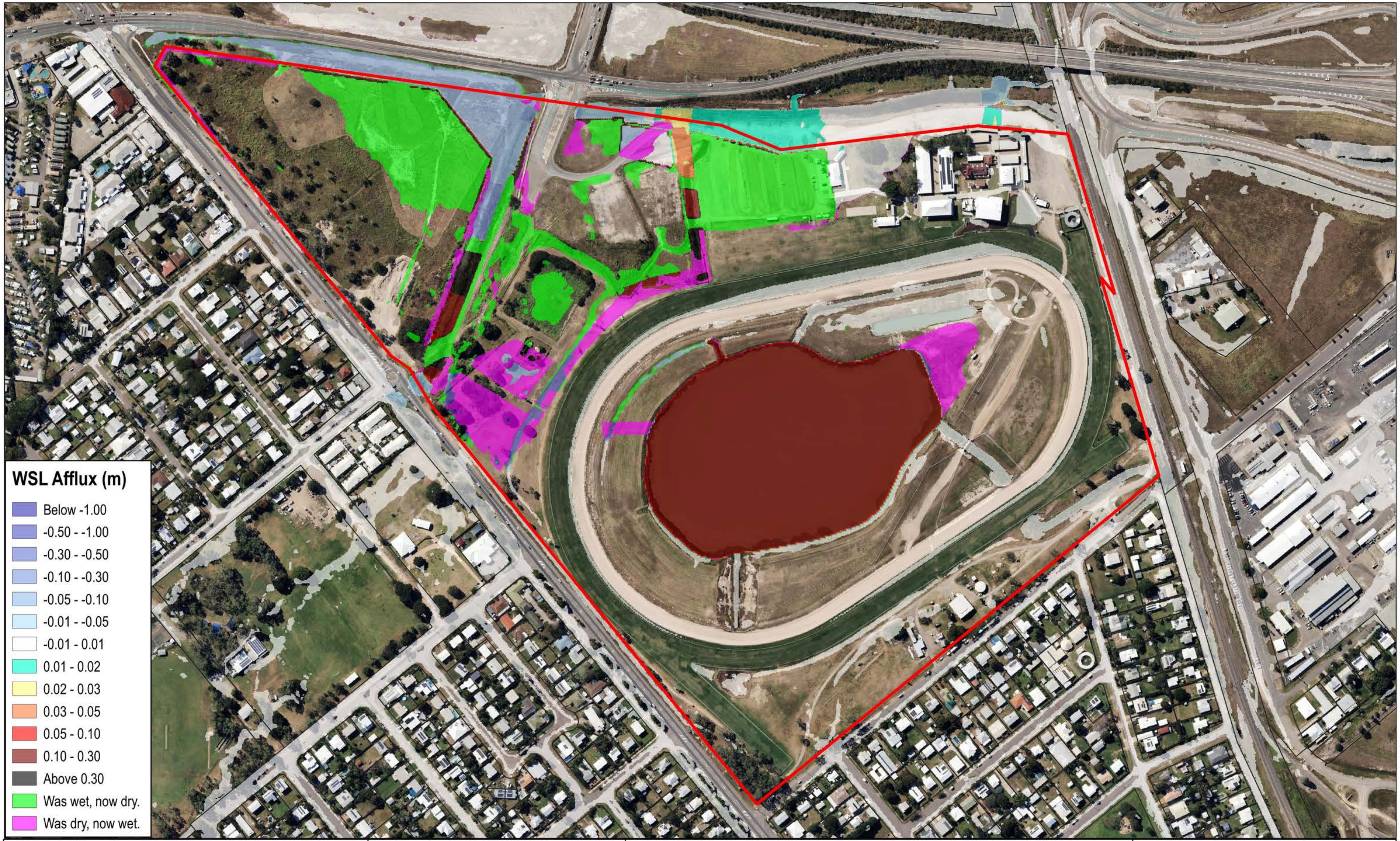
Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h WSL AFFLUX

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet B01



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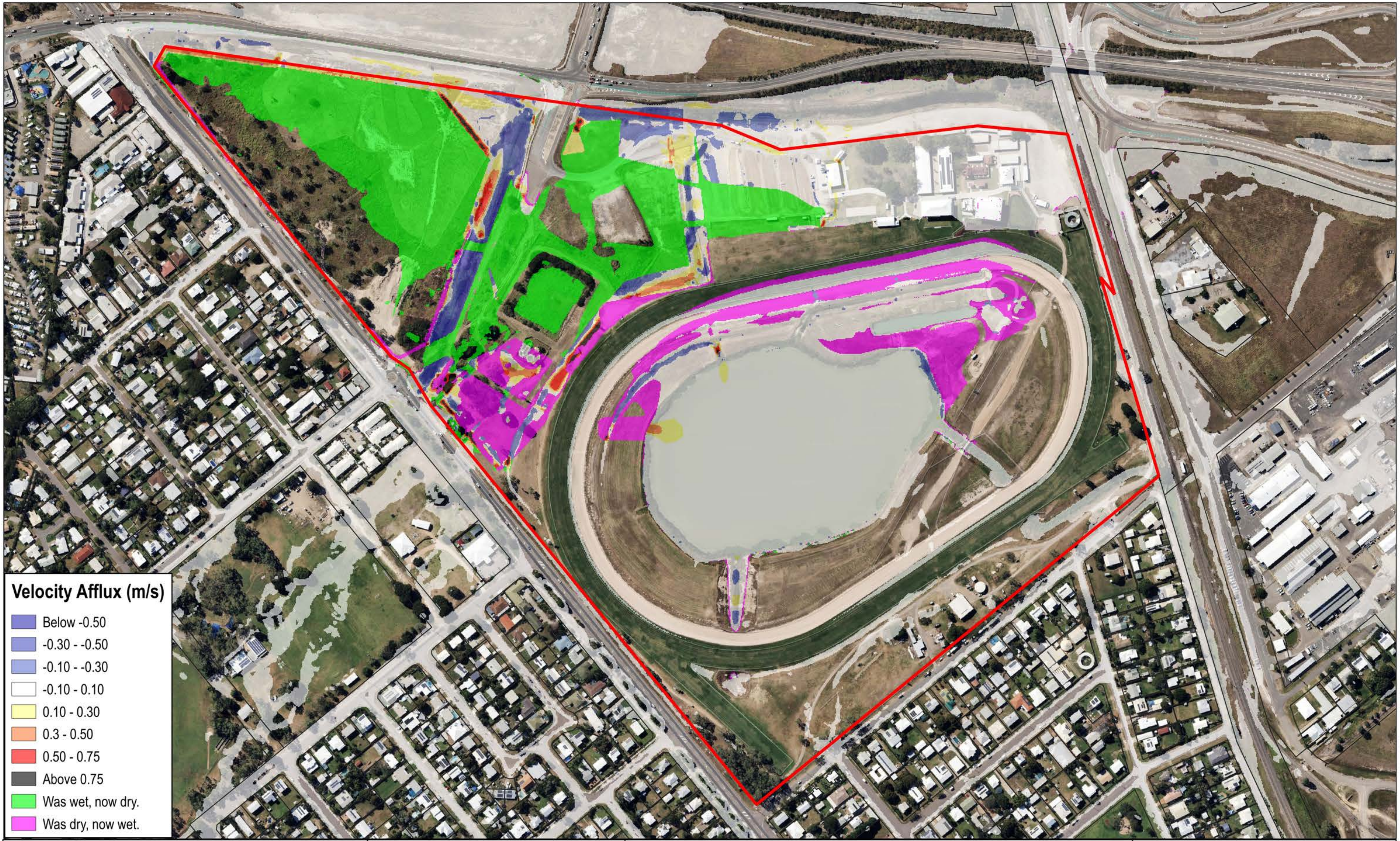
Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h WSL AFFLUX

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet B02



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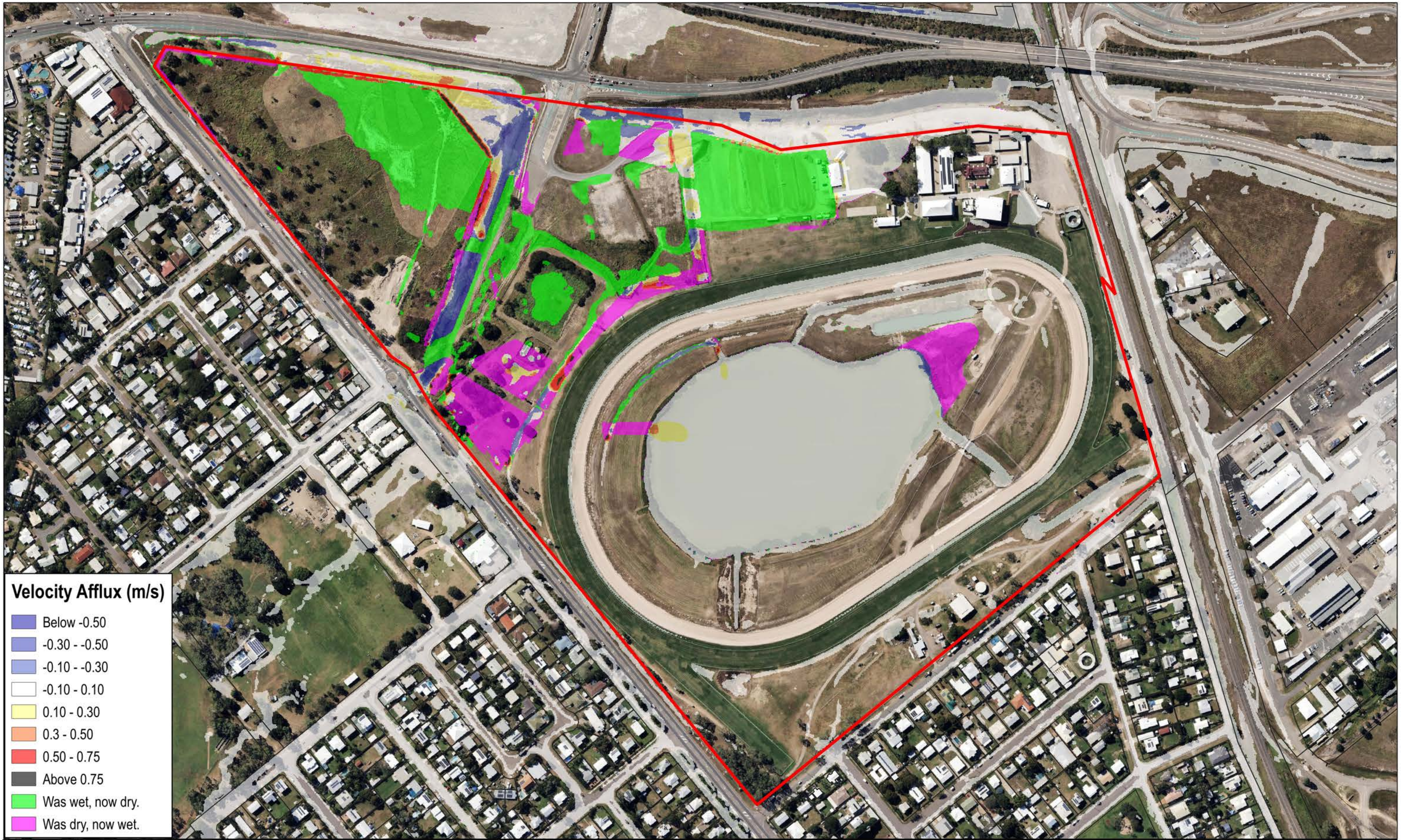
TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h VELOCITY AFFLUX

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet B03

Document Set ID: 26418548
Version: 1, Version Date: 24/10/2024



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0 50 100 150 200 m

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Legend

Development Site | TCC Land Parcels

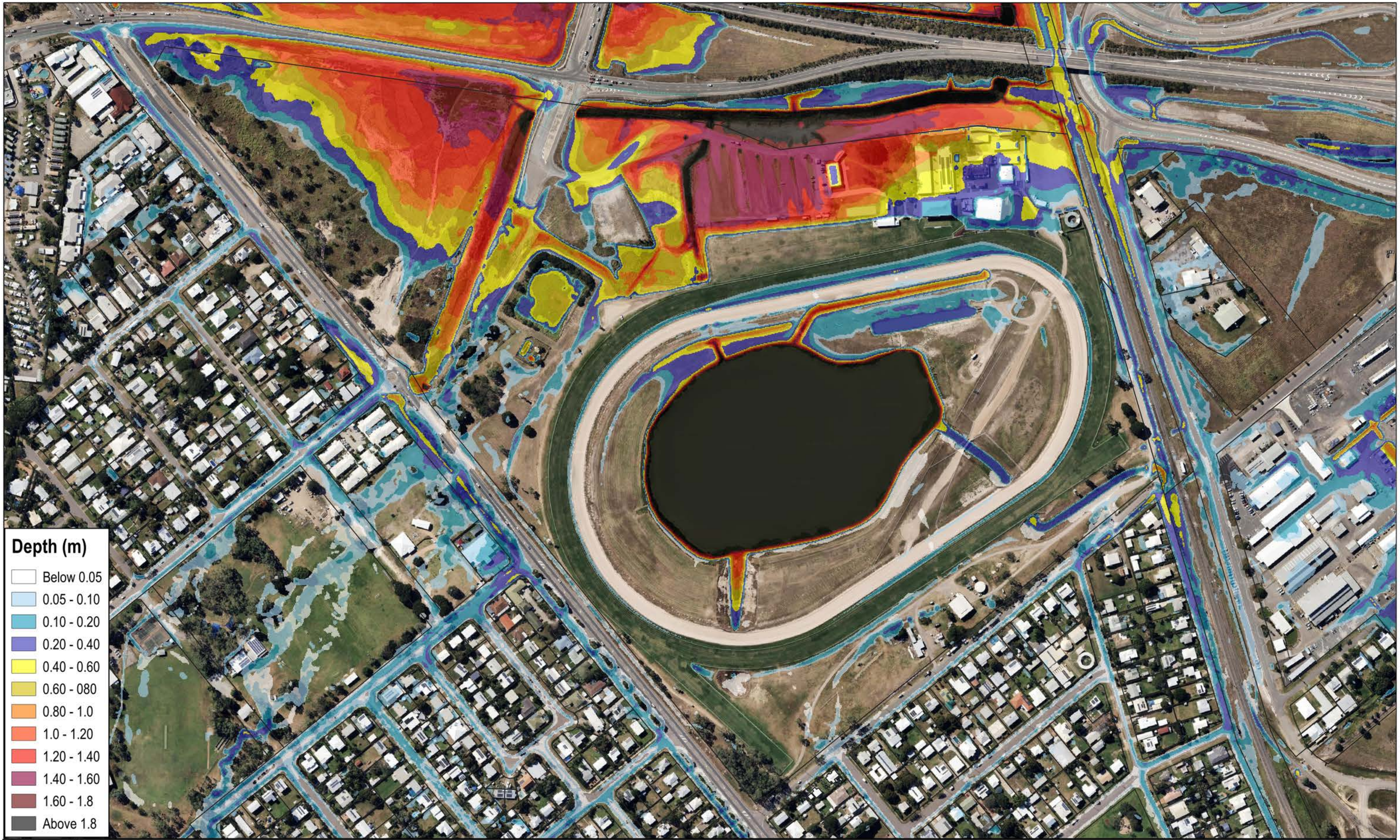
TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h VELOCITY AFFLUX

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet B04

APPENDIX C

Flood Depth Results – Developed by NCE



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0 50 100 150 200 m

1:4,000

N

Legend

Development Site

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TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

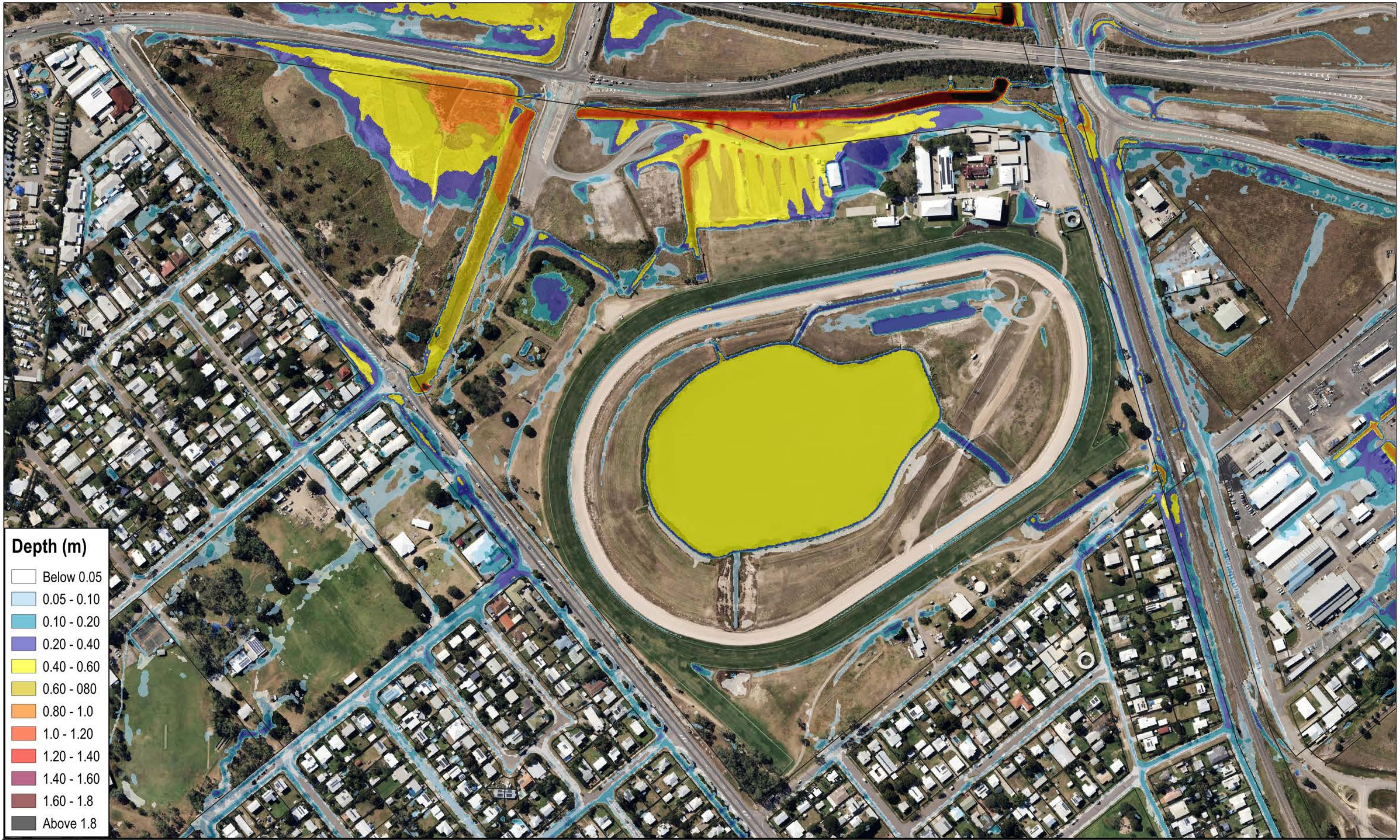
1% AEP 9h BASELINE DEPTH

Prepared By: BB
Reviewed by: AW

Date: 08/08/2024
Revision: A
NCE Ref: BNC0084

Size: A3

Sheet: C01



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0 50 100 150 200 m

1:4,000

N

Legend

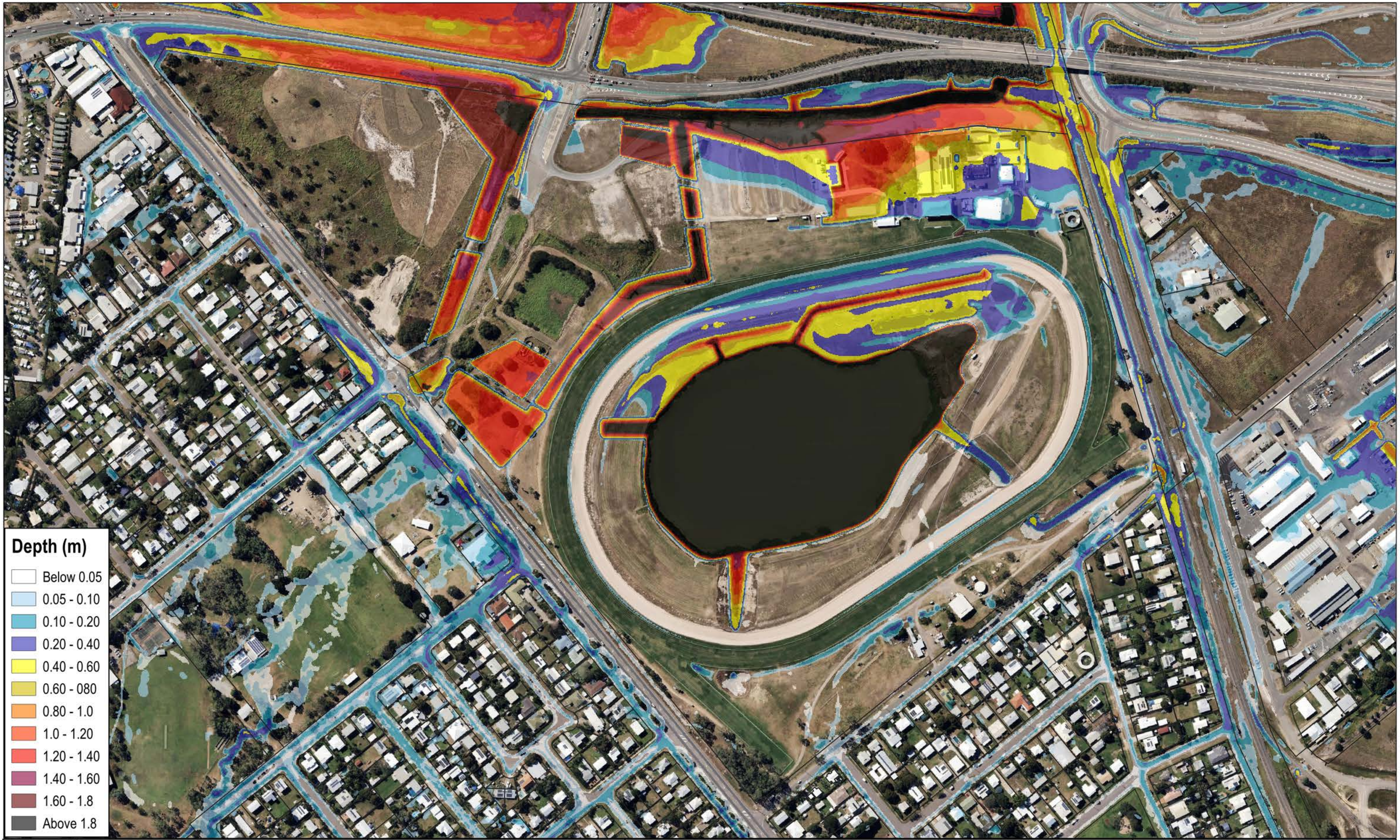
Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h BASELINE DEPTH

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet C02



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0 50 100 150 200 m

1:4,000

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Legend
- Development Site
- TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h DEVELOPED DEPTH

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet C03

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MCK TSV Pty Ltd

0 50 100 150 200 m

1:4,000

N

Legend

Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h DEVELOPED DEPTH

Prepared By: BB Reviewed by: AW	Date: **08/08/2024** Revision: **A** NCE Ref: **BNC0084**	**Size** **A3**	**Sheet** **C04**

APPENDIX D

Flood Velocity Maps – Developed by NCE

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Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
ACN 100 817 356

In Association With:

MCK TSV Pty Ltd

0 50 100 150 200 m

1:4,000

N

Legend

Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h BASELINE VELOCITY

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet D01

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Legend

Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h BASELINE VELOCITY

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet D02

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Legend

Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h DEVELOPED VELOCITY

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet D03

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Development Site

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h DEVELOPED VELOCITY

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet D04

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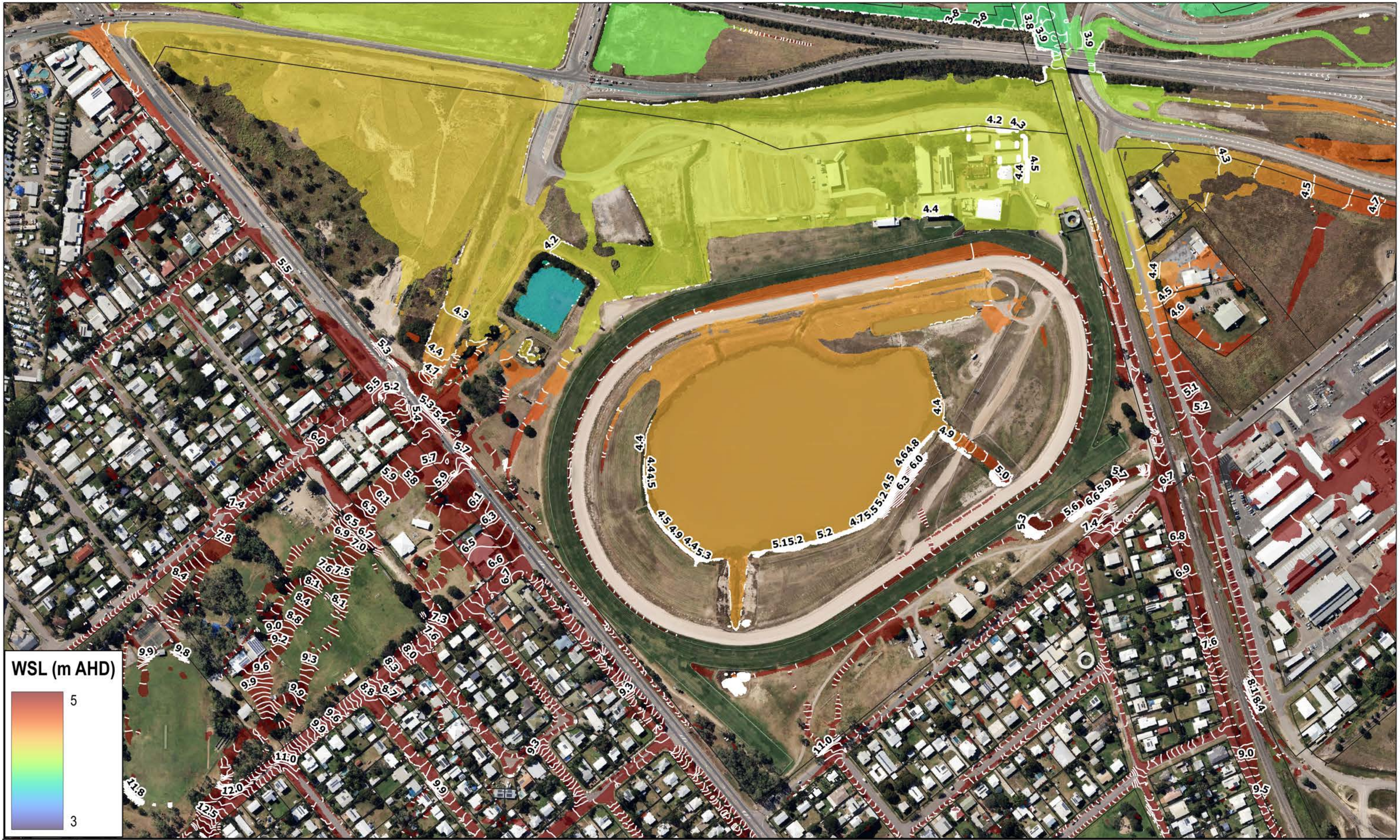
APPENDIX E

Flood WSL Results – Developed by NCE



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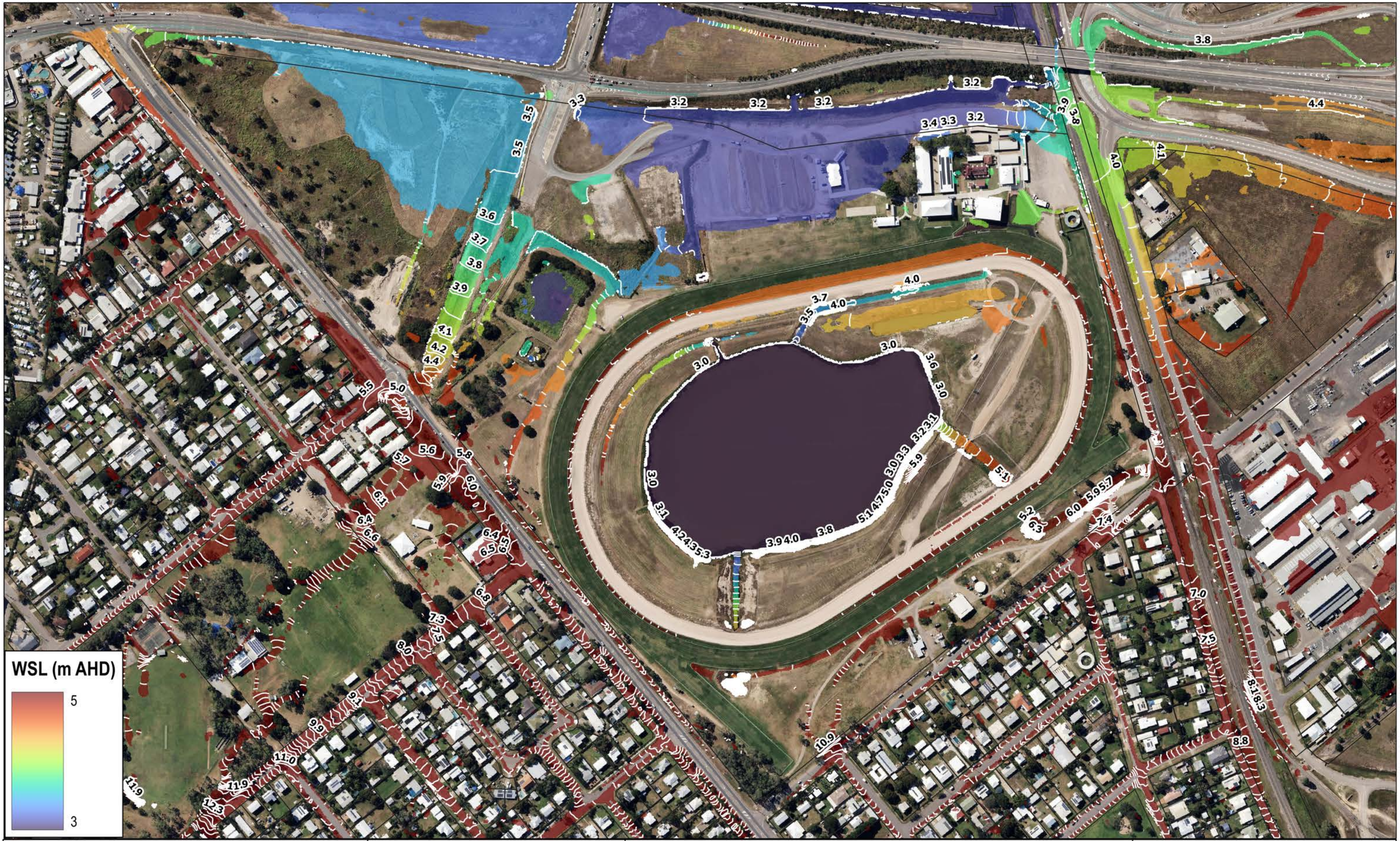
Legend

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h BASELINE WATER SURFACE LEVEL

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet E01



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0 50 100 150 200 m

1:4,000

N

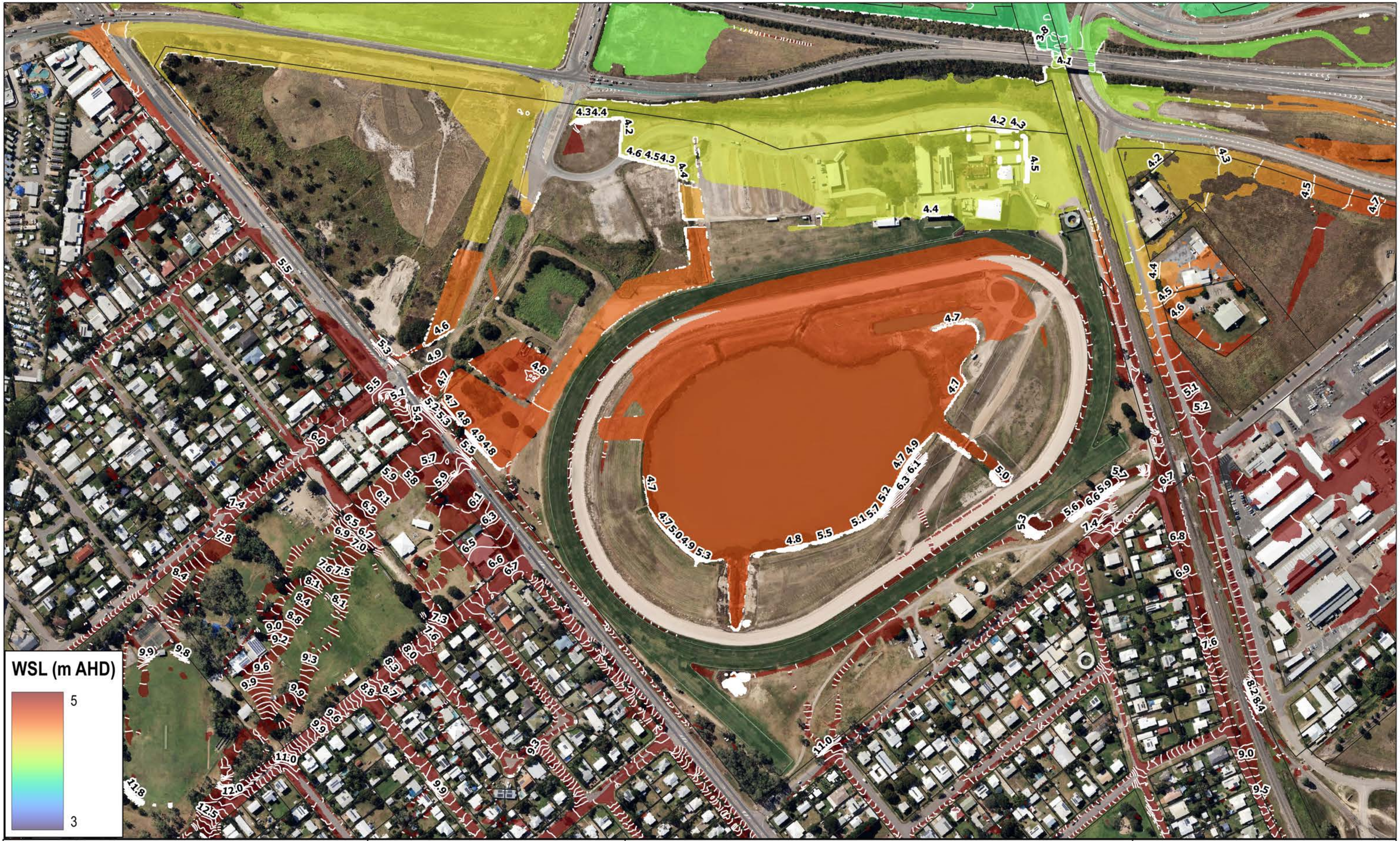
Legend

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h BASELINE WATER SURFACE LEVEL

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet E02



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N

Legend

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h DEVELOPED WATER SURFACE LEVEL

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet E03

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0 50 100 150 200 m

1:4,000

N

Legend

TCC Land Parcels

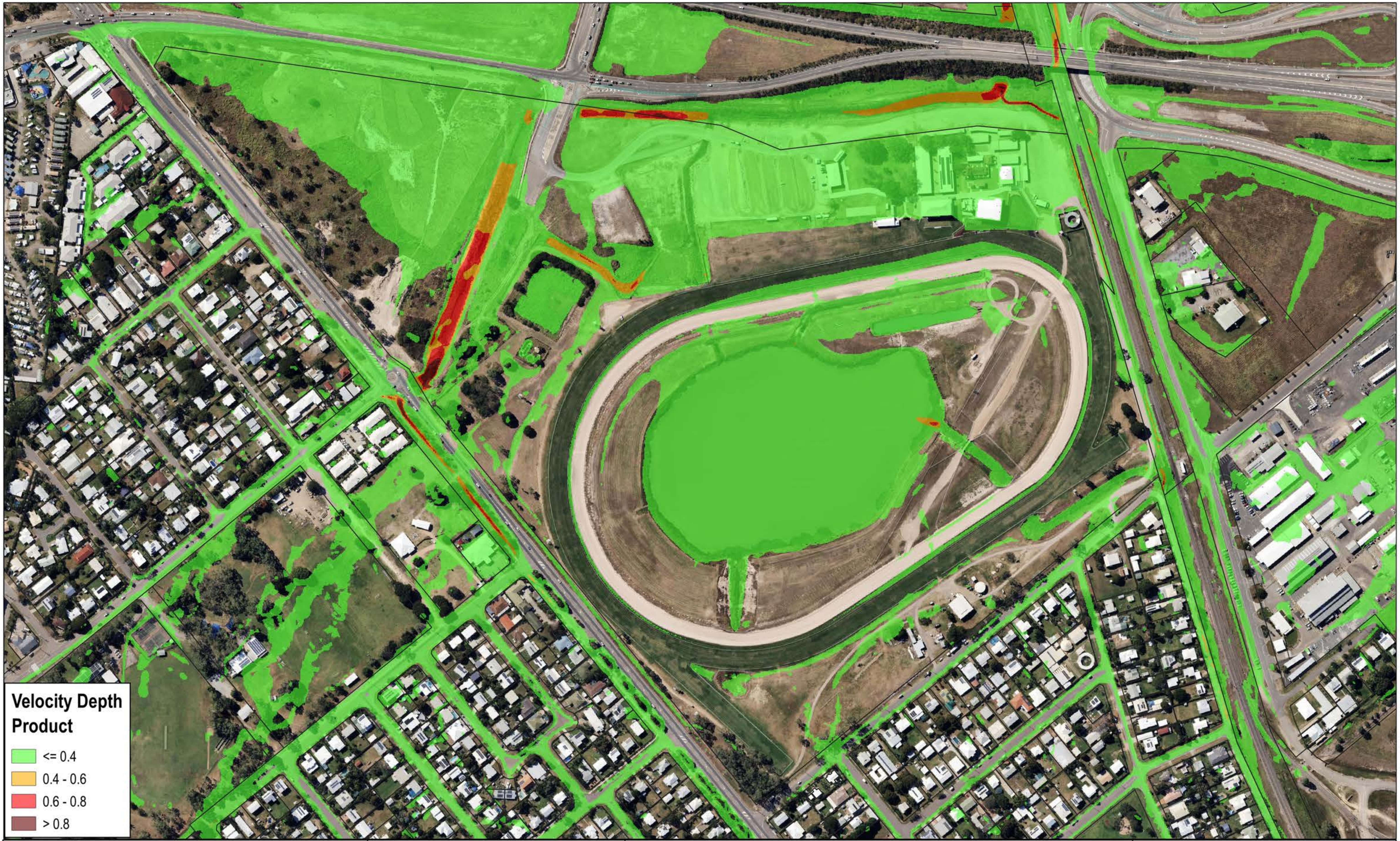
TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h DEVELOPED WATER SURFACE LEVEL

Prepared By: BB Reviewed by: AW	Date: 09/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet E04

APPENDIX F

Flood Hazard Results – Developed by NCE



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0 50 100 150 200 m

1:4,000

N

Legend

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h BASELINE FLOOD HAZARD

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet F01

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0 50 100 150 200 m

1:4,000

N

Legend

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h BASELINE FLOOD HAZARD

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet F02

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0 50 100 150 200 m

1:4,000

N

Legend

TCC Land Parcels

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

1% AEP 9h DEVELOPED FLOOD HAZARD

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet F03

Document Set ID: 26418548
Version: 1, Version Date: 24/10/2024

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0 50 100 150 200 m

1:4,000

N

Legend

TCC Land Parcels

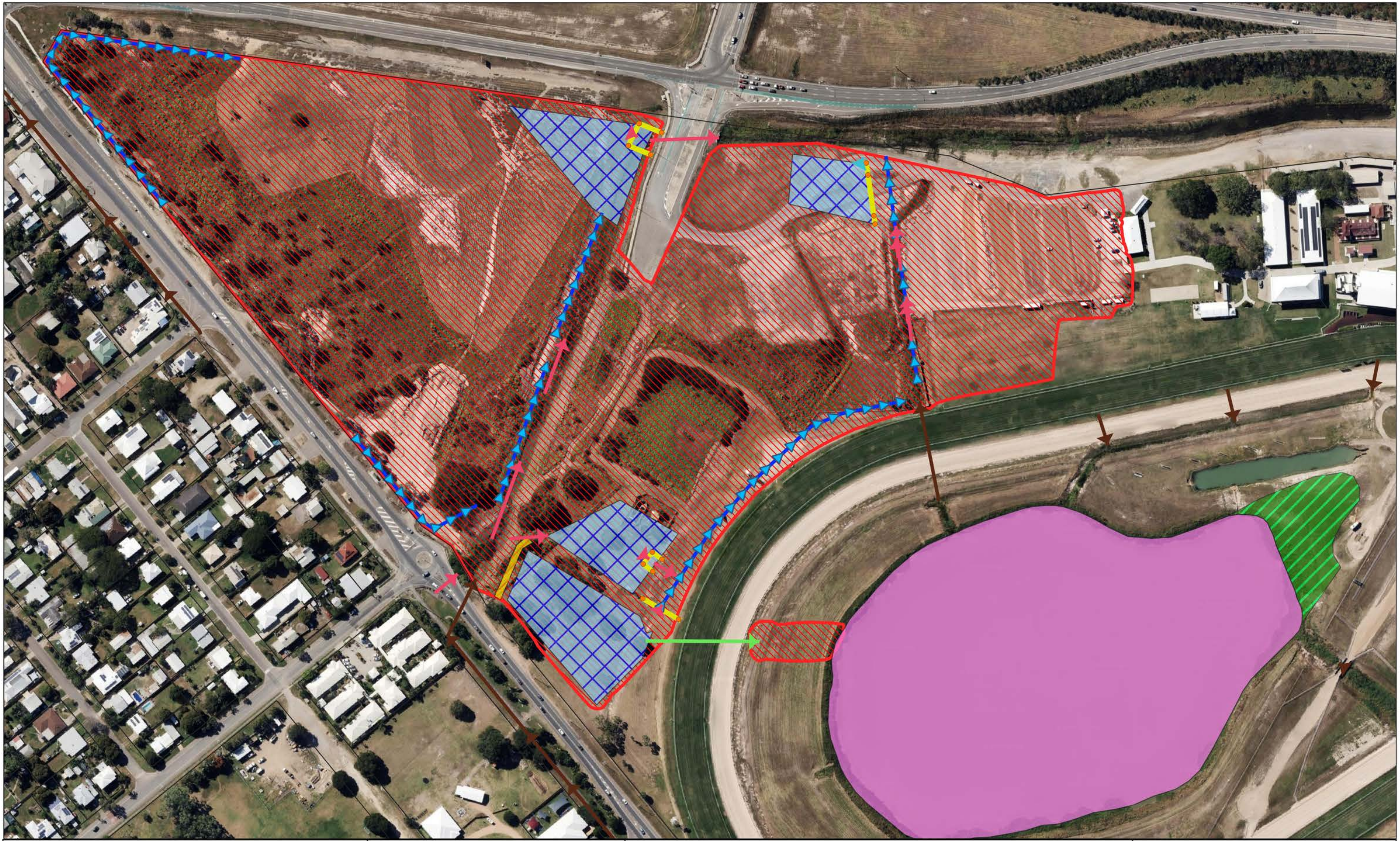
TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

20% AEP 2h DEVELOPED FLOOD HAZARD

Prepared By: BB Reviewed by: AW	Date: 08/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet F04

APPENDIX G

Mitigation Measures – Developed by NCE



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0 25 50 75 100 125 m

1:2,500

N

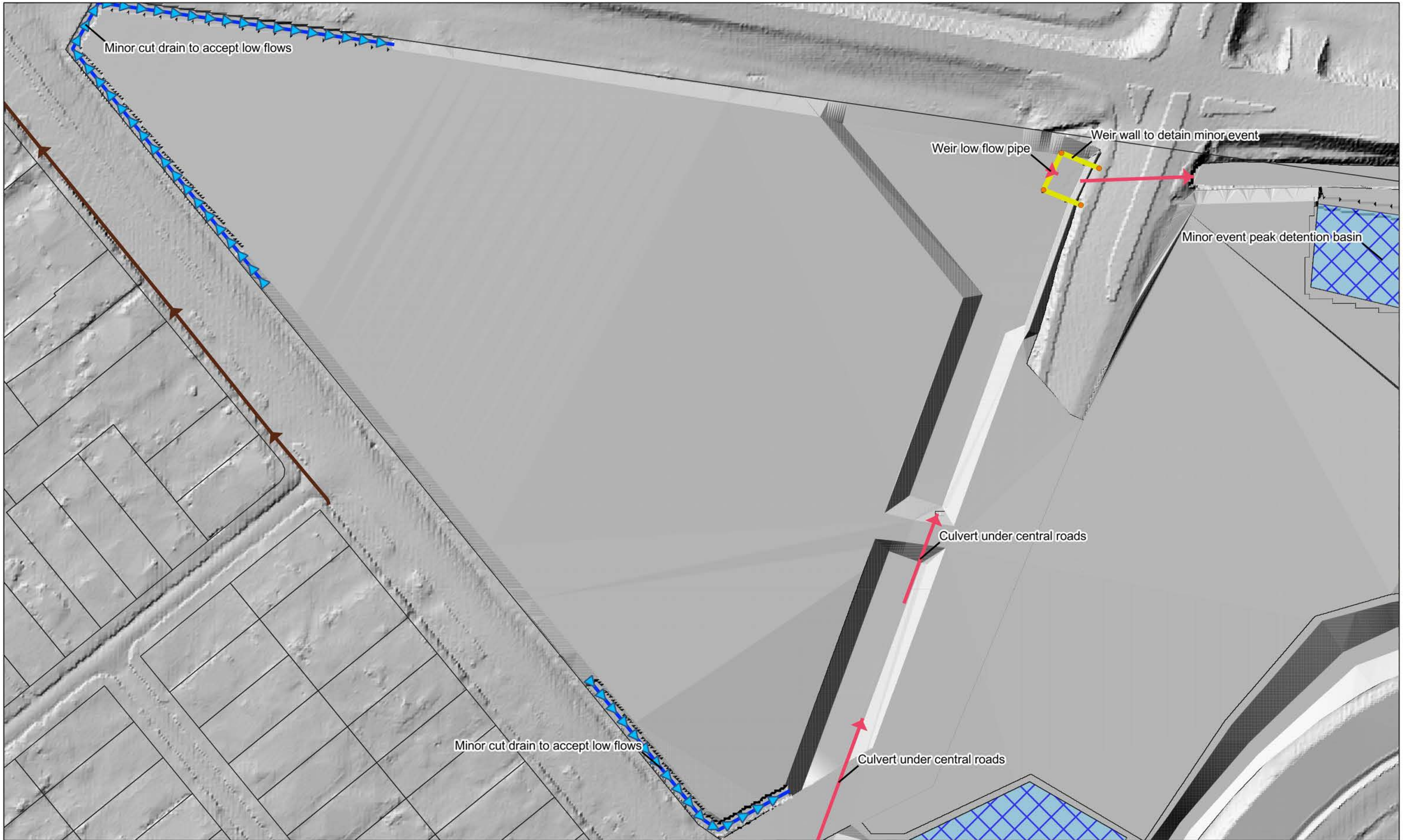
Legend

TCC Land Parcels	Earthworks Cut	Rectangular Culvert
Drain	Weir	Circular Culvert
Weir	Existing Lake	Unidirectional Circular Culvert
Detention Basins	Earthworks Extent	Unidirectional Rectangular Culvert

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

PROPOSED DEVELOPMENT MITIGATION MEASURES

Prepared By: BB Reviewed by: AW	Date: **14/08/2024** Revision: **A** NCE Ref: **BNC0084**	Size **A3**	Sheet **G01**



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0 15 30 45 60 75 m

1:1,500

N

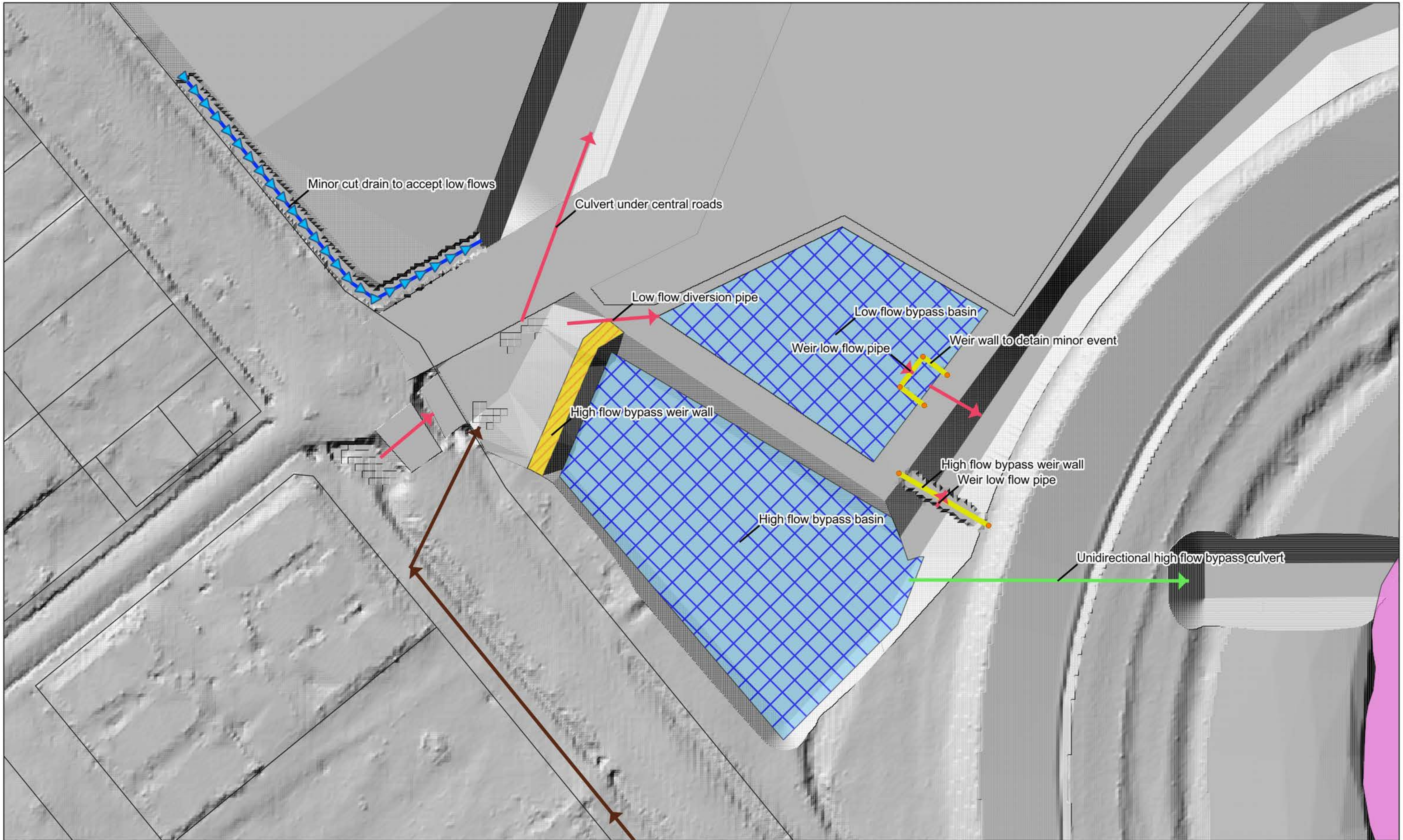
Legend

TCC Land Parcels	Earthworks Cut	Rectangular Culvert
Drain	Weir	Circular Culvert
Weir	Existing Lake	Unidirectional Circular Culvert
Detention Basins	Earthworks Extent	Unidirectional Rectangular Culvert

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

PROPOSED DEVELOPMENT MITIGATION MEASURES

Prepared By: BB Reviewed by: AW	Date: **09/08/2024** Revision: **A** NCE Ref: **BNC0084**	Size **A3**	Sheet **G02**



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Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
ACN 100 817 356

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MCK TSV Pty Ltd

0 10 20 30 40 50 m

1:1,000

N

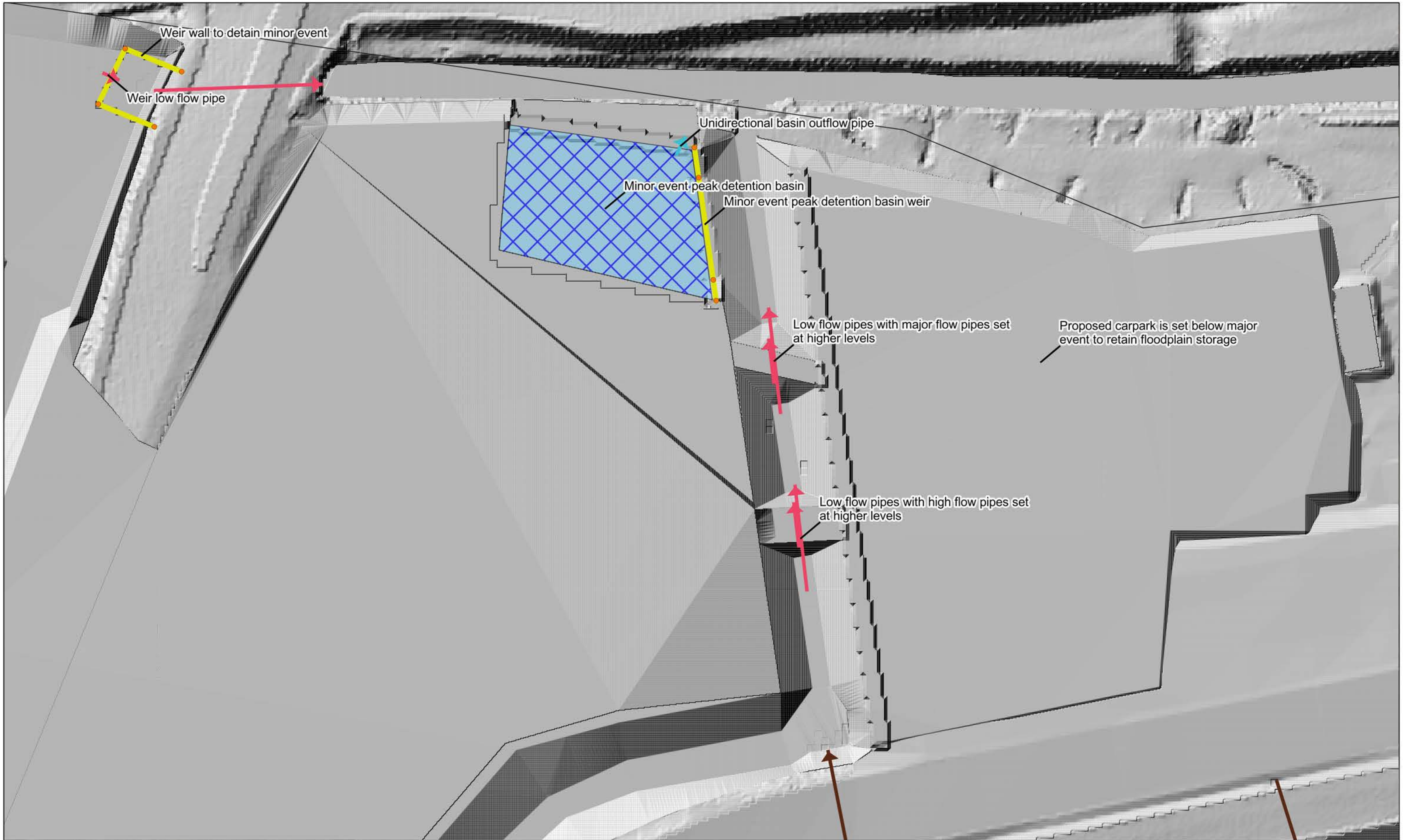
Legend

TCC Land Parcels	Earthworks Cut	Rectangular Culvert
Drain	Weir	Circular Culvert
Weir	Existing Lake	Unidirectional Circular Culvert
Detention Basins	Earthworks Extent	Unidirectional Rectangular Culvert

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

PROPOSED DEVELOPMENT MITIGATION MEASURES

Prepared By: BB Reviewed by: AW	Date: 09/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet G03



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Phone: [07] 4725 5550
Email: mail@nceng.com.au
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ACN 100 817 356

In Association With:

MCK TSV Pty Ltd

0 10 20 30 40 50 m

1:1,000

N

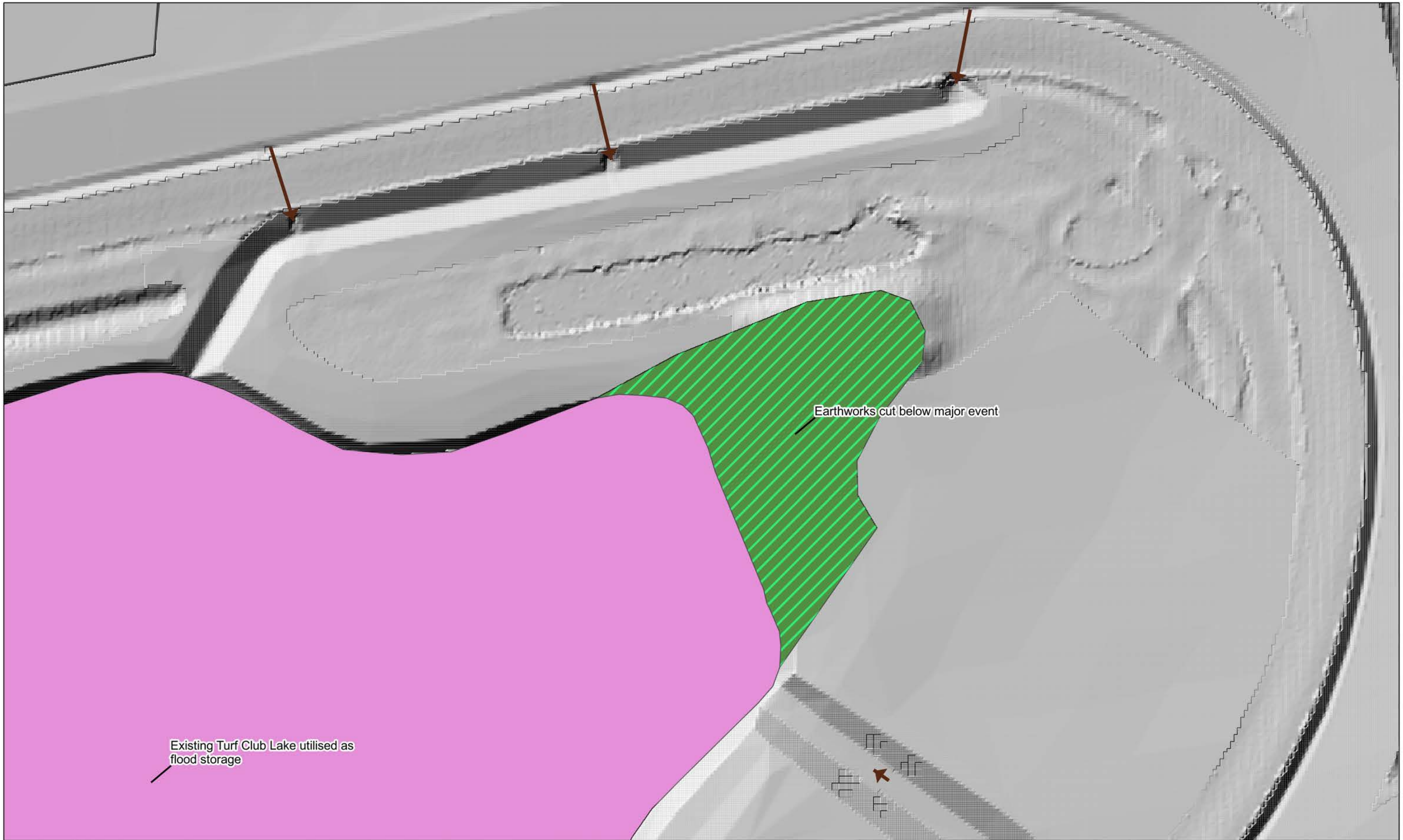
Legend

TCC Land Parcels	Earthworks Cut	Rectangular Culvert
Drain	Weir	Circular Culvert
Weir	Existing Lake	Unidirectional Circular Culvert
Detention Basins	Earthworks Extent	Unidirectional Rectangular Culvert

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

PROPOSED DEVELOPMENT MITIGATION MEASURES

Prepared By: BB Reviewed by: AW	Date: **09/08/2024** Revision: **A** NCE Ref: **BNC0084**	Size **A3**	Sheet **G04**



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0 10 20 30 40 50 m

1:1,000

N

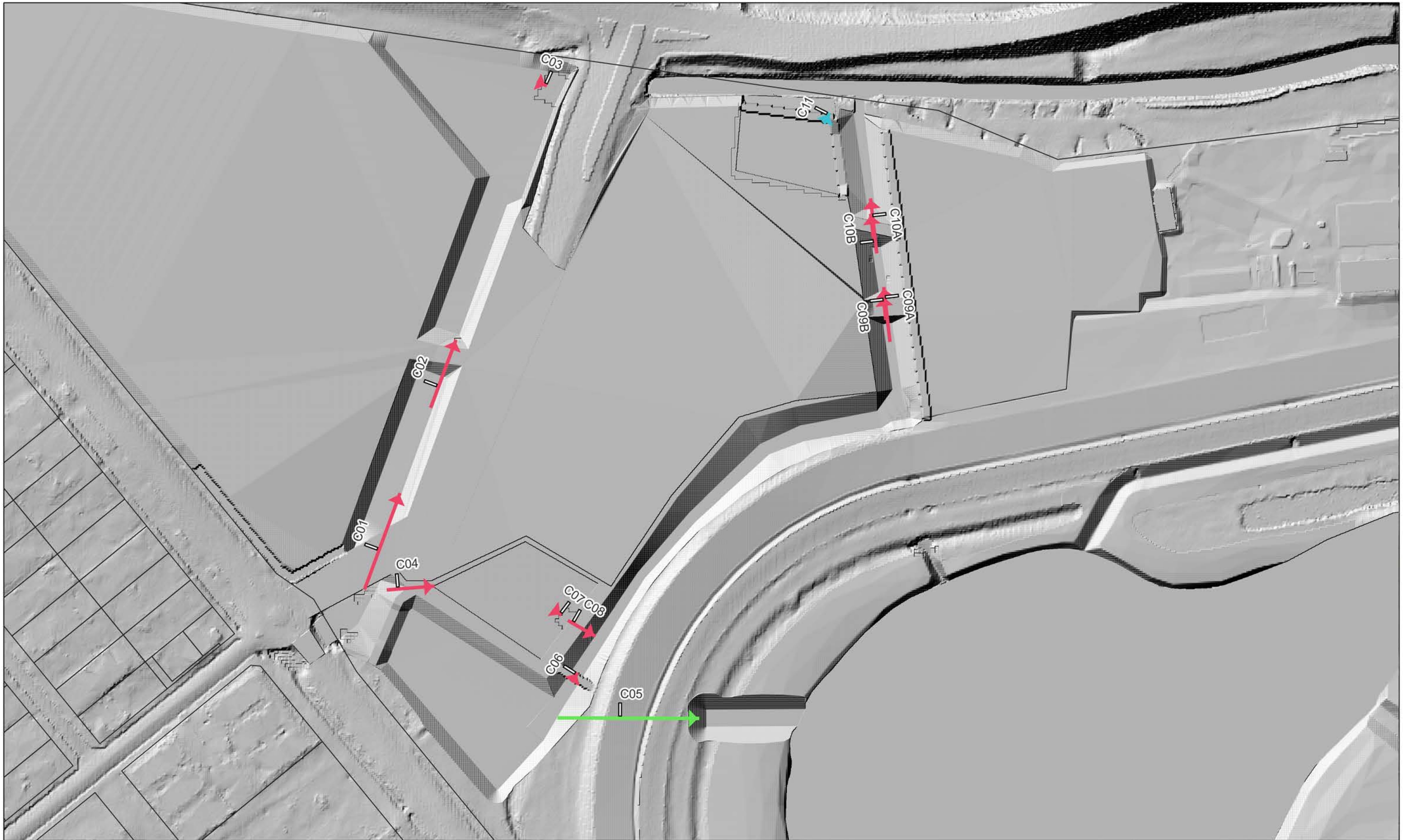
Legend

TCC Land Parcels	Earthworks Cut	Rectangular Culvert
Drain	Weir	Circular Culvert
Weir	Existing Lake	Unidirectional Circular Culvert
Detention Basins	Earthworks Extent	Unidirectional Rectangular Culvert

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

PROPOSED DEVELOPMENT MITIGATION MEASURES

Prepared By: BB Reviewed by: AW	Date: **08/08/2024** Revision: **A** NCE Ref: **BNC0084**	Size **A3**	Sheet **G05**



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0 20 40 60 80 100 m

1:2,000

N

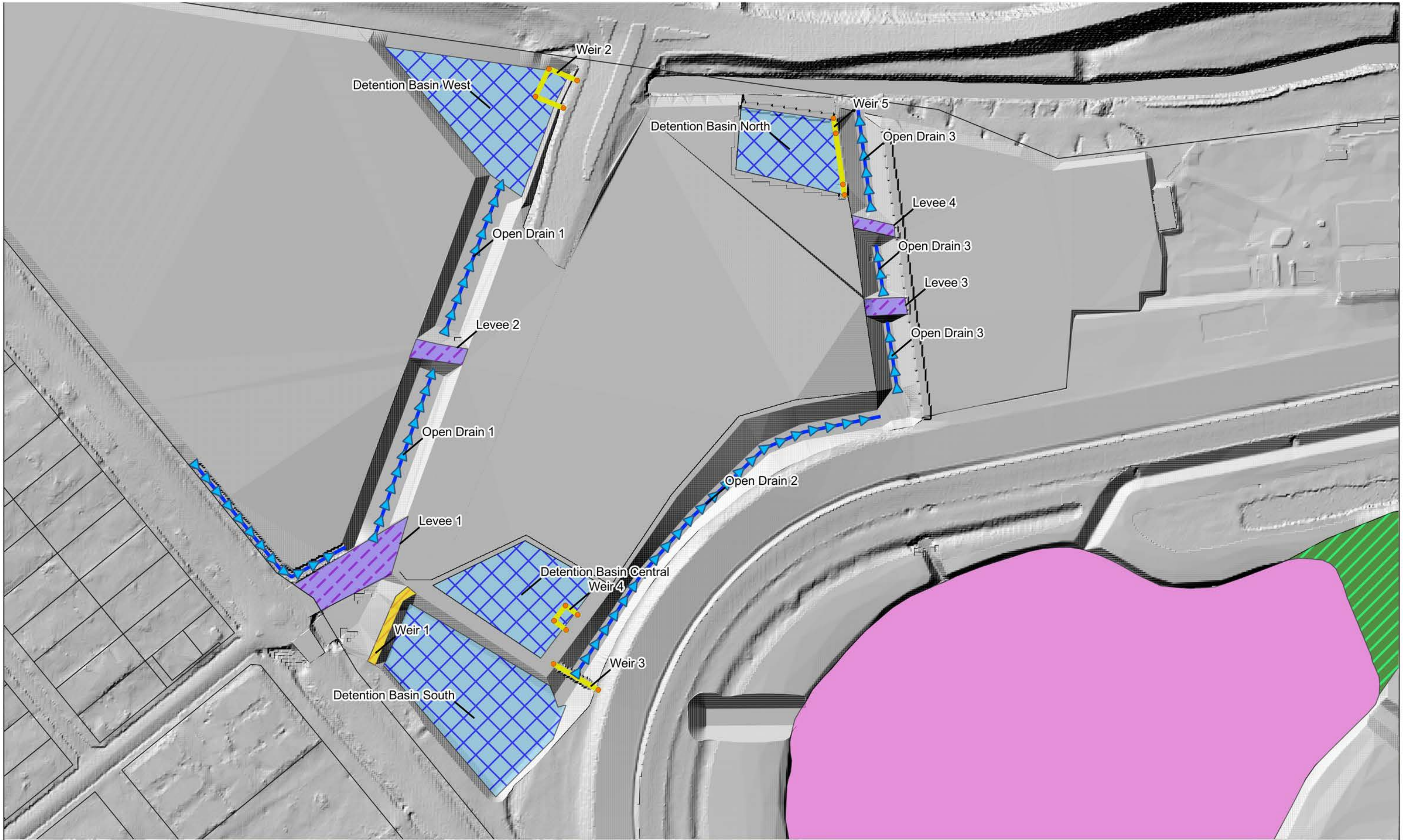
Legend

- TCC Land Parcels
- Rectangular Culvert
- Circular Culvert
- Unidirectional Circular Culvert
- Unidirectional Rectangular Culvert

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

PROPOSED DEVELOPMENT CULVERTS

Prepared By: BB Reviewed by: AW	Date: 13/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet G06



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Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
ACN 100 817 356

In Association With:

MCK TSV Pty Ltd

0 20 40 60 80 100 m

1:2,000

N

Legend

TCC Land Parcels	Detention Basins
Drain	Earthworks Cut
Weir	Weir
Existing Lake	Levee

TOWNSVILLE WATERPARK AND HOTEL - STUART DRIVE, CLUDEN

PROPOSED DEVELOPMENT MITIGATION MEASURE ID

Prepared By: BB Reviewed by: AW	Date: 14/08/2024 Revision: A NCE Ref: BNC0084	Size A3	Sheet G07

APPENDIX H

Hydrologic Modelling Technical Data

A1. HYDROLOGIC ANALYSIS

A1.1 Overview

The Ross River (2021) Flood model was obtained from Townsville City Council (TCC) under the Purpose and Confidentiality Deed dated 17/05/2024 and used for this assessment. Technical details of the model set-ups are described in the Ross River (2021) Flood Study report and therefore only a summary of the technical details is provided in the following sections. An audit of the hydrological models has not been undertaken as it's our opinion that models are fit for purpose as they have been approved and endorsed by TCC.

Generally speaking, unless noted otherwise, there were no changes applied to original hydrological models.

A1.2 Design Rainfall

Design rainfall intensities (charts and tables) were developed from the Intensity Frequency Duration (IFD) methods outlined in ARR. For the rain-on-grid extent the applied set of IFD depths were selected based on a manual inspection of the gridded IFD data for the area. Table A1-1 provides the representative IFD rainfall depths for the ARR2016 rainfall as depicted in Section 2.4.1.1 of the Ross River (2021) flood study.

Table A1-1 ARR2016 IFD depths (mm)

Duration	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
30 min	33.3	45.6	53.5	61	70.4	77.3
45 min	40.6	55.9	65.8	75.3	87.3	96.3
1 hour	46.2	63.9	75.6	86.7	101	112
1.5 hour	54.6	76.3	90.9	105	123	137
2 hour	60.9	86	103	119	141	158
3 hour	70.5	101	122	143	170	192
4.5 hour	81.2	118	144	169	204	231
6 hour	89.6	132	161	191	231	263
9 hour	103	154	190	226	274	312
12 hour	114	172	213	254	308	352
18 hour	133	202	250	298	362	412
24 hour	149	226	280	334	404	458
30 hour	162	246	305	364	438	496
36 hour	174	264	327	389	468	527
48 hour	195	294	363	432	516	579
72 hour	226	339	416	494	585	652
96 hour	248	369	453	537	634	705
120 hour	262	390	479	567	670	745
144 hour	272	404	497	589	697	777
168 hour	277	413	508	605	719	804

A1.3 Modelling Software

A1.3.1 XPRAFTS

The Ross River (2021) flood model has utilised XPRAFTS to predict flows of sub-catchments upstream to the model rain-on-grid domain, including adjacent catchments that influence the model domain. Broad areas where the natural fall of the land is very steep have also been modelled utilising XPRAFTS rather than rain-on-grid. The XPRAFTS models previously adopted for the superseded flood models/reports were adopted for use for each of the catchments within the study area. For information relating to the set up of the XPRAFTS model refer to the specific superseded flood study reports.

A1.3.2 XPRAFTS Modifications

NCE have not utilised any of the XPRAFTS models or results for this assessment and have instead extracted flows directly from the hydraulic model.

A1.3.3 Rain-on-grid (ROG)

Rain-on-grid (ROG) is a method of hydrologic determination that applies rainfall directly to the surface of a 2D hydraulic model, rather than routing rainfall through a separate hydrologic model. This method is particularly advantageous in the fact that local catchment boundaries do not need to be defined, providing the 2D hydraulic model adequately represents that natural terrain. Previous hydrology comparisons (undertaken by NCE) between XPRAFTS and ROG methods demonstrated good agreement in scenarios where the natural fall of the land is steep or flat.

In the TUFLOW model, the total rainfall depth is applied directly to the 2D grid with losses removed via soil infiltration, subject to the fraction impervious defined in the materials / land use mapping.

A1.3.4 ROG Modifications

Once the extent of fill had been defined, the area was modified to reflect 90% impervious land use, representing a ‘design’ discharge from the future potential development. NCE have updated the Manning’s ‘n’ value utilised by the TUFLOW model to better represent the materials across the mini-model in the fine-scale. This is also includes updating the percent impervious of certain land uses.

Updating the rain-on-grid hydrology in this manner maintains alignment with the current approved calibrated model adopted by TCC

A1.4 Losses

In the Ross River (2021) TUFLOW model, changes are applied dependent on the materials and events. The model does not utilise the percent impervious to calculate the loss and instead divides the loses between three soil types with varying initial and continuing losses.

A1.4.1 Loss Modifications

The losses in the mini-model have been applied via the percent impervious methodology rather than on a per soil type basis like the Ross River (2021) model. NCE have utilised the same loss values for the impervious areas from the Ross River model. The adopted losses area as follows:

- 1% AEP – 0.0 mm IL and 2.0 mm/hr CL
- 20% AEP – 26.3mm IL and 2.0 mm/hr CL

APPENDIX I

Hydraulic Modelling Technical Data

A2. HYDRAULIC ANALYSIS

The hydrodynamic analysis has focused on identifying the flood levels and depths, for the baseline scenario at the proposed development site.

A2.1 TUFLOW

The TUFLOW (Two-dimensional Unsteady FLOW) modelling software was utilised to undertake the hydraulic modelling required for this flood level assessment. TUFLOW is a powerful computational engine that allows the ROG method to be applied directly to the 2D hydraulic model which provides 1D and 2D solutions of the free-surface flow equations to simulate flood and tidal wave propagation. TUFLOW is specifically oriented towards establishing flow and inundation patterns in floodplains, coastal waters, estuaries, rivers and urban areas where the flow behaviour is essentially 2D in nature and cannot or would be onerous to represent using a 1D model. Subsequently, TUFLOW is ideally suited for this assessment.

TUFLOW currently incorporates two (2) grid-based solvers:

- TUFLOW Classic: A second order semi-implicit solution available for computations using CPU hardware on a single core; and
- TUFLOW HPC (Heavily Parallelised Compute): A second order explicit solver. TUFLOW HPC can run a simulation using multiple CPU cores, or alternately GPU hardware for high-speed execution without sacrificing model accuracy.

Outputs from TUFLOW include GIS compatible maps of flood depths, water surface levels (WSL), velocities and inundation extents.

TUFLOW also offers the use of sub-grid sampling (SGS). This method allows high resolution results and finer scale modelling while keeping run times low. This method calculates cell volume via a cell elevation-volume curve and cell face on cell width-elevation curve. SGS samples a specified number of points across the cell (sampling frequency of 11 generating a 10x10 grid) to create the elevation-volume curve and width-elevation curves for each cell. This allows more accurate calculation of storage transfer between cells however; the shallow water equations are only calculated on a cell-by-cell basis.

The Ross River (2021) flood model utilises a 5m grid with an default SGS sampling distance of 1m equating to a sampling frequency of 6.

A2.2 DEM Modifications

For this assessment, a site specific 1D / 2D TUFLOW model has been developed which has adopted the HPC SGS solver on a 2m grid with an SGS sampling frequency of 11.

2016 LiDAR data was used for the DEM which was transposed onto a 2 m grid that covers an area of ~3.4 km^2. The extent of the model setup is shown in Appendix A.

A2.2.1 Hydraulic Roughness Modifications

The hydraulic roughness is defined by the Manning's 'n' values applied to the materials defined within the TUFLOW model. These roughness values and areas have been defined via aerial imagery and by reference to various guidelines such as ARR2019 and QUDM in conjunction with site visits and photographs. The below

Table A1-2 indicates the Manning's 'n' values applied to each land use as depicted in the materials mapping in Appendix A.

Table A1-2 Land use / materials inputs

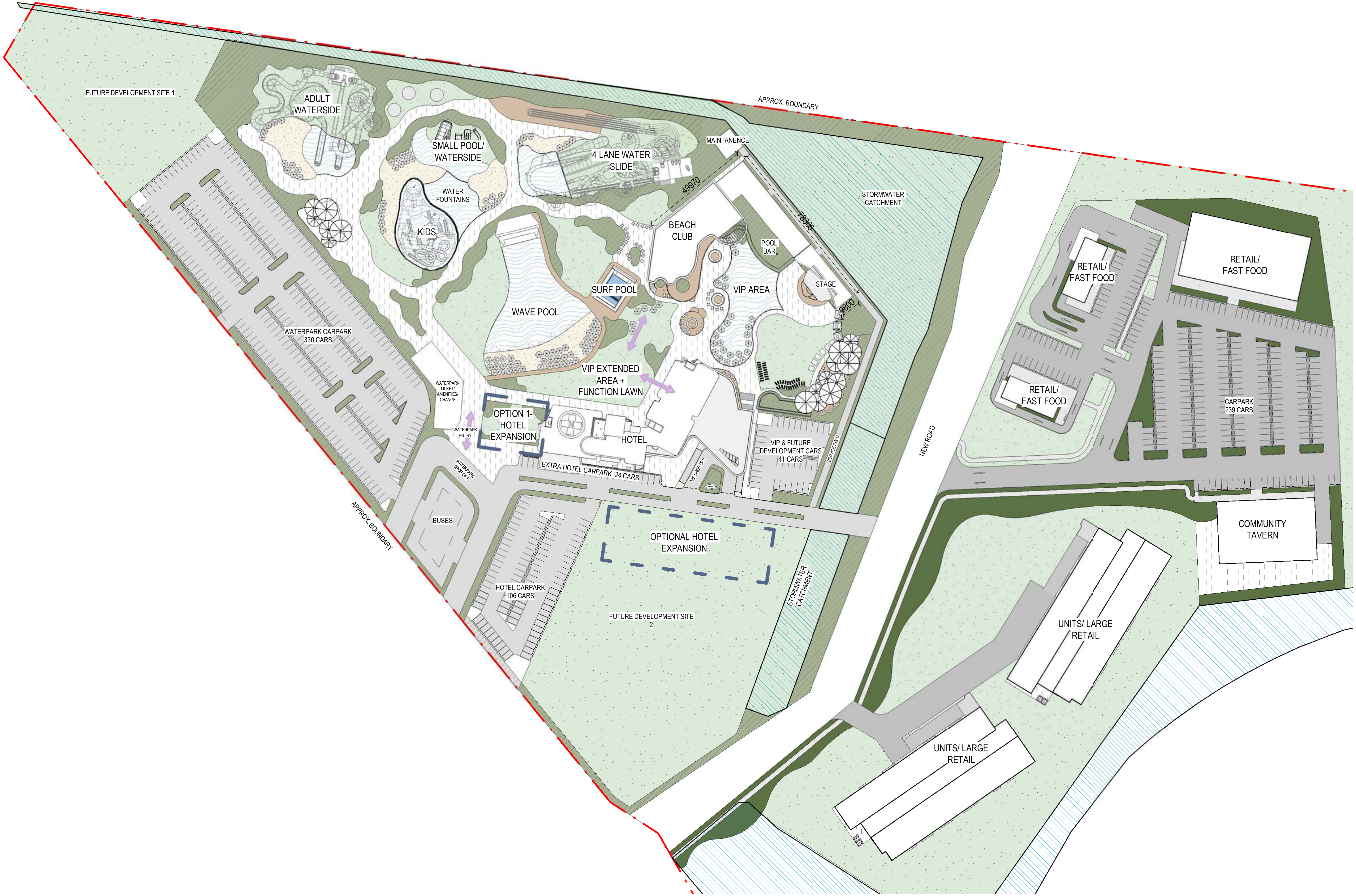
Material ID	Material Description	**Manning's 'n'**	Percent Impervious
1	Roads	0.02	100
2	Urban	0.08	65
3	Buildings / Commercial Complex	0.09	90
4	Water	0.025	100
5	Concrete Channels	0.02	100
6	Vegetation (light)	0.03	0
7	Vegetation (medium)	0.06	0
8	Vegetation (dense)	0.1	0
9	Waterways (natural)	0.07	0
10	Development	0.02	90

A2.2.2 Percent Impervious Modifications

The percent impervious is utilised by the TUFLOW model to calculate the percentage of the losses to be applied through the soils file. The values adopted by the mini-model are as outlined in Table A1-2 which apply to the land uses as depicted in the materials mapping in Appendix A. These values have been defined with reference to the TCC City Plan in conjunction with site visits, photographs and aerial imagery.

APPENDIX J

Preliminary Architectural Plans



2407 TSV Hotel & Water Park

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Masterplan

2407_ PD A-001
Drawn: FT Check: JH
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MASTERPLANNING

Shaun McCarthy 1 : 1500 @ A3

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