IRC Clermont, Moranbah and Nebo Flood Model & Hazard Mapping 2022

Clermont

Isaac Regional Council

11 July 2023

→**The Power of Commitment**

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The Power of Commitment

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1. Introduction

1.1 Overview

GHD Pty Ltd (GHD) was engaged by Isaac Regional Council (IRC) to update the flood models for the towns of Clermont, Moranbah, and Nebo within the Isaac Regional Council Local Government Area (LGA). The intention of the project is to update the flood models to be in line with the latest Australian Rainfall and Runoff guidelines (2019), including the development of flood hazard mapping. The updated flood models are level 3 flood models for each study area, seen as suitable for urban zones within these points of interest and as defined by the Guide for Flood Studies and Mapping in Queensland (BMT-WBM, 2017). This report focusses on the Clermont study area as part of the overall project.

1.2 Purpose of this report

This report aims to provide IRC with a better understanding of flood behaviour in Clermont. It is envisaged that the outcomes presented in this report may assist Council in:

- Incorporating it’s findings into the IRC Planning Scheme and also for disaster management purposes
- improving their understanding regarding the flood resilience of residents and infrastructure located in the study area by assessing locational risk profiles for a range of flood events.

1.3 Scope and limitations

This report: has been prepared by GHD for Isaac Regional Council and may only be used and relied on by Isaac Regional Council for the purpose agreed between GHD and Isaac Regional Council as set out in this report.

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

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared the RAFTS and TUFLOW model (“Model”) for, and for the benefit and sole use of Isaac Regional Council to support the design and documentation of the works and must not be used for any other purpose or by any other person.

The model is a representation only and does not reflect reality in every aspect. The model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the model. Accordingly, the outputs of the model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD’s scope.

GHD has prepared this report based on information provided by Isaac Regional Council and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Clarifications

The following outlines clarifications associated with this report:

– The corresponding Annual Exceedance Probability (AEP) notation for the following events is as follows:

- 1 in 2 AEP, or 50% AEP
- 1 in 5 AEP, or 20% AEP
- 1 in 20 AEP, or 5% AEP
- 1 in 50 AEP, or 2% AEP
- 1 in 100 AEP, or 1% AEP
- 1 in 500 AEP, or 0.2% AEP
- PMF.

1.5 Assumptions

The following identifies further assumptions made throughout the hydrological and hydraulic assessment:

– All data supplied is correct and/or suitable to IRC for use in this assessment (i.e., no data has been verified at this stage of the study, we recommend verification of data upon receipt of community feedback).

– Fraction impervious and Manning's 'n' values were selected based on a combination of the existing land use through review of aerial photography, zoning data and cadastral data.

– Lag times were derived by applying velocities from the hydraulic model over each catchment's longest watercourse (or streamflow path where appropriate).

– The accuracy of the modelling was based on the quality of LiDAR data provided. A key limitation of LiDAR is that in areas of dense vegetation the LiDAR may not accurately pick up significant flow paths.

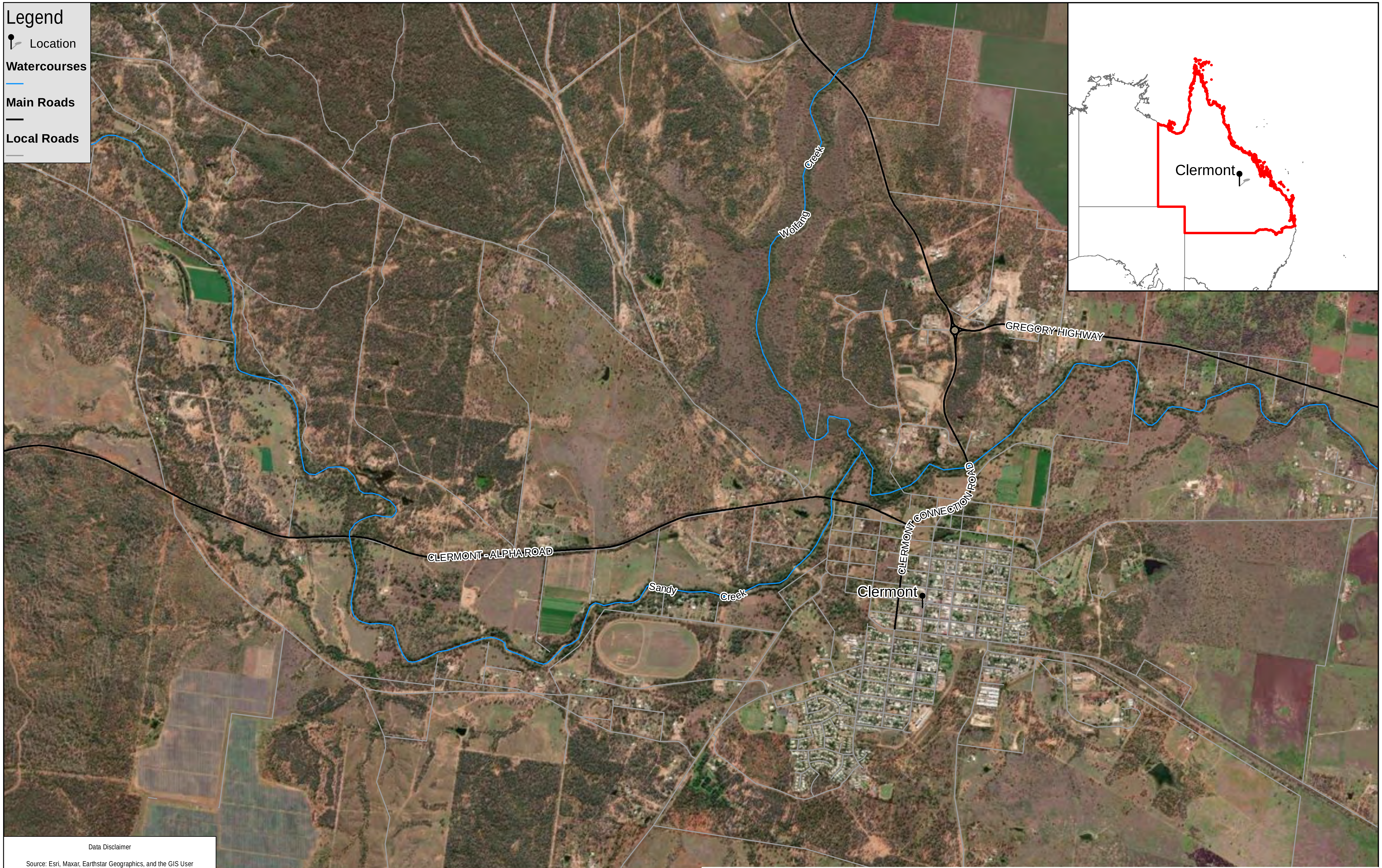
– It is advised LiDAR may not account for any new developments since the LiDAR data was captured. Until then, all data provided is assumed accurate and up to date, with any development/changes since the data capture excluded from the modelling (i.e., the modelling was undertaken using the LiDAR data supplied as nothing newer was available).

– The model assumed fully functioning stormwater infrastructure; however, IRC acknowledge that an incomplete dataset was provided. As such, assumptions were made regarding invert levels, cover, and grades of the 1D network. Should these assumptions not be sufficient to cover IRC's risk profile, it is recommended that a detailed survey of all the stormwater infrastructure is undertaken and remodelled in the hydraulic simulations.

2. Site information

2.1 The study area

This study is focused on locality of Clermont which is located on a floodplain between Sandy Creek and Hoods Lagoon, just downstream from the point where Sandy Creek and Wolfang Creek converge. The area consists of Clermont town that includes an urban area with stormwater drainage collection systems. The study area has been developed considering the original town's flood study (Clermont Flood Hazard Mapping Study, WRM, 2014). For this study, level 3 hazard mapping has been produced in line with the Queensland Government Department of Natural Resources and Mines (DNRM) Guide for Flood Studies and Mapping in Queensland (DNRM, 2017). The study area is presented in Figure 2.1.



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Modelling completed using TUFLOW software in 2023

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Flood Model and Hazard Mapping

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Clermont Locality Map

Figure 2-1

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Print date: 10 Jul 2023 - 14:54 (SMA record: 2)

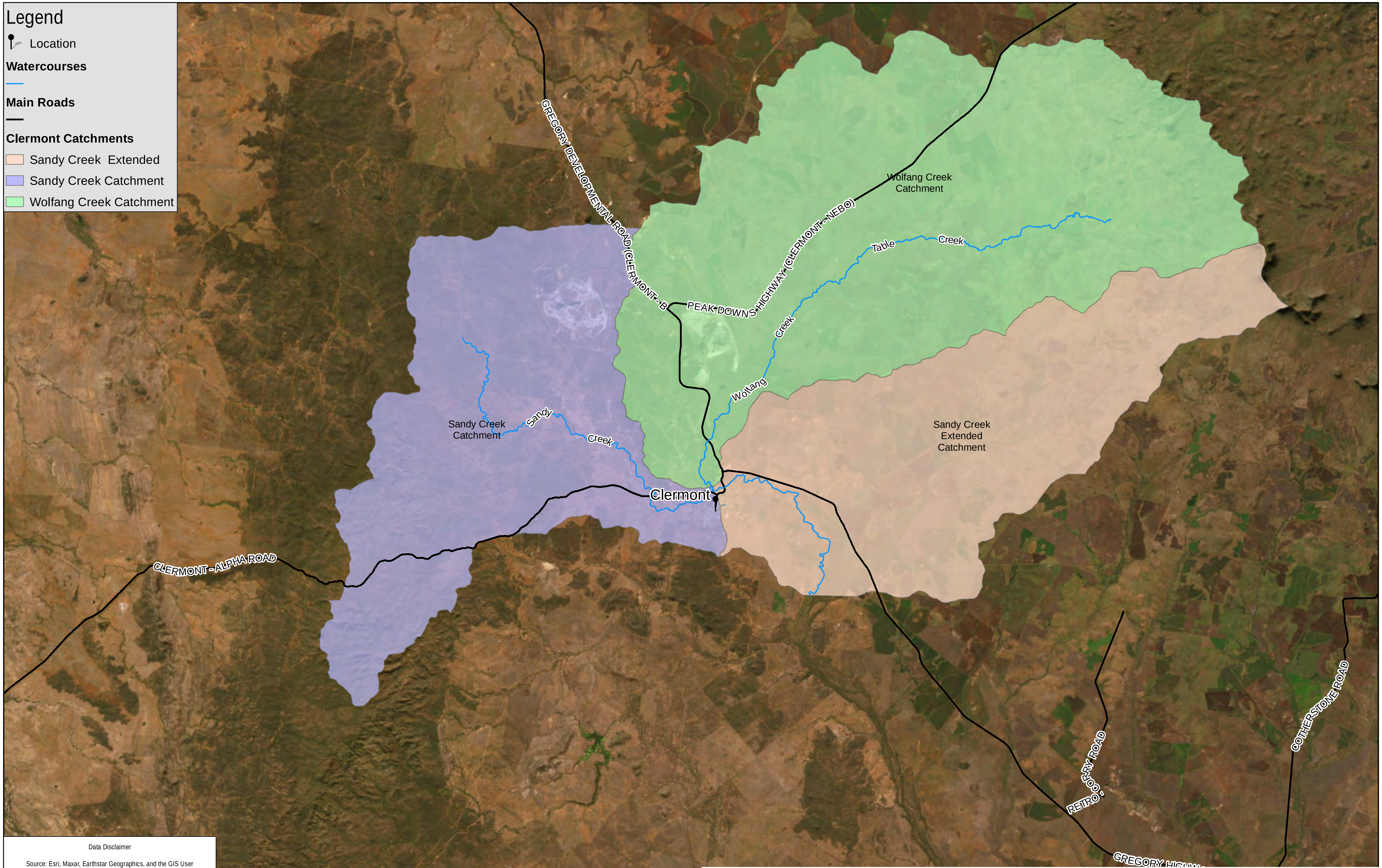
Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane

2.2

2.2 Review of catchments

Upon initial review of the catchments and major flow paths within the study area, the study area predominantly includes rural and pastoral land along with state forest forming different land use zoning comprising industrial, community facilities, township, open space and recreation and special purpose. This has been assessed as per the Isaac Regional Planning Scheme 2021 (Zoning) ZM 1.6 mapping, see Figure 2.3.

For the Clermont locality, the catchment is comprised of a diverse range of land uses from forested areas in the headwaters of the catchment, impervious areas in the mid part of the catchment with the town and coal mines, plus farmland and flat pervious areas dispersed over study area. Similar to the WRM Clermont Flood Hazard Mapping Study in 2014, the catchment area can be split into 2 zones with respect to the major rivers coming into and intersecting at Clermont, Sandy Creek travelling downstream from west and east. Wolfang Creek is the main tributary of Sandy Creek which intersects Sandy Creek on the north of Wolfang Street. Both catchments are bound by steep hillside around their extents, with water travelling through the flat farmland towards the low point near the Clermont town. It is noted that Sandy Creek does continue to travel in the same direction after the Wolfang Creek intersection towards Cheeseborough, reflected in the “extended” Sandy Creek catchment being implemented underneath the Wolfang Creek catchment, differing to the WRM flood study, see Figure 2.2.



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Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 1.5 3 4.5 6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Clermont Catchment map

Figure 2-2

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Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane

2.3 Land use assessment

A review of the latest IRC Planning Scheme 2021 documentation also produced the IRC nominated land use zone, which form the basis of land use allocations for the hydraulic modelling. The land use zones for the study are depicted in Figure 2.3:

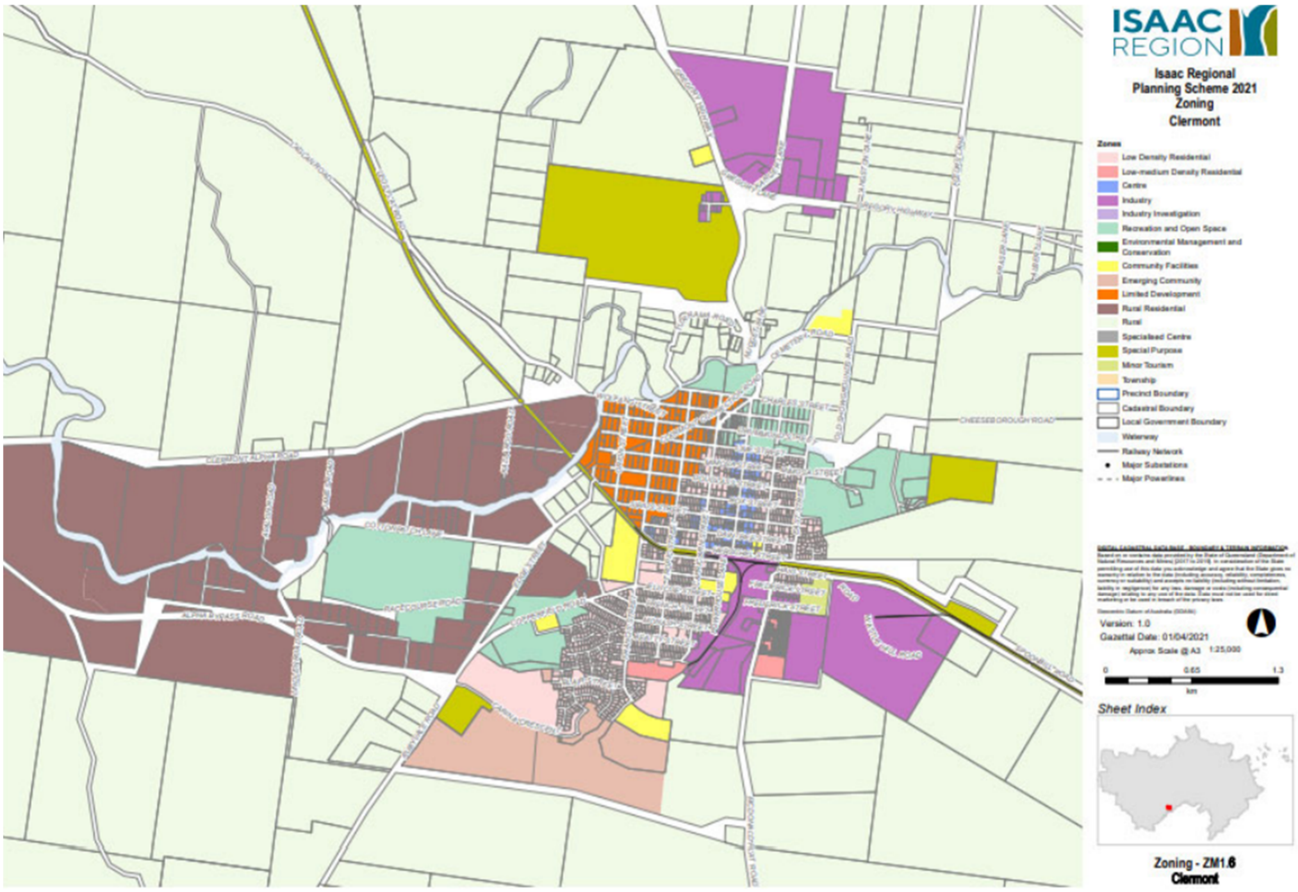


Figure 2.3 Isaac Regional Council Planning Scheme Zoning – Clermont (IRC,2021)

2.4 Available information

2.4.1 Previous studies

IRC provided GHD with the following existing studies for the points of interest:

- Clermont Flood Hazard Mapping Study (May 2014)

  This study generated a TUFLOW flood model for the town of Clermont. It generated flood hazard mapping for the 2%, 1% and 0.2% Annual Exceedance Probability (AEP) design flood events for both the Sandy and Wolfang Creeks catchment plus the December 1916 historical flood event.

- Borilla, Serpentine and Sandy Creek – Rating Curve Report (November 2019)

  This study developed a 2D TUFLOW model to generate a rating curve for the Sandy Creek. The rating curve was then compared to the evaluated performance of the 1916 flood event, demonstrating that the model effectively depicted the anticipated flow depth for that event.

- Isaac River Flood Study (July 2021)

  This study generated a TUFLOW flood model for the Isaac River catchment that covers the Nebo Creek catchment, containing all the points of interest in question. It modelled scenarios for the 5%, 2%, 1%, 0.5% and 0.1% AEP and Probable maximum Flood Events. It was calibrated with the 2015 Cyclone Debbie flood event. The study also produced hazard mapping suitable for disaster planning and amendment to the IRC Current Planning Scheme.

2.4.2 Design rainfall data

2.4.2.1 Basis

Design Australian Rainfall and Runoff 2019 (ARR; 2019) rainfall Intensity Frequency Duration (IFD) data for the catchment was obtained from the Bureau of Meteorology (BoM). The IFD data is attached in Appendix A. Rainfall data for the Probable Maximum Flood (PMF) event was calculated using the Generalised Short Duration Method (GSDM) and Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Tropical Storm Method Revised (GTSMR) (2003) guidelines.

2.4.3 Topographic data

The previous studies had topographic data attached in their respective files, GHD completed an assessment of the validity of this detailed LiDAR topographic data against known topographic features to comment on any limitations (if any) that are present in the data. Detailed LiDAR topographic data was sourced from the ELVIS spatial data portal with a grid cell size of 1 metre for the Clermont township and 1 second sampled data from the Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) for the upper reaches of the catchment where the detailed data was not available.

3. Hydrologic analysis

This section summarises the hydrologic investigations undertaken on the catchment. The scope of work included:

– Data collection and review of available hydrological information.

– Hydrologic model setup (GIS and RAFTS).

– Estimation of design event flow rates , hydrographs and validation of flows.

The hydrological assessment is based on delineated regional catchment for the Sandy Creek and Wolfang Creek catchments.

3.1 Data collection

The following data was used to undertake this assessment:

– LiDAR derived elevation data – obtained from ELVIS Spatial data portal.
– IFD Rainfall Data – obtained from Bureau of Meteorology (BoM) website
– Other design hydrology inputs (e.g., temporal patterns, losses, pre-burst rainfall) – ARR (2019) Data Hub

3.2 Hydrologic model setup

3.2.1 Model selection

There are several methods that can be used to undertake the design flood hydrologic analysis, see Figure 3.1 that identifies the common methods for hydrologic analysis and their level of accuracy.

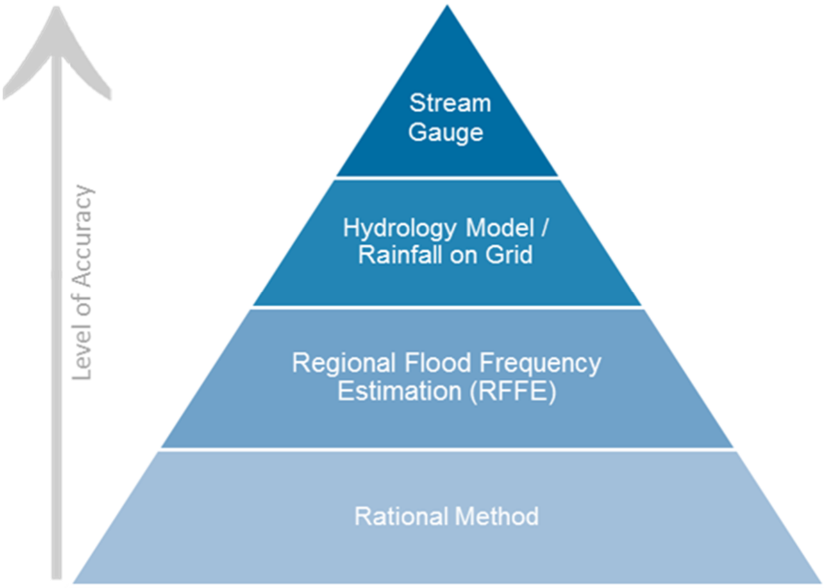


Figure 3.1 Methods of hydrologic analysis

Stream gauges are the preferred method of choice as they collect real time data for rainfall events. Hydrologic models can be calibrated with the stream gauge data to represent the site's historic rainfall events. There is no stream gauge in Wolfang Creek with a period of available data suitable for use in Flood Frequency Analysis (FFA). Therefore, peak design discharges in Wolfang Creek have been estimated by scaling flows from the Sandy Creek stream gauge derived FFA estimates. While there is a gauge operated by the Queensland Government nearby the bridge over Sandy Creek (Sandy Creek Bridge TM; 535103), the gauge did not have a long enough data record which could directly assist in the calibration of the hydrology. Therefore, the calibration of flows using the FFA method was undertaken using the gauge number 130207A – Sandy Creek at Clermont gauged data. This data was acquired from the Queensland Government Water Monitoring Portal as well as details.

For validation of these existing gauge readings, RAFTS hydrologic modelling (rainfall-runoff model) was the preferred option as this approach enabled a detailed assessment of rainfall runoff for each study area. Limitations of the hydrologic models include program constraints around model parameterisation and a heavy reliance on the user input data.

RAFTS hydrologic modelling software is based on the Regional Stormwater Drainage Model (RSWM) developed by the Snowy Mountains Engineering Corporation (SMEC) and is an industry standard rainfall-runoff routing analysis package. It is capable of modelling changes due to development for both rural and urban sub-catchments and is an accepted model used to quantify flood flows from catchments as specified in the ARR (2019) guidelines.

RAFTS is used in this study to estimate the runoff hydrograph from individual sub catchments based on rainfall intensities, temporal patterns, catchment losses and the definition of parameters describing the sub-catchment characteristics. These parameters include the sub-catchment area, slope, PERN ‘n’ roughness, and fraction of impervious area. Sub-catchment outflow hydrographs are routed downstream through the model via links (either lag links or routing links) that connect these sub-catchments. Once the RAFTS model is configured, Storm Injector is used to simulate the model within a storm-management framework that allows for the easy application and assessment of the multitude of simulated design flood results from RAFTS.

Methods such as the Regional Flood Frequency Estimation (RFFE) from ARR and the Rational Method are high-level catchment peak discharge assessments. These methods are often used as a validation to the adopted hydrologic method, providing an order of magnitude check. As the flows from the stream gauge data were able to be analysed using the FFA technique and validated against the RAFTS model, the rational method was not adopted for validation of the flows for this study. The RFFE technique was used to further validate the hydrologic model results and the FFA peak flow estimates.

3.2.2 Model development

For each study area, the development of the RAFTS model entailed:

– Sub-dividing the catchment into a series of sub-areas to suit the catchment topography and other key features, such as the location of culverts and subterranean drainage networks.
– Determination of model parameters including design rainfall and initial/continuing loss rates based on available guidelines.
– Hydrologic model simulations using the Initial Loss-Continuing Loss approach based on the Ensemble Method, as outlined in ARR (2019).
– Review and validation of model results.

3.2.3 Model parameters

The RAFTS model required the inputs described in the following sections.

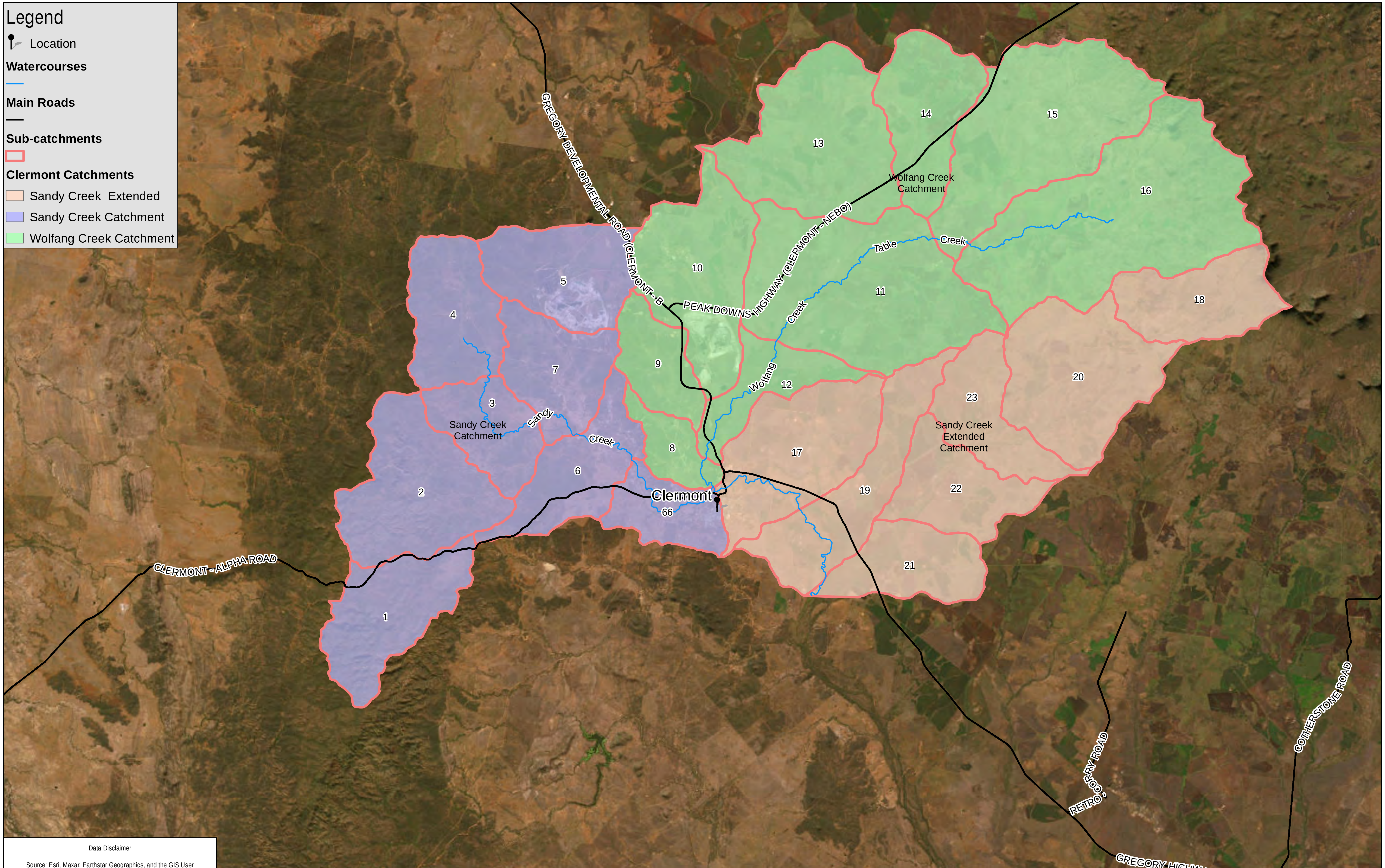
3.2.3.1 Catchment delineation

Establishment of the respective hydrological model required delineations of the catchments for Sandy Creek and Wolfang Creek which were delineated based on:

– Identified flow paths.
– Land use types / catchment characteristics.
– Key points of interest

Delineation was undertaken using GIS software (QGIS) using the DEM as described in Section 2.4.3 in accordance with the methods detailed in QUDM. Characteristics of each catchment were then determined for input to the RAFTS model. A catchment map and the summary of each catchment were then determined for input to the RAFTS model.

For Clermont, similar to the WRM Clermont Flood Hazard Mapping study (2014), the study area was divided into two major catchments for Wolfang and Sandy Creek, with 24 sub-catchments being delineated, as seen in Figure 3.2. The characteristics adopted for each sub-catchment are provided in Appendix B.



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Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

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Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Clermont Sub-catchment map

Figure 3-2

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Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane

3.2.3.2 Catchment slope

Equal Area Slope (EAS) utilises the elevation profile of the Longest Flow Path (LFP) to determine the slope where half the points fall above and below the slope line. LFP is the distance from the furthest point of a catchment to the catchment's outlet. The length and respective EAS for each sub-catchment were determined by using the profile tool in the QGIS software to define the terrain profile along the longest flowpath line, the profile was then analysed to calculate the EAS. These results are provided for all sub catchments in Appendix B Catchment Characteristics.

3.2.3.3 Land use/roughness

PERN 'n' roughness was determined for each sub-catchment based on an assessment of the existing land use as determined through a review of aerial photography, zoning data and cadastral data. Values adopted for different ground types are provided in Table 3-1, which vary within these classes based on density of the vegetation. For each sub catchment, the PERN 'n' for the pervious portion of the sub-catchment is provided in Appendix B Catchment Characteristics.

Table 3-1 Adopted hydrologic PERN 'n' roughness

Adopted PERN 'n' Roughness	Ground Type
0.012	Impervious (i.e., roads, buildings etc.)
0.035 – 0.050	Combination of low density to medium density vegetation
0.050 – 0.070	Combination medium density to high density vegetation
0.080 – 0.120	Forested/high density vegetation

3.2.3.4 Losses

Initial losses for all pervious ground types were adopted based on the ARR Data Hub information from ARR 2019 guidelines. Continuing losses were adopted based on reconciling the RAFTS peak flows against the FFA derived peak flows for various AEP's. The values from the ARR 2019 guidelines were adopted initially and adjusted until a reasonable fit against the FFA peak flows was achieved. A zero value for initial loss and one for continuing loss was adopted for the Probable Maximum Precipitation (PMP) event per ARR 2019 recommendations, interpolation of the initial and continuing loss values between the 1% AEP and PMP events was completed to derive the loss adopted for the 0.2% AEP event. Table 3-2 summarises the adopted storm loss parameters for a 12-hour storm duration event in the sub-catchment closest to the Clermont town for the various AEP's simulated.

Table 3-2 Loss parameters (12-hours event)

Ground Type	Rainfall Event	Initial Loss (mm)	Median Pre-burst Depth (mm)	Net Initial Losses (mm)	Continuing Loss (mm/hr)
Impervious	All	1.00	N/A	1.0	0.0
Pervious	50 % AEP	26.0	0	26.0	3.0
	20 % AEP	26.0	1.2	24.8	
	10 % AEP	26.0	2	24.0	
	5 % AEP	26.0	2.7	23.3	
	2 % AEP	26.0	11.6	14.4	
	1 % AEP	26.0	18.3	7.7	
	0.2% AEP	12.0	18.0*	0.0	
	PMP	0.0	-*	0.0	1.0

* - ARR 2019 data hub does not specify a median pre-burst rainfall depth for this AEP, values shown in table is as adopted for the modelling.

3.2.3.5 Design storm

The design storm events that were assessed in this study included the 50%, 20%, 5%, 2%, 1%, 0.2% AEP, and the Probable Maximum Flood (PMF) events. To generate design rainfall for various durations, the RAFTS model simulated through Storm Injector used either extracted ARR (2019) Data Hub rainfall and temporal pattern data, or manually input rainfall and temporal pattern data. To determine peak discharge rates, design storm events were assessed for a range of design storm durations and methods, as listed in Table 3-3.

Table 3-3 Design storm durations

Rainfall Event	Duration (min)	Source of Rainfall Data and Temporal Patterns
50% - 1%AEP	1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 45, 60, 90, 120, 180, 270, 360, 540, 720, 1080, 1440, 1800, 2160, 2880, 4320, 5760, 7200, 8640, 10080	ARR Data Hub for each study area
0.2% AEP	540, 720, 1080, 1440, 2160, 2880, 4320, 5760, 7200	ARR Data Hub for each study area
PMP	540, 720, 1080, 1440, 2160, 2880, 4320, 5760, 7200	Generalised Tropical Storm Method Revised (GTSMR)

The design rainfall depths that were utilised are summarized in Appendix A BoM Design Rainfall IFD's.

3.2.3.6 Probable Maximum Precipitation/Flood

As indicated in Table 3-3, PMP rainfall data was calculated based on GTSMR method by BoM, 2003. The design rainfall depth and the temporal patterns were manually input into Storm Injector and simulated through the RAFTS model to generate the PMF hydrographs. Please note that the Generalsied Short Duration Method (GSDM) is not applicable for the study as the catchment area considered is beyond the catchment area limits (<1000 km^2) for this method.

The PMP rainfall depths and parameters applied to determine these depths are detailed in Table 3-4.

Table 3-4 PMP parameters

Parameter	Duration (min)									
	360	540	720	1080	1440	2160	2880	4320	5760	7200
Elevation Adjustment	0.0 (site is below 1,500 m AHD)									
Topographic Adjustment Factor, TAF	1.0									
Moisture Adjustment Factor, MAF	0.74									
Initial Depth Rough, Dr	410	470	510	580	874	1026	1167	1416	1611	1702
PMP (mm)	410	470	510	580	870	1030	1170	1420	1610	1700

Note that PMF uses a different set of temporal patterns to that used in smaller AEP events. For PMF simulations, 11 temporal patterns have been considered in order of assess the PMF. Ten temporal patterns from the historical and the Average Variability Method (AVM) temporal pattern as defined in the GTSMR guideline were used to form the set of 11 temporal patterns.

3.2.3.7 Areal reduction factors

Areal reduction factors for the events up to the very-rare rainfall event (0.2% AEP) were applied based on the ARR 2019 areal reduction factor parameters. The coefficients informing these factors are summarised in Table 3-5.

Table 3-5 Areal reduction factor coefficients

Parameter	Value
Zone	Semi-arid Inland Queensland
A	0.159
B	0.283
C	0.250
D	0.308
E	7.3E-07
F	1.000
G	0.039
H	0.000
I	0.000

For the PMP rainfall depths, areal reduction has been applied based on the ARR 2019 recommendations in Book 2 Chapter 4 Section 4.3.2. These areally reduced rainfall depths for the PMP event are shown in Figure 3.3.

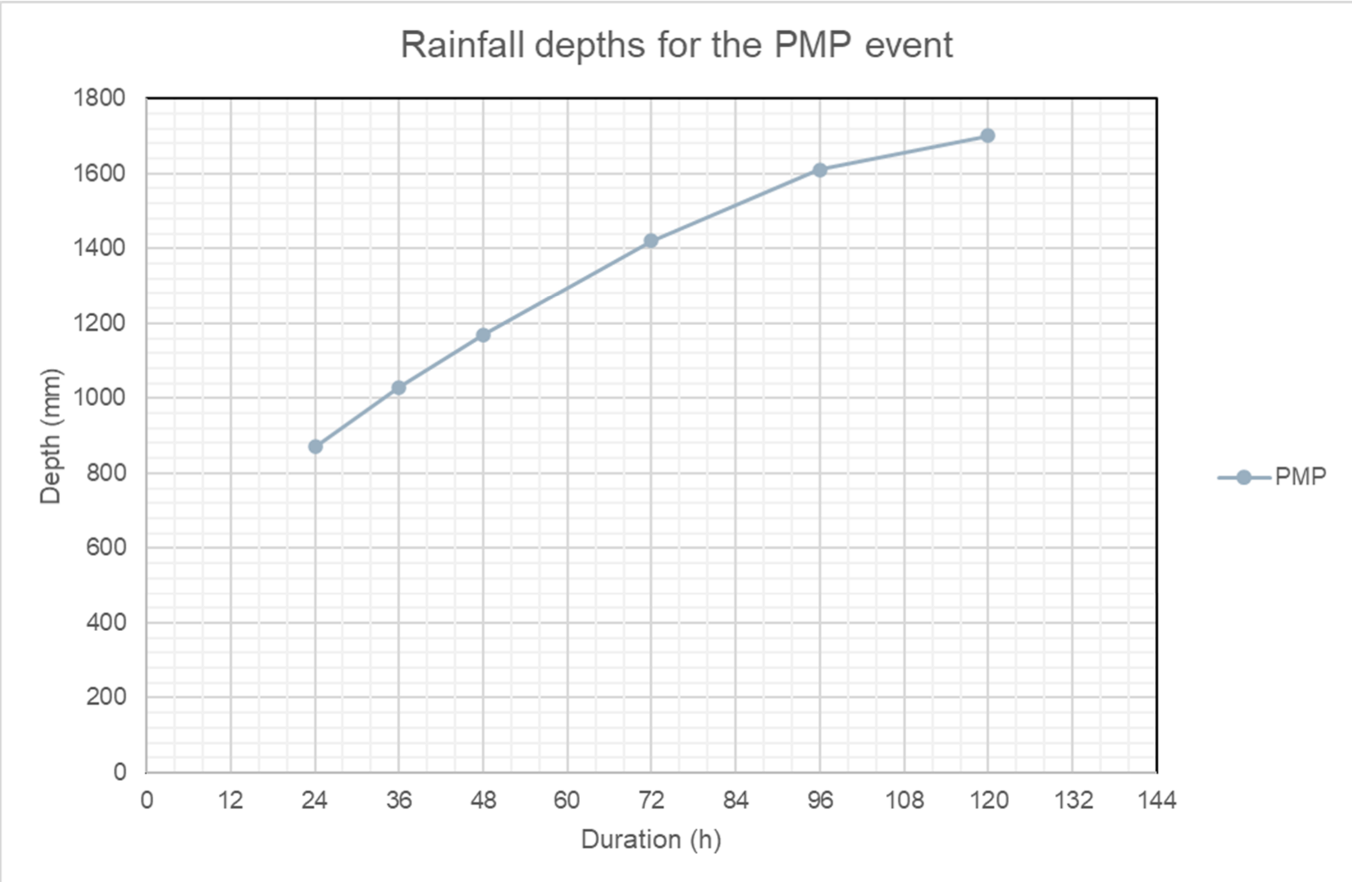


Figure 3.3 Rare rainfall interpolation

3.2.3.8 Climate Change

The parameter adjusted to account for climate change impacts in this study have been limited to the rainfall intensity only. Climate change scenarios for 2050- and 2100-time horizons were modelled for the 1% AEP event The rainfall depth percentage increase for the 2100-time horizon was extrapolated from the time horizons gathered from ARR 2019 and plotted to derive a line of best fit, the line of best fit was used to undertake the extrapolation. The climate change scenarios considered an increase in the design rainfall as specified in Table 3-6.

Table 3-6 Climate change variables

Year	Rainfall Intensity Increase (%)
2050	6.2
2100	12.67

3.3 Model results

Due to the ARR (2019) ensemble method of determining the duration and critical temporal pattern combination from a range of potentially critical storm combinations for each AEP, a wide range of outcomes were possible. An initial assessment of the results indicated that for the PMF event, the 48 hours (2880 minutes) event was critical in 95% of the sub-catchments within the study area. Further analysis indicated that 72hrs (4320 minutes), historical temporal pattern 1974JAN09-4 storm produced the highest flow of the events simulated at the critical location within the model for this study (the town of Clermont). As such, the 72 hour historical temporal pattern 1974JAN09-4 storm was adopted as the critical storm for the PMF event.

The peak discharge results from the RAFTS model simulations the same location within the model as the streamflow gauge (130207A – Sandy Creek at Clermont) are presented in Table 3-7.

Table 3-7 Peak discharge results from the RAFTS model

Storm Events	Peak Flow (m^3/s)	Critical Duration (hours) and Temporal Pattern
50% AEP	80.5	12 hour temporal pattern 934
20% AEP	236.4	12 hour temporal pattern 939
5% AEP	556.7	12 hour temporal pattern 939
2% AEP	845.9	12 hour temporal pattern 939
1% AEP	1079.1	12 hour temporal pattern 939
1% AEP 2050 Climate Change	1187.1	12 hour temporal pattern 939
1% AEP 2100 Climate Change	1299.5	12 hour temporal pattern 939
0.2% AEP	1269.9	24 hour temporal pattern 1989MAR14-1
PMF	6435.6	72 hour temporal pattern 1974JAN09-4

4. Flood frequency assessment

To quantify the Sandy Creek flows a FFA was undertaken using data recorded at the streamflow gauge (130207A – Sandy Creek at Clermont), this analysis was then used to validate the RAFTS model design event flows, which in turn was used to inform the upstream boundary condition for the hydraulic model. The results of the FFA are presented in the following report sections.

4.1.1 Analysis methodology

An Annual Maximum Series (AMS) approach was adopted for the flood frequency analysis based on the peak flow rate gauged in each water year (also referred to as the annual maxima), this analysis was completed through integrating the data into MS Excel. Once the AMS was established, the values were included in TUFLOW FLIKE, the data interrogated for any outliers and then the analysis complete. Using a Log Pearson III distribution (LPIII) and the Bayesian Inference Method with Gaussian prior distributions via the RFFE outputs the analysis was completed.

4.1.2 Annual maxima

A time series of the annual maxima at the Sandy Creek at Clermont gauge has been obtained from the Department of Regional Development, Manufacturing and Water (DRDMW) Water Management Information Portal (WMIP), including 57 years of stream gauge data. This data is presented in Table 4-1. A value from the Clermont 1916 extreme flood event was also included in this analysis, this value has been extracted from the 2013 WRM flood study which contained further details of this historical flood event within the Sandy Creek catchment.

Table 4-1 AMS for the Sandy Creek gauge

Hydrological year	Peak Discharge (m^3/s)	Hydrological year	Peak Discharge (m^3/s)
1916	1530	1994	50.5
1965	79.8	1995	342.6
1966	99.6	1996	57.7
1967	130.4	1997	46.6
1968	187.8	1998	260.7
1969	182.0	1999	64.9
1970	214.5	2000	115.9
1971	114.8	2001	0.4
1972	67.9	2002	153.8
1973	624.7	2003	129.8
1974	296.3	2004	36.4
1975	228.8	2005	66.3
1976	163.8	2006	53.5
1977	725.5	2007	696.9
1979	169.8	2008	48.4
1980	46.6	2009	85.2
1981	169.8	2010	76.8
1982	24.4	2011	209.4
1983	322.8	2012	2.0

Hydrological year	Peak Discharge (m^3/s)	Hydrological year	Peak Discharge (m^3/s)
1984	43.5	2013	52.7
1985	65.5	2014	3.9
1986	53.7	2015	104.0
1987	164.9	2016	68.6
1988	21.7	2017	55.9
1989	108.9	2018	233.9
1990	184.6	2019	57.4
1991	15.9	2020	128.9
1992	33.9	2021	338.2
1993	332.5	2022	N/A

It is noted that the 2001, 2012 and 2014 values were omitted from analysis as they were found to be outliers.

4.1.3 Results

The FLIKE software package was used to analyse the Sandy Creek annual maxima with the LPIII distribution, as recommended by ARR 2019. The flood frequency curve depicted in Figure 4.1 illustrates the model outputs for the Sandy Creek analysis. The observed values visually fit well along the curve, which is accompanied by a set of well fitted confidence bands. This assessment was used to predict peak flow rates commensurate with a range of AEP's up to the 1% AEP at Sandy Creek at Clermont gauge location. These peak flows were used to validate the RATFS model peak flows at the same location within the model and which were then utilised as inflow hydrographs to the TUFLOW hydraulic model (discussed further in Section 5).

As no gauge data is available for Wolfang Creek, the peak design discharges have been estimated by factoring the Sandy Creek FFA derived design event peak discharges based on the Wolfang Creek catchment area using the following equation:

$$Wolfang\ Creek\ Discharge\ (m^3/s) = Sandy\ Creek\ Discharge\ \times (\frac{Wolfang\ Creek\ Catchment\ Area}{Sandy\ Creek\ Catchment\ Area})^{0.7}$$

Table 4-2 illustrates the peak discharges for Wolfang and Sandy Creek during different AEP events.

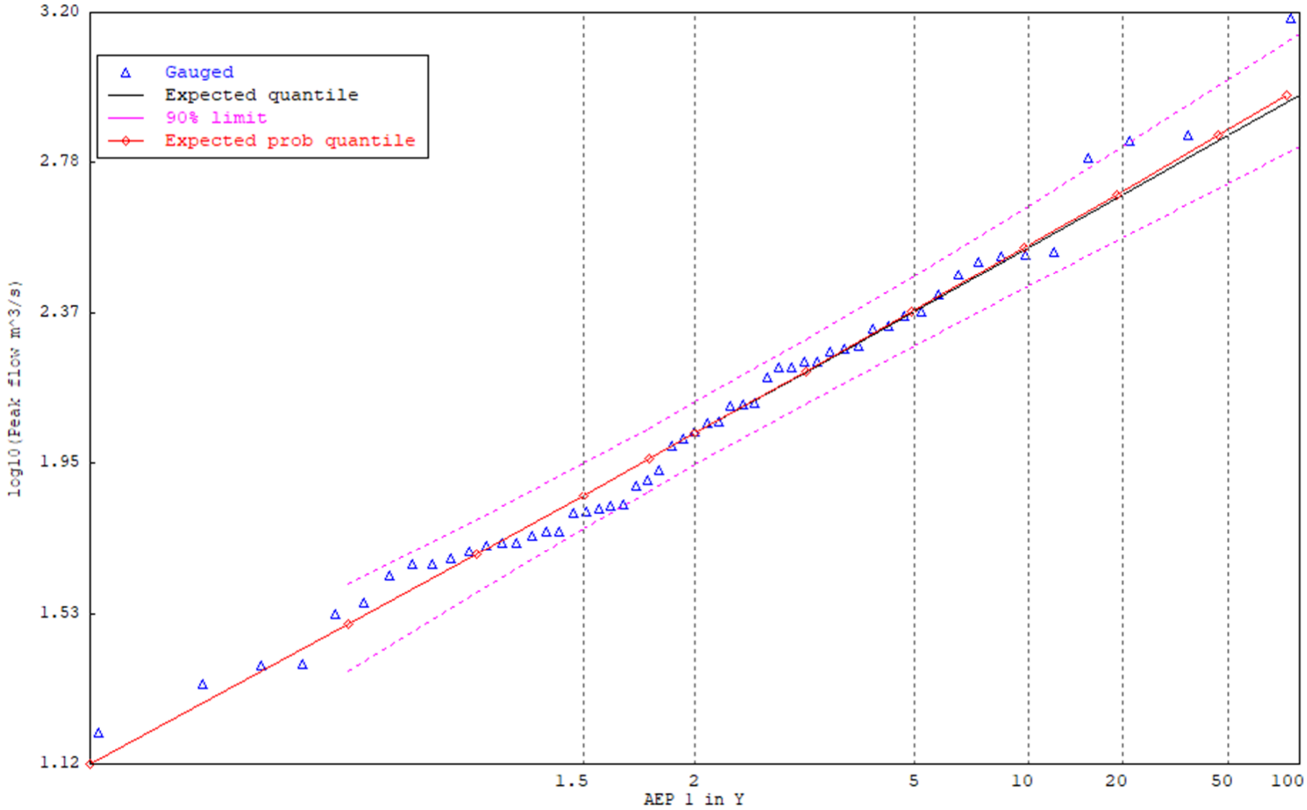


Figure 4.1 Flood frequency curve at Sandy Creek gauge – FLIKE output

Table 4-2 Peak discharge comparison for Sandy and Wolfang Creek

AEP 1 in Y Event	FLIKE Exp Parameter Quantile – Sandy Creek	Wolfang Creek Factored Result
2	107.6	159.1
5	233.7	345.4
20	492.9	728.7
50	722.6	1068.3
100	933.4	1379.8
500	1570.5	2321.7

4.1.4 Comparison of results

To determine the validity between the results, the following comparison in was completed between the FFA, RFFE ARR nearby gauge output, XPRAFTS design event peak flows as well as the previous 2014 WRM report for the Sandy Creek gauge. The RFFE technique is a regional flood estimation method the looks at nearby gauges to the area of interest and using fitting techniques to derive peak flow estimates. Inputs to the RFFE method include catchment centroid coordinates, outlet coordinates and catchment area.

Table 4-3 Comparison of discharge outputs (m^3/s)

Rain Event	FLIKE peak flow (m^3/s)	WRM 2014 Flood Report peak flow (m^3/s)	RFFE peak flow (m^3/s)	XPRAFTS peak flow (m^3/s)
50% or 1 in 2 AEP	107.61	-	102.2	80.49
20% or 1 in 5 AEP	233.66	-	243.3	236.44
5% or 1 in 20 AEP	492.94	-	541	556.69
2% or 1 in 50 AEP	722.62	864	804.1	845.87
1% or 1 in 100 AEP	933.37	1174	1043.1	1079.1
0.2% or 1 in 500 AEP	1570.49	2242	-	1269.9

The results show a good correlation between the FLIKE analysis and the XP-RAFTS model results for the 50% AEP up to the 1% AEP. The RFFE estimates also generally show a good comparison to both FLIKE and RAFTS estimates. The WRM results are generally higher for events where the results are available for comparison. On this basis the XP-RAFTS model parameters were adopted for simulating the design flood events to be used as inflow boundary conditions for the TUFLOW hydraulic model.

5. Hydraulic analysis

This section summarises the hydraulic investigations undertaken for the study area. Hydraulic modelling was undertaken to estimate design event flood levels and velocities, and to determine flow patterns across the study area to inform flood hazard predictions.. A two-dimensional (2D) flood modelling approach was adopted to simulate the complex 2D nature of flood flows, in conjunction with a one-dimensional (1D) hydraulic structures. Hydraulic results were utilised to identify key areas of flood risk and can be used to potentially develop flood mitigation options in the future.

The scope of work involved:

- Data collection and review of available hydraulic information
- Hydraulic model setup (GIS and TUFLOW)
- Estimation of event-based flood inundation

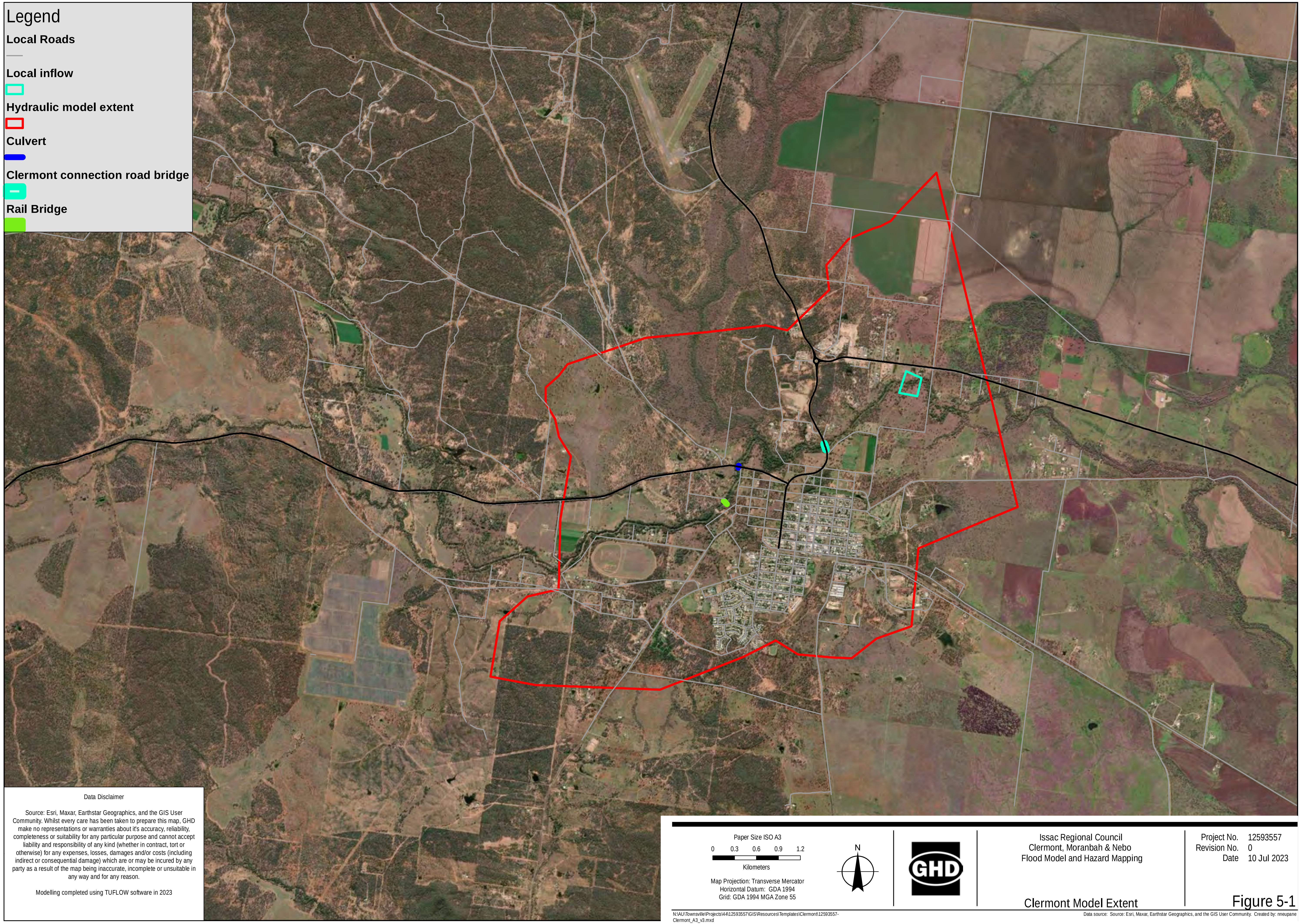
The hydraulic assessment utilised local catchment hydrographs produced in the hydrologic analysis and elevation data. A plan showing the extent of the hydraulic models is provided in Figure 5.1 highlighting upstream inflow boundaries and downstream outflow boundaries from the hydraulic model.

5.1 Data collection

The following data was used to undertake this assessment:

- 2022 High resolution Aerial Imagery -provided by IRC
- 1 m LiDAR terrain Data – obtained from ELVIS Spatial
- SRTM Terrain Data – provided by IRC
- GIS Land Use Zoning – provided by IRC
- Hydrographs output from the RAFTS model

Note that there was no asset data provided for any pit, pipe, culverts or hydraulic structures. Resulting assumptions have been identified throughout the following sections of the report.



Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Flood Model and Hazard Mapping

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Clermont Model Extent

Figure 5-1

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5.2 Hydraulic model setup

5.2.1 Model selection

Hydraulic modelling has been undertaken using the TUFLOW hydraulic modelling software. TUFLOW is a 2D unsteady flow hydrodynamic modelling tool developed by BMT-WBM. TUFLOW is oriented towards establishing 2D flow and inundation patterns in coastal waters, rivers and floodplains, as well as urban areas. TUFLOW solves the depth-averaged 2D shallow water equations for flows such as the free-surface flows occurring from floods and tides based on the creation of an appropriate-resolution DEM, surface inflows, surface roughness and boundary conditions. TUFLOW is recognised as an industry standard 2D hydrodynamic modelling package within Australia and is well suited to the modelling of the waterways and networks within the study area. Furthermore, the sub-grid sampling (SGS) method of TUFLOW is made available, which improves the definition of terrain features and 2D conveyance and storage calculations.

5.2.2 Model development

Development of the TUFLOW model entailed:

- Ingesting of terrain data
- Implementations of hydrographs from RAFTS at identified inflow locations
- Determination of other model parameters including downstream boundary conditions, material properties (hydraulic roughness) and hydraulic conveyance and control infrastructure
- Hydraulic model simulations
- A critical review of model results.

5.2.3 Cell size convergence

To justify a balance between hydraulic model detail and performance, a grid cell size convergence assessment was undertaken to determine the effect of the model cell resolution on the following:

- Model predicted flood levels
- Simulation time
- Data volumes.

The previous model (WRM, 2014) provided by IRC utilized a 10-metre grid cell size. In the study presented in this report, the hydraulic model was tested using a 3, 5 and 8 metre grid cell size for the assessment. The results of the assessment are detailed in Table 5-1.

Table 5-1 Comparison of grid cell size results

Grid cell size (m)	Number of cells	Runtime (hours)[1]	Maximum grid output (MB)	Δ1% AEP in peak water level[2] (m)
3	17,050,484	22.68	769	0.01
5	10,230,291	4	277	-
8	6,393,932	1.5	108	0.0051

Based on the results of the comparison detailed above, the 5-metre grid cell size was selected for the hydraulic model simulations. The decision was made based on the following key points:

- Maintains a practical runtime to complete hydraulic model simulations within a reasonable timeframe.
- Maintains a level of model detail appropriate for the assessment.
- Provides a reasonable balance between model detail and data volumes.

[1] For 1% AEP 12-hour storm duration temporal pattern 939 selected as this event is the critical event for the 1% AEP in the vicinity of Clermont.
[2] Relative to 5 m grid cell size

5.2.4 Model parameters

The TUFLOW model required the following input parameters:

5.2.4.1 Topography

The terrain data obtained from ELVIS Spatial was ingested into TUFLOW using a model grid cell size of 5 m with a Sub Grid Sampling (SGS) distance of one metre 1 m. SGS allows the use of a larger model grid cell size whilst maintaining the topographic accuracy of a smaller grid cell size. This is done by interpreting the grid cells and applying a dynamic elevation across the cell rather than assuming a static elevation for the entire cell face.

5.2.4.2 Design event modelling

Design storm events assessed in this study were 50%, 20%, 5%, 2%, 1%, 0.2% AEP events, and the PMF. Critical storm durations were used to generate maximum flood results. Critical storm durations were determined by modelling all durations from RAFTS and selecting the critical storm based on the peak flow at the modelled sub-catchment that corresponds closest to the area of interest for the study (Clermont).

5.2.4.3 Inflow boundaries

Hydrographs sourced from the RAFTS models were adopted as the upstream inflow boundary conditions (QT or flow vs. time) for the required events and were applied across the model extent at the applicable upstream location (within the model boundary). Local inflow hydrographs were applied as source-area inflow boundary conditions directly to the 2D domain where the sub-catchment is contained within the model extent.

5.2.4.4 Outflow boundaries

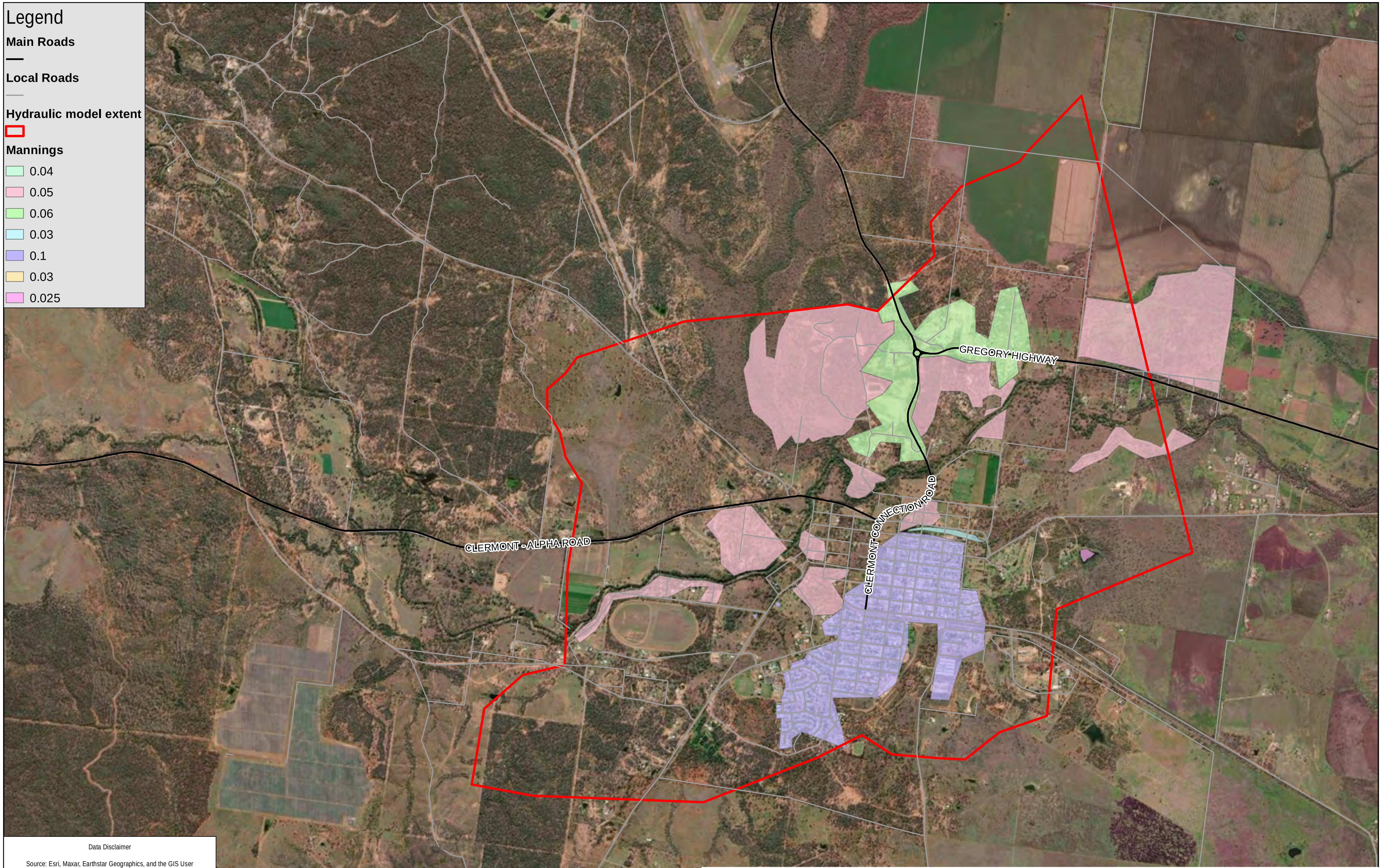
Outflow boundaries were setup as “HQ” boundaries, with slopes based on the energy grade line of the waterway conveying the outflow at each location. These boundary conditions were located across the Sandy Creek floodplain. Boundary conditions within the hydraulic model are shown in Figure 5.1.

5.2.4.5 Hydraulic roughness

Hydraulic roughness values across the study areas were determined based on a combination of the existing land use through review of aerial photography and zoning data. The Manning’s ‘n’ roughness values adopted for different land uses are presented in Table 5-2 and a roughness map illustrating the spatial variation is presented in Figure 5.2. High roughness values were adopted for buildings to represent their obstruction to flows potentially caused by the buildings.

Table 5-2 Manning’s ‘n’ roughness values

Ground Type	Manning’s ‘n’ roughness
Water Body	0.025
Road	0.017
Natural channel	0.030
Scattered brush, heavy weeds	0.05
Cultivated Lands	0.040
Buildings	0.1



Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Flood Model and Hazard Mapping

Project No. 12593558
Revision No. 0
Date 10 Jul 2023

Clermont TUFLOW Hydraulic Roughness

Figure 5-2

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Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane

5.2.4.6 1D hydraulic infrastructure

5.2.4.6.1 Culverts

Culverts were modelled in TUFLOW as 1D flow objects with inputs such as: type or configuration, size, invert levels, number of barrels, material roughness and blockage. GIS coverage for the 1D elements including details such as diameter and invert levels were missing from the data received from IRC. To overcome this, GHD has used inputs for these fields from the associated DEM.

5.2.4.6.2 Blockage factors

The ARR (2019) guidelines were used to calculate the TUFLOW blockage factors for the 1D network cross drainage culverts.

5.2.4.7 Bridge structures

Two bridges within the model were represented as a 2D Layered Flow Constrictions (LFC) within the TUFLOW model. Layered flow constrictions work by separating the cross section of a structure into four layers:

– **Layer 1:** Beneath the bridge deck, blockage for this first layer is assigned to account for the proportion of the cross-sectional area that is blocked typically by the piers and abutments, this layer also has a form loss coefficient to account for the energy losses associated with the obstruction caused by these piers.

– **Layer 2:** The bridge deck, this layer is 100% blocked and typically has a large form loss coefficient to account for the additional energy losses associated with the flow surcharging the deck.

– **Layer 3:** Typically accounts for the bridge guardrails and any flow obstruction above the bridge deck, this layer has set to be 0% for rail bridge within this study area due to the absence of the rails and 50% for the Sandy Creek bridge which was adopted from the previous flood study model and as no further detailed information was made available for this study.

– **Layer 4:** Flow over the top of the rails – flow is assumed to be unobstructed.

5.3 Model results

5.3.1 Flood inundation mapping

As per the agreed scope for the project, 50% AEP, 20% AEP, 5% AEP, 2% AEP, 1% AEP, 0.2% AEP and PMF events were simulated and the results from these simulations were mapped (See Appendix C). Using the simulated results, the following observations were made in Section 5.3.2.

5.3.2 Discussion of flood behaviour

The general flood behaviour across the study area as observed from the simulations is characterised in Table 5-3 for the various AEP events simulated for this study. Peak flood depths, velocity, and hazard category maps for all the storm events are provided in Table 5-3.

Table 5-3 Summary of general flooding concern within the area

Flood Event (AEP)	Flood Behaviour
50%	– Most of the overland flow is simulated to be contained within the major waterways and the roads. There are some notable exceptions which initiate during a 50% AEP event and increase in severity through to PMF event.
20%	– Areas in the northwest across Laglan Road is simulated to be inundated by Wolfang Creek floodwater to depths of up to 0.8 m. – Floodwaters extend east from Wolfang Creek towards Gregory Development Road. Some low-lying properties are simulated to be inundated by floodwaters

Flood Event (AEP)	Flood Behaviour
5%	– The Clermont Connection Road is simulated to be inundated to depths of up to 1.6 m overtopping the bridge. – Areas along Charles Street are simulated to be affected by flood depths of up to 0.9 m.
2%	– West of the racecourse is simulated to be affected by flood depths of up to 0.3 m. – Lime Street on the south side of Clermont is simulated to be affected by Sandy Creek floodwater. Some properties are simulated to be submerged by up to 1 m of flow depth towards Drummond Street – The bridge across Clermont Connection Road is simulated to be overtopped to a depth of 1.8 m above the deck level.
1%	– Flood simulated to extend towards the northeast of Gregory Development to depths up to 1 m. – Low lying parts of properties on Mimosa Street are simulated to be affected by floodwaters from Wolfang and Sandy Creek – The Clermont Connection Road bridge is simulated to be overtopped to a depth of approximately 2 m above the deck level.
1% plus Climate Change 2050	– The Clermont Connection Road bridge is simulated to be overtopped by floodwaters that rise up to 8.9 m above the gauge level at the Sandy Creek gauge (535103) – South of Sandy Creek including Clermont State School, Clermont Showground and Clermont Kindergarden Day Care Centre is simulated to remain unaffected by floodwaters during the event.
1% plus climate change 2100	– The railway is simulated to be overtopped. Southern side of the Sandy Creek is simulated to be flood free. – Tropic Street is simulated to be affected by flood waters extending from Sandy Creek. The properties along the street are simulated to be submerged up to a depth of 1.3 m. – Clermont Cemetery is simulated to be affected by floodwaters up to a depth of 0.8 m. – Gregory Development Road to the eastern side of Fleurs Lane is simulated to be inundated by floodwater up to a depth of 1 m.
0.2%	– Wolfang Street near the intersection of Orion Street is simulated to be inundated by floodwaters up to depths of 1 m. – Sandy Creek floodwaters are simulated to reach Cheeseborough Rd on the East at an intersection with Old Showground Rd. Flooding is simulated along the Cheeseborough Rd to a depth up to 1.5 m. – Properties lying on the edge of Mimosa Street are simulated to be submerged up to 1 m. – Properties on the southern side of Edge Street are simulated to be submerged to a depth of up to 1.5 m.
PMF	– Floodwaters have affected most of the Clermont township in both lower lying catchment areas and main overland flow channels as predicted by the model simulation. – Low lying parts of properties in Copperfield Road are simulated to be inundated to depths of up to 2.5 m.

5.4 Model validation

The hydrology model was validated to the streamflow gauged data as described in Section 4. As detailed calibration information was not made available for the hydraulic model, reasonableness checks were undertaken to confirm that the model was providing outputs consistent with the inputs and the surrounding hydraulic conditions.

5.5 Sensitivity assessment

Sensitivity testing was conducted for the Manning's 'n' parameter where the hydraulic roughness was adjusted by 10% (higher and lower). The +/- 10% value represents bands of Manning's n value that fall within industry accepted-values. The results were compared against the adopted Manning's n and a histogram chart of water level difference within the model domain is presented in Figure 5.3 and Figure 5.4. These plots show that majority of the differences in results are in the 50-100 mm band for both the increased and decreased Manning's 'n' value scenarios. As such, it is considered that the model is generally sensitive to changes in roughness. Some significant difference in flood extent was observed particularly in downstream boundary of the model, though this area is beyond the main focus study area (Clermont) covered by this report. The values are adopted according to the industry standard range.

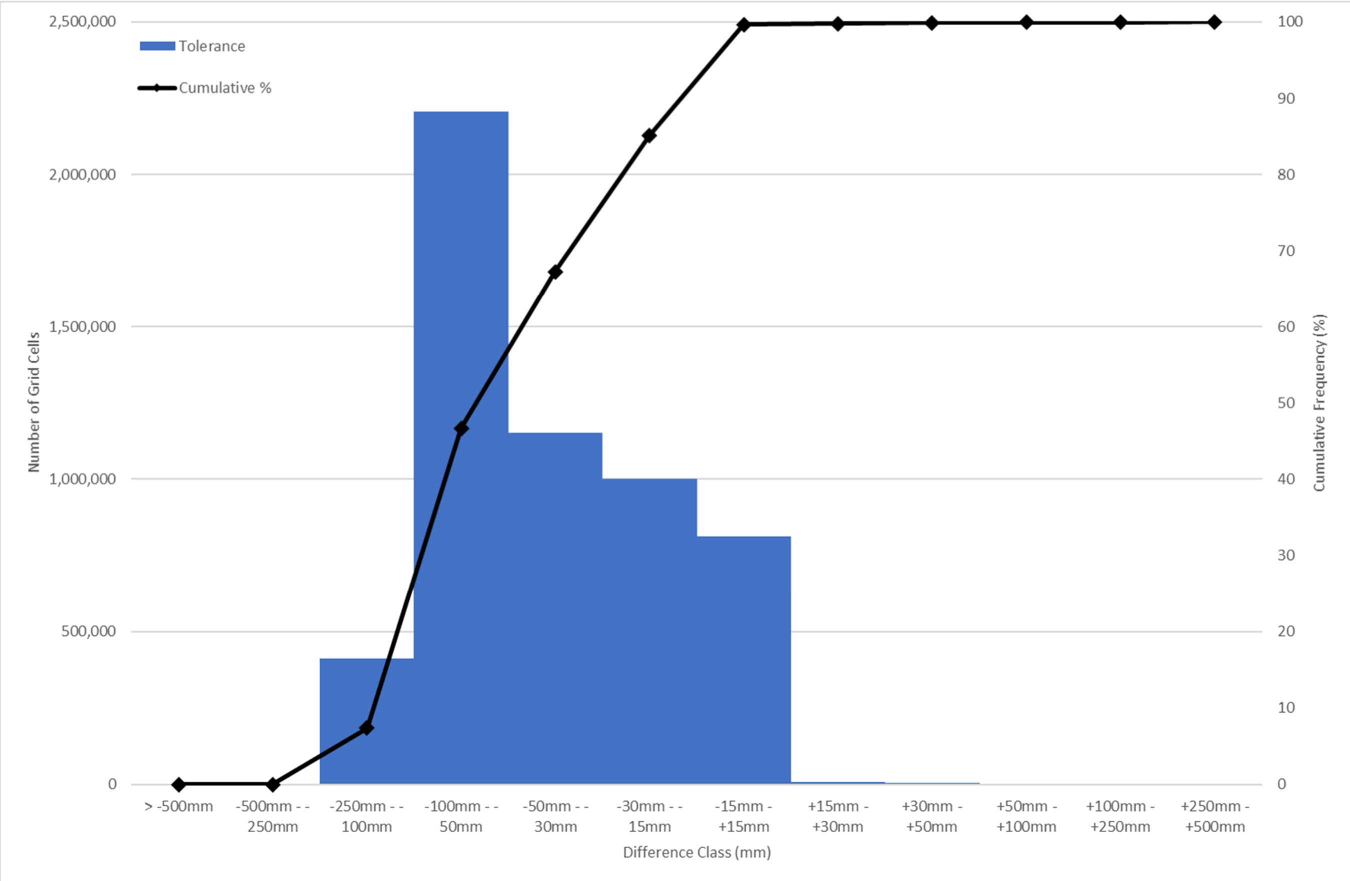


Figure 5.3 Water level difference histogram considering adopted Manning's n and 10% reduced Manning's n

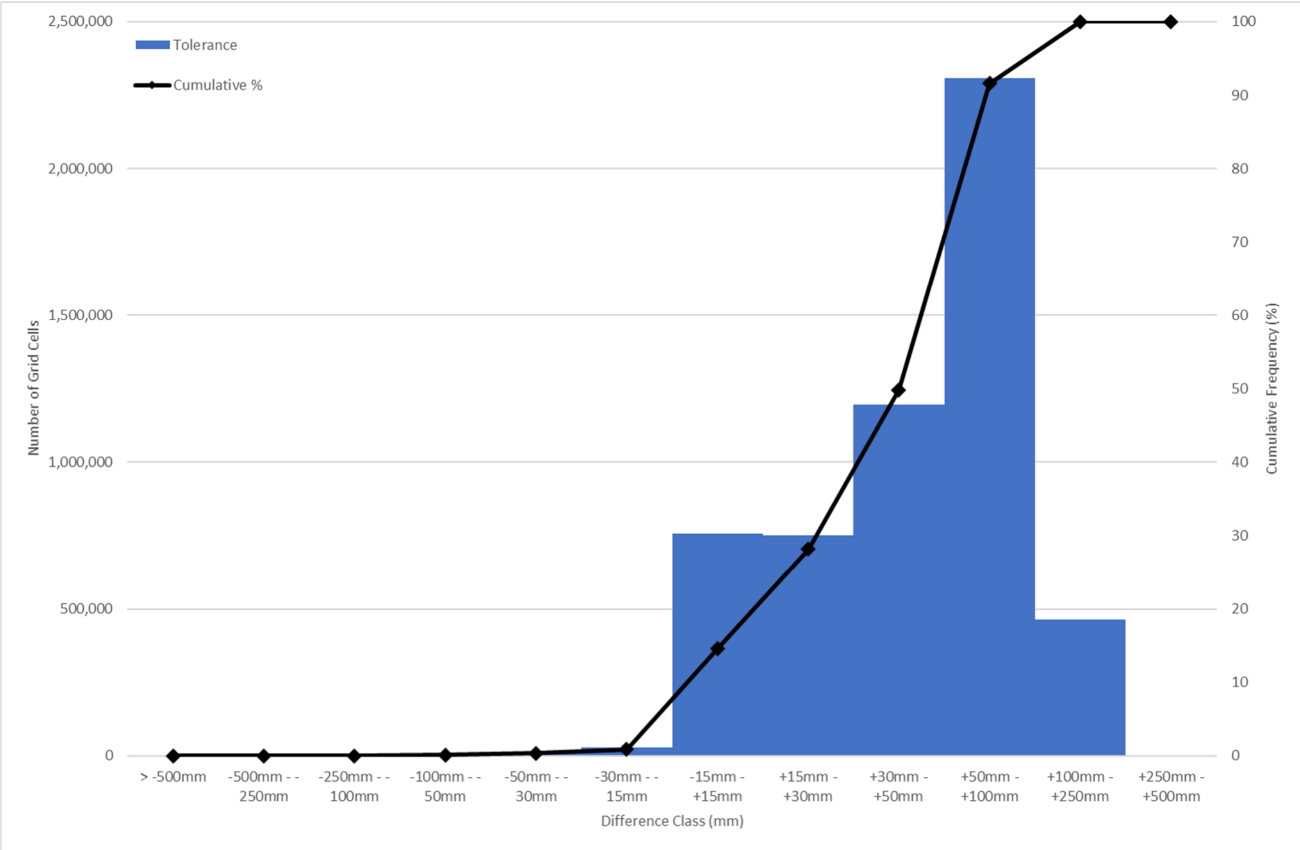


Figure 5.4 Water level difference histogram considering adopted Manning's n and 10% increased Manning's n

6. Summary

GHD was engaged by IRC to update the flood models for the town of Clermont and undertake flood and hazard mapping from the flood model outputs. This report documents the analysis, which involved:

– Review of available data and historic flood information
– Hydrologic and hydraulic modelling of current catchment flood conditions for a range of AEP events.
– Development of flood maps (including hazard maps) for each of the design events.

To develop an understanding of existing flooding and drainage issues, detailed hydrologic and hydraulic modelling and flood inundation mapping of the Clermont area have been undertaken in accordance with the best practice approaches. Table 5-3 has be presented again in this Section to further highlight the findings from this study.

Table 6-1 Summary of general flooding issues (from Section 5.3.2)

Flood Event (AEP)	Flood Behaviour
50%	– Most of the overland flow is simulated to be contained within the major waterways and the roads. There are some notable exceptions which initiate during a 50% AEP event and increase in severity through to PMF event.
20%	– Areas in the northwest across Laglan Road is simulated to be inundated by Wolfang Creek floodwater to depths of up to 0.8 m. – Floodwaters extend east from Wolfang Creek towards Gregory Development Road. Some low-lying properties are simulated to be inundated by floodwaters
5%	– The Clermont Connection Road is simulated to be inundated to depths of up to 1.6 m overtopping the bridge. – Areas along Charles Street are simulated to be affected by flood depths of up to 0.9 m.
2%	– West of the racecourse is simulated to be affected by flood depths of up to 0.3 m. – Lime Street on the south side of Clermont is simulated to be affected by Sandy Creek floodwater. Some properties are simulated to be submerged by up to 1 m of flow depth towards Drummond Street – The bridge across Clermont Connection Road is simulated to be overtopped to a depth of 1.8 m above the deck level.
1%	– Flood simulated to extend towards the northeast of Gregory Development to depths up to 1 m. – Low lying parts of properties on Mimosa Street are simulated to be affected by floodwaters from Wolfang and Sandy Creek – The Clermont Connection Road bridge is simulated to be overtopped to a depth of approximately 2 m above the deck level.
1% plus Climate Change 2050	– The Clermont Connection Road bridge is simulated to be overtopped by floodwaters that rise up to 8.9 m above the gauge level at the Sandy Creek gauge (535103) – South of Sandy Creek including Clermont State School, Clermont Showground and Clermont Kindergarden Day Care Centre is simulated to remain unaffected by floodwaters during the event.
1% plus climate change 2100	– The railway is simulated to be overtopped. Southern side of the Sandy Creek is simulated to be flood free. – Tropic Street is simulated to be affected by flood waters extending from Sandy Creek. The properties along the street are simulated to be submerged up to a depth of 1.3 m.

Flood Event (AEP)	Flood Behaviour
	– Clermont Cemetery is simulated to be affected by floodwaters up to a depth of 0.8 m. – Gregory Development Road to the eastern side of Fleurs Lane is simulated to be inundated by floodwater up to a depth of 1 m.
0.2%	– Wolfang Street near the intersection of Orion Street is simulated to be inundated by floodwaters up to depths of 1 m. – Sandy Creek floodwaters are simulated to reach Cheeseborough Rd on the East at an intersection with Old Showground Rd. Flooding is simulated along the Cheeseborough Rd to a depth up to 1.5 m. – Properties lying on the edge of Mimosa Street are simulated to be submerged up to 1 m. – Properties on the southern side of Edge Street are simulated to be submerged to a depth of up to 1.5 m.
PMF	– Floodwaters have affected most of the Clermont township in both lower lying catchment areas and main overland flow channels as predicted by the model simulation. – Low lying parts of properties in Copperfield Road are simulated to be inundated to depths of up to 2.5 m.

Appendices

Appendix A

BoM design rainfall IFDs (Frequent, infrequent and rare)

Table A-1 BoM Design Rainfall IFDs (Frequent and Infrequent) – Clermont

Duration	Annual Exceedance Probability (AEP)					
	63.2%	50%	20%	5%	2%	1%
1 min	2.25	2.53	3.41	4.54	5.25	5.78
2 min	3.75	4.25	5.79	7.82	9.15	10.2
3 min	5.31	6.01	8.17	11	12.8	14.2
4 min	6.79	7.68	10.4	13.9	16.2	17.9
5 min	8.17	9.22	12.5	16.7	19.3	21.3
10 min	13.7	15.4	20.7	27.4	31.6	34.7
15 min	17.6	19.8	26.5	35.1	40.5	44.5
20 min	20.5	23.1	31	41.1	47.4	52.1
25 min	22.8	25.7	34.6	45.9	53.1	58.4
30 min	24.7	27.9	37.5	50	57.8	63.7
45 min	28.8	32.6	44.1	59.2	68.8	76.1
1 hour	31.7	35.8	48.7	65.8	76.9	85.3
1.5 hour	35.5	40.3	55.3	75.5	88.8	99
2 hours	38.2	43.4	59.9	82.5	97.5	109
3 hours	42.1	47.9	66.7	92.9	111	125
4.5 hour	46.2	52.7	73.9	104	125	141
6 hours	49.4	56.4	79.5	113	136	154
9 hours	54.3	62.2	88.1	126	152	174
12 hours	58.3	66.8	94.8	136	166	189
18 hours	64.6	74	105	152	186	213
24 hours	69.5	79.7	114	165	201	231
30 hours	73.6	84.4	121	175	214	246
36 hours	77.1	88.4	126	183	225	258
48 hours	82.7	94.9	136	197	242	279
72 hours	90.5	104	149	217	267	307
96 hours	95.7	110	159	231	284	326
120 hours	99.3	115	165	242	297	340
144 hours	102	118	171	250	306	351
168 hours	104	120	175	257	314	359

Table A-2 BoM Design Rainfall IFDs (Rare) – Clermont

Duration	Annual Exceedance Probability (1 in x)			
	1 in 200	1 in 500	1 in 1000	1 in 2000
1 min	6.54	7.65	8.56	9.53
2 min	11.7	13.7	15.3	17.1
3 min	16.3	19.1	21.4	23.8
4 min	20.4	23.9	26.8	29.8
5 min	24.2	28.3	31.7	35.3
10 min	39.1	45.7	51.1	56.9
15 min	50.0	58.5	65.4	72.8
20 min	58.7	68.6	76.8	85.4
25 min	65.8	77.0	86.2	95.9
30 min	72.0	84.2	94.2	105
45 min	86.4	101	113	126
1 hour	97.3	114	127	142
1.5 hour	113	133	149	166
2 hours	126	147	164	183
3 hours	144	168	188	210
4.5 hours	164	191	214	238
6 hours	179	209	234	260
9 hours	203	237	265	295
12 hours	221	258	289	322
18 hours	250	292	327	364
24 hours	273	319	357	397
30 hours	292	342	383	427
36 hours	308	361	405	452
48 hours	334	392	440	491
72 hours	372	436	488	543
96 hours	397	465	519	577
120 hours	416	485	540	599
144 hours	430	500	556	614
168 hours	440	510	566	625

Appendix B

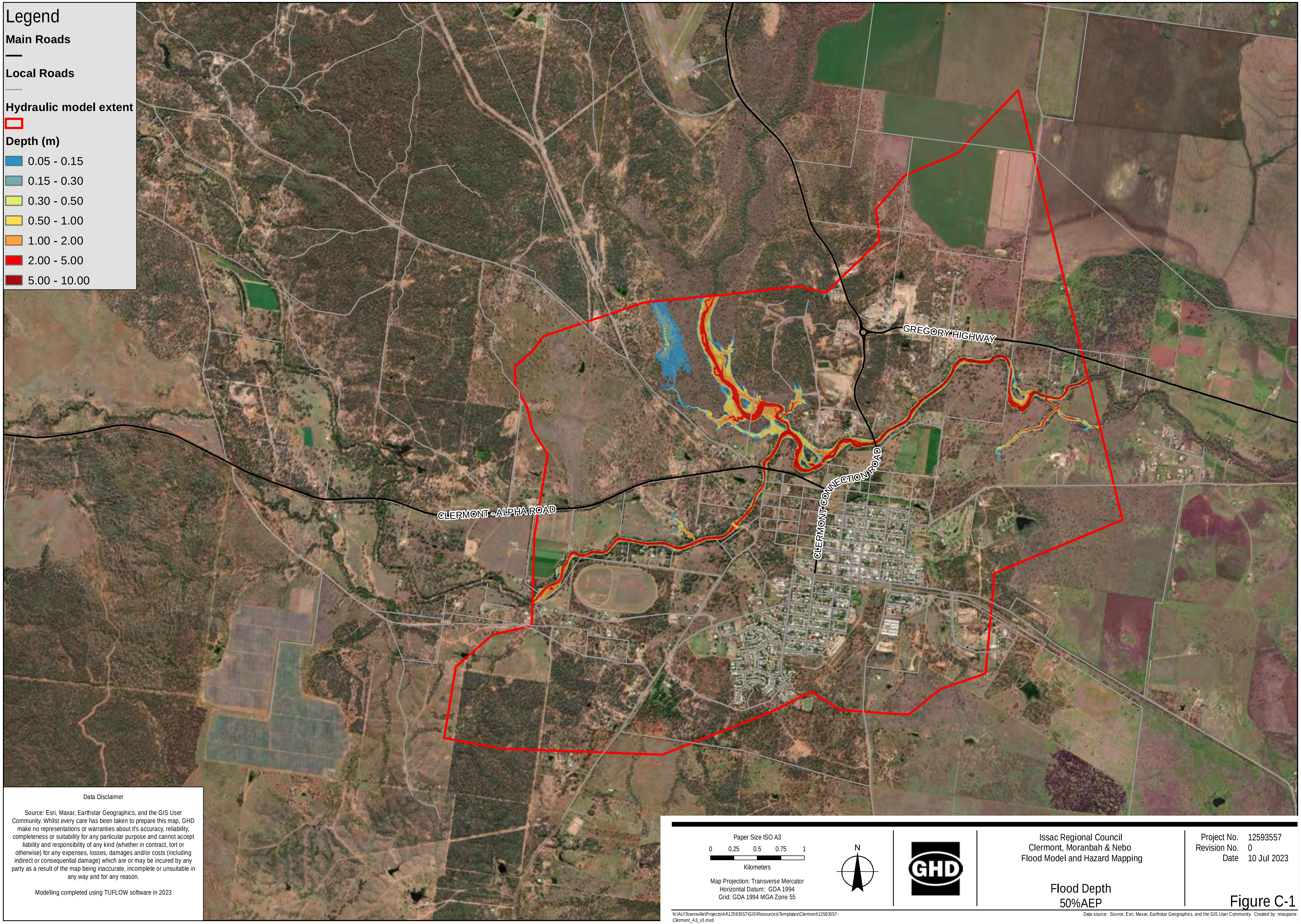
Catchment Characteristics

Table B-1 Clermont sub-catchment characteristics

Catchment ID	Area (ha)	Pervious Manning's value	Fraction Impervious (%)	EA Slope %
1	6772.11	0.05	0	1.01
2	9182.19	0.05	0	0.74
3	4534.65	0.05	0	0.5
4	6170.99	0.05	0	0.54
5	6688.63	0.04	18.25	0.73
6	5694.55	0.035	0	0.57
66	3640.12	0.035	6.09	0.34
7	5525.73	0.04	0	0.53
8	2254.52	0.035	0	0.33
9	3668.43	0.04	0	0.48
10	9166.85	0.025	21.21	0.62
11	15846.43	0.025	0	0.16
12	3893.59	0.025	0	0.15
13	11132.65	0.025	0	0.49
14	6427.76	0.025	0	0.49
15	13415.76	0.025	0	0.67
16	18356.88	0.025	0	0.46
17	8946.91	0.025	2.37	0.18
18	5773.09	0.025	0	1.27
19	7361.99	0.025	0	0.33
20	9934.66	0.025	0	0.42
21	5015.59	0.025	0	0.29
22	5418.49	0.025	0	0.49
23	5128.25	0.025	0	0.88

Appendix C

Flood maps



Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Depth
50%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-1

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
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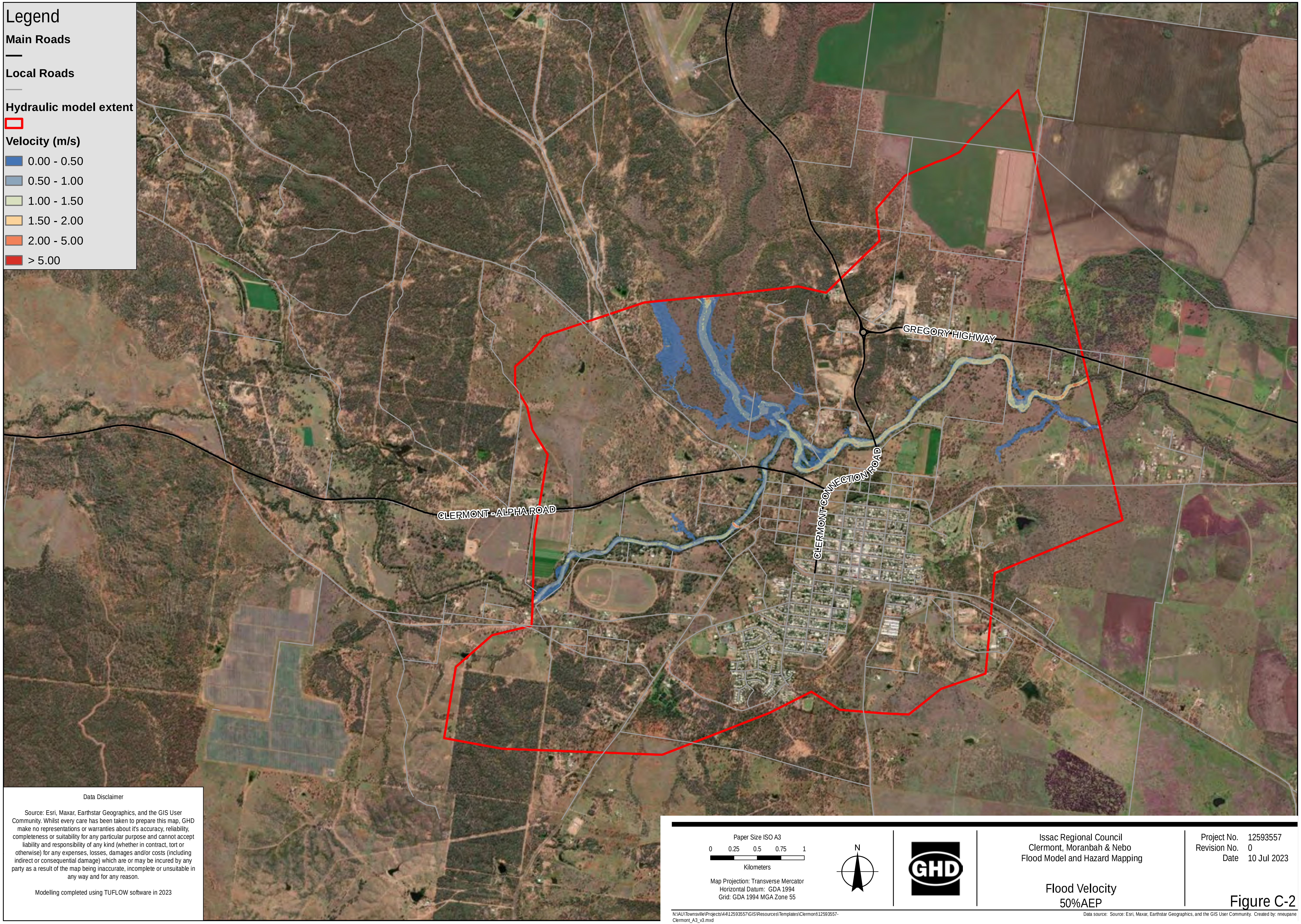
Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Velocity
50%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-2

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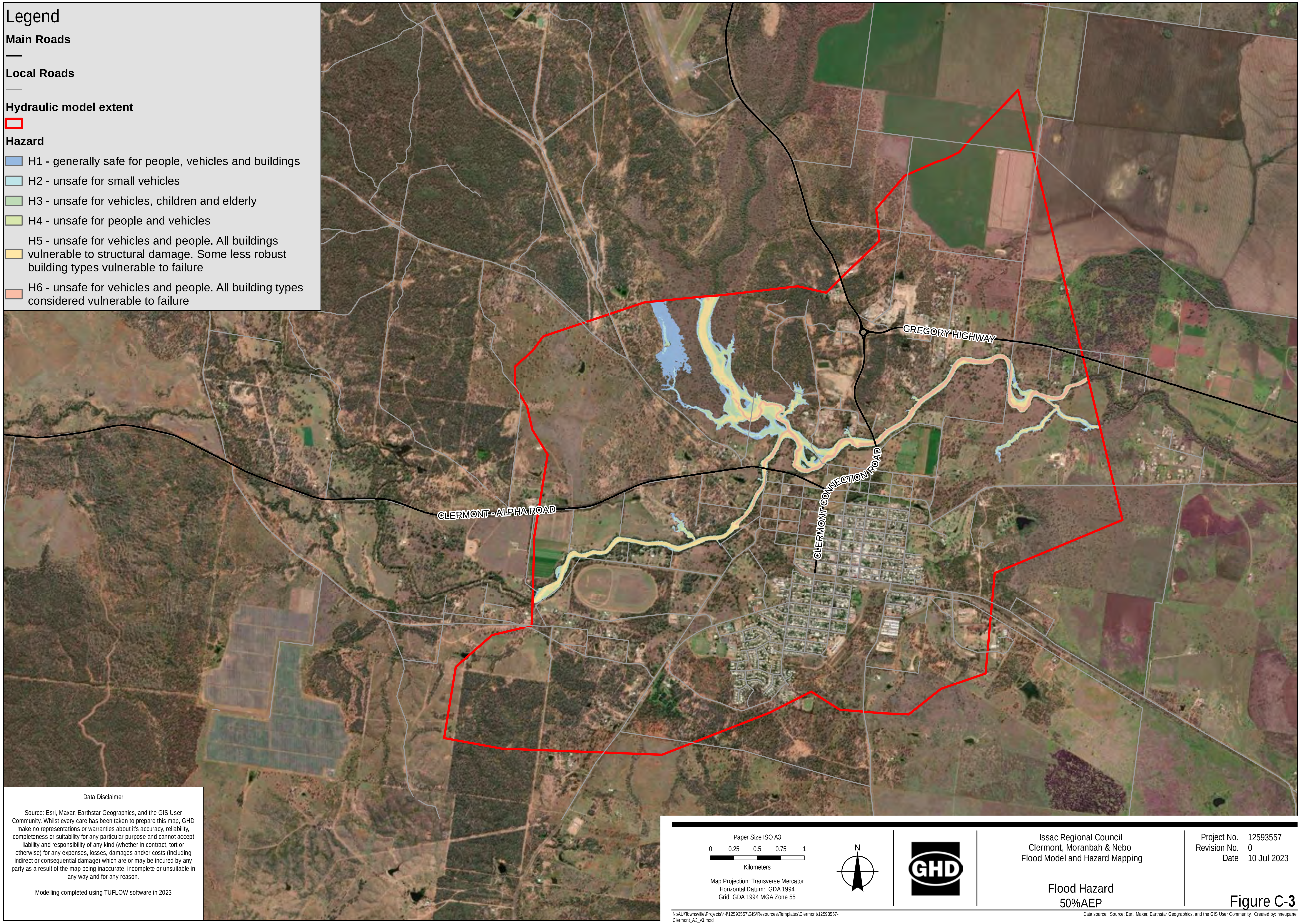
Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Legend

Main Roads

Local Roads

Hydraulic model extent

Hazard

- H1 - generally safe for people, vehicles and buildings
- H2 - unsafe for small vehicles
- H3 - unsafe for vehicles, children and elderly
- H4 - unsafe for people and vehicles
- H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - unsafe for vehicles and people. All building types considered vulnerable to failure

Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard
50%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-3

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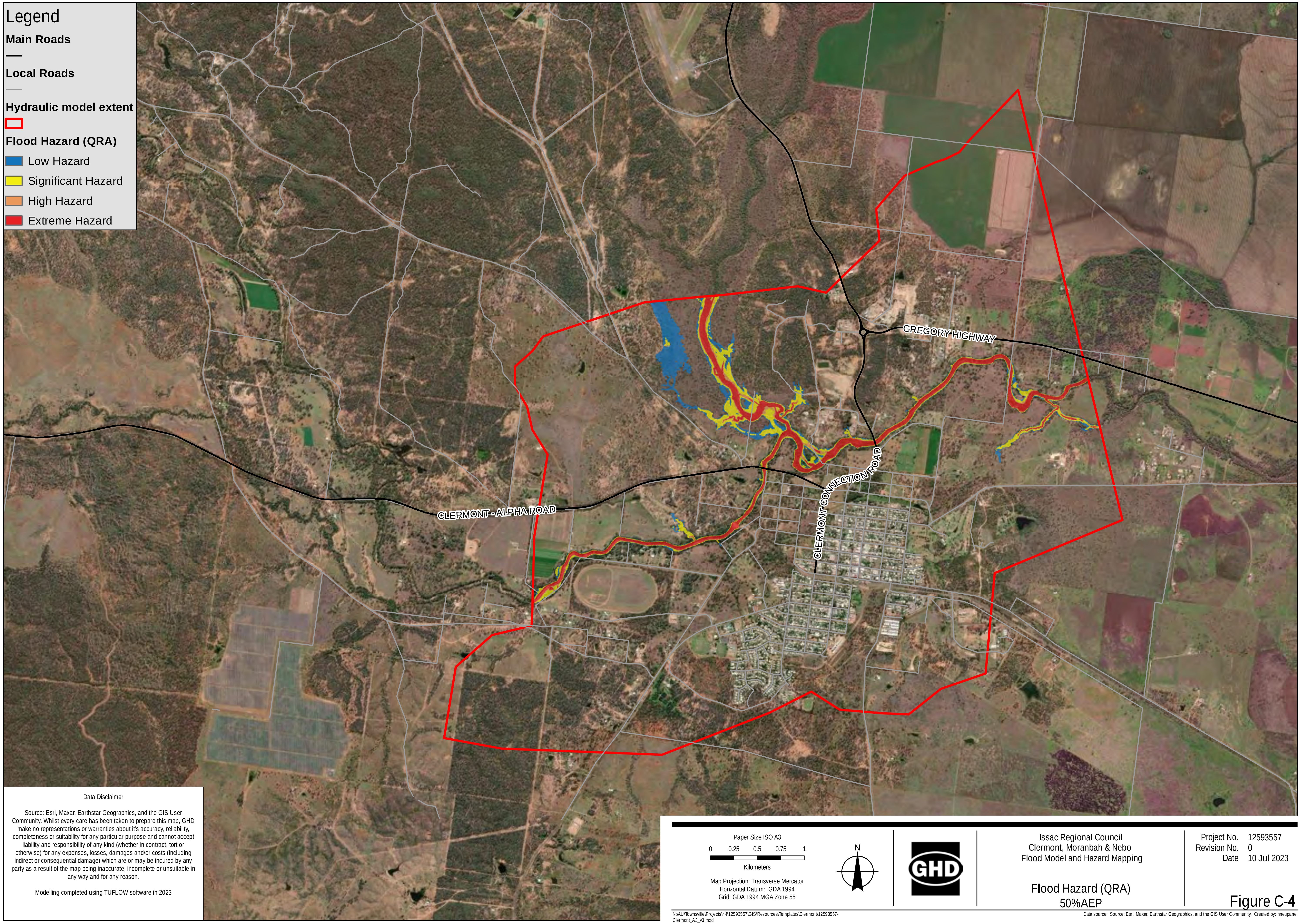
Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard (QRA)
50%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**4**

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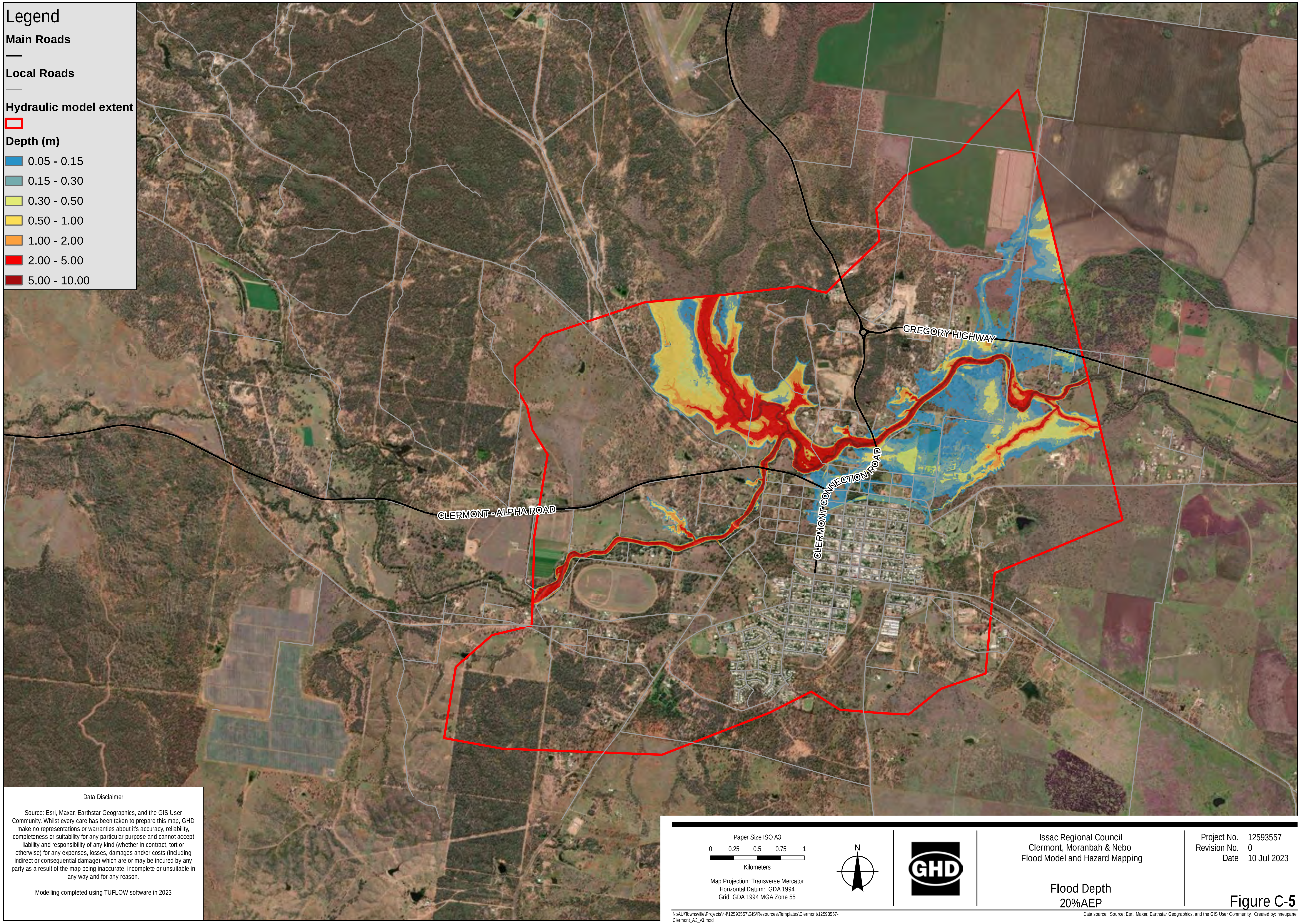

Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Depth
20%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-5

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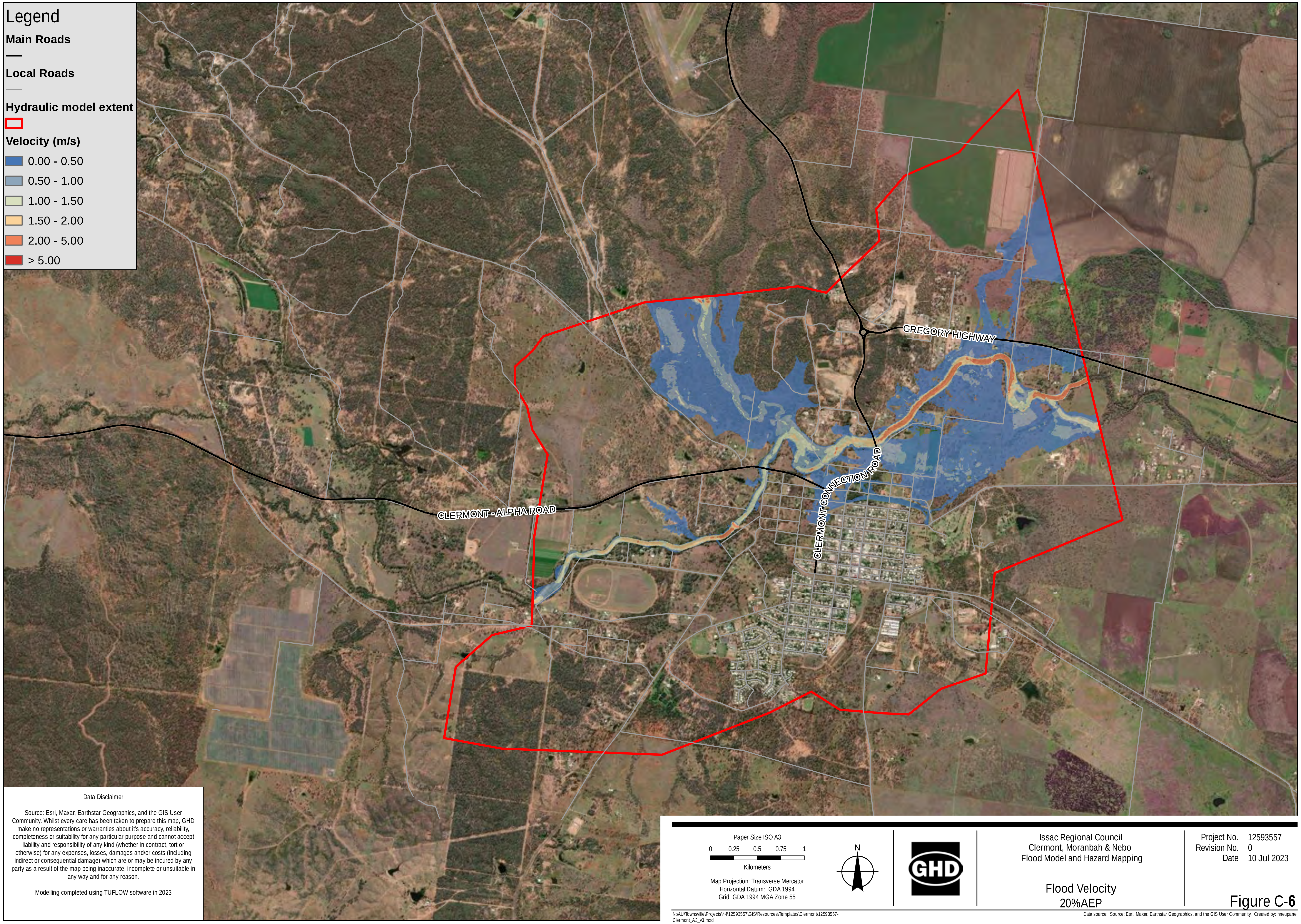
Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Velocity
20%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-6

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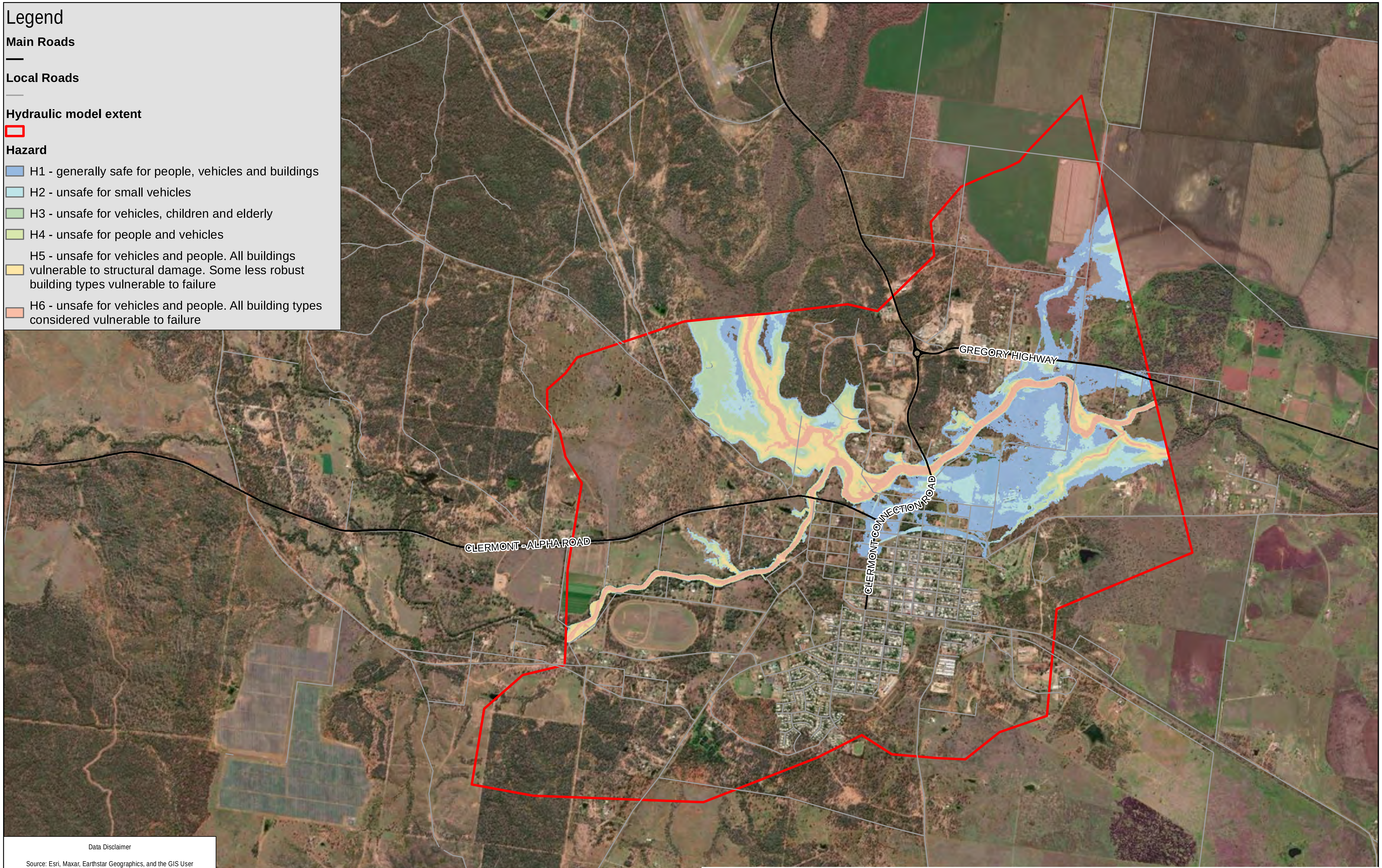
Document Set ID: 5266979
Version: 1, Version Date: 29/08/2024



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Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard
20%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-7

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
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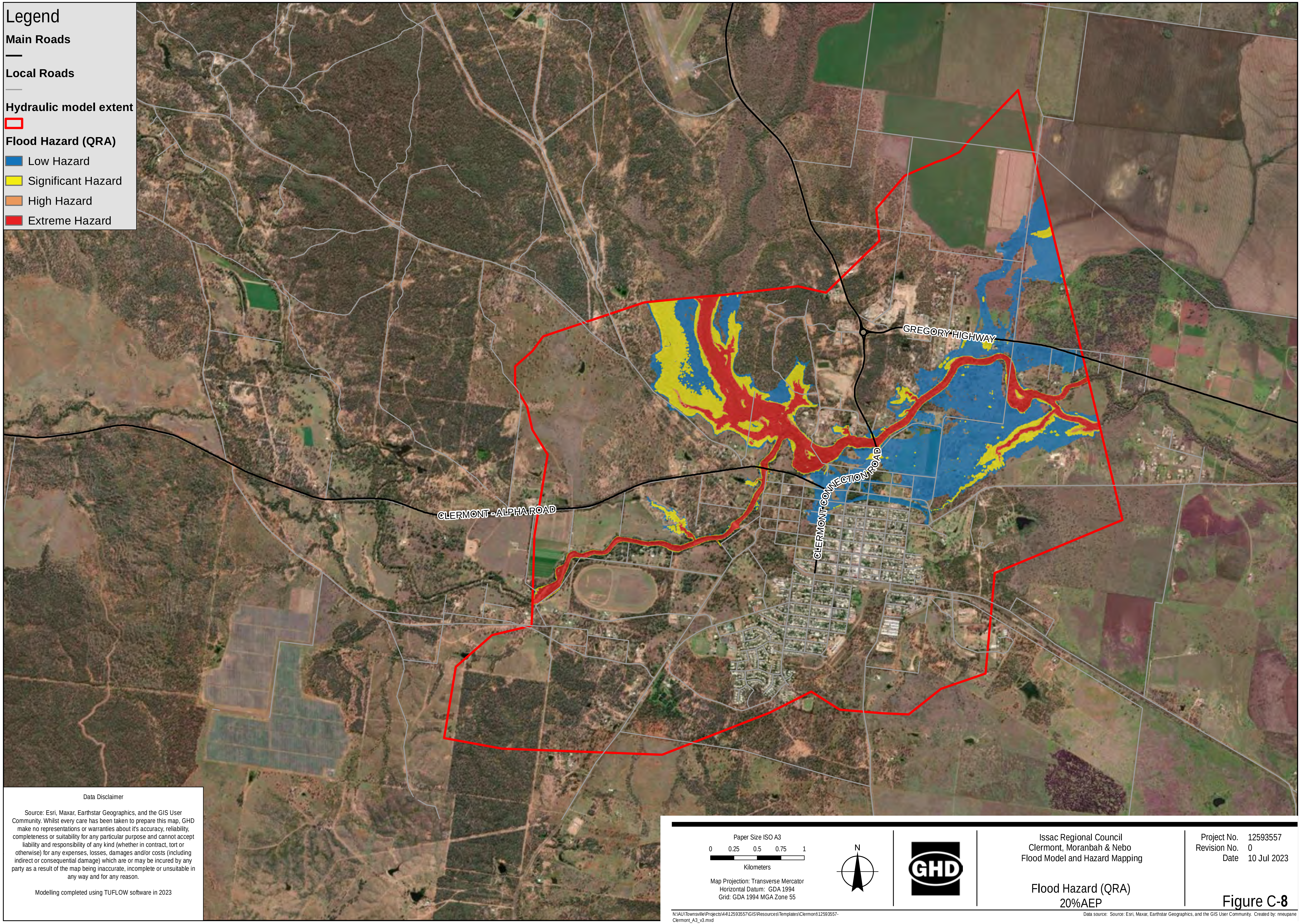

Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard (QRA)
20%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-8

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
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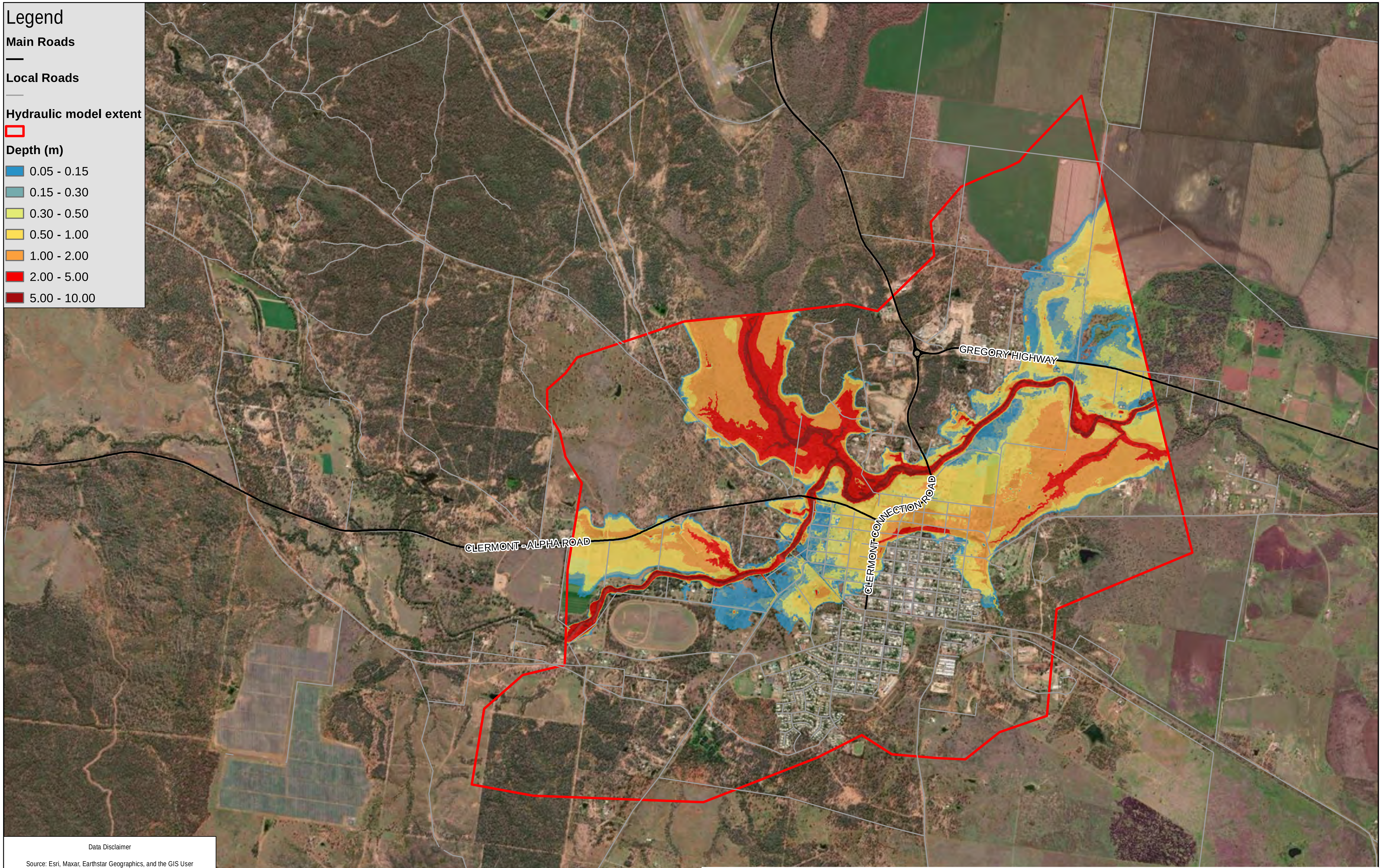

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Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Depth
5%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-9

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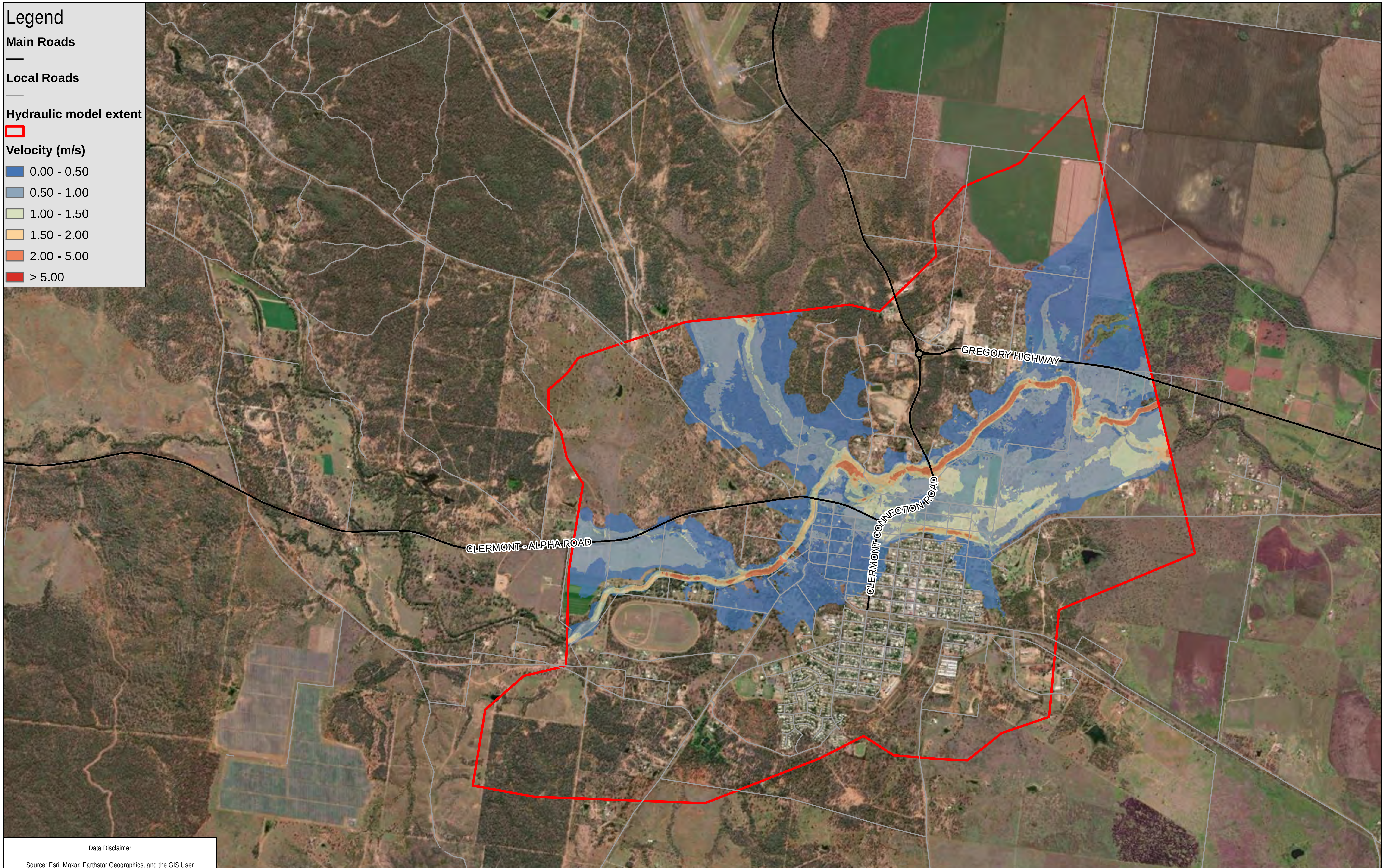

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Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Velocity
5%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**10**

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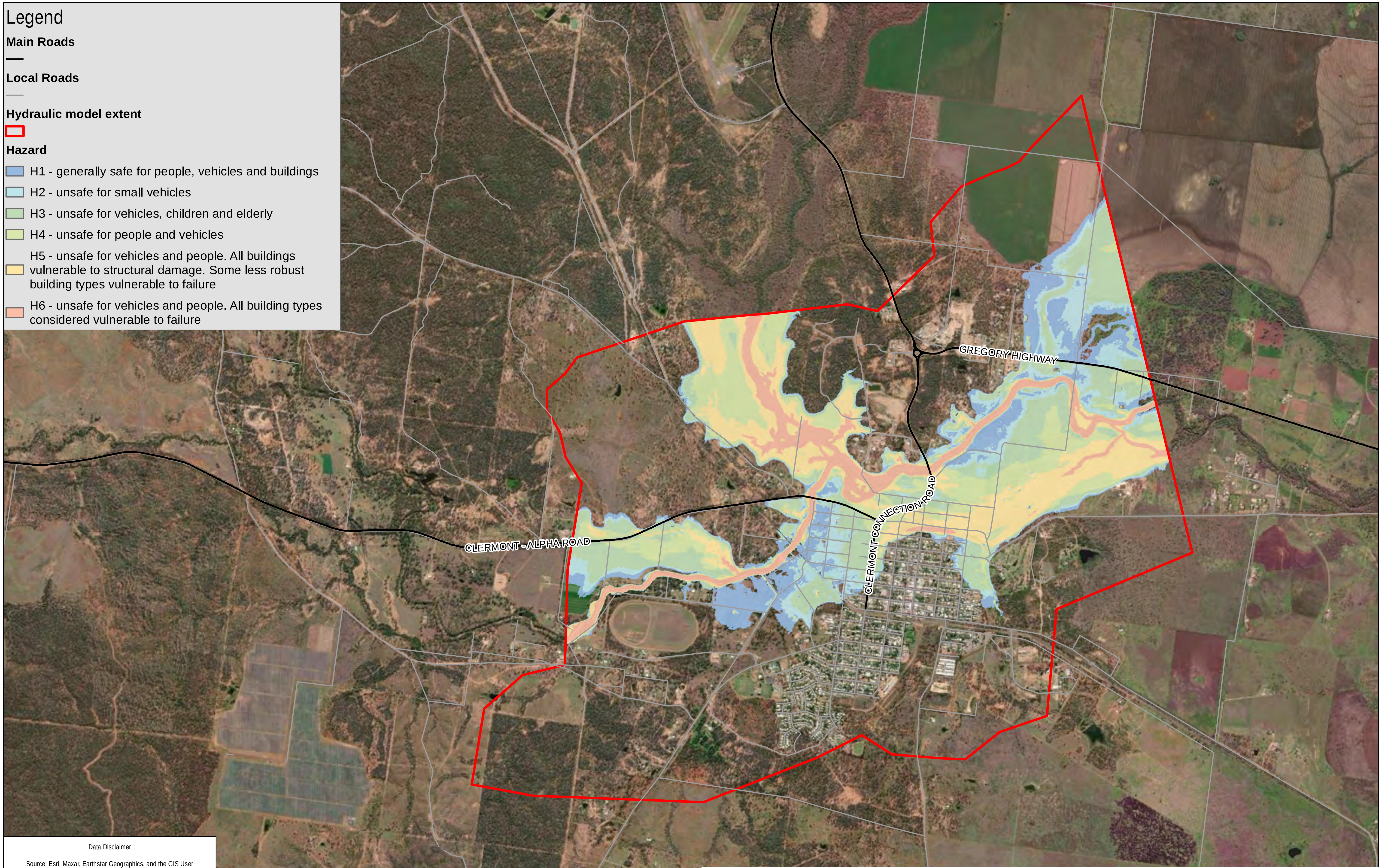

Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard
5%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-11

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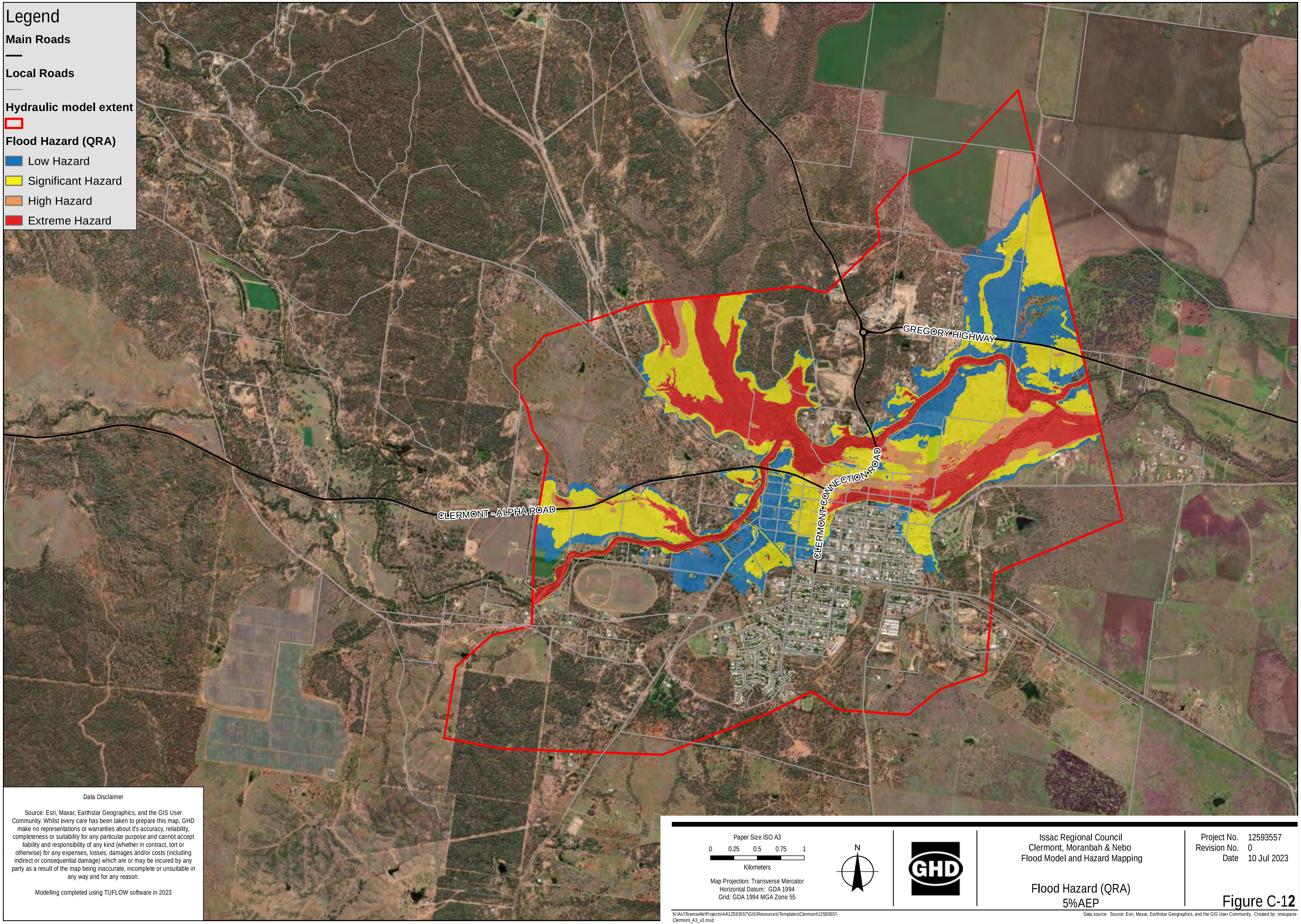

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard (QRA)
5%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-12

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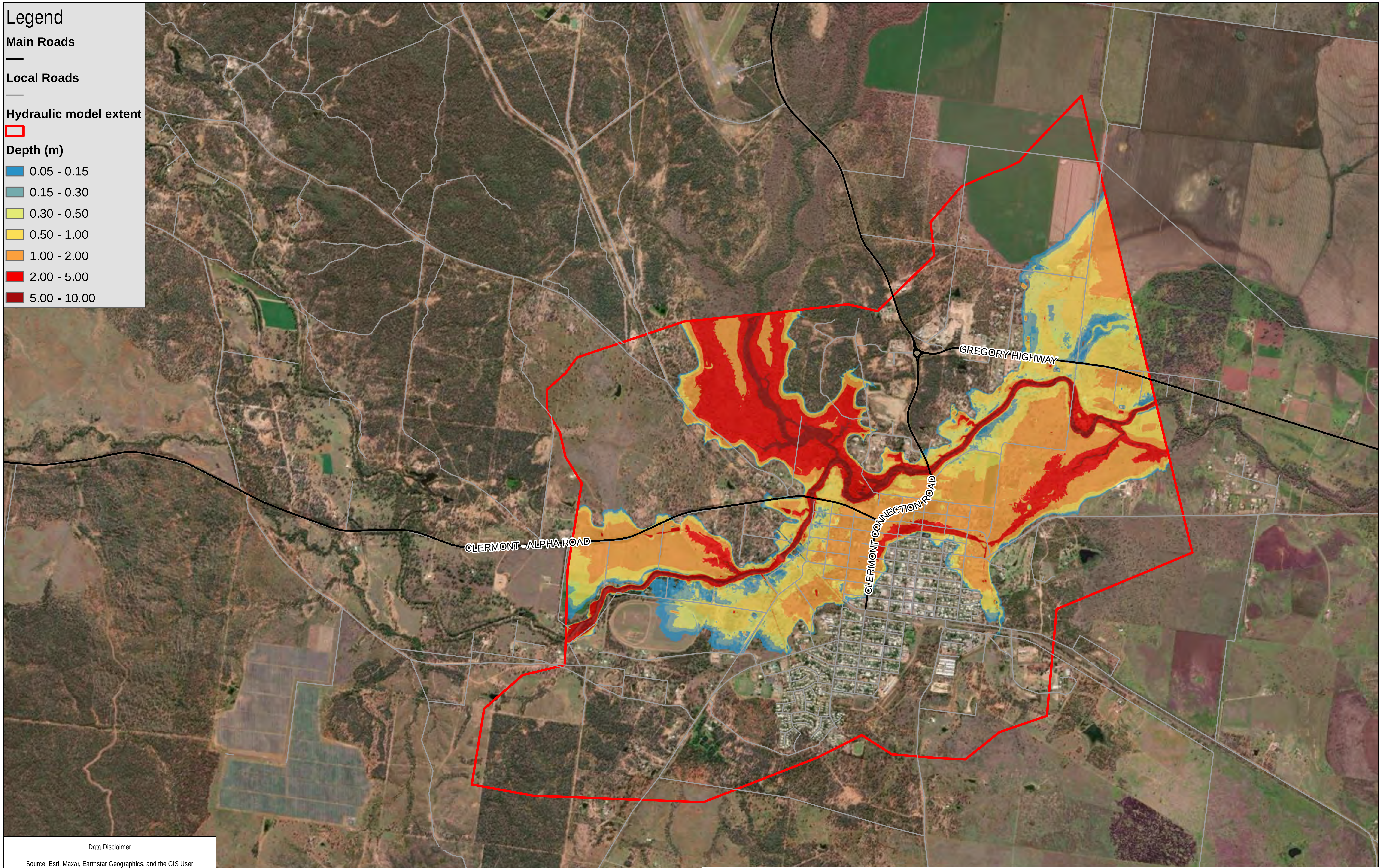

Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Depth
2%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-13

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Print date: 10 Jul 2023 - 14:22 (SMA record: 22)

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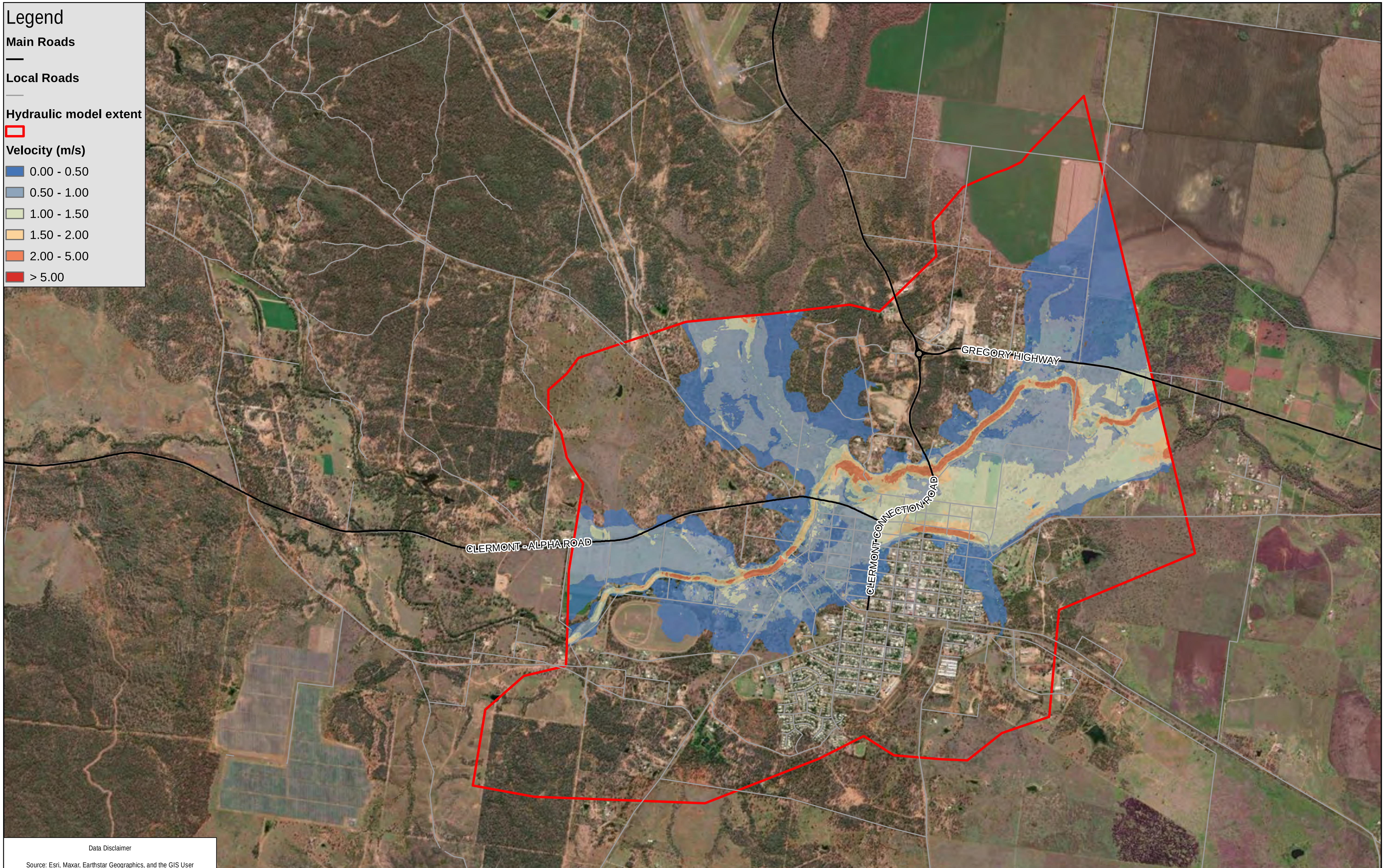
Document Set ID: 5266979
Version: 1, Version Date: 29/08/2024



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Velocity
2%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-14

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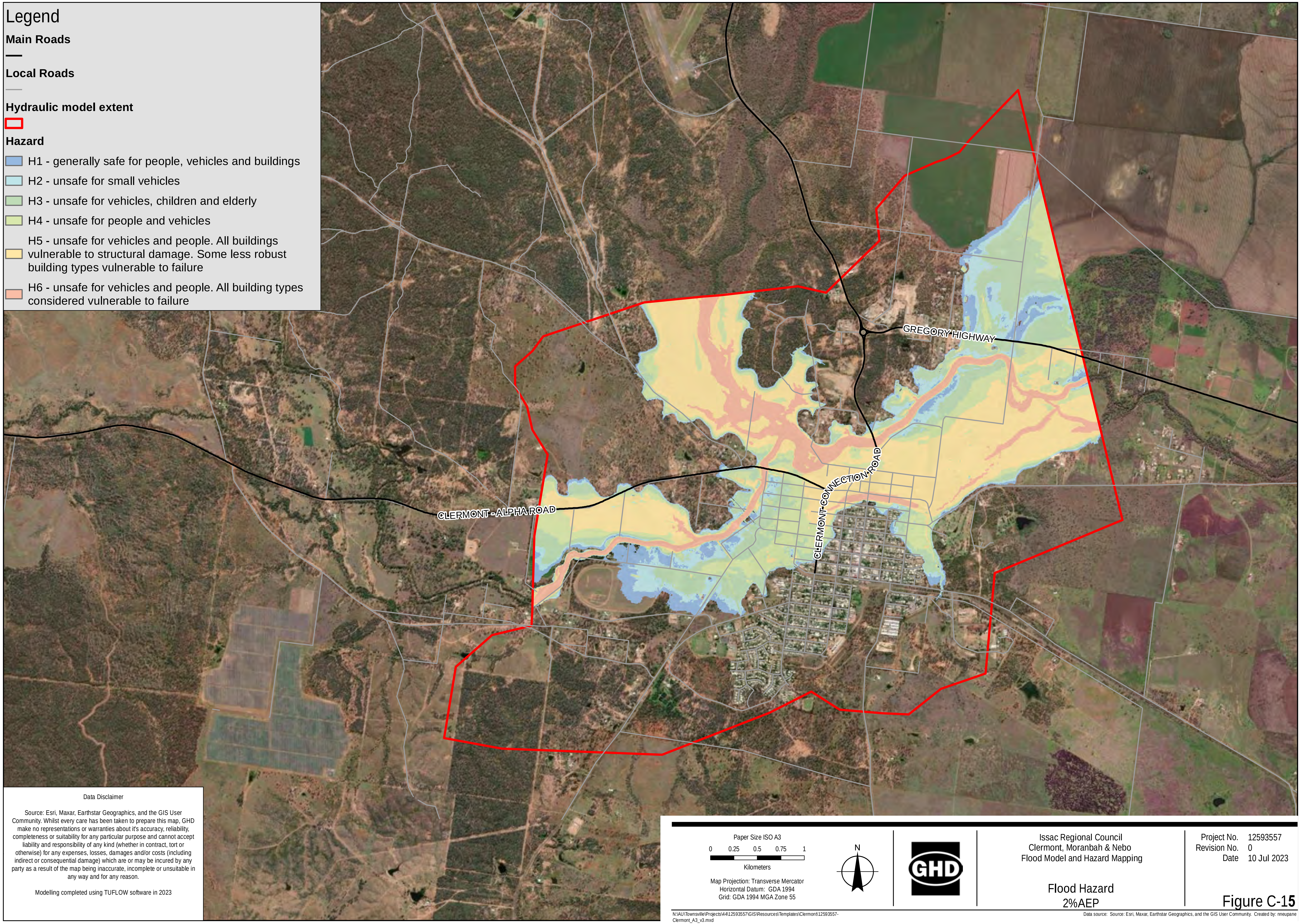

Legend

Main Roads

Local Roads

Hydraulic model extent

Hazard

- H1 - generally safe for people, vehicles and buildings
- H2 - unsafe for small vehicles
- H3 - unsafe for vehicles, children and elderly
- H4 - unsafe for people and vehicles
- H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - unsafe for vehicles and people. All building types considered vulnerable to failure

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard
2%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-15

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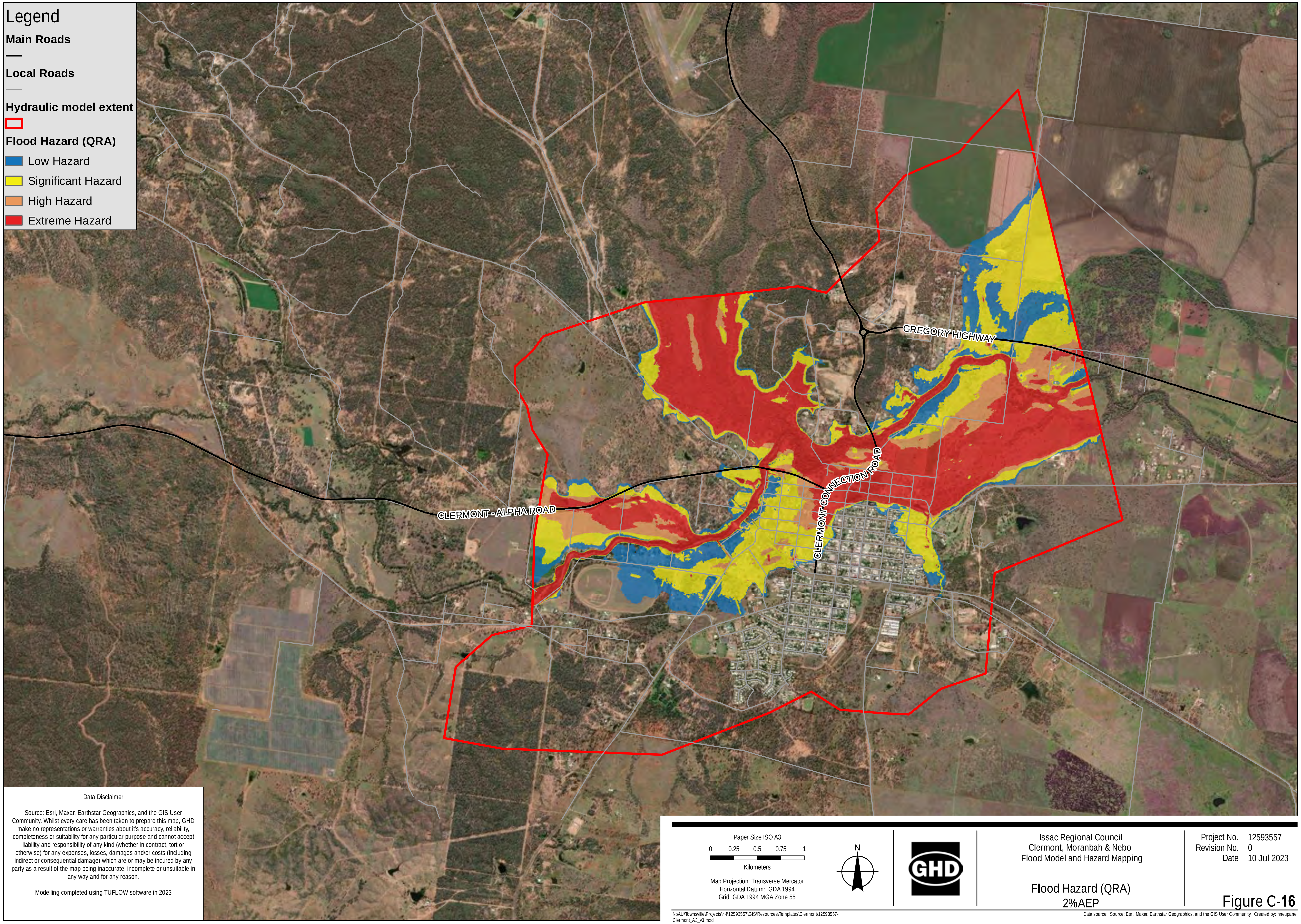
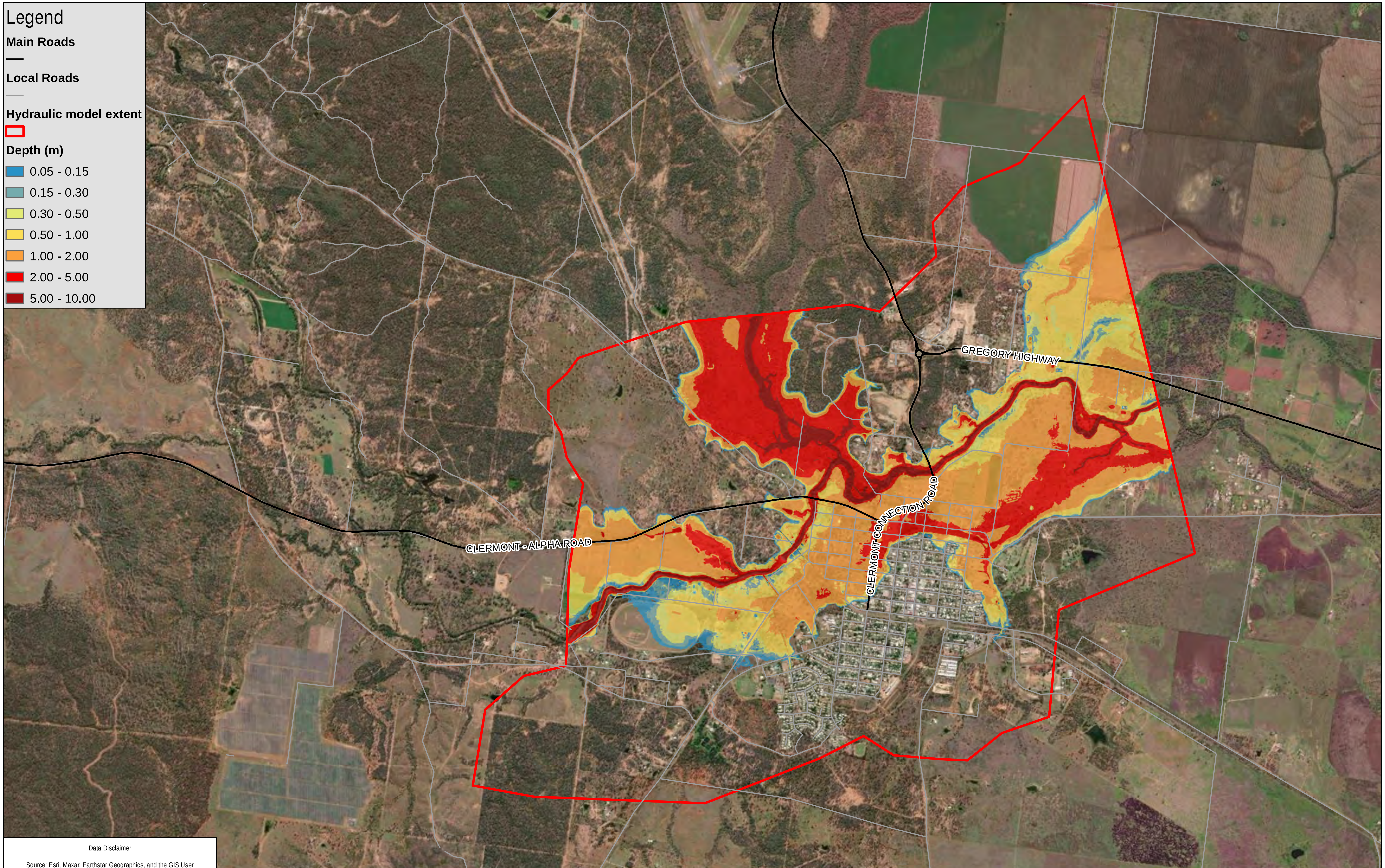
Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Document Set ID: 5266979
Version: 1, Version Date: 29/08/2024



Data Disclaimer

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Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Depth
1%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**17**

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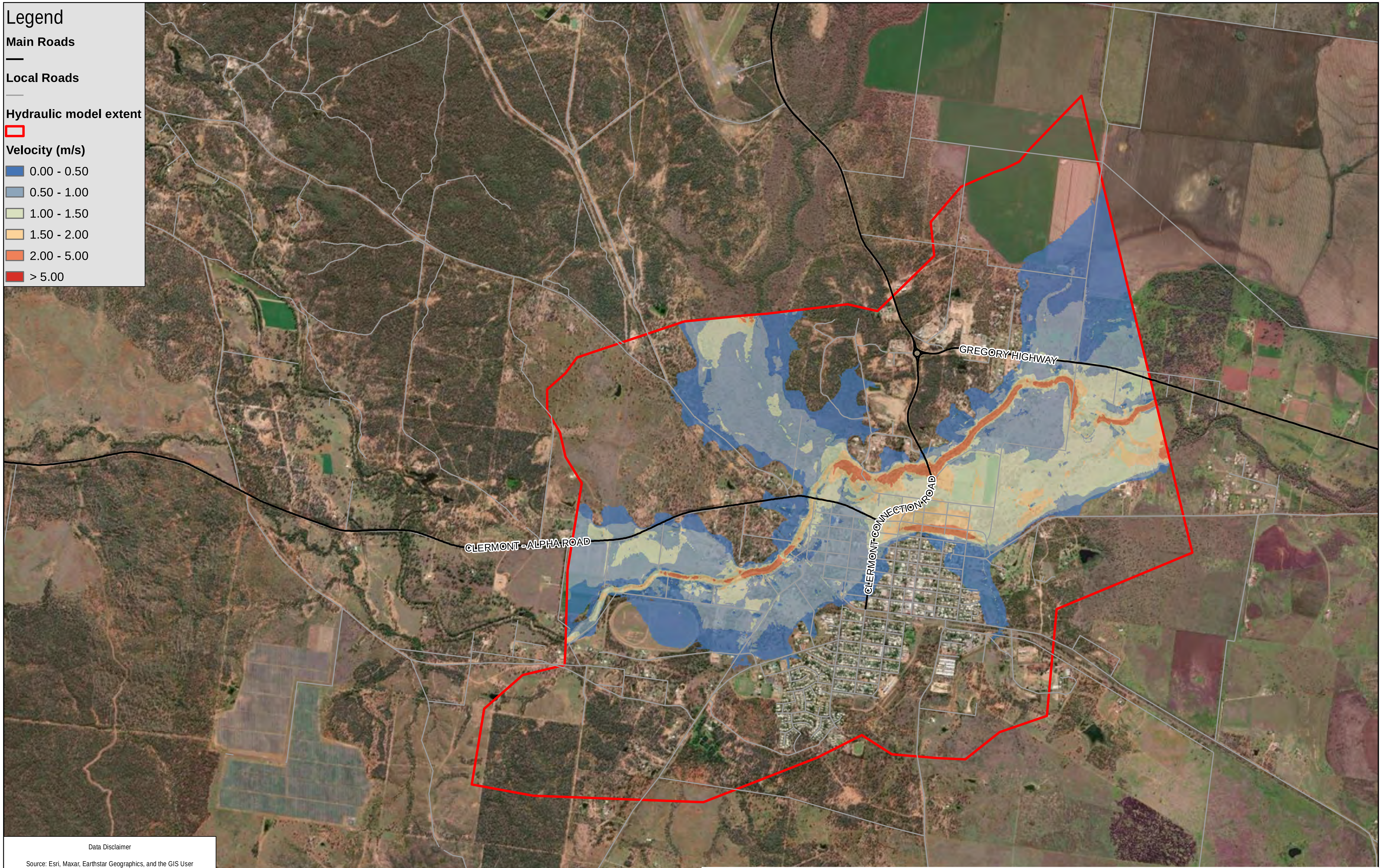
Print date: 10 Jul 2023 - 14:23 (SMA record: 27)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

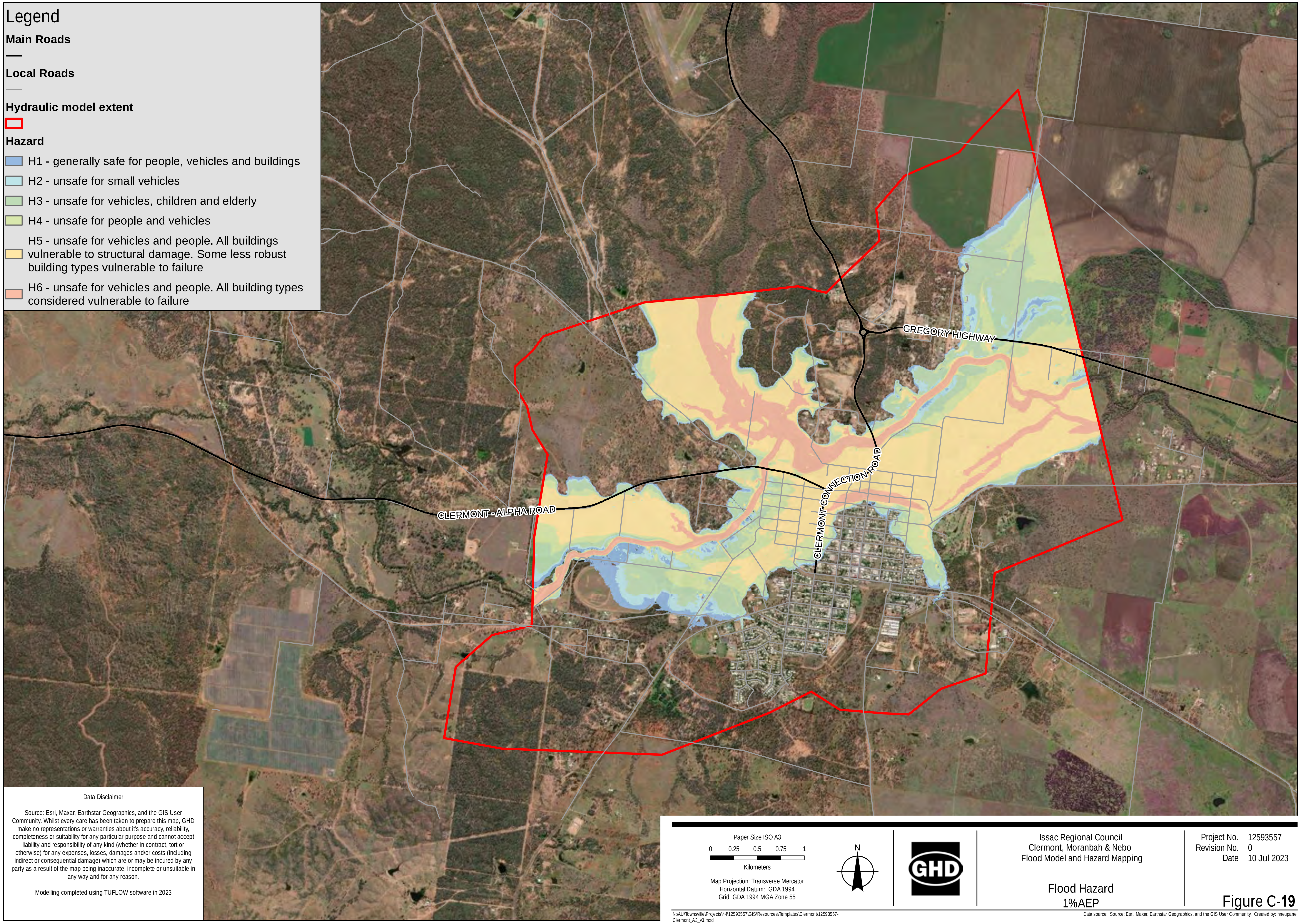
Flood Velocity
1%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-18

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:23 (SMA record: 28)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Legend

Main Roads

Local Roads

Hydraulic model extent

Hazard

- H1 - generally safe for people, vehicles and buildings
- H2 - unsafe for small vehicles
- H3 - unsafe for vehicles, children and elderly
- H4 - unsafe for people and vehicles
- H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - unsafe for vehicles and people. All building types considered vulnerable to failure

Data Disclaimer

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

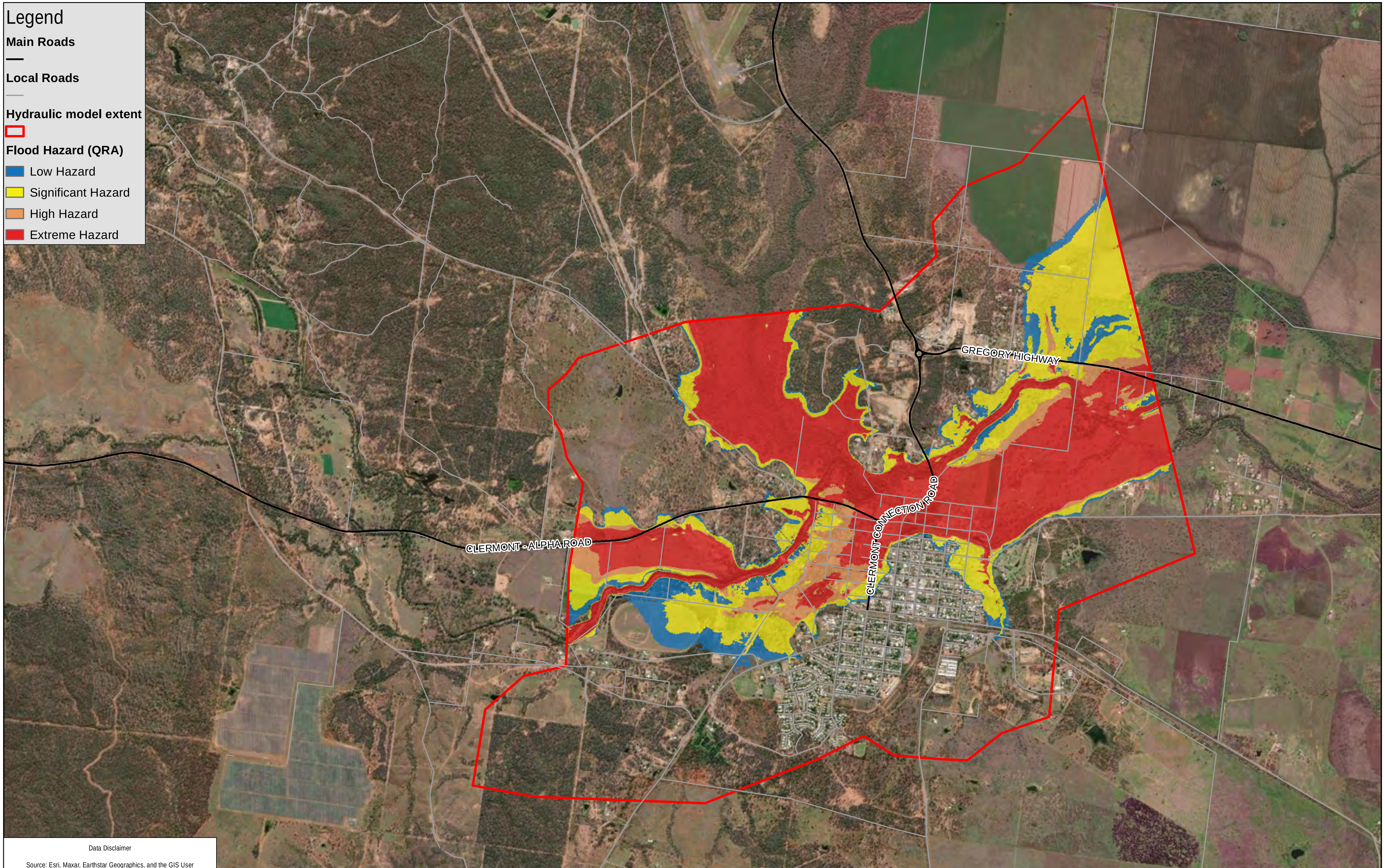
Flood Hazard
1%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**19**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:23 (SMA record: 30)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard (QRA)
1%AEP

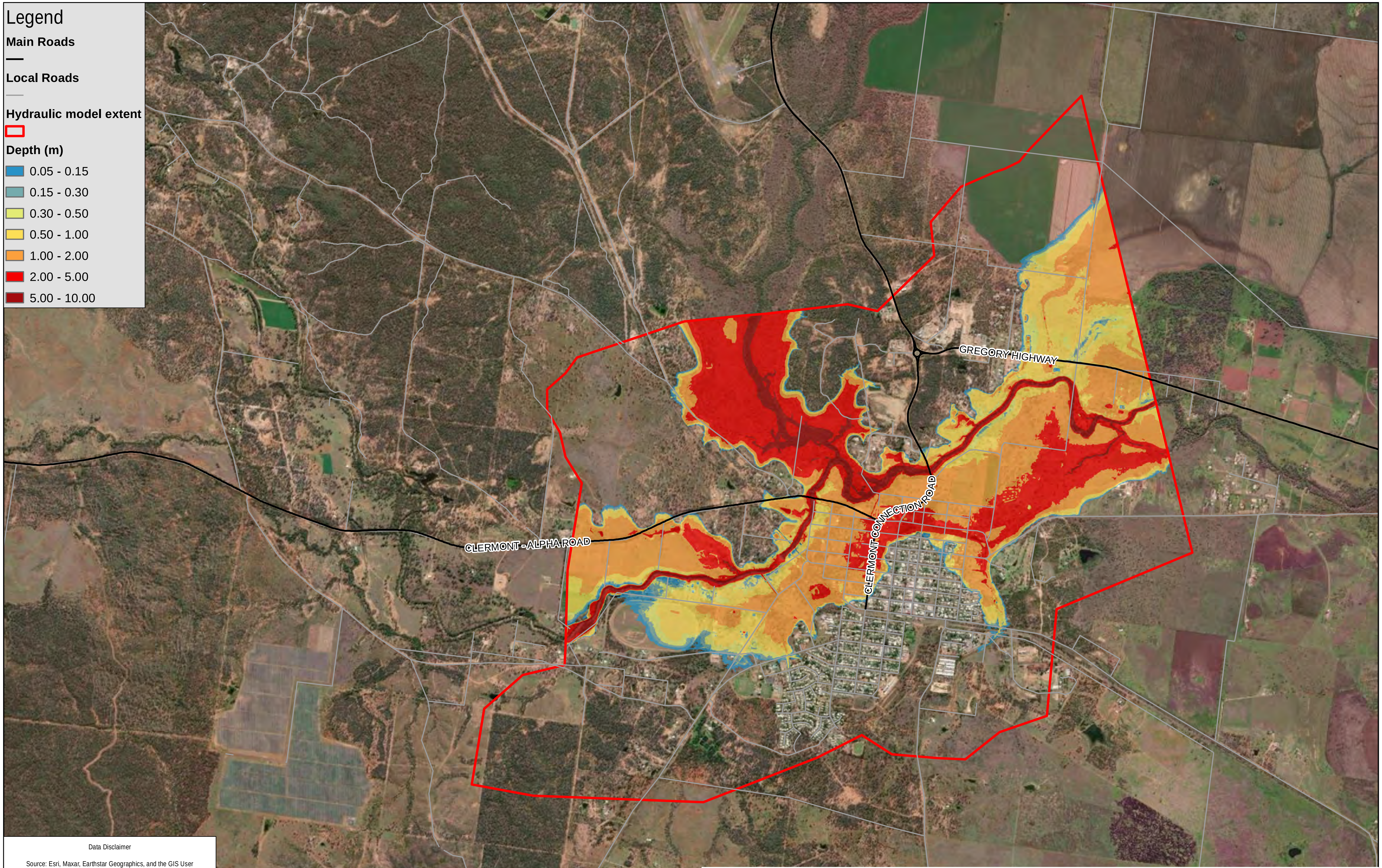
Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-20

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:24 (SMA record: 31)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane

Document Set ID: 5266979
Version: 1, Version Date: 29/08/2024



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

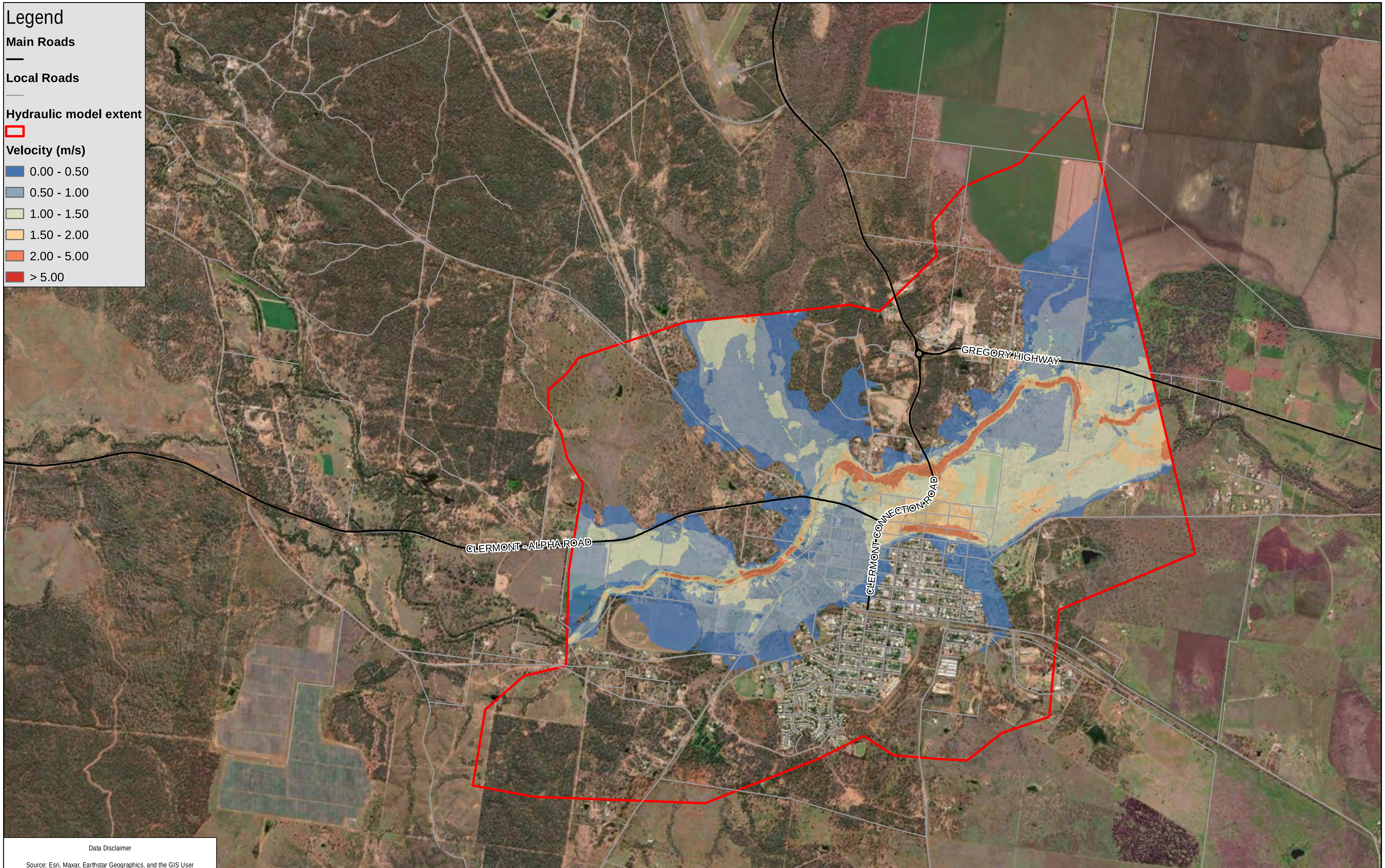
Flood Depth
1%AEP plus climate change (2050)

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-21

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:24 (SMA record: 32)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Velocity
1%AEP plus climate change (2050)

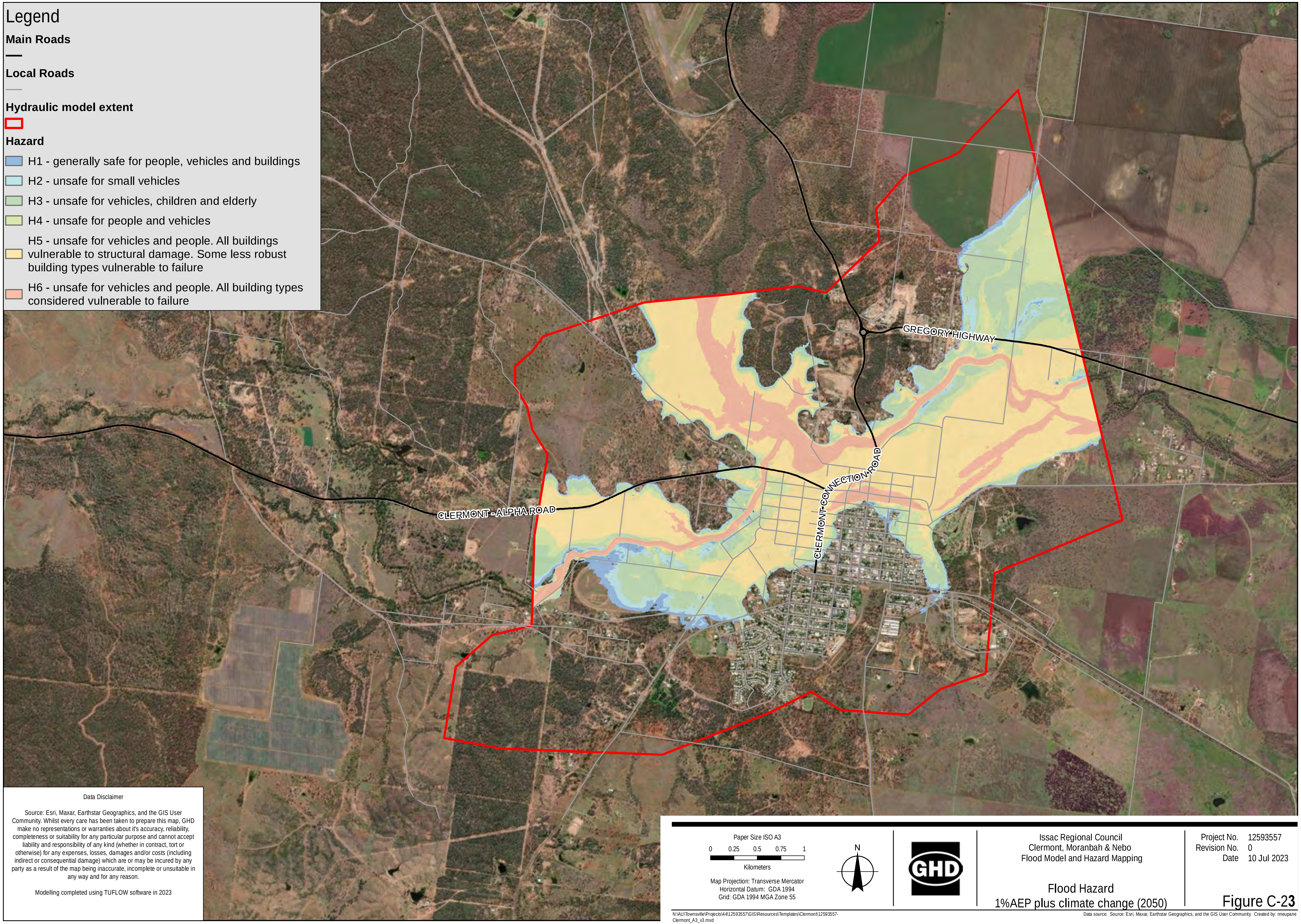
Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-22

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:24 (SMA record: 33)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane

Document Set ID: 5266979
Version: 1, Version Date: 29/08/2024



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

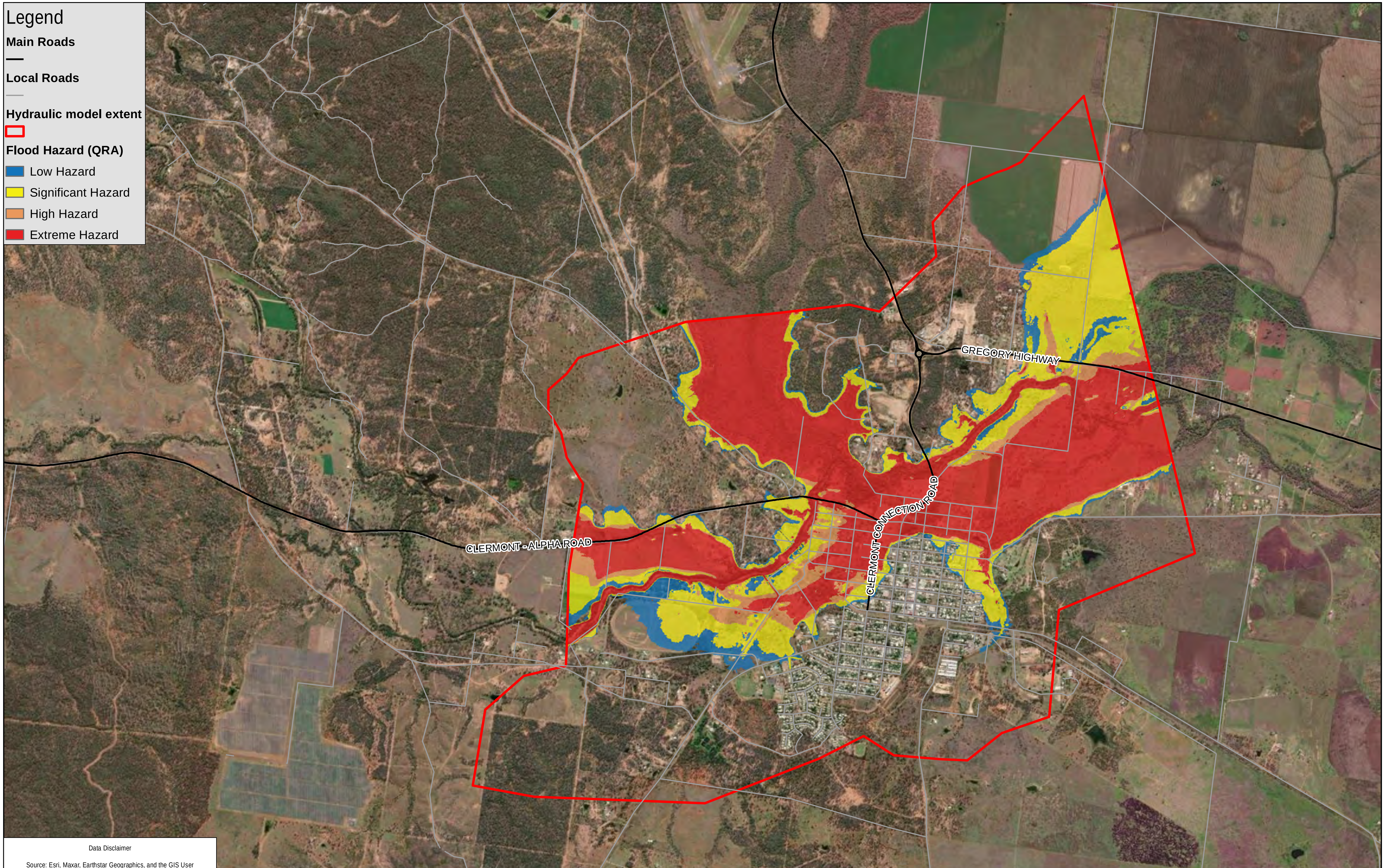
Flood Hazard
1%AEP plus climate change (2050)

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-23

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:25 (SMA record: 35)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

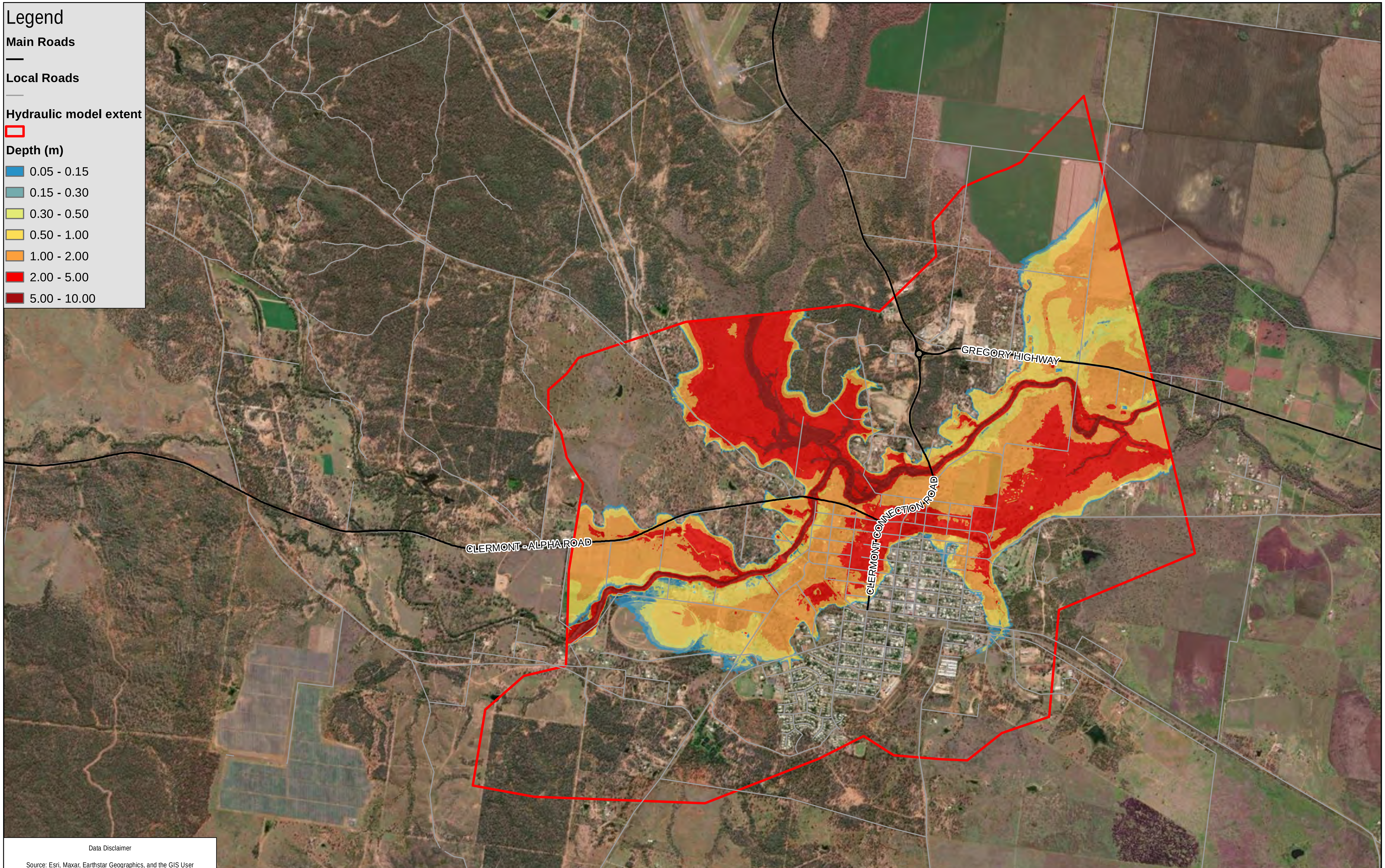
Flood Hazard (QRA)
1%AEP plus climate change (2050)

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-24

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:25 (SMA record: 36)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

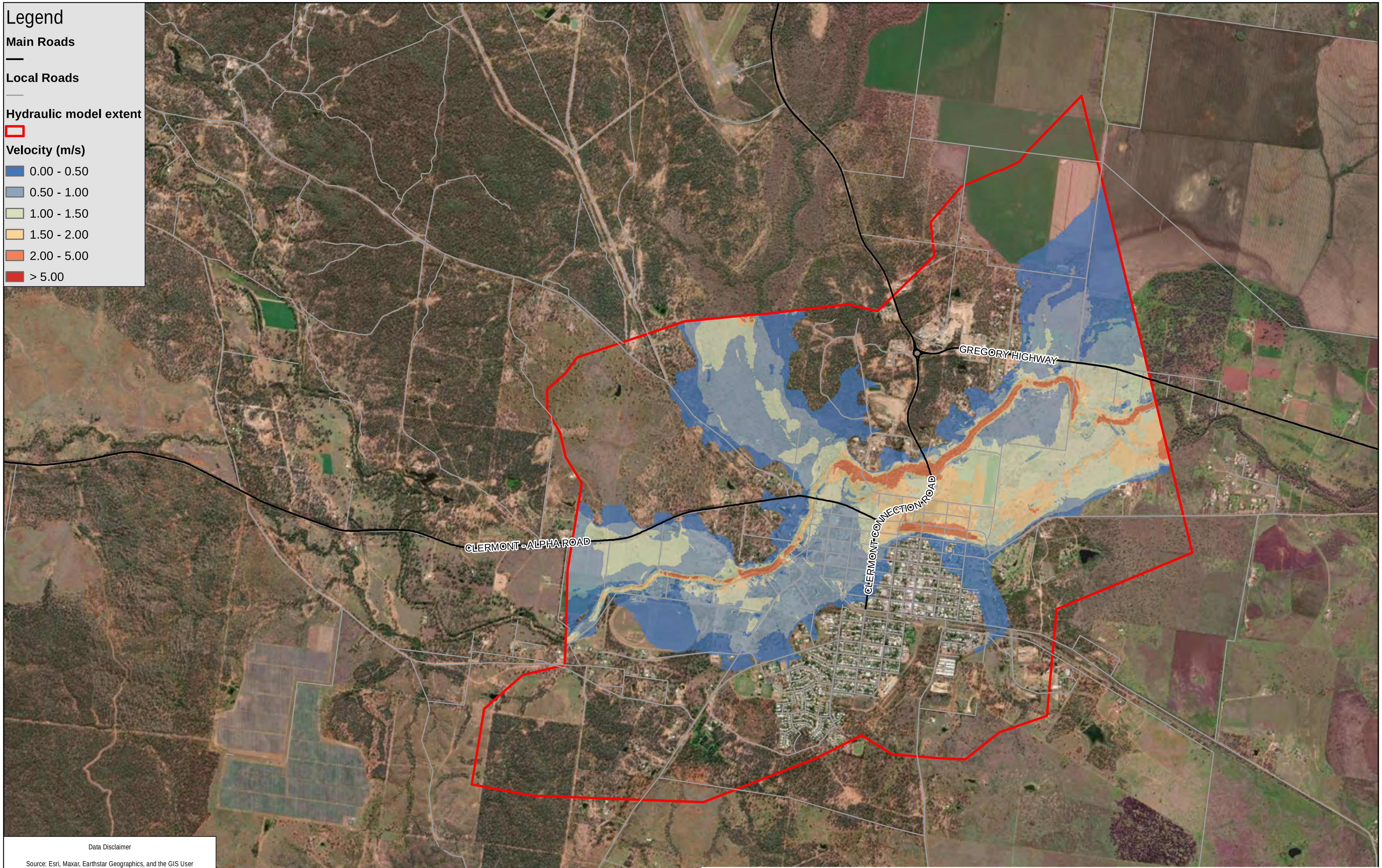
Flood Depth
1%AEP plus climate change (2100)

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**25**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:25 (SMA record: 37)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Velocity
1%AEP plus climate change (2100)

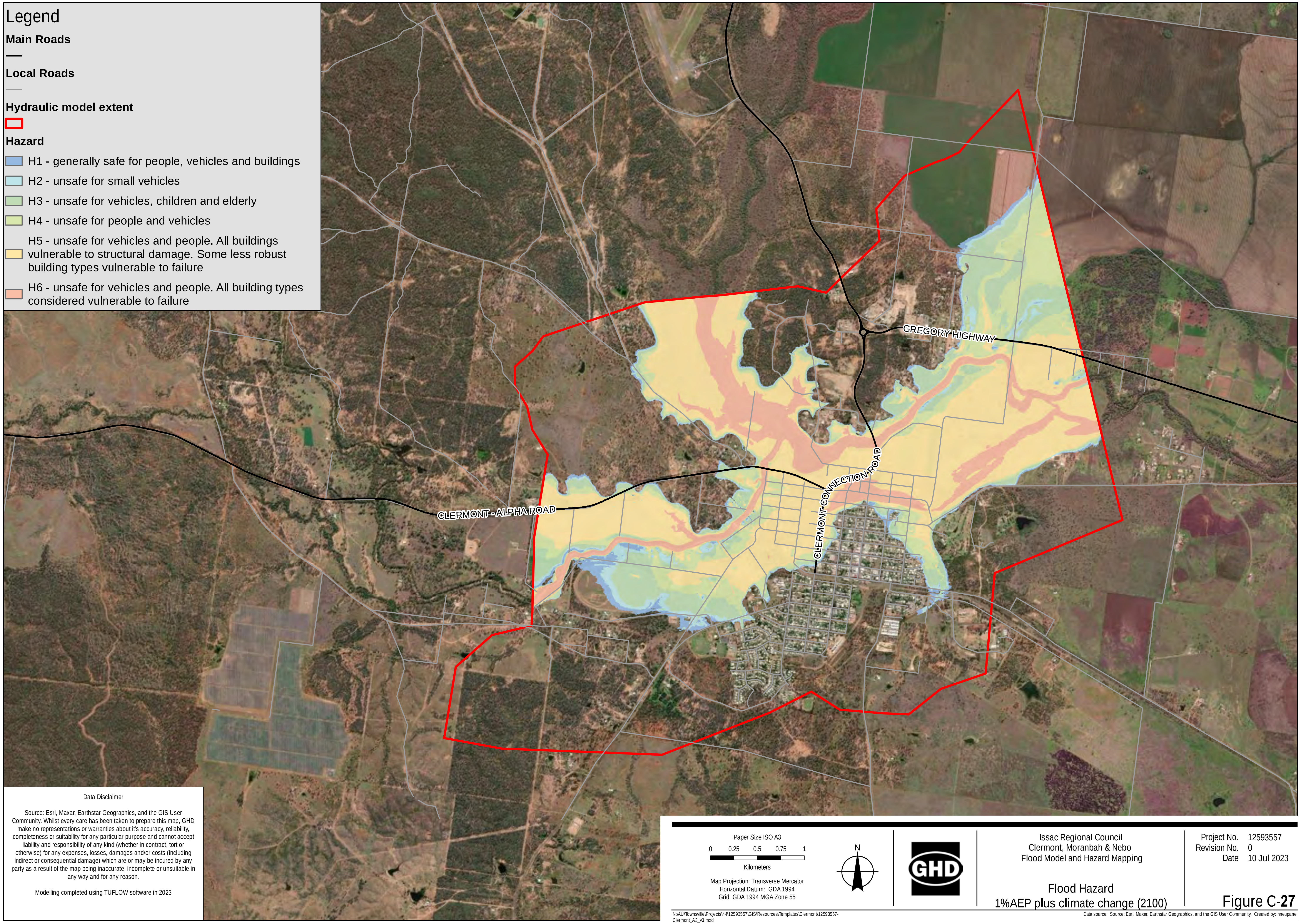
Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**26**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:25 (SMA record: 38)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane

Document Set ID: 5266979
Version: 1, Version Date: 29/08/2024



Legend

Main Roads

Local Roads

Hydraulic model extent

Hazard

- H1 - generally safe for people, vehicles and buildings
- H2 - unsafe for small vehicles
- H3 - unsafe for vehicles, children and elderly
- H4 - unsafe for people and vehicles
- H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - unsafe for vehicles and people. All building types considered vulnerable to failure

Data Disclaimer

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

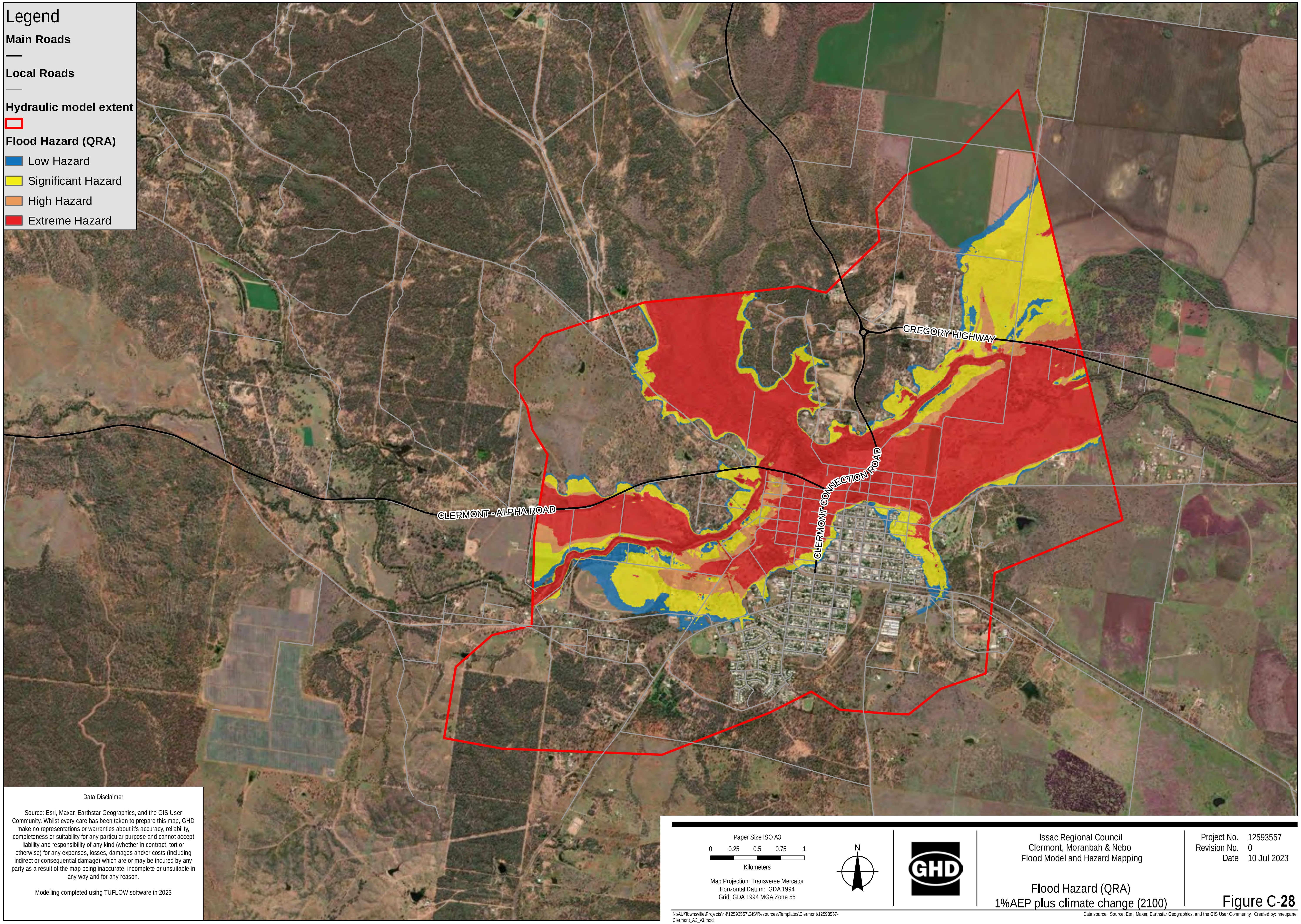
Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Flood Hazard
1%AEP plus climate change (2100)

Figure C-**27**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:26 (SMA record: 40)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

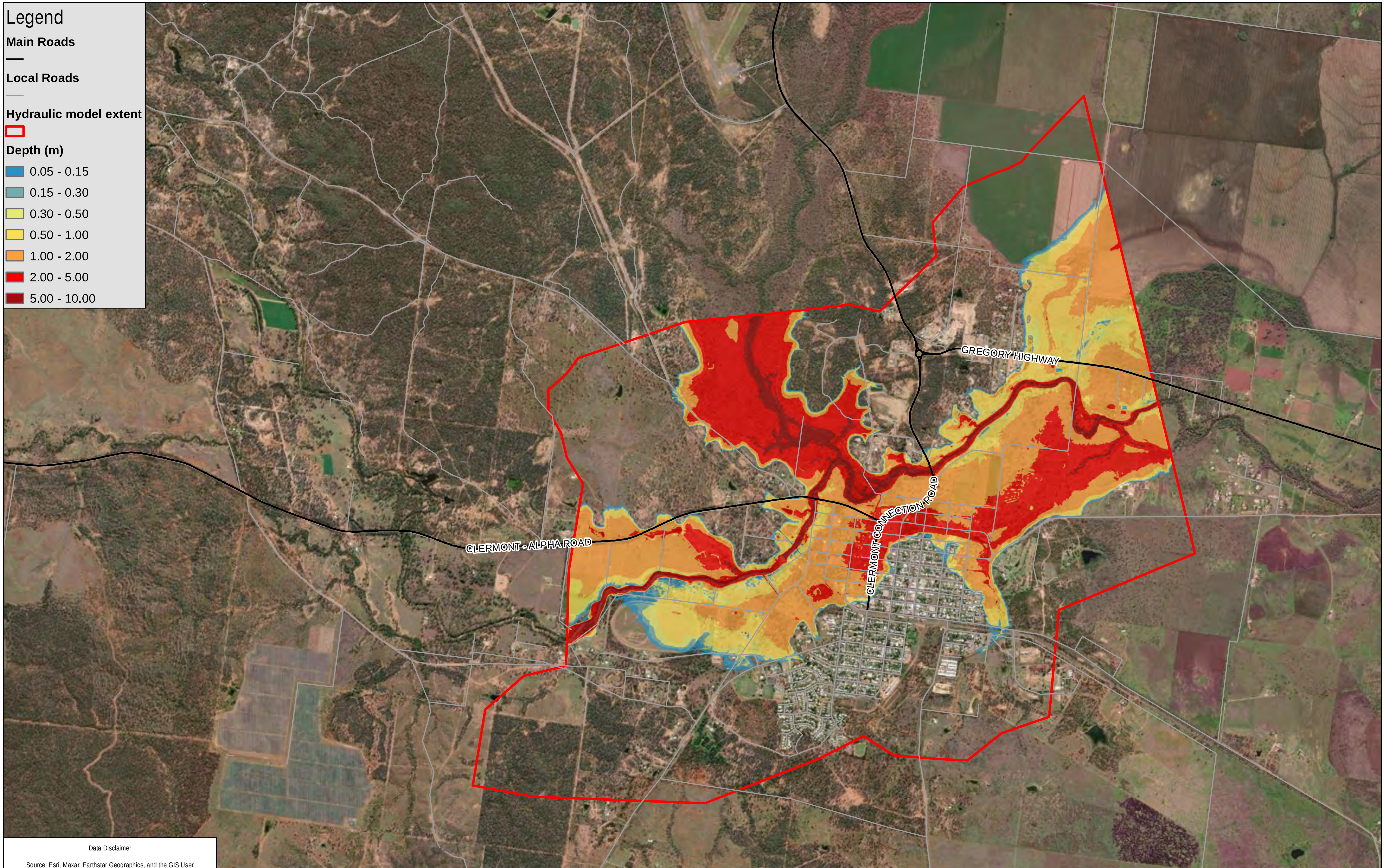
Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Flood Hazard (QRA)
1%AEP plus climate change (2100)

Figure C-**28**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:26 (SMA record: 41)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

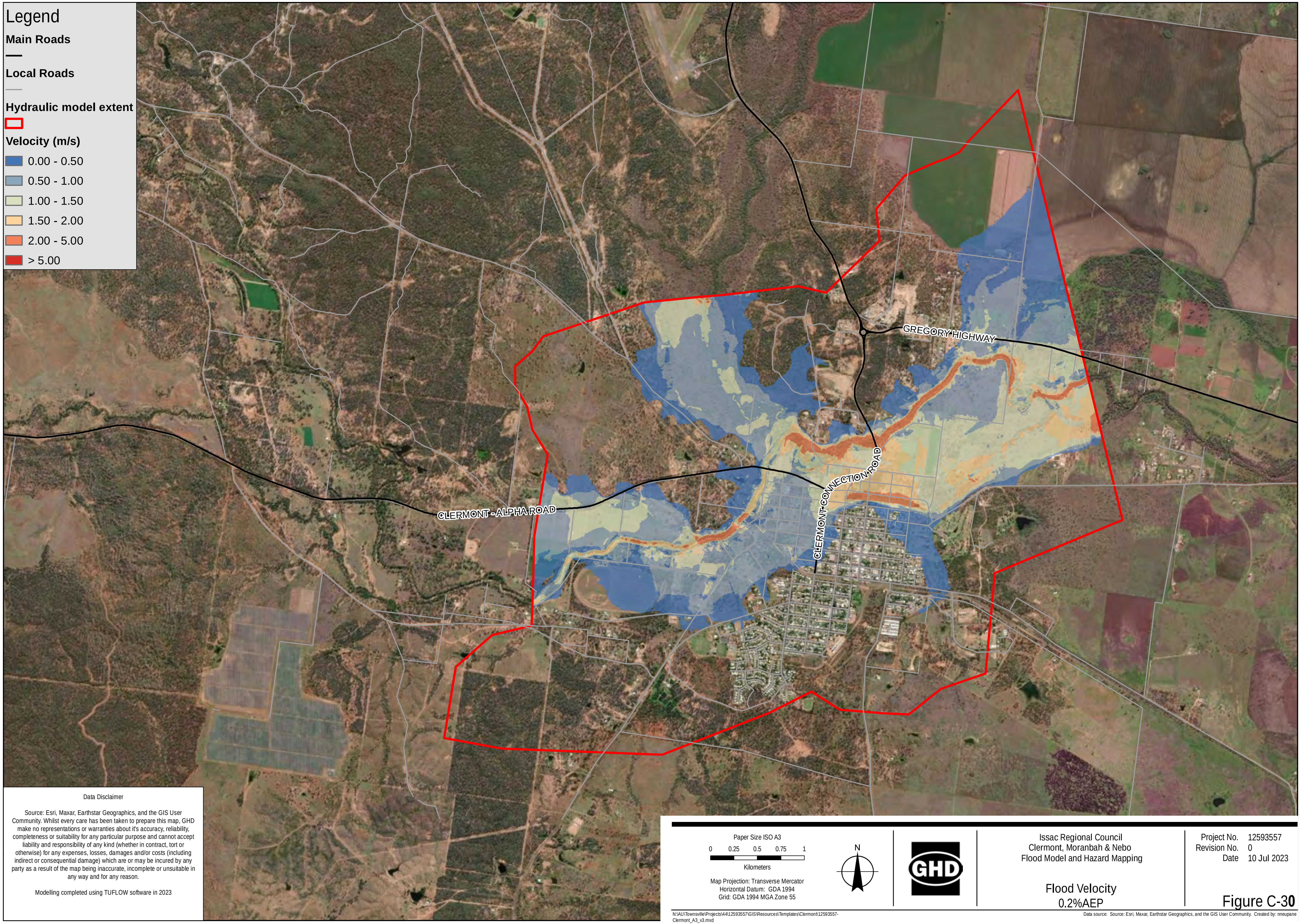
Flood Depth
0.2%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**29**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:26 (SMA record: 42)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

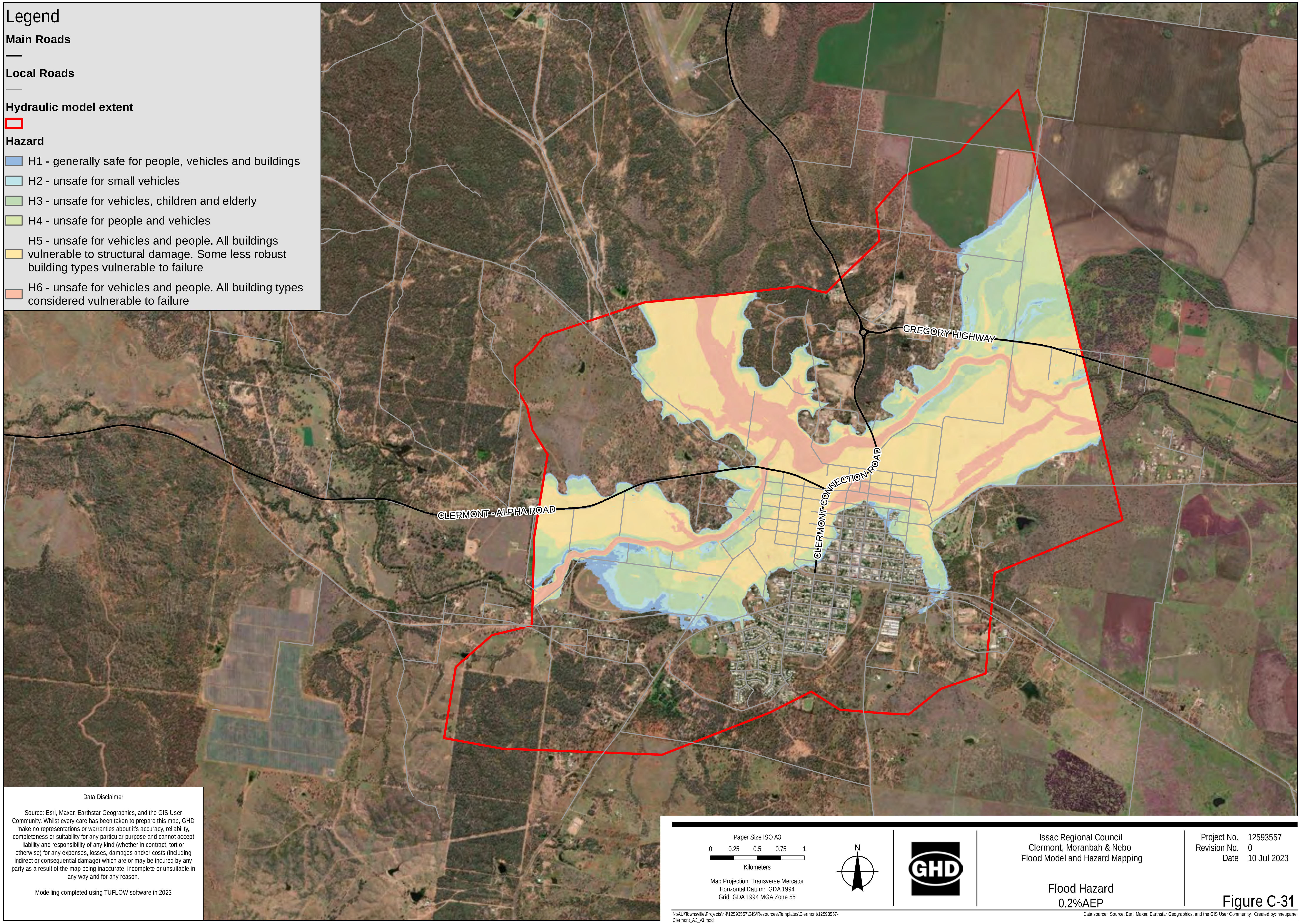
Flood Velocity
0.2%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-30

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:27 (SMA record: 43)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Legend

Main Roads

Local Roads

Hydraulic model extent

Hazard

- H1 - generally safe for people, vehicles and buildings
- H2 - unsafe for small vehicles
- H3 - unsafe for vehicles, children and elderly
- H4 - unsafe for people and vehicles
- H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - unsafe for vehicles and people. All building types considered vulnerable to failure

Data Disclaimer

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

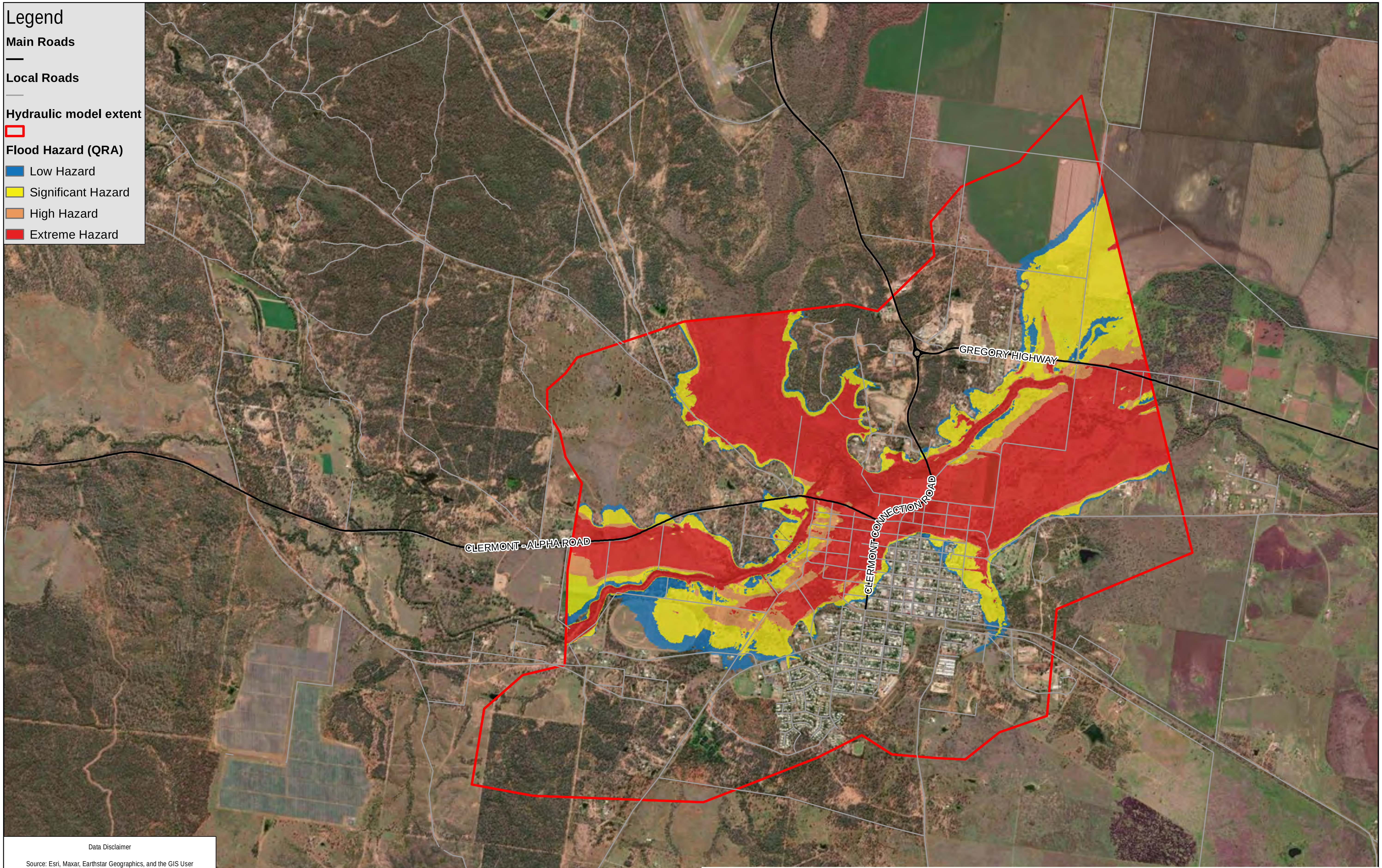
Flood Hazard
0.2%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-31

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:27 (SMA record: 45)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

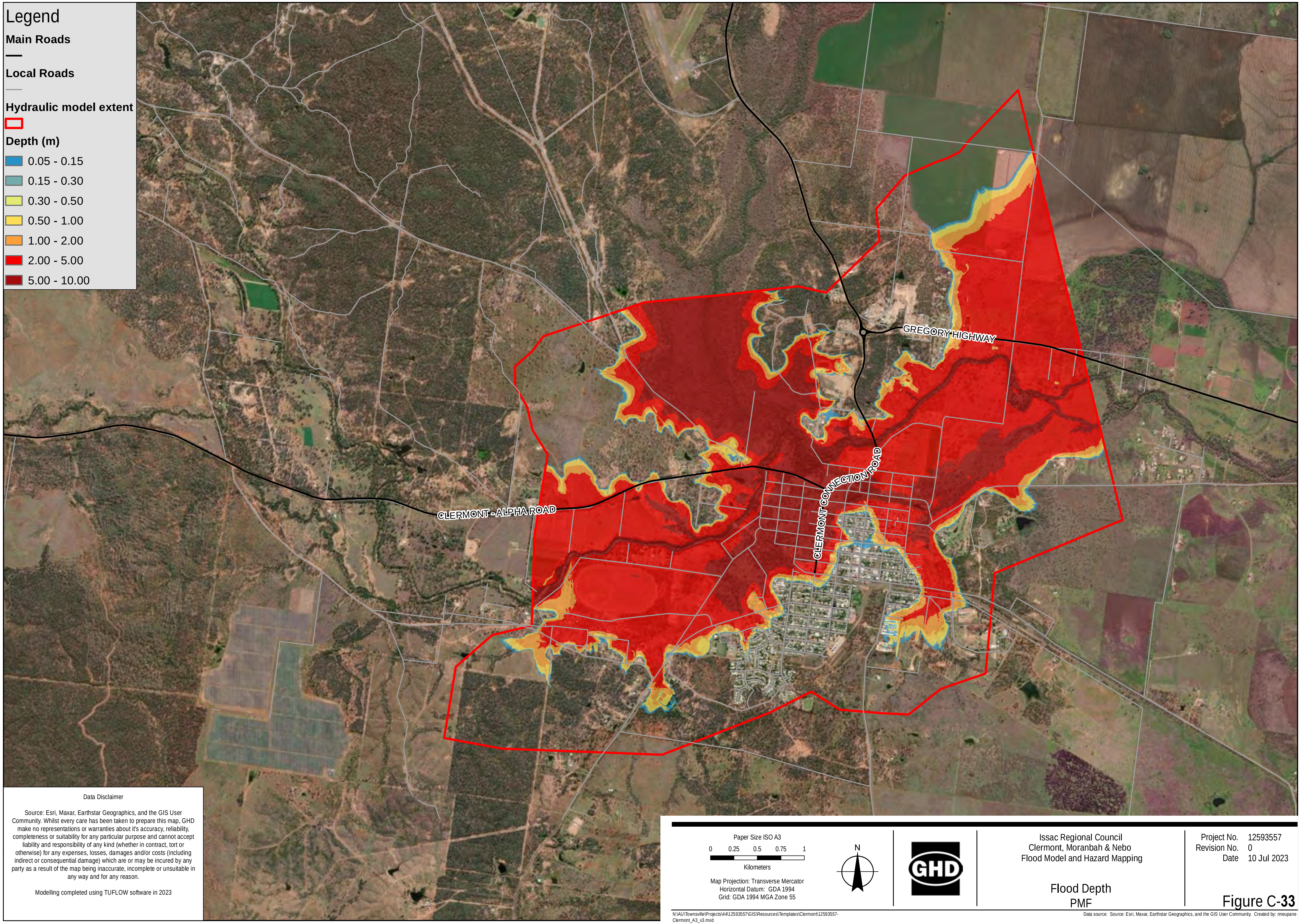
Flood Hazard (QRA)
0.2%AEP

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**32**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:27 (SMA record: 46)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

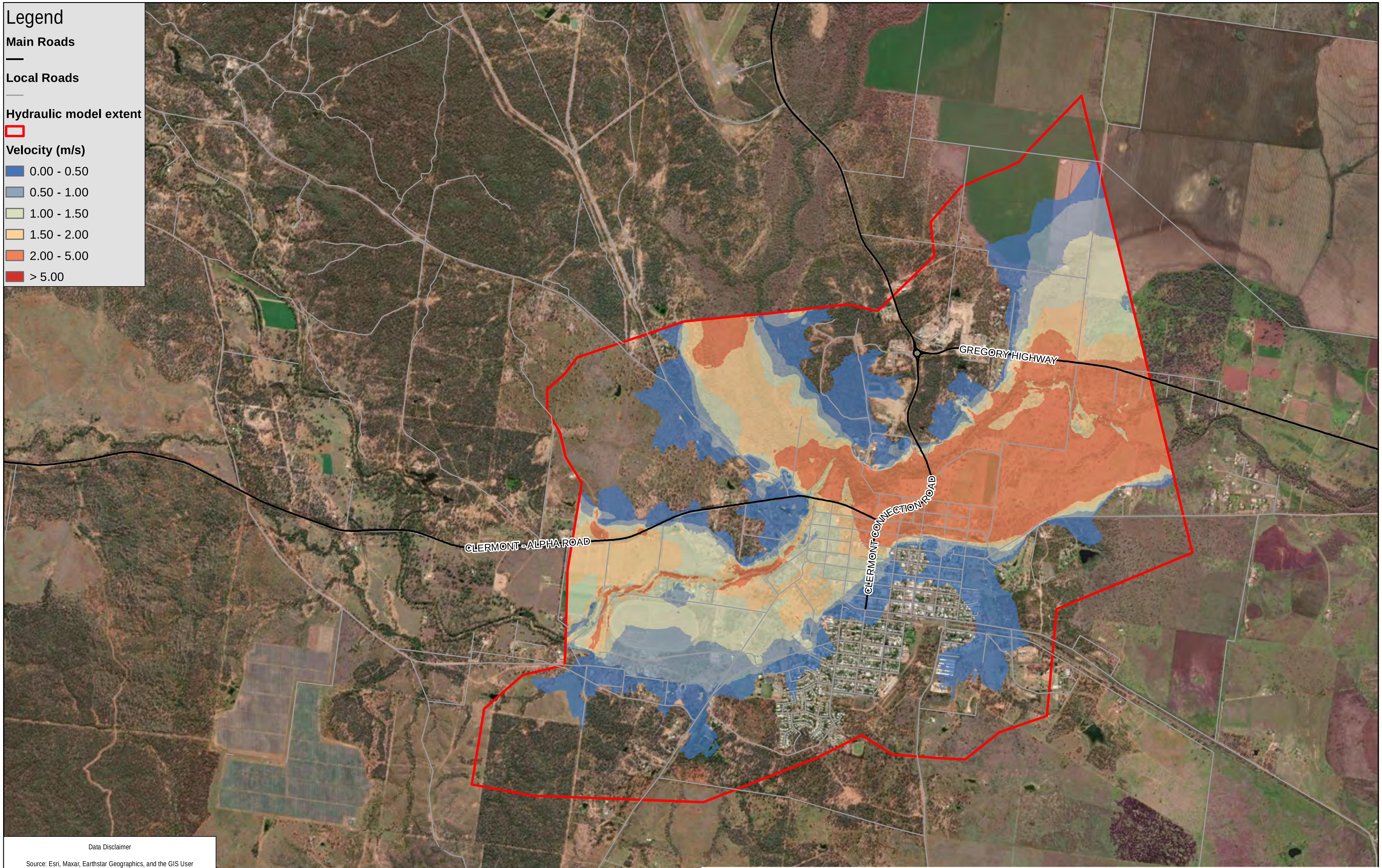
Flood Depth
PMF

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-33

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:28 (SMA record: 47)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

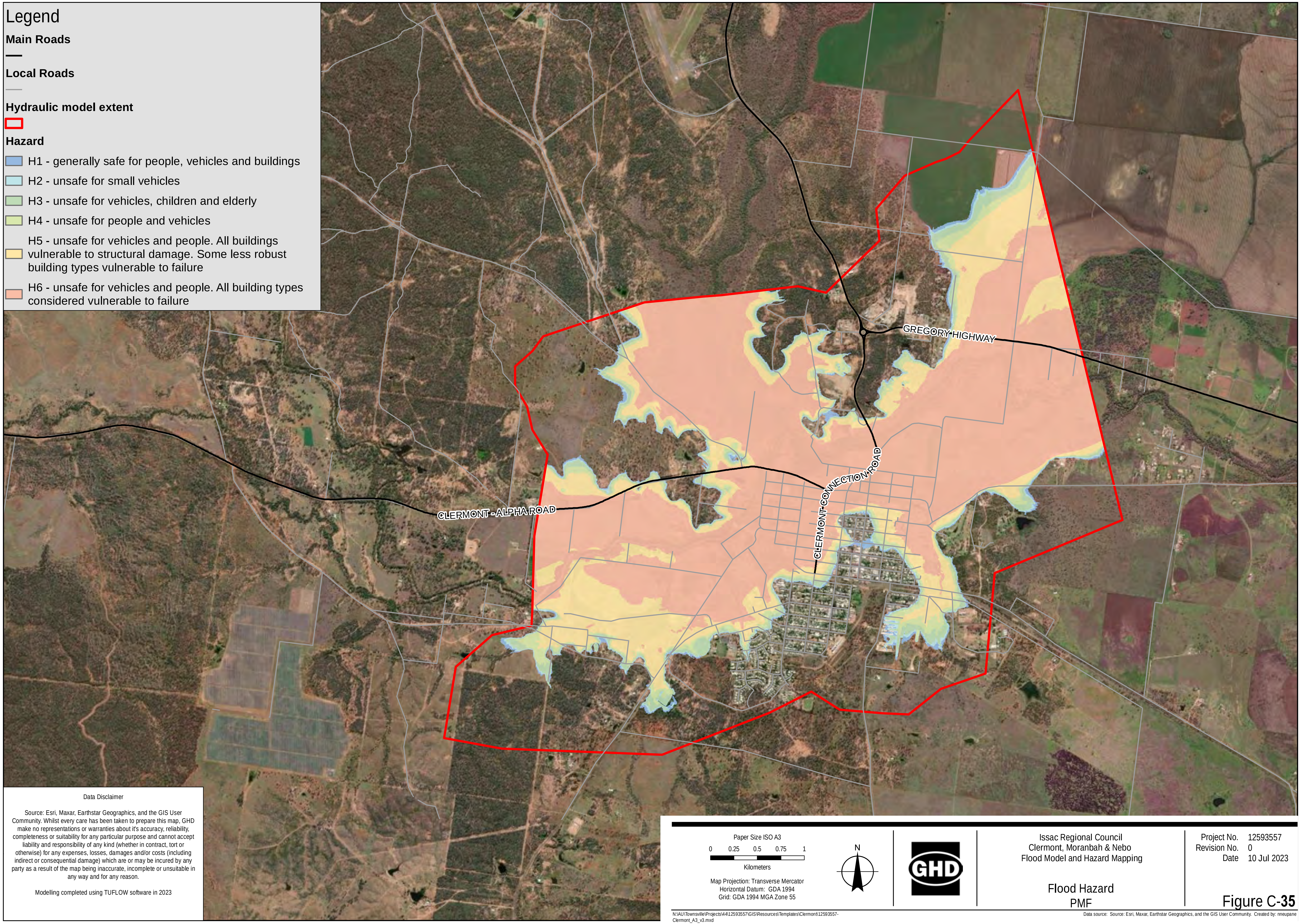
Flood Velocity
PMF

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**34**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:28 (SMA record: 48)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Legend

Main Roads

Local Roads

Hydraulic model extent

Hazard

- H1 - generally safe for people, vehicles and buildings
- H2 - unsafe for small vehicles
- H3 - unsafe for vehicles, children and elderly
- H4 - unsafe for people and vehicles
- H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - unsafe for vehicles and people. All building types considered vulnerable to failure

Modelling completed using TUFLOW software in 2023

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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GHD

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

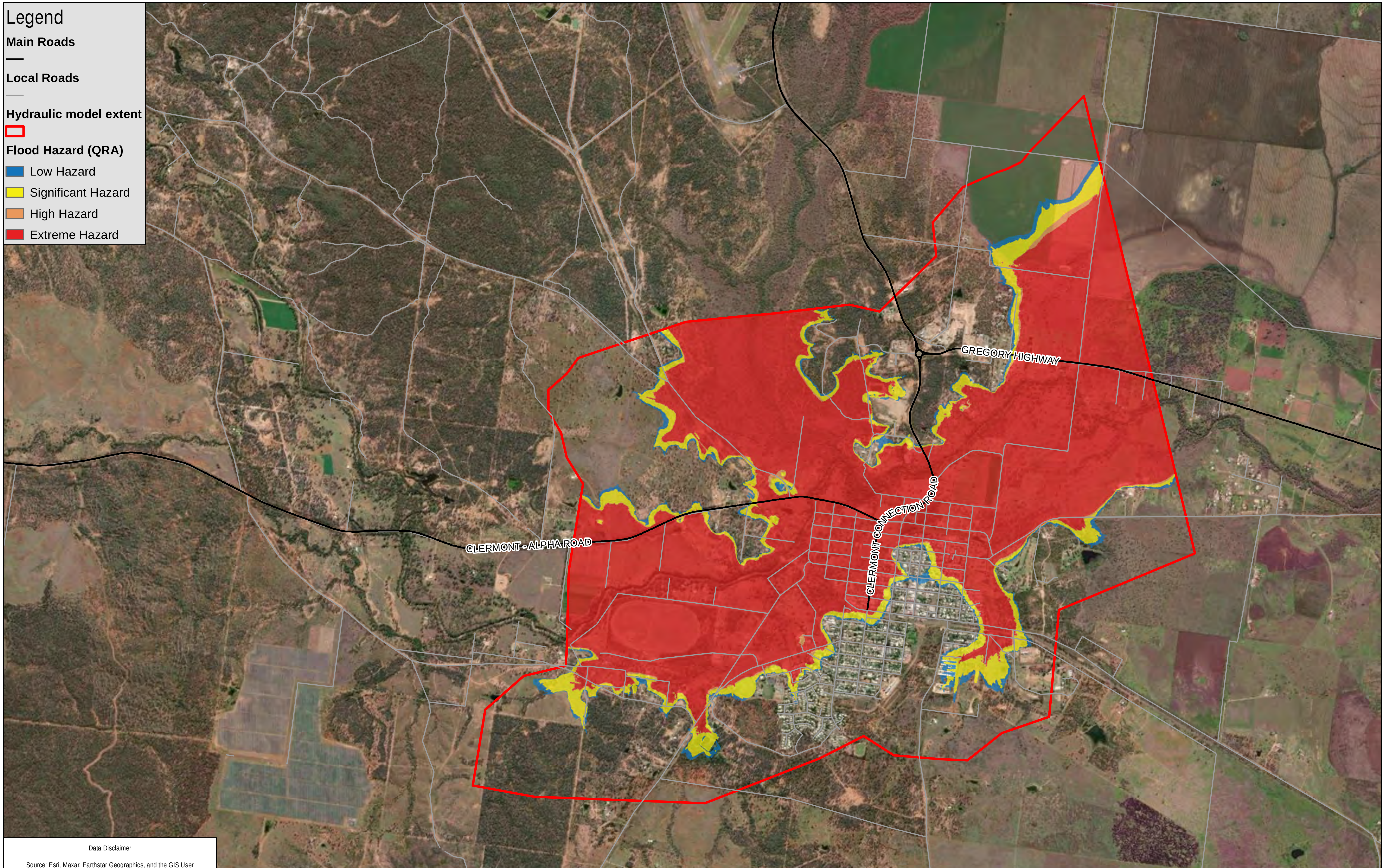
Flood Hazard
PMF

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**35**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:28 (SMA record: 50)

Data source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: nneupane



Data Disclaimer

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about it's accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incured by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Modelling completed using TUFLOW software in 2023

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Issac Regional Council
Clermont, Moranbah & Nebo
Flood Model and Hazard Mapping

Flood Hazard (QRA)
PMF

Project No. 12593557
Revision No. 0
Date 10 Jul 2023

Figure C-**36**

N:\AU\Townsville\Projects\44\12593557\GIS\Resources\Templates\Clermont\12593557-Clermont_A3_v3.mxd
Print date: 10 Jul 2023 - 14:29 (SMA record: 51)

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