QRA QUEENSLAND RECONSTRUCTION AUTHORITY

Queensland Statewide Assessment of Flood Risk Factors

Technical Report
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- Balonne Shire Council
- Banana Shire Council
- Barcaldine Regional Council
- Barcoo Shire Council
- Boulia Shire Council
- Brisbane City Council
- Bulloo Shire Council
- Bundaberg Regional Council
- Burdekin Shire Council
- Burke Shire Council
- Cairns Regional Council
- Carpentaria Shire Council
- Cassowary Coast Regional Council
- Central Highlands Regional Council
- Charters Towers Regional Council
- Cherbourg Aboriginal Shire Council
- City of Gold Coast
- Cloncurry Shire Council
- Cook Shire Council
- Croydon Shire Council
- Diamantina Shire Council
- Doomadgee Aboriginal Shire Council
- Douglas Shire Council
- Etheridge Shire Council
- Flinders Shire Council
- Fraser Coast Regional Council
- Gladstone Regional Council
- Goondiwindi Regional Council
- Gympie Regional Council
- Hinchinbrook Shire Council
- Ipswich City Council
- Isaac Regional Council
- Livingstone Shire Council
- Lockhart River Aboriginal Shire Council
- Logan City Council
- Longreach Regional Council
- Mackay Regional Council
- Mapoon Aboriginal Shire Council
- Maranoa Regional Council
- Mareeba Shire Council
- Moreton Bay Regional Council
- Mornington Shire Council
- Mount Isa City Council
- Murweh Shire Council
- Noosa Shire Council
- North Burnett Regional Council
- Northern Peninsula Area Regional Council
- Palm Island Aboriginal Shire Council
- Paroo Shire Council
- Quilpie Shire Council
- Redland City Council
- Richmond Shire Council
- Rockhampton Regional Council
- Scenic Rim Regional Council
- Somerset Regional Council
- South Burnett Regional Council
- Southern Downs Regional Council
- Sunshine Coast Regional Council
- Tablelands Regional Council
- Toowoomba Regional Council
- Townsville City Council
- Weipa Town Authority
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Contents

Introduction

Background

The Queensland Government is committed to strengthening disaster resilience so our communities are better equipped to deal with the increasing prevalence of natural disasters. Queensland is the most disaster impacted state in Australia. The Queensland Strategy for Disaster Resilience 2022-2027 acknowledges flooding is the highest priority hazard to Queensland due to the potential impacts statewide. The 2021-22 Southern Queensland Floods event impacted 34 local government areas with an estimated total cost of $7.7 billion to Queensland including direct costs and the net present value of lifelong health and social costs (Deloitte, 2022).

As Queensland's population grows and the impacts of global warming result in an increased frequency of large-scale destructive flood events, more needs to be done to increase Queensland's resilience to flooding.

The role of the Queensland Reconstruction Authority (QRA) in flood risk management is outlined in the Queensland Flood Risk Management Framework ('The Framework') as setting the direction for flood risk management (FRM) in Queensland. Under the Framework QRA has responsibilities including:

- identification of priority catchment areas
- coordination of funding streams.

The Statewide Assessment of Flood Risk Factors (SAFRF) project was developed by the QRA to support delivery of these responsibilities by identifying opportunities and priorities for investment to reduce flood risk through the statewide assessment of current need.

Purpose

The purpose of the SAFRF is to support the Framework through providing a state overview of our current strengths, needs, gaps and challenges. The SAFRF will deliver Queensland's first ever comprehensive statewide assessment of flood risk management based on analysis of key flood risk factors for every local government area in Queensland. This technical report describes in detail the development, rationale and findings of the SAFRF and outlines recommendations for future revisions of the tool.

Project principles

This project was guided by the following principles:

- **Transparency**: All data used in the methodology is documented in this report and listed in the 'flood score' tool.
- **Consistency:** Unless stated otherwise, scores for each council are generated using the same methodology. Similarly, the data used in the assessment was only selected if it was able to be applied across the entire state.
- **Repeatable**: This project aimed to use the latest data available, however recognises that datasets will change and evolve with time. As such the

methodology used was developed to be easily revisable. Advice on future releases is provided in the methodology section.

- **Evidence based:** The factors used in the assessment were derived from an evidence base of published sources on flood risk. In addition, the factors were workshopped with stakeholders and industry experts to ensure they aligned with the latest scientific knowledge and best practice.

- **Feedback loop:** This project aimed to encourage a feedback loop between state and councils, through the provision of data and review of assessment outcomes, with the intent to create continuing conversations on flood risk management, investment needs, and state priorities.

Terminology

The following definitions have been used throughout this report:

- The terms ‘locality’, ‘town’, ‘location’, ‘city’, ‘populated place’, ‘places’ have been used interchangeably. Multiple terms are used to improve readability or to place an emphasis that one of these terms conveyed better than another.

- Unless stated otherwise, the term ’flood study‘ refers to a study no older than five years ago that investigates an area of interest over a wide range of events, from the very frequent to the Probable Maximum Flood (PMF). Flood studies develop hydrologic and hydraulic modelling to map and analyse flood characteristic (flood extents, depths, velocities, hazard) using approaches recommended by Australian Rainfall and Runoff (Geosciences Australia, 2019).

Analysis of flood risk factors

Flood risk factors are used in the statewide assessment as a means to measure gaps and needs of local authorities in delivering their flood risk management responsibilities, as set out in the Framework.

This section outlines the flood risk factors used in the assessment, the rationale for each factor, data sources, and explains how each factor has been measured or modified, and the potential for improvements to the factors in future versions of the SAFRF.

Twelve flood risk factors have been used. These factors and these are grouped into three broad categories: 'Base Data'; 'Exposure'; and 'Management' as outlined in
Table 1.

Table 1. Flood risk factors analysis categories and subcategories

Category	Group	Flood Risk Factors
Base Data	A	LiDAR coverage
	B	Flood studies
Exposure	C	Future population in the floodplain
	D	Historically known flood risk and DRFA activations
	E	Exposure to flooding - population in the floodplain (Defined as the 1% Annual Exceedance Probability (AEP) extents)
	F	Council and State roads in the floodplain (Defined as the 1% AEP event)
	G	Community Vulnerability - related to flooding
Management	H	Flood Risk Management Strategies and the Maturity of those Strategies
	I	Flood Warning System: Rain Gauges
	J	Flood Warning System: Water level stations
	K	Community Awareness and Education
	L	Council capacity

Base data – This category considers the availability of LiDAR and the coverage of contemporary flood studies. Topographic data is a key input into developing a flood study, whilst the flood study is often the starting point for understanding an areas exposure to flooding, and the characteristics of the floods which may occur.

Exposure – This category is a mix of present, past and future consequences arising from flooding. Population growth and future residential land reflect the typically growing need to house new residents entering the local government area (LGA). Land zoned residential that lies within the 1% AEP flood extents (if available otherwise the Queensland Floodplain Assessment Overlay, QFAO, which is considered to represent the area potentially at threat of inundation by flooding).

Present risks are captured with three factors: exposure to flooding, roads in the floodplain, and community vulnerability:

- Exposure to flooding is a direct measure of the population living in the floodplain defined as the 1% AEP extent as the highest magnitude flood with the most statewide coverage.
- Roads capture the impact of flooding from a lack of access in, around and out of an LGA.
- Community vulnerability highlights the socio-economic factors that can influence the consequences of flooding.

Historical knowledge is used to understand how much of the population lives in an area that has flooded in the past coupled with the number of flooding, storms and cyclonic DRFA activations for an LGA.

Management – This category focuses on actions or systems in place that have been deployed to reduce the flood risk.

Each factor is discussed in detail in the following sections.

Base data

LiDAR coverage

Light detection and ranging (LiDAR) is a method for creating 3-dimensional representations of the Earth's surface by varying the wavelength of light. LiDAR data is typically used to build the ground surface definition for incorporation in one and two-dimensional flood models, as such can be considered critical for the development of flood studies.

Knowledge of the LiDAR availability across Queensland was sourced from the Queensland Spatial Catalogue (QSC) layer "Queensland LiDAR Data - LiDAR coverage" (Table 2).

Table 2. LIDAR data sources

Data	Source
LiDAR	Queensland Spatial Catalogue layer "Queensland LiDAR Data - LiDAR coverage" Identifier: ELV.QLD_LiDAR_Projects_Extents
Built up areas	Queensland Spatial Catalogue layer "Built up areas - Queensland" Identifier: BUILT.Habitation\BUILT.BuiltUpAreas
Subbasins	Queensland Spatial Catalogue layer "Drainage basin sub areas - Queensland" Identifier: PROP.QLD_DRNCATCHMENT_100K\PROP.QLD_BASINSUBAREA_100K

Ideally LiDAR coverage would span an entire LGA. However, complete coverage of an entire LGA with LiDAR is rare in Queensland. Only 12 out of the 78 LGAs have 100% LiDAR coverage, with the remainder laying between 98% to 0%, and a median coverage of 36%.

Not all areas of an LGA require LiDAR coverage to conduct a flood study. Definition of the catchment, floodplain, or at least areas of interest (typically populated areas) are most critical.

LiDAR coverage of populated areas and catchment basins has been assessed.

LiDAR in populated areas

To assess the availability of LiDAR within populated areas, a layer of the built-up urban areas was sourced. This layer "Built up areas – Queensland" was sourced from QSC (Table 2). A buffer of 3km was placed around the built-up areas (clipped to the shoreline for coastline LGAs) and designated as the area required. This produced an automatic and replicable approach to determining the area required by LiDAR. The percentage covered by LiDAR of the area required was calculated for each council. The percentage was then converted to score with the following formula:

$$\text{Scoring} = 5 - 4 * \text{LiDAR percentage coverage of built up areas}$$

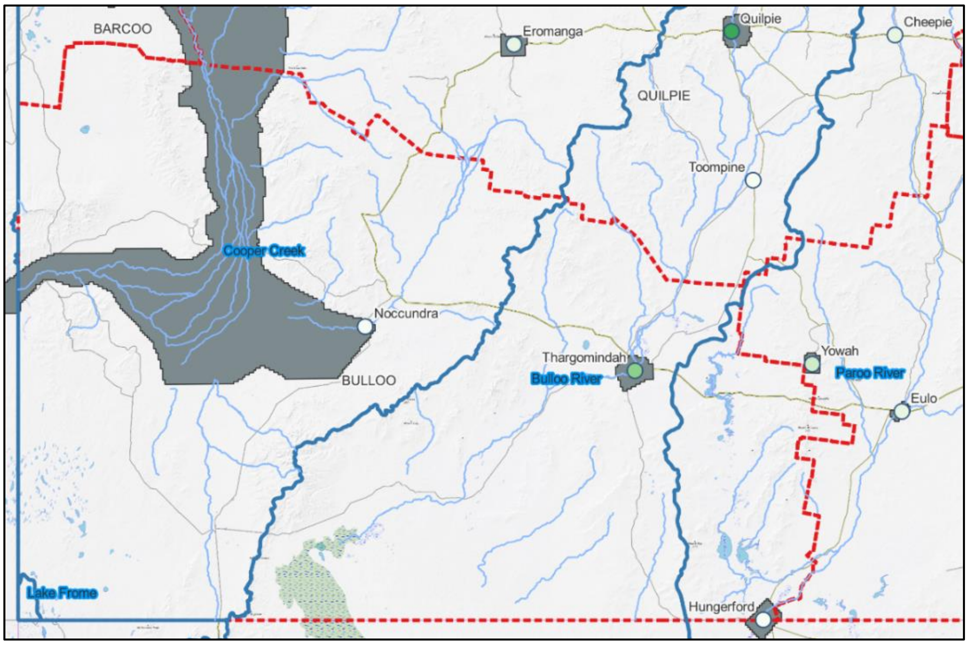
Using this approach, it was found that 23/78 LGAs had 100% coverage with range from 99% to 36% and median coverage of 93%.

LiDAR basin coverage

LiDAR coverage of a catchment is key to ensuring the flow paths and floodplain risks can be modelled. Ideally all catchments would be covered by LiDAR, however only 15 out of 130 sub basins have 100% coverage with coverage varying across basins. For example, Bulloo Shire spans across three basins (Cooper Creek, Bulloo River and Paroo River) and LiDAR coverage differs significantly on the basin with the Cooper Creek having the greatest coverage (Figure 1). To capture the difference the average coverage of LiDAR of each basin was calculated. This average was calculated by estimating how much LiDAR the LGA would need to achieve full coverage within its LGA. For Bulloo Shire, the LiDAR coverage of each basin is 0% for Lake Frome, 0.8% for Bulloo River, 19% for Cooper Creek and 1% for Paroo. Giving an average basin coverage of 5.1%. This process was done for all councils. This percentage was directly converted into a 1 to 5 score using the formula below:

$$\text{Scoring} = 5 - 4 * \text{Average basin percentage value}$$

Figure 1. Bulloo shire (red dashed line) and its subbasins (dark blue) and the LiDAR coverage (Grey)



LiDAR currency

In addition to coverage the age and quality of the LiDAR was considered in the factors scoring. This was achieved by taking the start capture date of all the LiDAR tiles in the LGA and calculating the average date. The number of days since the present day was calculated to give an age of the LiDAR in days. To score on a scale of one to five the number of days were scaled based on the minimum and maximum values of LiDAR age using the formula below:

$$\text{Relative Value} = \frac{\text{LGA age} - \text{Minimum LiDAR age}}{\text{Maximum LiDAR age} - \text{Minimum LiDAR age}}$$

This formula provides a value for LGAs varying between 0% (lowest LGA average basin LiDAR coverage by LGA in Queensland) and 100% (highest LGA average basin LiDAR coverage by LGA in Queensland). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = \ 5 - 4 * \text{Relative value}$$

LiDAR quality

The quality of the LiDAR data influences the accuracy of hydraulic models to provide useful outputs such as a water surface levels. To measure the LiDAR quality, the vertical and horizontal accuracy of each individual LiDAR tile in the LGA was compared the standard set by the Intergovernmental Committee on Surveying and Mapping (ICSM) guidelines for digital elevation data – category 1. That is, a vertical accuracy of +/- 0.3m and +/- 0.8m for horizontal accuracy, both at a 95% confidence interval.

The number of tiles that meet this standard for both horizontal and vertical accuracies were tallied and compared to the total number of tiles per LGA to gain a percentage that meets the standard (in situations where tiles overlapped each other, the older tiles were excluded in favour of the newer LiDAR). An overall average percentage was calculated across both vertical and horizontal tiles. The inverse of this gave the average percentage of tiles that failed to meet either the horizontal or vertical standard.

With the average percentage of failed tiles was categorised into five bins or quality categories spanning from very low to very high (Table 3).

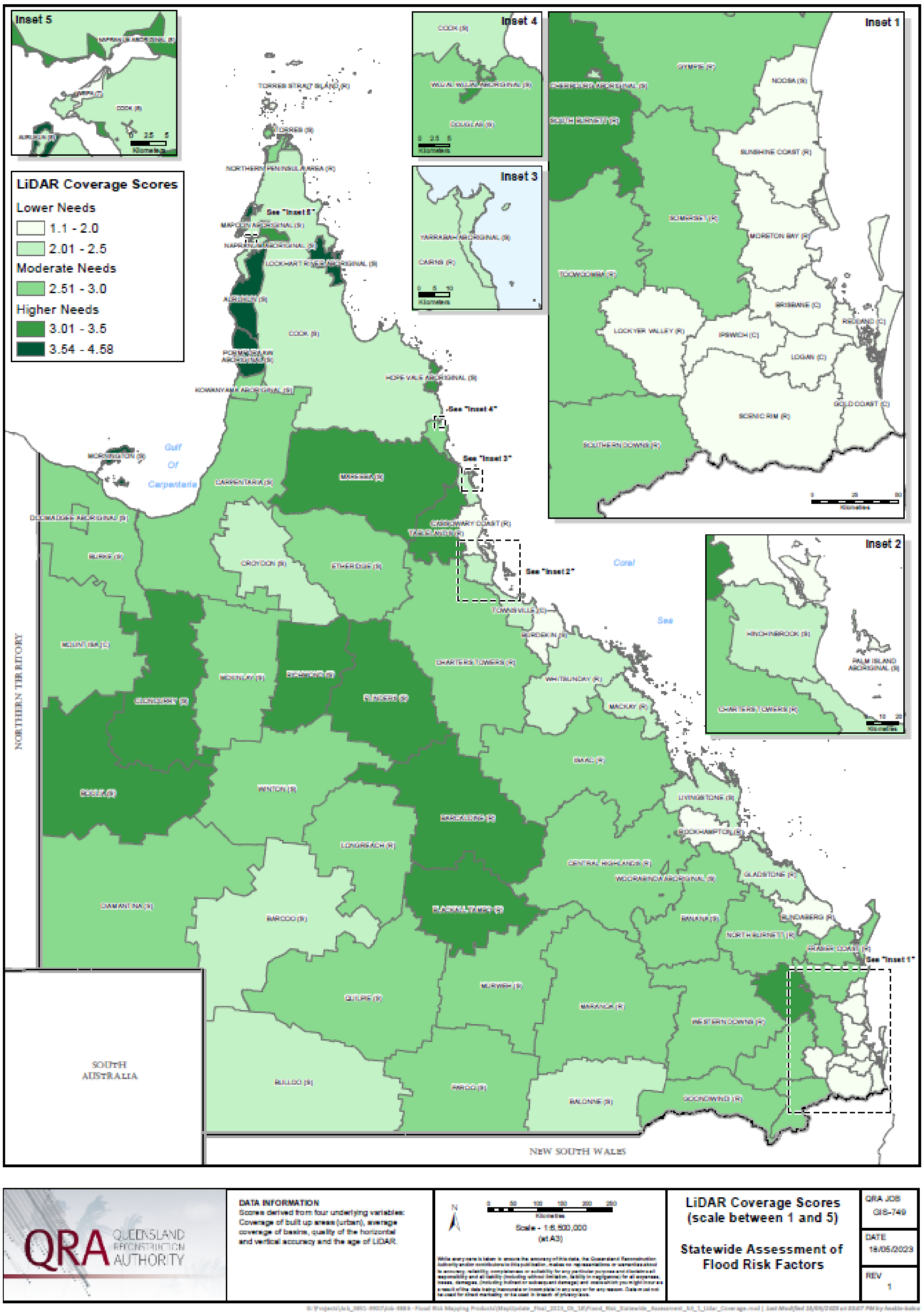
Table 3. LiDAR quality classification table

Percentage of LiDAR tiles that failed the ICSM accuracy standard	Quality category
80-100%	Very low
60-80%	Low
40-60%	Medium
20-40%	High
0-20%	Very high

LiDAR factor scores

The resulting LiDAR scores for each council is a combination of LiDAR age, quality, coverage of built-up areas and the average coverage of basins. All four variables were equally weighted in the overall score. Mapping the scores across Queensland's councils highlights several trends (Figure 2). South East Queensland has the overall best LiDAR, in terms of coverage and quality. The greatest need for new LiDAR is concentrated in the councils of Pormpuraaw, Aurukun and Lockhart River. Overall, all of Queensland has a need for new LiDAR with central and northern Queensland having the largest gaps in overall LiDAR coverage.

Figure 2. LiDAR coverage scores



Flood studies

Flood studies provide a comprehensive understanding of the likelihood and behaviour of flooding in a given area. Flood studies are a technical analysis of a catchment and provide information on the extent, level, velocity, and depths of flood waters in a range of defined flood events, from the very frequent to very rare.

Coverage of flood studies is a key factor to understanding our flood risk across Queensland. LGAs that lack coverage, poor quality studies or out-dated studies will not have sufficient information about their existing, or potential future risks.

The data on floods studies (Table 4) documents that there is no central register of all flood studies in Queensland. Instead, local government council officers, websites and other sources were used to document coverage. The focus of the flood studies factor in this assessment is on risk to people, which resulted in an emphasis on habitable localities. These localities were defined by the layer "populated places" that represents the named towns and cities of Queensland.

Table 4. Flood study data sources

Data	Source
Flood Study	Council websites, council staff, floodcheck and floodhub
Populated places	Populated places - Queensland Identifier: BUILT.Habitation\BUILT.PopulatedPlaces

Across Queensland towns and cities many flood studies have been completed to varying levels in terms of geographic area, flood events modelled and hydrological and hydraulic standards. To provide a method for quantifying this factor, a series of definitions were developed to define the "level" of a flood study with Level 3 being required to count towards the factor. The flood study level definitions are:

1. **Level 1 flood study**: QFAO (Queensland Floodplain Assessment Overlay), a flood study which spatially identities where flooding has occurred or could potentially occur. This mapping does not provide any depth, velocity or hazard and is not based on a specific AEP event.

2. **Level 2 flood study**: Studies that typically focus on a specific town or locality and map depth, velocity and hazard for at least the 1% AEP event and potentially also an extreme event (something rarer than the 1% AEP). Limited in scope and may only provide narrow information the overall floodplain. Hydrological investigation may be confined to using default Australian Rainfall and Runoff (ARR) values. A large number of these studies were done in the Queensland Flood Mapping Program (2014).

3. **Level 3 flood study**: A comprehensive study done in past 5 years that investigates an area of interest over a wide range of events (usually the 0.5EY (2yr) all the way to the PMF) and identifies and maps flood characteristics (flood extents, depths, velocities, hazard) as well as assessing impacts to buildings and lives within the flood extents. They would include a detailed hydrological assessment to ensure hydrological inputs to the 2D model are rigorously tested and validated (to ARR2019 standards).

56 of the 739 named locations in the populated places layer were found to have had a level 3 flood study.

As localities across Queensland can vary significantly in population, the percentage of an LGA covered by a level 3 flood study was calculated. These percentages were then converted to a 1 to 5 scale of investment need for flood studies using the formula below:

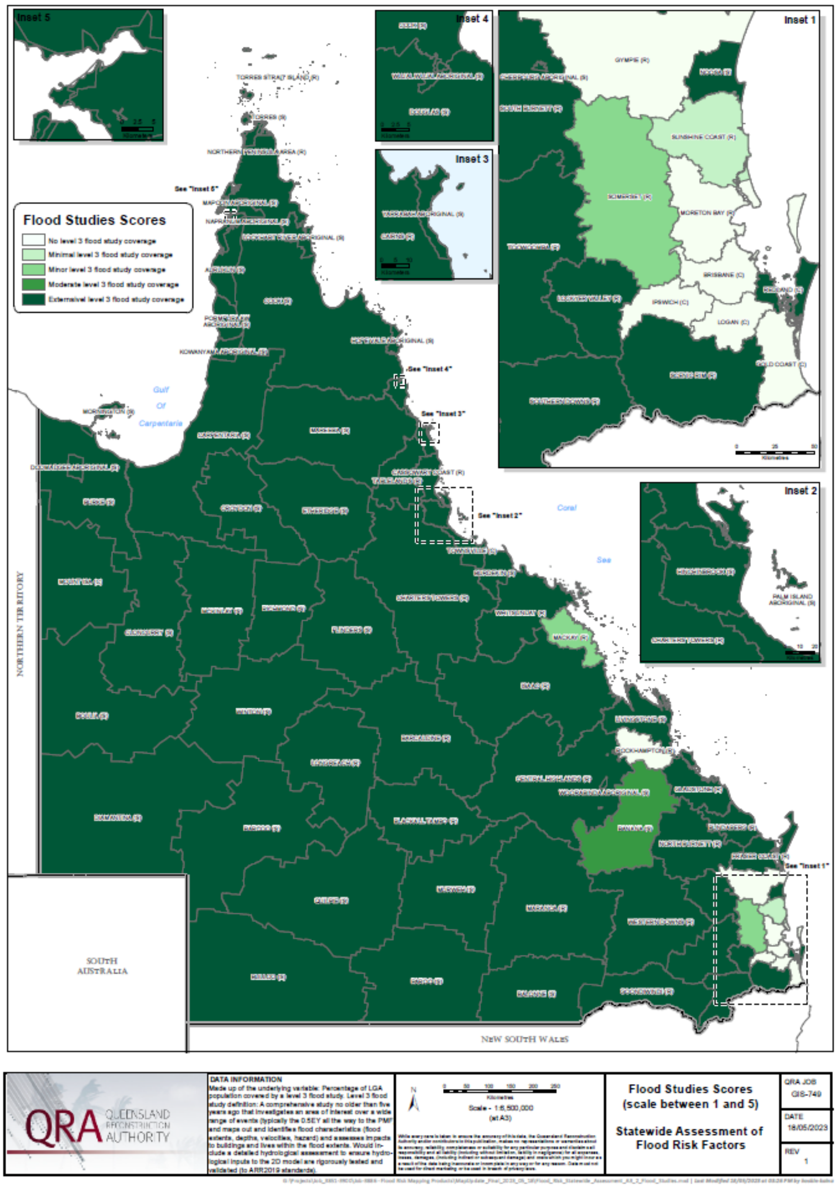
$$\text{Scoring} = 5 - 4 * \text{Percentage of population covered by a level 3 flood study}$$

Overall, 7.6% of populated places in Queensland have a level 3 flood study which accounts for approximately 47.1% of the state's population. Leaving 52.9% of Queensland's population without a contemporary assessment of flood behaviour.

Flood study factor scores

Mapping the flood study factor scores across Queensland highlights several trends (Figure 3). Four councils in South East Queensland had 100% coverage of their population with contemporary flood studies, leaving the remaining 74 local governments with only partial or no coverage. Overall, the need for new flood study investment spans across nearly the whole state.

Figure 3. Flood study scores



Exposure

Historically known flood risk and DRFA activations

Not all of Queensland has been flood modelled. As a result, the flood risk across the entire state is not known. To improve this assessment's understanding of flood risk, historical flood events have been included.

Flood prone populated places

In the 2014 Queensland Flood Mapping Program (QFMP) on-ground investigations, interviews and historical records were used to understand whether a locality had flooded in the past. This was combined with information from a survey undertaken by the then Department of Community Safety which documented flood prone areas in Queensland, and the list of published by the Bureau of Meteorology that were known to flood.

The towns in the populated places layer were compared with the flood prone list. And those that intersected marked as flood prone. This then allowed the percentage of an LGAs population that resided somewhere known to flood be calculated. The formula below was used to calculate a score for this measure:

$$\text{Measure score} = 5 - 4 * \text{Percentage of LGA population living in a floodprone location}$$

Across Queensland 55 out of 78 local governments were found to have 100% of their population living somewhere known to flood historically.

Activations for Disaster Recovery Funding Arrangements

Disaster Recovery Funding Arrangements (DRFA) is a jointly funded program between the Australian Government the state and territory (state) governments. The program provides financial assistance to support state governments with disaster recovery costs. DRFA can be activated when an event meets the definition of an eligible disaster.

Data for DRFA activations in Queensland spans from 2010 to 2022. This dataset provides a list of flood events for all Queensland councils over this timespan. From this, the total number of activations for each council was calculated.

To score on a scale of one to five the number of activations were scaled based on the minimum and maximum values of activations using the formula below:

$$\text{Relative Value} = \frac{\text{Total LGA 2010} - \text{2022 activations} - \text{Minimum number of activations by any LGA}}{\text{Maximum number of activations by any LGA} - \text{Minimum number of activations by any LGA}}$$

This formula provides a value for an LGA that varies between 0% (lowest LGA total number of activations) and 100% (highest LGA number of activations). To scale it to a one to five score, the formula below was used:

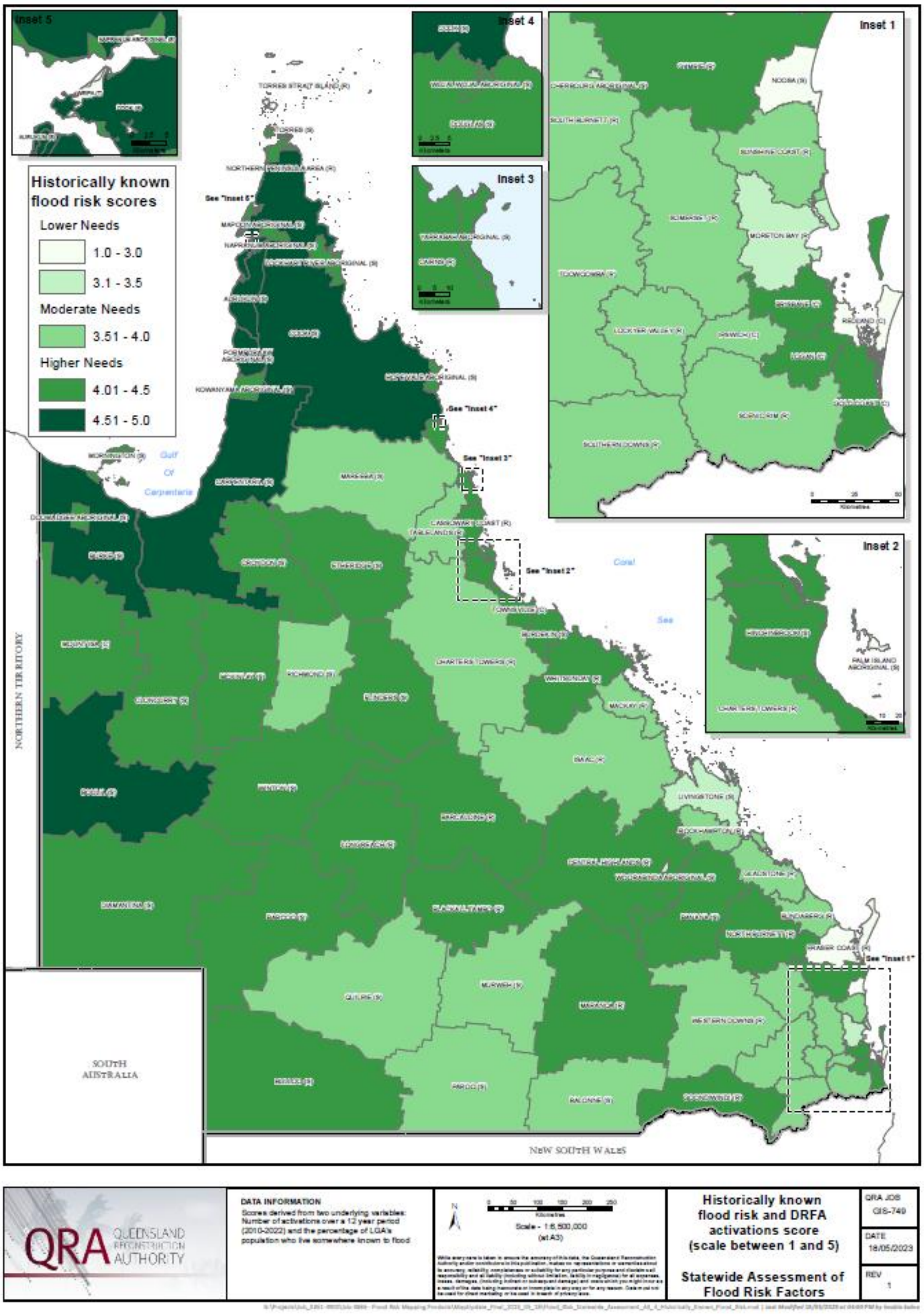
$$\text{Measure score} = 5 - 4 * \text{Relative value}$$

Within Queensland the most activated councils from flooding are the Gulf of Carpentaria and the York peninsula with Cook (20), Carpentaria (19), and Aurukun (17) having the most. On average an LGA in Queensland gets activated once a year due to flooding.

Historically known flood risk and DRFA activations factor scores

The two scores from historically flood prone places and DRFA activations were combined to gain an overall picture of historic flooding for each LGA. The two measures were weighted equally in the overall score. Mapping the scores across Queensland highlights several trends (Figure 4). The greatest historical score was in the north between the Gulf of Carpentaria and the York peninsula. Overall, 47 out 78 local government areas have a score greater than 4 and highlights the high historical need to management the risk from flooding.

Figure 4. Historically known flood risk and DRFA activations score



Exposure to flooding – population in the floodplain

The exposure to flooding is a measure of the population within areas at risk of flooding, typically defined as the floodplain. The floodplain can be considered to be the extent of the Probable Maximum Flood (PMF), however there is very little data available to define the PMF across the state, with data at the LGA level only available for 7 councils. For the remaining 71 local governments their basin-wide flood studies from the QFMP (of the 1 in 2000 AEP) or the QFAO would have to be used.

Rather than attempting to scale flood extents to the PMF the 1% AEP event was chosen instead for this factor as the largest, most consistently available flood extent. The smaller typical gap between the 1% AEP and QFAO meant that a scaling up the QFAO's number of buildings in the floodplain to match the 1% AEP could be achieved with a smaller value of 1.49 rather than 6.76 for the PMF.

Flooding exposure sources by council

The sources of 1% AEP flood data for the councils depending on availability. Table 5 demonstrates the three sources of data that was used to estimate the number of buildings in the floodplain (for the 1% AEP extents). The three sources of data were the QFAO, QFMP basin-wide flood studies of the 1% AEP event and outputs from individual flood studies.

Table 5. Exposure factor data sources

1% AEP data source	Council
Flood study 1% AEP event	Ipswich, Sunshine Coast, Moreton Bay, Logan, Brisbane, Redland, Townsville, Kowanyama Aboriginal, Gold Coast
Queensland Flood mapping program: Basin studies – 1% AEP event	Yarrabah Aboriginal, Gympie, Fraser Coast, Cairns, Toowoomba, Woorabinda Aboriginal, Cassowary Coast, Bundaberg, Western Downs, Cherbourg Aboriginal, Gladstone, North Burnett, Central Highlands, South Burnett, Rockhampton, Burdekin, Maranoa, Hinchinbrook, Banana, Charters Towers, Isaac
QFAO (scaled up)	Hope Vale Aboriginal, Napranum Aboriginal, Lockhart River Aboriginal, Northern Peninsula Area, Weipa, Cook, Wujal Wujal Aboriginal, Mapoon Aboriginal, Lockyer Valley, Torres Strait Island, Pormpuraaw Aboriginal, Scenic Rim, Aurukun, Somerset, Noosa, Doomadgee Aboriginal, Palm Island Aboriginal, Mareeba, Livingstone, Torres, Douglas, Whitsunday, Mornington, Burke, McKinlay, Tablelands, Richmond, Mackay, Southern Downs, Goondiwindi, Etheridge, Winton, Balonne, Carpentaria, Barcoo, Barcaldine, Blackall Tambo, Croydon, Flinders, Cloncurry, Paroo, Quilpie, Mount Isa, Boulia, Diamantina, Murweh, Longreach, Bulloo

Table 6. Exposure factor building footprint source

Data	Source
Building footprints	Microsoft/AustraliaBuildingFootprints (Public) Website: *https://github.com/microsoft/AustraliaBuildingFootprints*
Land use	Land use mapping - 1999 to 2017 - Queensland Identifier:DP_QLD_LANDUSE_June_2019.zip

Flooding exposure sources calculation

The aim of this factor is to measure the number of persons in the floodplain. To achieve this, the number of buildings in the floodplain had to be converted into an estimate of the population in the floodplain. This method began by allocating each Queensland building into a type of use based on its underlying land use. The number of buildings that were classified as residential in the floodplain was calculated for each LGA. With an average number of people per household from ABS census the number of residential buildings in the floodplain could be multiplied together to estimate the population in the floodplain for each LGA.

To convert the population estimates into scores along a 1 to 5 scale the formula below was used:

$$\text{Relative Value} = \frac{\text{LGA number of persons in the floodplain} - \text{Minimum number of persons in the floodplain}}{\text{Maximum number of persons in the floodplain} - \text{Minimum number of persons in the floodplain}}$$

This formula provides a value for a LGA that varies between 0% (lowest population in the floodplain LGA) and 100% (highest population in the floodplain LGA). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

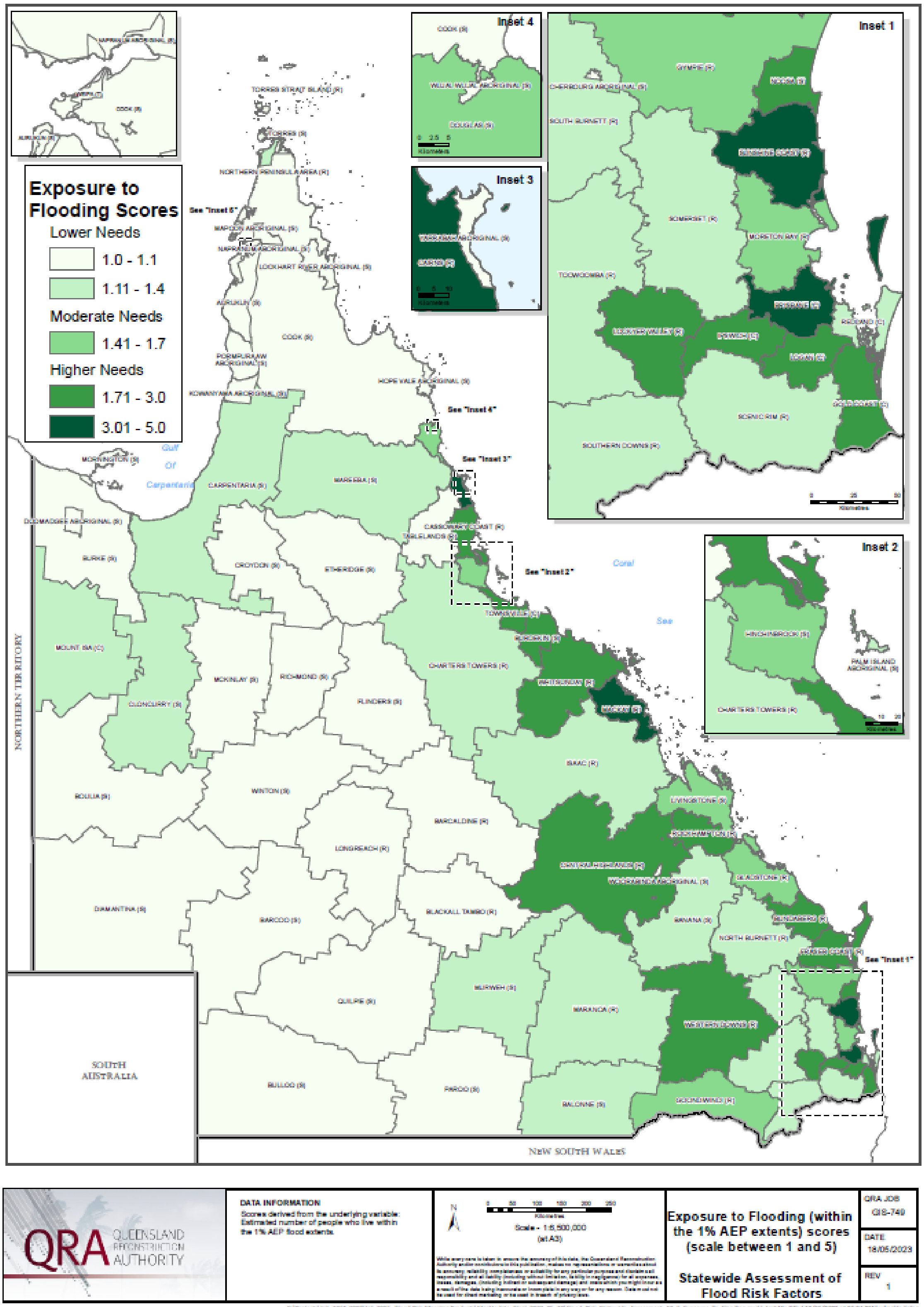
These scaled scores were used for the exposure to flooding – population in the floodplain factor.

Exposure to flooding – population in the floodplain factor scores

The exposure to flooding – population in floodplain scores (Figure 5) highlight that four cities (Brisbane, Sunshine Coast, Mackay and Cairns) contain the highest number of persons in the floodplain, each city with more than 45,000 people in the 1% AEP floodplain. In the next ‘higher needs’ band are the LGAs of Bundaberg, Rockhampton, Townsville, Ipswich, Noosa and Western Downs, each containing 20 thousand people or more in the floodplain.

Estimates across Queensland ranged from a high of 77,000 (Mackay) down to a low of 30 persons in the floodplain (Weipa). In total an estimated 741,341 persons (or 14%) out of a population of 5,141,305 Queenslanders reside within the 1% AEP floodplain.

Figure 5. Exposure to flooding scores



Future population in the floodplain

Population growth places a demand for new housing and potential expansion of the urban limits. This expansion could occur in flood-prone areas and may increase the population exposed to floods. To capture this pressure, the future population in the floodplain was added as a flood risk factor.

This factor is a combination of three variables:

- Median population growth rate (2015-2020) (%)
- Future residential land in the floodplain
- Exposure factor scores

Median population growth rate

The information on population by LGA was sourced from the Australian Bureau of Statistics (Table 7). Five years of data was sourced between 2015-2020. The population growth between the years was calculated as a percentage. The median growth rate was calculated from the population growth of those five years. The median was selected to provide a calculation of what population growth the LGA 'typically' experiences. Using a median value avoids the possibility of unusual spikes or declines in population affecting the typical population growth estimate.

Table 7. Population data sources

Data	Source
Population	Australian Bureau of Statistics "estimated-resident-population-lga-qld-1991-2020p.xlsx" Identifier: Estimated resident population by local government area (LGA), Queensland, 1991 to 2020p
Future residential land	QSPATIAL: Residential land supply - Queensland Identifier: RLST.QLD_LANDAREAS *Note: Not used in the scoring but to inform floodscore spreadsheet users*
Exposure Factor	See Exposure factor for details

Table 8 demonstrates that the typically fastest growing LGAs are in South East Queensland and in North Queensland. Whereas the LGAs with lowest population growth are found in Western Queensland with declining populations.

Once the median population growth was determined it was found to range between a high of 3.3% (Ipswich) down to a low of -3.8% (Bulloo). With a median growth rate across Queensland's LGAs of 0.6%, suggesting that LGAS are typically experiencing population increase.

To score on a scale of one to five the population growth rates they were scaled based on the minimum and maximum values of population growth using the formula below:

$$\text{Relative Value} = \frac{\text{LGA population growth rate} - \text{Minimum population growth rate}}{\text{Maximum population growth rate} - \text{Minimum poulation growth rate}}$$

This formula provides a value for a LGA that varies between 0% (lowest LGA population growth rate in Queensland) and 100% (highest LGA population growth rate in Queensland). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

These scaled scores were used for the future population in the floodplain flood risk factor.

Table 8. Top and bottom 5 LGAs in population growth or decline

Rank	LGA	2015 population	2016 population	2017 population	2018 population	2019 population	2020 population	2015-2020 Median population growth	Score (Out of one to five)
1	Ipswich	194,274	200,103	206,500	213,568	222,311	229,845	3.3%	1.0
2	Hope Vale ABORIGINAL	1,009	1,014	1,046	1,081	1,117	1,140	3.1%	1.1
3	Napranum ABORIGINAL	959	989	1,018	1,047	1,076	1,099	2.8%	1.3
4	Sunshine Coast	295,317	302,841	311,142	319,837	328,390	336,482	2.6%	1.4
5	Gold Coast	561,629	575,303	591,141	606,528	620,437	635,191	2.4%	1.5
74	Boulia	459	436	424	425	423	416	-1.7%	3.8
75	Diamantina	301	296	287	292	291	286	-1.7%	3.8
76	Murweh	4,527	4,386	4,305	4,317	4,294	4,220	-1.8%	3.8
77	Longreach	3,812	3,727	3,598	3,529	3,469	3,407	-2.0%	4.0
78	Bulloo	372	356	343	330	325	324	-3.8%	5.0

Future residential land in the floodplain

Using the publicly available data on future residential land zoned the amount of land allocated within the floodplain was calculating using intersection tools in QGIS. The specific amount of land allowed an estimation of the number of potential dwellings in the floodplain for each LGA. A range was generated between the upper and lower estimate. The upper and lower bounds depend upon the type and density of the future dwellings. This was also broken down by years at which the development may occur. Councils with known future residential land in the floodplain were marked as "yes" or "no" if none was discovered.

In determining a 'Future population in the floodplain' factor this methodology gave councils with known future residential land in the floodplain a score of "5" indicating a high need in the future and with councils with no future land in the floodplain a score of "1", a low need.

Exposure factor scores

To incorporate the present-day risk to residents already living within the 1% AEP extents the exposure factor scores were used to create the base-level risk which is considered to be at-risk of becoming worse through additional persons living in the floodplain.

Future population increase in the floodplain, factor score

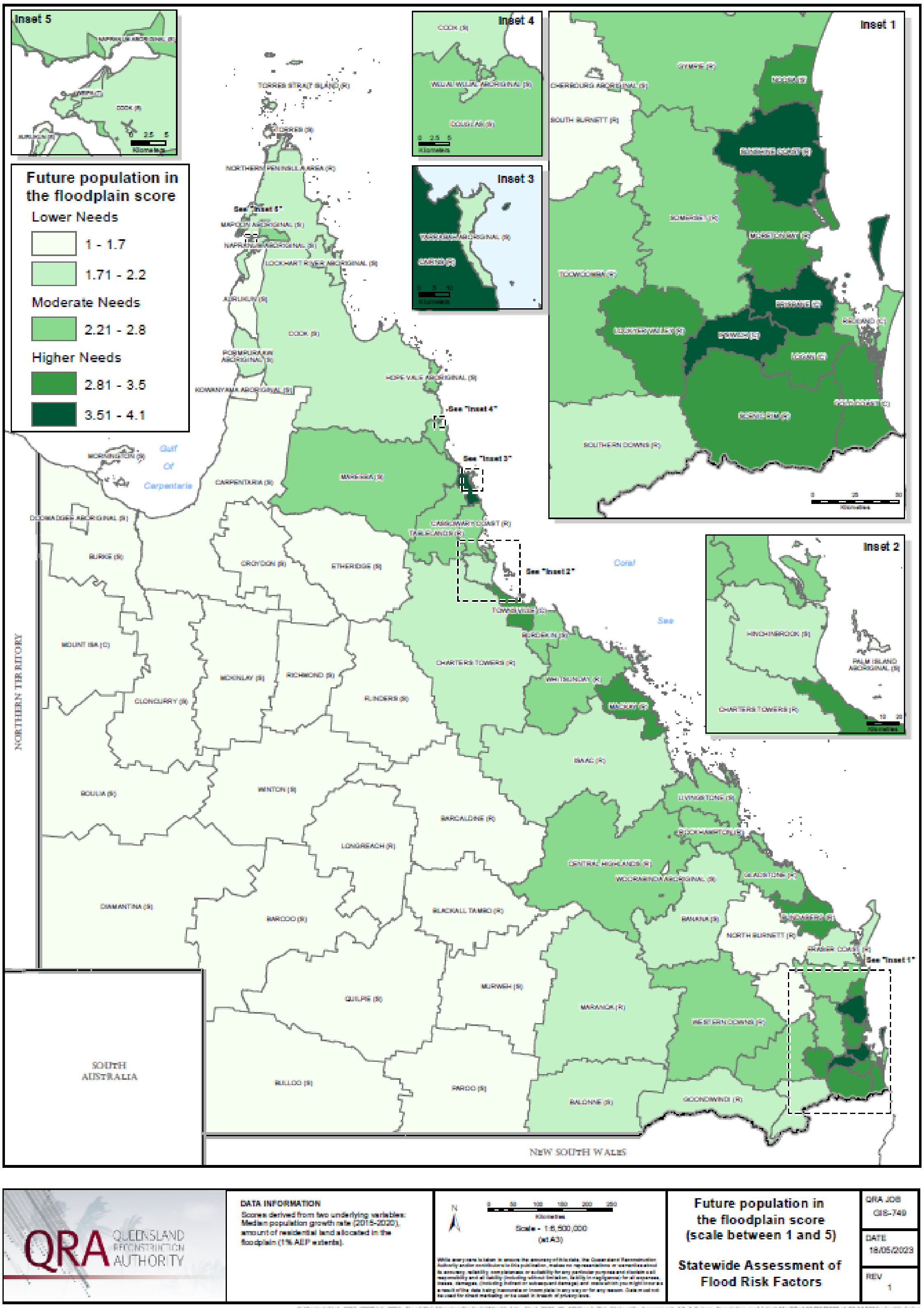
The three variables listed above where combined using the formula below to calculate a future population in the floodplain flood risk factor between 1 and 5.

$$\text{Scoring} = 0.25 * \text{Future residential land in the floodplain Score} + 0.375 * \text{Population Growth Rate Score} + 0.375 * \text{Exposure Factor Scores}$$

The weightings were developed to give 37.5% of the present-day exposure and the remaining score coming from 25% of whether there is future residential land in the floodplain and remaining 37.5% from the population growth rate.

The Future population increase in the floodplain factor score highlights (Figure 6) that the Sunshine Coast, Ipswich and Brisbane were the top three LGAs due to having future residential land in the floodplain, high population growth rate >1.8% and high flood exposure factor scores >2.6.

Figure 6. Future population increase in the floodplain score



Council and state roads in the floodplain

For communities affected by flooding the loss of connection with surrounding communities and logistic chains can have direct consequences on the wellbeing of the community. Losing access to food, clean water and medicinal supplies are a few examples of how isolated communities can experience hardship during and after a flood event. A key link to ensuring communities can be supplied and evacuate when necessary is the roads.

To measure the potential impact of flooding on a local government the length and percentage of roads in the floodplain was investigated. The investigation focused on the 1% AEP event due to data availability (for more detail – see Exposure to flooding). The roads investigated were state and council roads sourced from the Queensland Spatial Catalogue (QSC) layer "State controlled roads - Queensland" and "Queensland roads and tracks" (Table 9):

Table 9. Road factor data sources

Data	Source
State roads data	State controlled roads - Queensland Identifier: TMR.QLD_SC_ROADS
Council roads data	Queensland roads and tracks Identifier: BUILT.QLD_ROADS_AND_TRACKS Filtered to council roads
Flood study data	See section E) - Table 5

Length of roads in the floodplain

Length of road within the floodplain was assessed on the assumption that the more road network in the floodplain the greater the chance of road damage and community isolation from flooding.

The length of state and council roads were calculated in QGIS. Due to size of the roads layer creating difficulties with the overlap tool an alternative method was employed to calculate the total length of roads in the floodplain by LGA, based on area intersect converted back to length.

The council with the longest road network in the floodplain is Western Downs with 2412 km^2 which is significantly higher than average of all Queensland councils of 594 km^2.

To convert the road length estimates into scores along a 1 to 5 scale the formula below was used:

$$\text{Relative Value} = \frac{\text{LGA's length of roads in the floodplain} - \text{Minimum length of roads in the floodplain}}{\text{Maximum length of roads in the floodplain} - \text{Minimum length of roads in the floodplain}}$$

This formula provides a value for a LGA that varies between 0% (LGA with the lowest length of roads in the floodplain) and 100% (LGA with the highest length of roads in the floodplain). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

This provided one of three variables that fed into the council and state roads in the floodplain factor.

Percentage of roads in the floodplain

Given the significant variability in the size of Queensland councils, which range from 10.8 km² (Weipa) to 105,719 km² (Cook), the factor results are skewed. The percentage of roads in the floodplain was incorporated in the roads factor to mitigate this. 13 councils had 50% or more of their roads in the floodplain and four had over 80% (Kowanyama, Carpentaria, Burdekin and Pormpuraaw).

To convert the percentage of road in the floodplain estimates into scores along a 1 to 5 scale the formula below was used:

$$\text{Relative Value} = \frac{\text{LGA's percentage of roads in the floodplain} - \text{Minimum percentage of roads in the floodplain}}{\text{Maximum percentage of roads in the floodplain} - \text{Minimum percentage of roads in the floodplain}}$$

This formula provides a value for a LGA that varies between 0% (LGA with the lowest percentage of roads in the floodplain) and 100% (LGA with the highest percentage of roads in the floodplain). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

This provided one of three variables that fed into the council and state roads in the floodplain factor.

Number of roads in and out of the LGA

A recommendation from stakeholder engagement was to consider cross-LGA boundary road connectivity. There are 11 councils in Queensland with only one road connection into their LGA (either council or state road). To improve the road's factor the number of state roads (or council if no state roads existed) was counted that entered an LGA. This provides a proxy for the isolation potential of a council as the fewer number of roads could increase the risk of inaccessibility if roads get cut from flooding.

With the number of roads tallied the estimates were converted into scores along a 1 to 5 scale the formula below was used:

$$\text{Relative Value} = \frac{\text{Number of roads in and out of the LGA} - \text{Minimum number of roads in and out of all LGAs}}{\text{Maximum number of roads in and out of all LGAs} - \text{Minimum number of roads in and out of all LGAs}}$$

This formula provides a value for a LGA that varies between 0% (lowest number of roads in and out of all LGAs) and 100% (highest number of roads in and out of all LGAs). To scale it to a one to five score, the formula below was used:

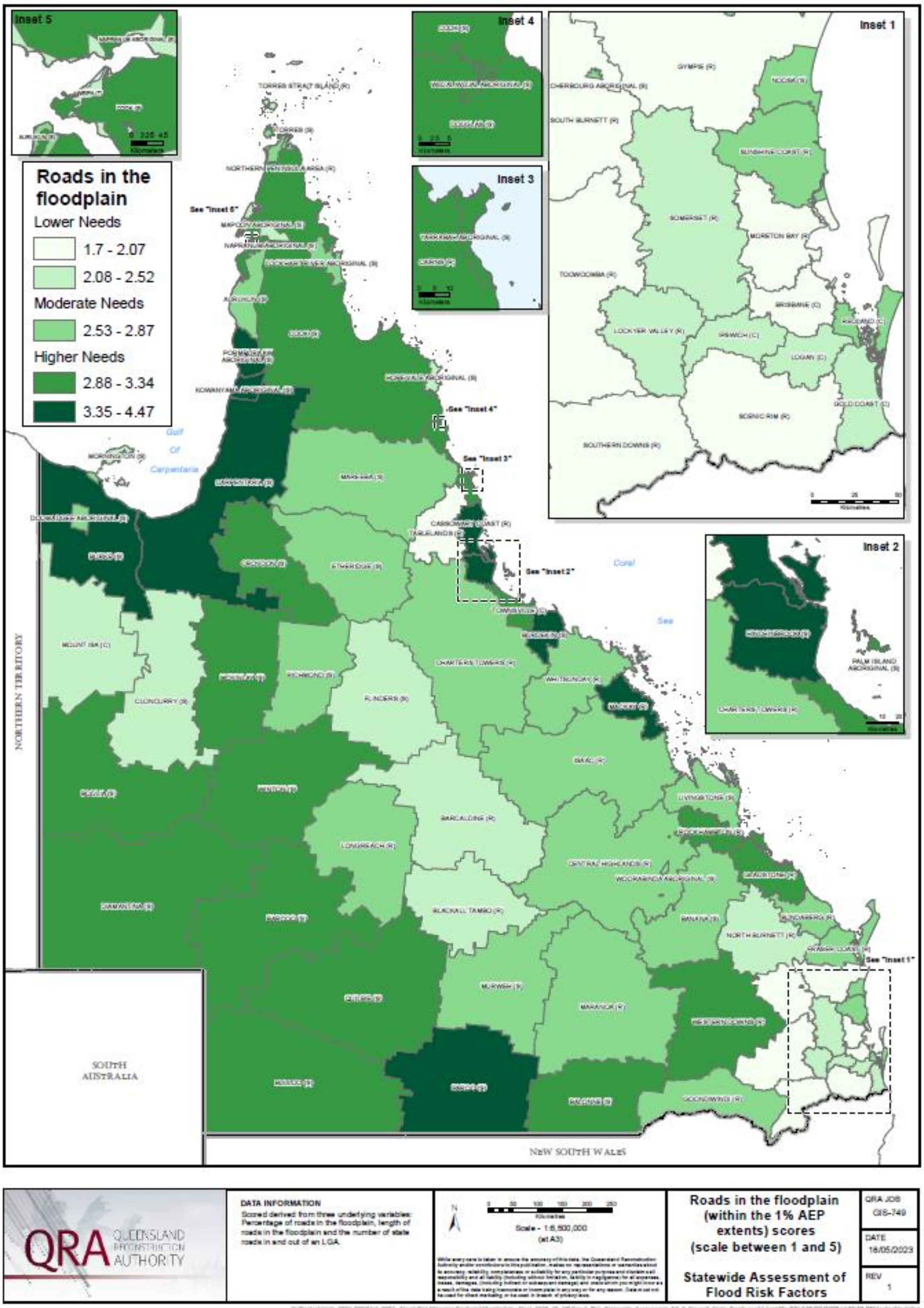
$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

This provided one of three variables that fed into the council and state roads in the floodplain factor. Note, island councils were defaulted to a score of 5 to highlight the challenges of resupply over water compared to direct road access.

Council and state roads in the floodplain factor score

The resulting factor scores for each council is a combination of the length, percentage of state and council roads in the floodplain, and the number of state (or council) roads in and out of the LGA. The three measures were equally weighted in the overall score. Mapping the scores across Queensland's councils (Figure 7) highlights several trends. South East Queensland exhibits a low need with the coastal LGAs of Gold Coast, Sunshine Coast and Noosa having a moderate need. Along the eastern seaboard, Mackay, Burdekin, Hinchinbrook and Cassowary Coast are all high need, likely the result of all having over 1500km of road and 50% or more percentage of these roads residing in the floodplain. Similarly, along the Gulf of Carpentaria two councils (Carpentaria and Burke) had over 70% of their roads in the floodplain and Carpentaria had nearly 4000km of roads in the floodplain. Councils in western Queensland, south of Cloncurry and west of Toowoomba have a likely high need for mitigation to their road networks to reduce the risk of cut-off from flooding.

Figure 7. Roads in the floodplain scores



Community vulnerability

Communities have varying resources, capacity and capabilities, which may affect the consequences of a flood should it occur. To measure the socio-economic characteristics of Queensland's communities the "Combined Vulnerability" framework originally developed as part of the Technical Evidence Report of the Brisbane River Strategic Floodplain Management Plan (BMT, 2018) was adopted. This framework uses four vulnerability indices that relate to vulnerability during floods.

- Physical
- Mobility
- Awareness
- Socio-economic

The framework was applied with some minor changes (Table 10). The 'language other than English indicator' was moved to the community awareness and education factor (section K). Secondly the 'Over 65 and lone person household' indicator could not be found in the aggregated LGA data from the ABS. However instead the lone person households and the population over 65 were included as separate indicators. Finally, the transient population (place of residence less than 1 year) was added as a new indicator to incorporate the vulnerability that can come from arise from living in a new and unfamiliar area.

Data was collected from the ABS General Community Profiles available for all councils in Queensland. All indicators were converted to a percentage.

To provide an overall value for the community vulnerability the percentages of all eleven indicators had to be combined. To do this each indicator was marked as whether they increased or decreased vulnerability. For example, higher percentage of transient population increased the vulnerability, and a higher median income would reduce it. As such the median income percentage was reversed so that higher percentages would indicate a lower income and thus greater vulnerability. With all the percentage compiled the eleven indicators were averaged together to produce a single "Combined vulnerability percentage". This percentage was then converted to a 0 to 100% scale for all of Queensland's LGAs using the formulas below:

$$\text{Relative Value} = \frac{\text{LGA's combined vulnerability percentage} - \text{Minimum combined vulnerability percentage of all LGAs}}{\text{Maximum combined vulnerability percentage of all LGAs} - \text{Minimum combined vulnerability percentage of all LGAs}}$$

This formula provides a value for a LGA that varies between 0% (LGA with the lowest community vulnerability in Queensland) and 100% (LGA with the highest community vulnerability in Queensland). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

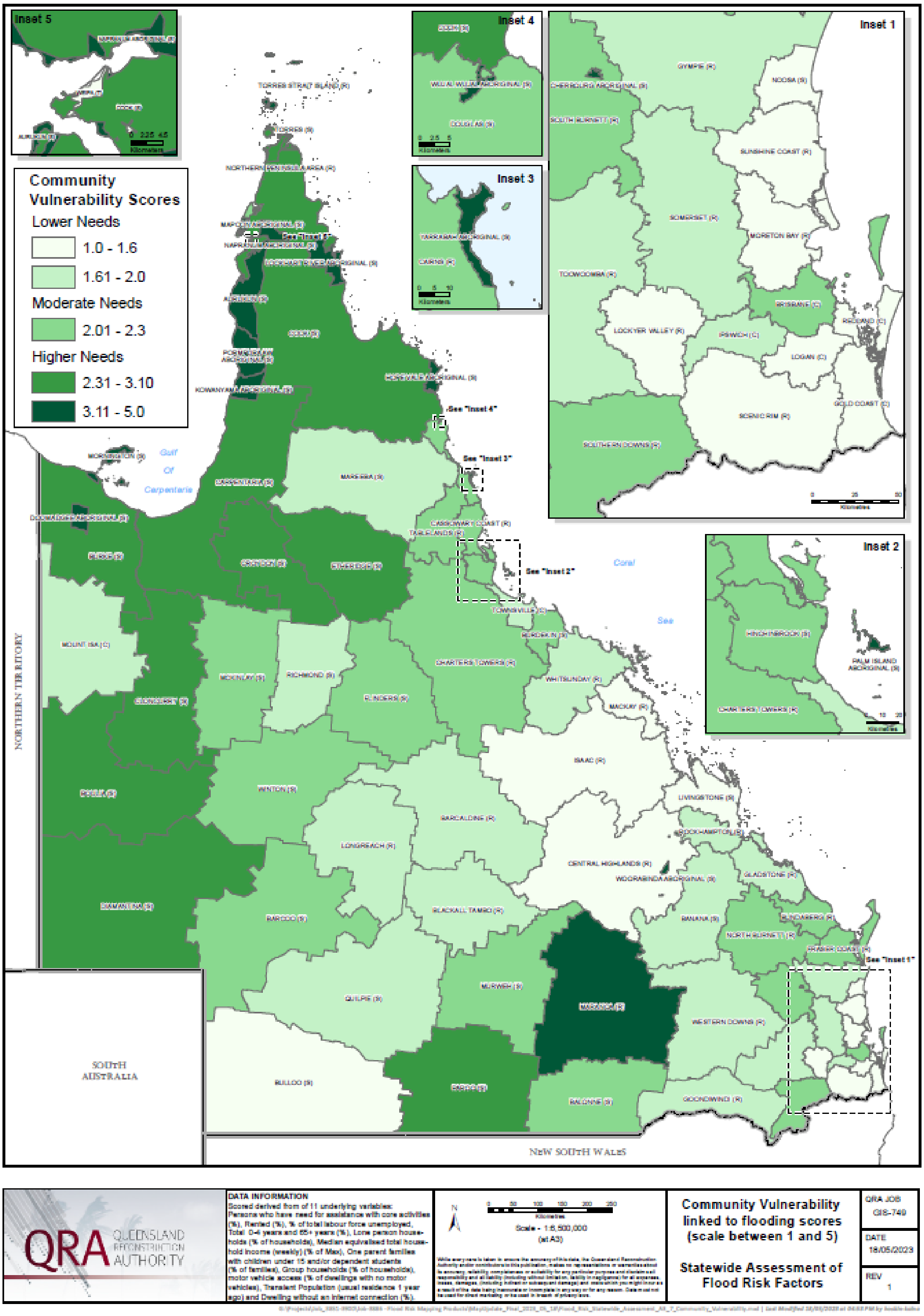
Table 10. Community vulnerability indicators that made up the factor

Categories	Vulnerability Indices	Australian Bureau of Statistics indicator used in the Statewide Assessment of flood risk factors
Physical Vulnerability	• Under 5 years • Over 65 years • Over 65 and lone person household (*note: wasn't available at the LGA level*) • Require assistance (age/disability)	• Total 0-4 years and 65+ years (%) • Lone person households (% of households) • Persons who have need for assistance with core activities (%)
Social & Economic Vulnerability	• Renting (house tenure) • Household income • Unemployed	• Rented (%) • Median equivalised total household income (weekly) • Percentage of total labour force unemployed
Mobility Vulnerability	• Without vehicle access • One parent families • Group households	• motor vehicle access (% of dwellings with no motor vehicles), • One parent families with children under 15 and/or dependent students (% of families) • Group households (% of households)
Awareness Vulnerability	• Speaks language other than English (LOTE) at home • Without internet access	• Transient Population (Place of usual residence 1 year ago) • Dwelling does not have an internet connection (%) • Note: Non-English speaking was moved to the 'Community Awareness and education' factor it was considered more important for awareness factor.

Community vulnerability factor score

Mapping of the resulting community vulnerability factor score (Figure 8) highlights several trends. Potential vulnerability to the impacts of flooding clusters in the Aboriginal shires and with the exception of Cape York most regions of Queensland have a mix of low, moderate and high vulnerability. South East Queensland has a low vulnerability with the exception of the Brisbane LGA, likely due to a higher transient population, lower access to motor vehicle access and having the highest single parent households in South East Queensland.

Figure 8. Community vulnerability factor scores



Management

Flood risk management strategies

Responsibility for flood risk management generally rests with local governments. An element of flood risk management is development and implementation of plans to reduce the risk. The factor aims to incorporate the level maturity of that council is along the Framework journey towards a completed and full-actioned flood risk management study. The scoring of this factor on a 1 to 5 scale was done based on what available plans the council had (Table 11). This included publicly available online and QRA sighted copies of drafts or reports not yet published.

Table 11. Flood risk management strategies sources

Data	Source
Flood risk management strategy	Council websites or sourced from council staff directly.

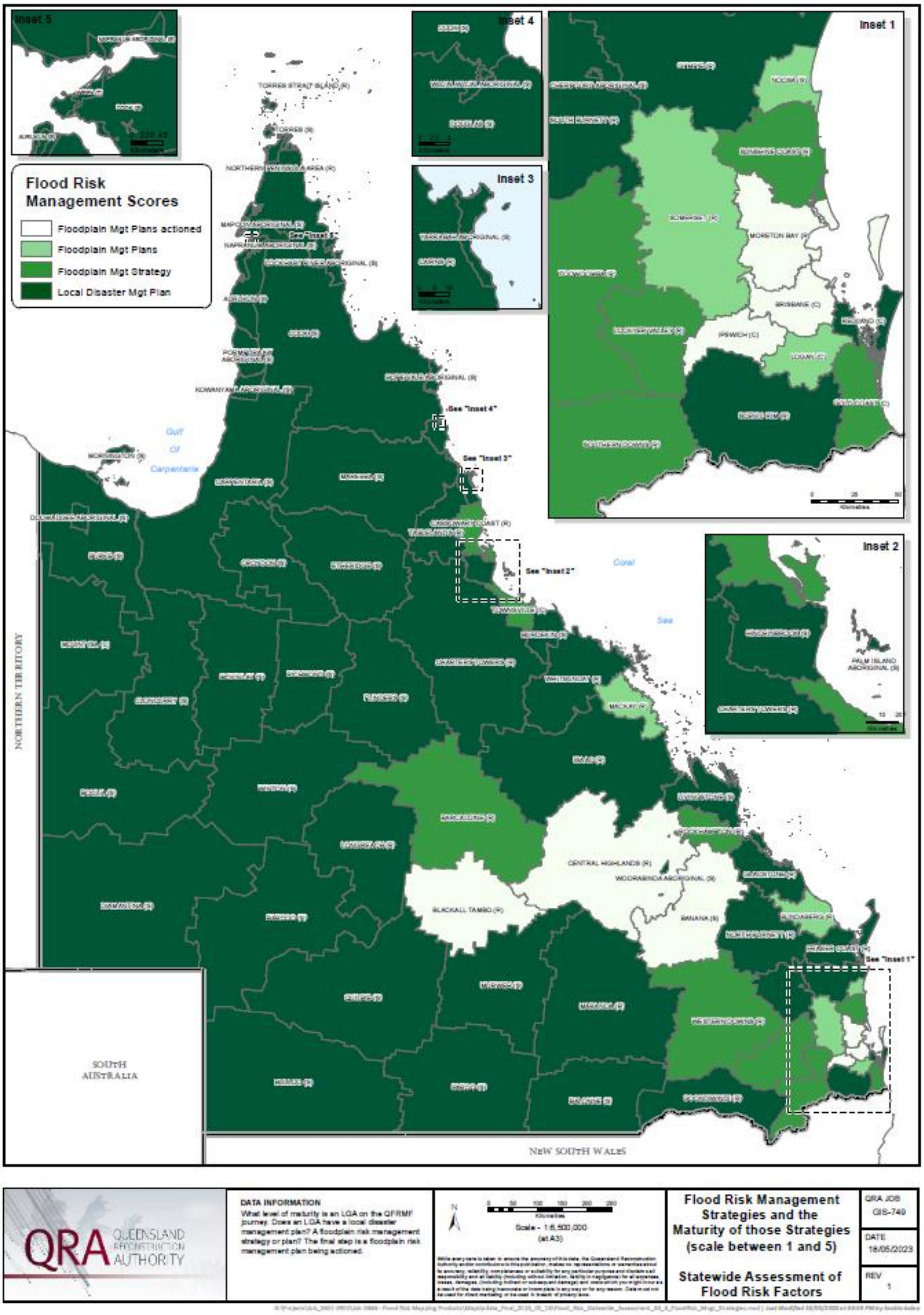
The scoring values were integers and based on what the most mature report was available:

1. No local disaster management plan
2. A local disaster management plan
3. Floodplain management strategy
4. Floodplain management plan
5. Floodplain management plan being actioned

Flood risk management factor score

Mapping the flood risk management scores across Queensland (Figure 9) highlights that most of the state has a local disaster management plan. Six councils were at the most mature stage of the Framework process with a floodplain management plan being actioned (Brisbane, Ipswich, Moreton Bay, Banana, Central Highlands and Blackall-Tambo). Sixteen councils were found to be at a strategy or plan level of maturity. Overall, this factor highlights that the need for new flood risk management plans is widespread across Queensland.

Figure 9. Flood risk management strategies factor scores

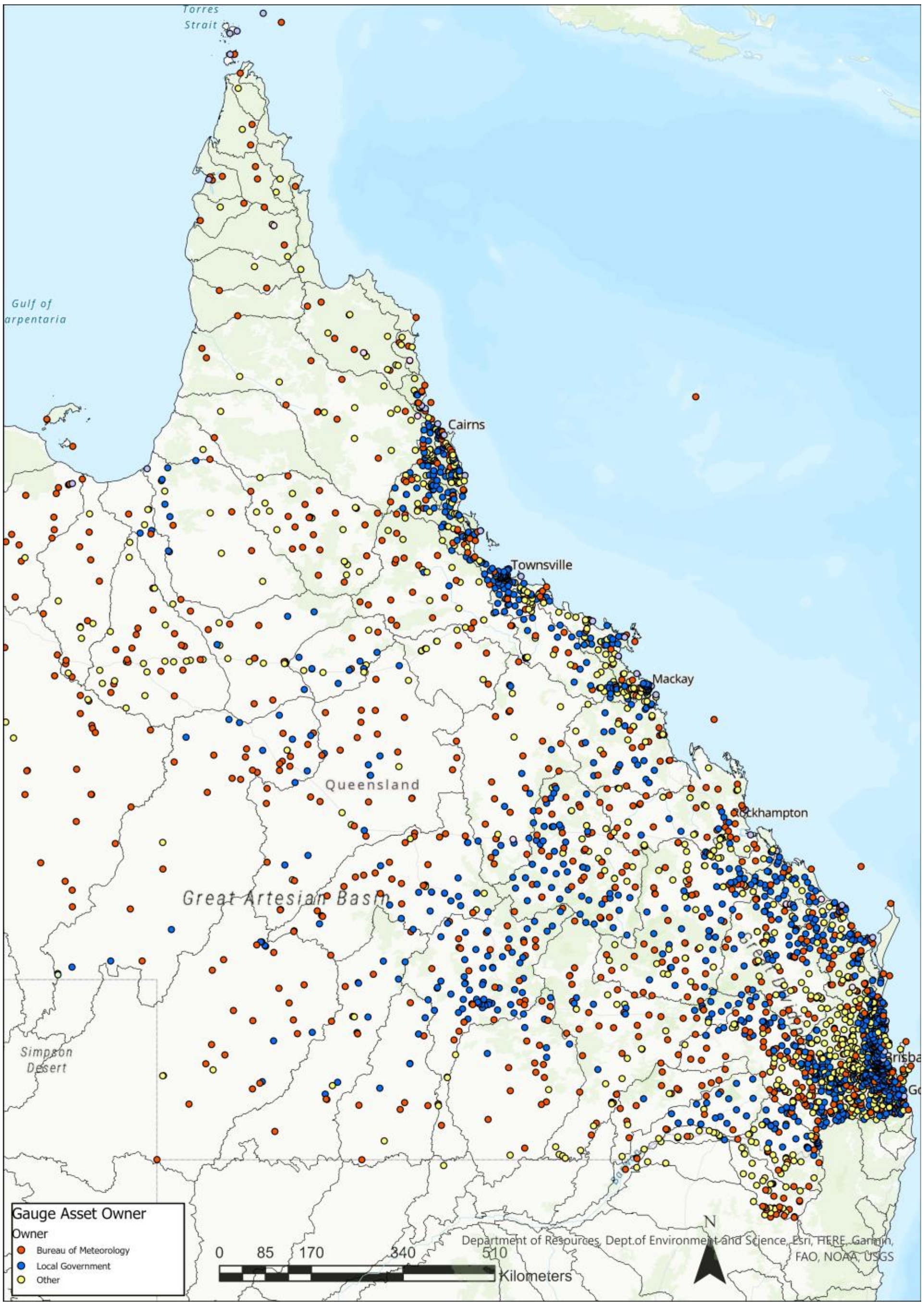


Flood warning system: Rain gauges

Flood warning relates to anticipating the nature of a developing flood and providing timely and useful information for communities prior to an event as to reduce the impacts from flooding. A crucial input to a successful flood warning system is the hydrological data provided by river and rain gauges.

The gauges that make up the flood warning network in Queensland are owned by a range of stakeholders (Figure 10). Flood warning is a multi-faced system that involves a wide range of stakeholders spanning from communities, local governments, state and federal agencies.

Figure 10. Map showing the geographical distribution of the flood warning observations network ownership (taken from BOM, 2021a)



This factor uses data from the Bureau of Meteorology's audit of the Queensland flood warning observations network, referred to as the "scoping study".

Linking proposed gauges to councils

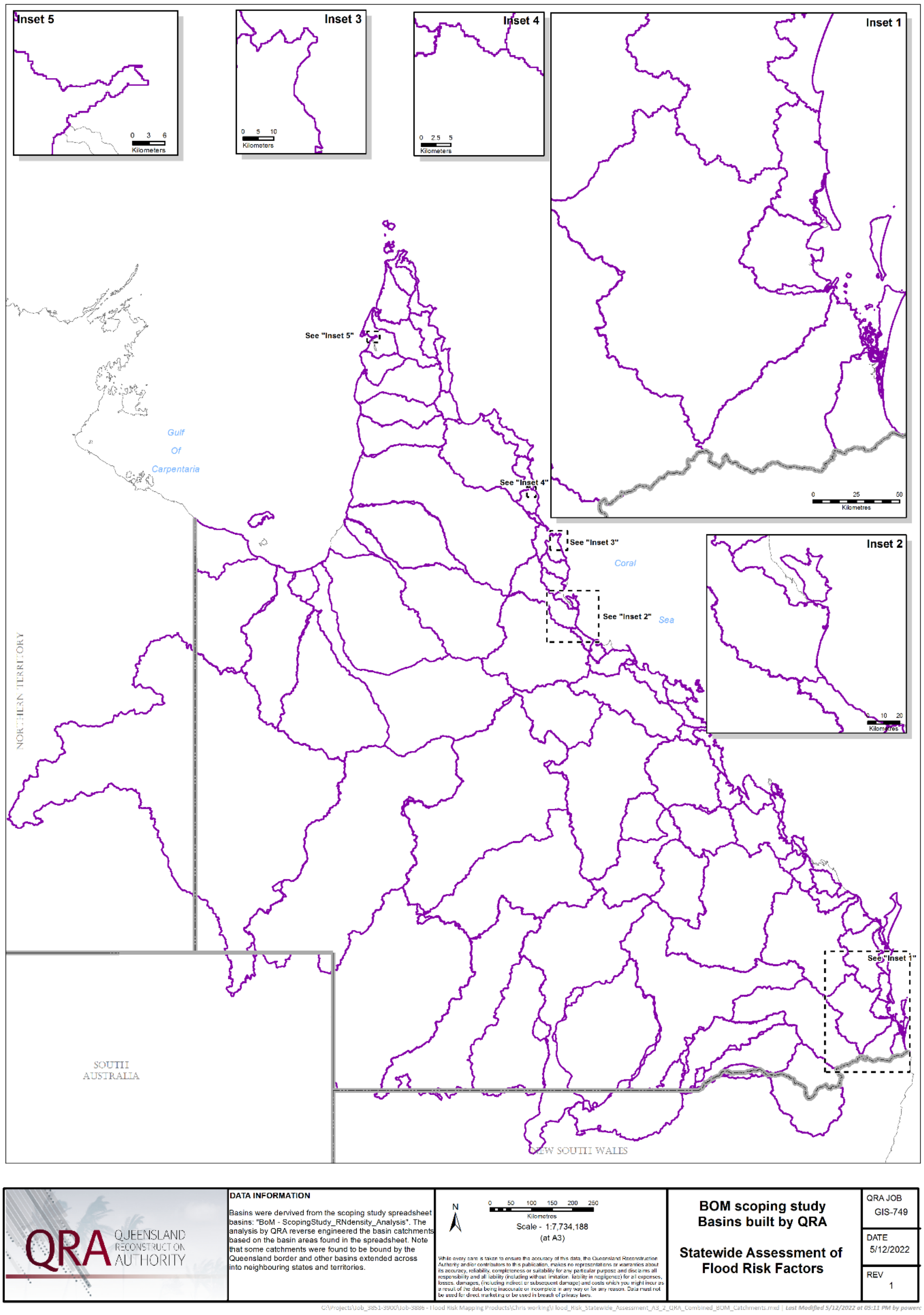
The scoping study audited the existing network infrastructure to ascertain what parts of the system were not meeting the standards of the national Flood Warning Infrastructure Standard (FWIS, 2019). The audit found that the network was adequate in most areas but concluded by proposing 89 river height stations and 364 rainfall stations to fill gaps in the monitoring network.

The rainfall stations were allocated to fill gaps in overall basins and not allocated to specific councils. The methodology to derive proposed rainfall gauges utilised a density measure from the World Meteorological Organisation (WMO) and a maximum rainfall density that the Bureau determined to be commensurate with the flood warning service for the basins. This method produces a proposed number of rainfall gauges that is proportional to basin area. A method was developed as part of this project to allocate the proposed rainfall gauges to a specific location

It was noted that the existing basin boundaries from QSPATIAL did not match those found in the spreadsheet used by the Bureau. For the purposes of this project the basin areas in the Bureau's spreadsheet (Figure 11) have been used.

To determine how many proposed gauges should be allocated to a council the percentage of a basin's area needed to be known by LGA. The total area of each basin in Queensland was divided up into percentages by how much area was covered by a council. This meant for example that if an LGA contained 50% of a basin's area then it would receive 50% of the proposed rainfall gauges. Depending upon the council, it might receive proposed rainfall gauges from multiple basins.

Figure 11. Scoping study basins (reverse engineered by QRA)



With all the proposed rainfall gauges allocated to councils it was then scored using the formula below:

$$\text{Relative Value} = \frac{\text{LGA proposed rain gauges} - \text{Minimum number of proposed rain gauges}}{\text{Maximum number of proposed rain gauges} - \text{Minimum number of proposed rain gauges}}$$

This formula provides a value for a LGA that varies between 0% (lowest number of proposed rainfall gauges for an LGA) and 100% (highest number of proposed rainfall gauges for an LGA). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

A multitude of rain gauges across northern Queensland have been installed over 2019-2022. The $8 million Flood Warning Infrastructure Network (FWIN) project funded through DRFA to support 28 councils following the 2019 Monsoon Trough disaster event has seen installation of the 180 new rain gauges. This FWIN project was funded as part of the $242 million DRFA Category C and D package (2019) jointly funded by the Australian and Queensland Governments.

In the basins where FWIN installed rain gauges the number of proposed rain gauges was reduced by the number installed. For councils that engaged with and received FWIN assets their scores were halved (lower need) to reflect the recent investment made (to a minimum score of 1).

All data used in this factor is shown in Table 12.

Table 12. Flood warning system rain gauges factor sources

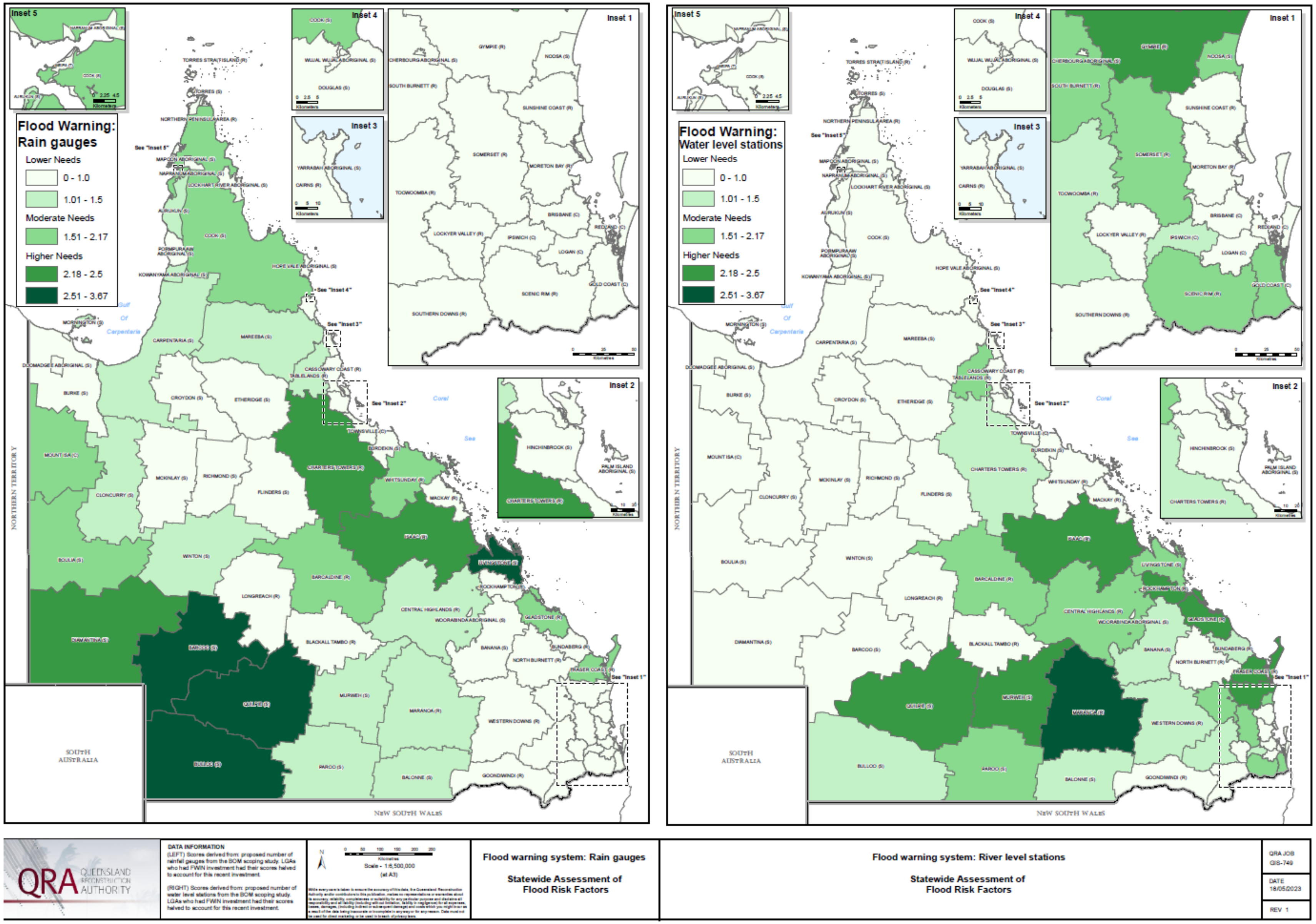
Data	Source
Proposed rain gauges	Bureau of Meteorology's Scoping Study: ScopingStudy_RNdensity_Analysis.xlsx (spreadsheet) Sheet: RN Density
Basin boundaries	Shapefile: QRA_Combined_BOM_Catchments.shp Created by QRA
FWIN assets	Sourced from: https://www.qra.qld.gov.au/fwin

Flood warning system: rainfall gauge scores

Mapping the proposed rainfall gauges scores across Queensland (Figure 12) highlights three councils with a high need: Bulloo, Barcoo and Livingstone. Similarly, there is a range of councils in central and western Queensland with a moderate to low need for more rain gauges. It is recommended that the scores be considered with respect to the population settlement and relevancy to the community for flood warning, noting this project and the scoping study were both desktop analyses as the step prior to community consultation and detailed locally-led flood warning infrastructure planning with stakeholders, such as a FWIN project.

Moreover, flood warning systems do not just rely on rainfall gauges. Instead, a 'total' flood warning system captures all the elements of a system that could exist to warn a community of an impending flood. Thus, although proposed river height stations are a separate factor (Section J) they should be viewed side-by-side with the proposed rainfall gauges and are shown together.

Figure 12. Flood warning systems (LEFT) rainfall gauges scores and (RIGHT) river level station scores



Flood warning system: Water level stations

To determine the gaps within the network the Bureau's scoping study conclusions on proposed water level stations was adopted. These conclusions listed out precise locations across Queensland to install new water level stations. Aside from one proposed location, (Gregory Development Road, -19.62981, 145.77317) where a water level station was installed as part of the FWIN project, all the proposed stations were used to score this factor.

The scoring allocated to councils used the formula below:

$$\text{Relative Value} = \frac{\text{LGA proposed water level stations} - \text{Minimum number of proposed water level stations}}{\text{Maximum number of proposed water level stations} - \text{Minimum number of proposed water level stations}}$$

This formula provides a value for a LGA that varies between 0% (lowest number of proposed water level stations for an LGA) and 100% (highest number of proposed water level stations for an LGA). To scale it to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Relative value}$$

For councils that engaged with and received FWIN assets their scores were halved (lower need) to reflect the recent investment made.

All data used in this factor is shown in Table 13.

Table 13. Flood warning system water level stations factor

Data	Source
Proposed water level stations	Bureau of Meteorology's Scoping Study: QLD FWON – Network Audit (Appendix 4 – Proposed River height stations)
FWIN assets	Sourced from: https://www.qra.qld.gov.au/fwin

Flood warning system: water level station scores

Mapping the proposed water level station scores across Queensland (Figure 12) highlights Maranoa has the highest need (13 proposed stations), however the need is across Queensland.

It is recommended that the scores be considered with respect to the population settlement and relevancy to the community for flood warning. Particularly as this project and the scoping study were both desktop analyses and are the step taken prior to council engagement, community consultation and detailed locally led flood warning infrastructure planning with stakeholders. QRA's FWIN (2019-2022) is an example of this process.

Moreover, flood warning systems do not just rely on water level stations. Instead, a 'total' flood warning system captures all the elements of a system that could exist to warn a community of an impending flood. Although proposed rainfall gauges are a separate factor (Section I) they should be viewed side-by-side with the proposed water level station scores and are shown together.

Community awareness and education

Community awareness and knowledge of flood hazards varies across Queensland. The QFRMF allocates the responsibility to the state agencies of QRA and Queensland Fire and Emergency Services (QFES) to increase community knowledge, awareness, and preparedness for flooding, with the local governments implementing the knowledge sharing through community engagement.

Knowledge of community preparedness in the face of natural disasters was sourced from the ABS and QRA's GetReady program (Table 14).

Table 14. Community awareness and education factor sources

Source	Community Awareness and education indicators
2022 GRQ Statewide Research Communications Plan (QRA GetReady Program)	*Do you have an Emergency Plan? (%)*
	Do you have an Emergency Kit? (%)
	Do you have an Evacuation Plan? (%)
	How well feel prepared for disasters? (%)
2021 Census of Population and Housing in Australia (Australian Bureau of Statistics)	*LGA that speaks a language at home that is not English (%)*
	Dwelling has an internet connection (%)

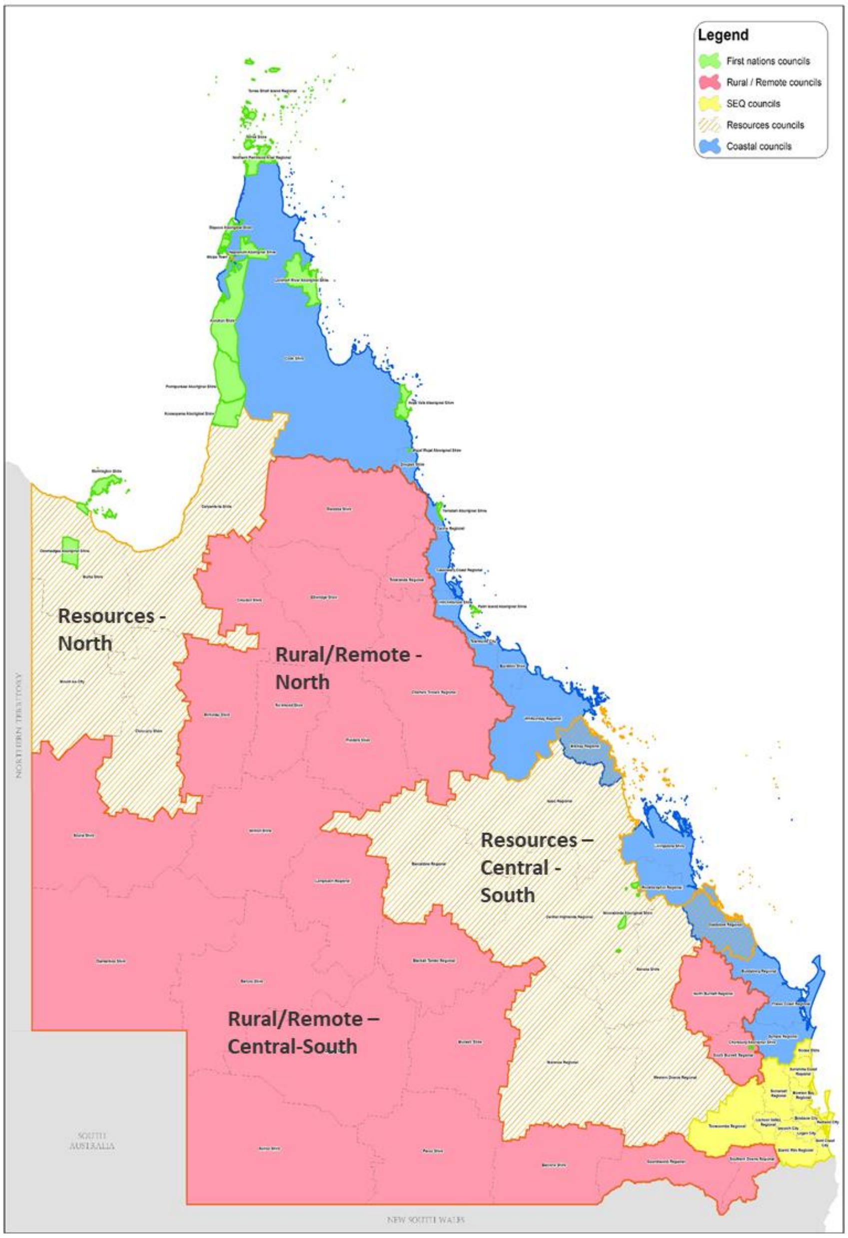
The source of information on community awareness grouped results together by regional sub-groups (Figure 13). Data was sought on an individual council level, however only 56 of 78 local governments had data, with 23 having less than 10 persons surveyed and 9 councils had only one person surveyed. These low sample sizes created a trade-off between precision and accuracy. Aggregating councils meant losing a precise view of individual councils but created the risk of false confidence by using small numbers of people to score an entire community. On balance the sub-group aggregation was considered more appropriate and was in line with the approach taken by those who conducted the research (MCR, 2022).

Of the four questions used in this factor one was not initially a percentage (How well feel prepared for disasters?). To convert to a 0 to 10 scale (0 representing not at all prepared and 10 being very prepared) to a percentage, it was divided by ten.

Each indicator was averaged together to get a single percentage of overall disaster preparedness. This average percentage scaled to a one to five score, the formula below was used:

$$\text{Scoring} = 5 - 4 * \text{Average percentage of disaster prepardness}$$

Figure 13. Regional definitions of the GetReady program (sourced from MCR, 2022)

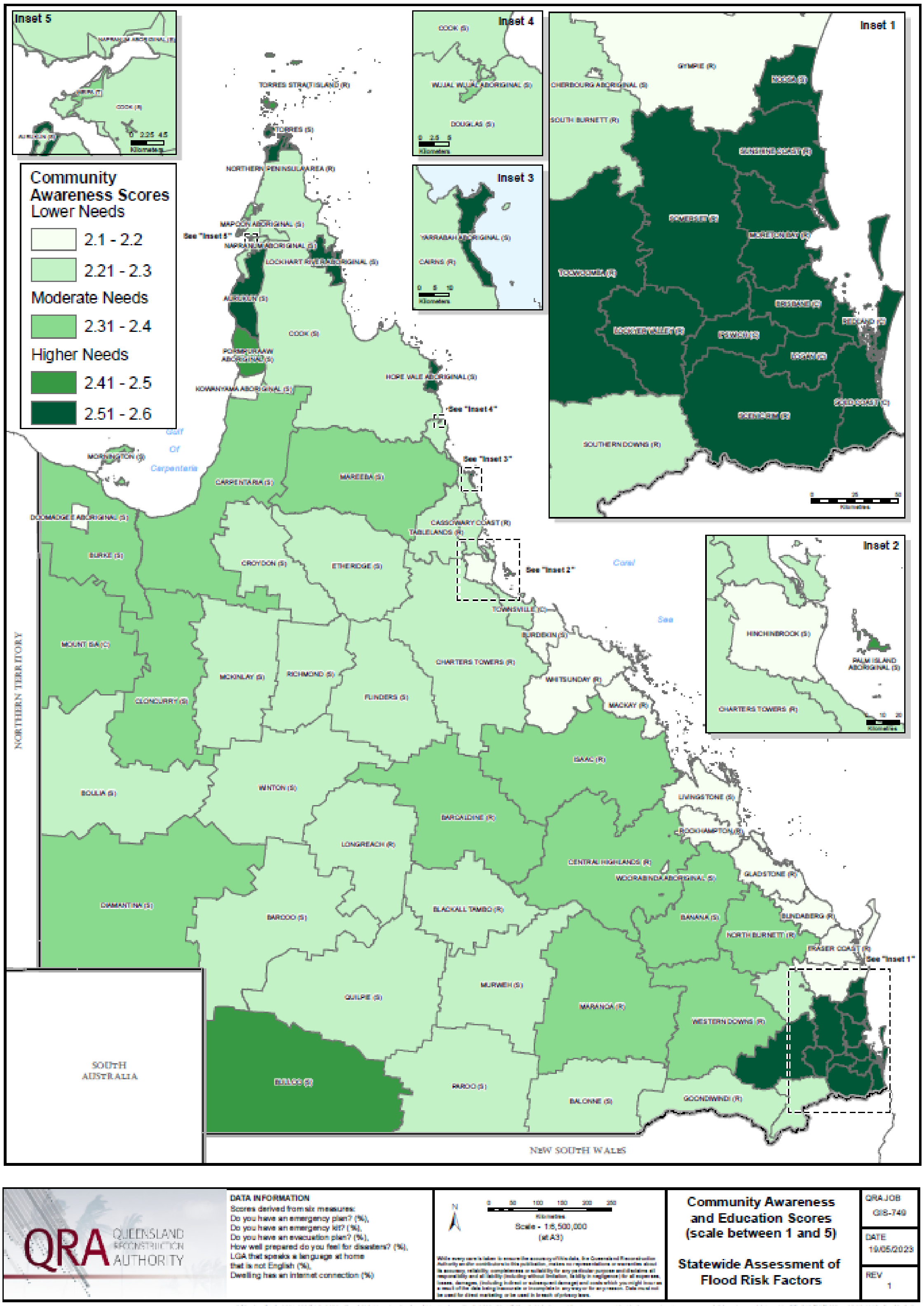


Community awareness and education factor

Mapping the community awareness and education factor (Figure 14) highlights that the eastern seaboard north of Noosa to the Cassowary coast have a low need (high preparedness) to disasters. The areas of highest need are located in patches around Queensland, showing several Aboriginal shires and SEQ councils with a highest need score. For the Aboriginal shires this is driven by the non-English speaking indicator and suggests an opportunity to use indigenous language awareness material in these areas to boost resiliency. South East Queensland relative to the rest of Queensland has lower percentages of persons with emergency plans (58%) and emergency kits (45%) and this is also the region with the lowest percentage of people feeling “well-prepared” for a disaster (62%).

Despite differences across Queensland scoring suggests that variance across Queensland is small, with scores ranging only between 2.1 and 2.8. The data shows differences in community awareness and education exist, but overall Queensland is more similar than it is different.

Figure 14. Community awareness and education scores



Council capacity

Responsibility for the delivery of flood risk management in Queensland is spread across federal, state and local government agencies. The responsibility is dispersed and relies on collaboration between the stakeholders to fulfill their roles as laid out in the Framework. For local governments this involves developing strategies and action plans for implementation to address local flood risk. The local governments in Queensland have varying degrees of resources to fulfil this role. These resources can include financial, personnel and existing knowledge to drawn upon. Council capacity was included as factor to account for this variability between local governments and inform decision makers on the likely need for councils to receive outside assistance to reduce flood risk. Refer to Table 15 data sources for this factor.

Table 15. Council capacity data sources

Data	Sourced from
Gross Rates and utility charges	Queensland Local Government Comparative Information 2020-21 Sourced from: 2. Rate revenue *https://www.statedevelopment.qld.gov.au/local-government/for-councils/resources/local-government-comparative-reports*
Number of indoor staff	Queensland Local Government Comparative Information 2020-21 Sourced from: 13. Personnel data *https://www.statedevelopment.qld.gov.au/local-government/for-councils/resources/local-government-comparative-reports*
Population	Australian Bureau of Statistics: "General Community Profile" spreadsheet for each Council Sourced from: *https://www.abs.gov.au/census/find-census-data/search-by-area*

Gross rates and utility charges

The first measure of council capacity is the rates base that the council draws upon. This measured was added to incorporate the financial resources a council has access to. Additional financial resources can support more staff and programs to develop and implement floodplain management strategies. The gross rates and utility charges vary significant across Queensland between zero, typically seen in Aboriginal shires and $1.24 Billion for Brisbane City Council. Scoring for this measure was done by placing them into bins (Table 16).

Table 16. Gross rates and utility charges scoring

Gross rates and utility charges	Score
0-10k	5
10-20k	4.5
20k-40k	4
40k-80k	3.5
80k-100k	3
100-200k	2.5
200-250k	2
250-500k	1.5
500-1.23M	1

The gross rates and utility charges were placed into bins because the small number of councils with large rates base skewed the overall scoring towards placing the overall majority of councils in a very similar category.

Number of indoor staff

Stakeholder engagement highlighted that gross rates and utility charges are not fully reflective of council capacity. Councils also require sufficient staff to action policies and strategies. Data was sourced on the number of staff and filtered to the indoor staff only to account for staff who would be more likely to coordinate the sourcing of new flood studies, implement floodplain management strategies and be involved in coordinating with stakeholders to reduce flood risk. The scoring for this measure was done by placing the number of indoor staff into bins (Table 17).

Table 17. Number of indoor staff scores

Number of indoor staff	Score
0-20	5
20-30	4.5
30-40	4
40-50	3.5
50-75	3
75-100	2.5
100-250	2
250-1000	1.5
1000-2000	1

Note: Several councils did not report their number of indoor staff. For these councils the number of indoor staff was estimated using linear interpolation between the population and indoor staff as these were closely correlated.

LGA population

During stakeholder consultations the council population was proposed to be included in council capacity. The total population in a LGA can be a proxy for the workforce diversity, economic activity, and resources in a community. This measure was scored using in the bins in Table 18.

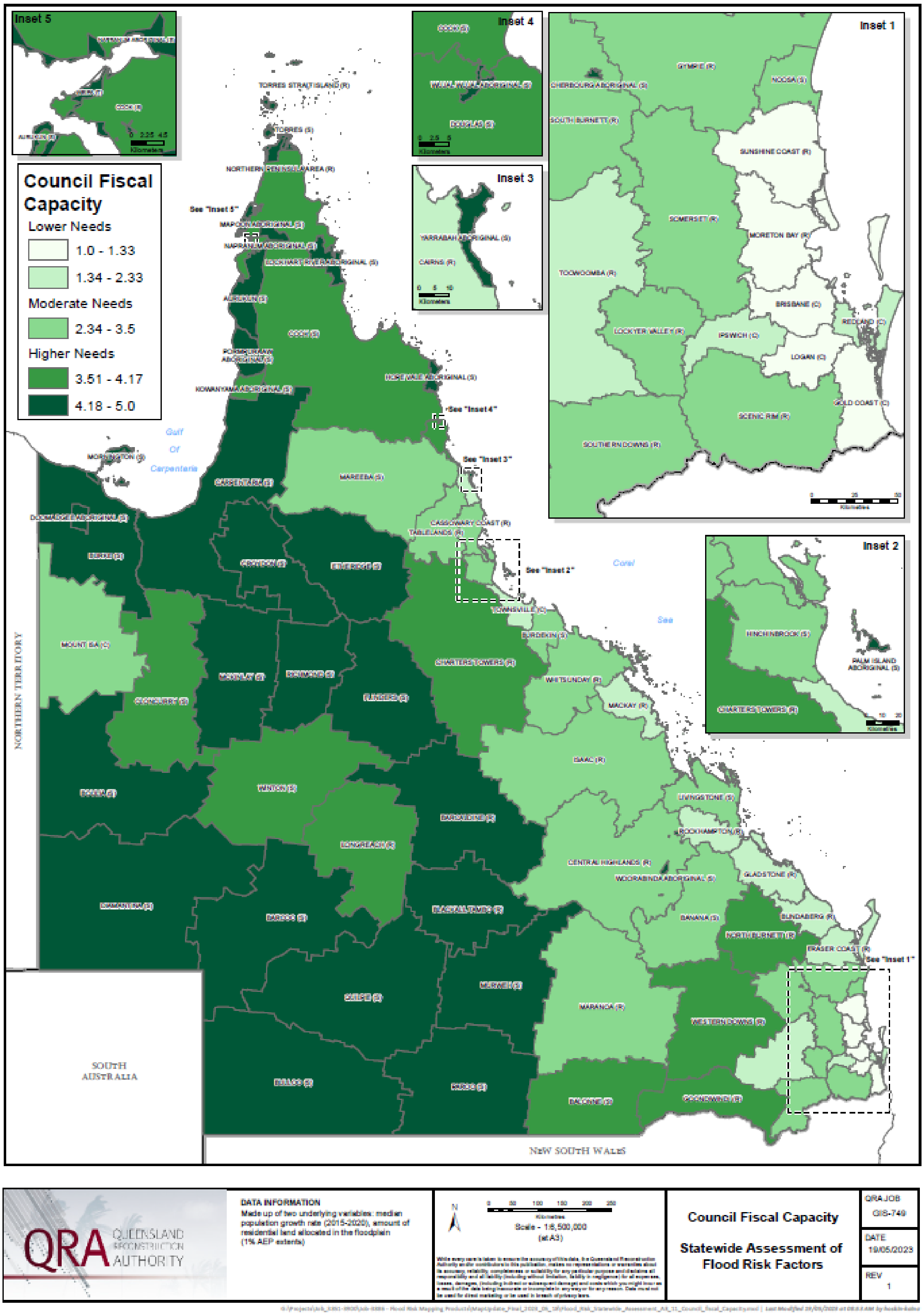
Table 18. Council population by score

LGA population	Score
0-10k	5
10-20k	4.5
20-40k	4
40-60k	3.5
60-80k	3
80-100k	2.5
100-250k	2
250-500k	1.5
500k+	1

Council capacity scores

The resulting council capacity scores for each council is a combination of gross rates utility charges, number of indoor staff and the LGA population. All three variables were equally weighted in the overall score. Mapping the scores across Queensland's councils highlights several trends (Figure 15). All 12 Aboriginal shires were in the high council capacity needs category. Similarly, western Queensland councils spanning from the NSW border up to the Gulf were in the same high needs category. In South East Queensland the councils had a low council capacity need except for Somerset, due to its smaller population. Overall council capacity broadly followed the Great Dividing Range, with those councils to east of the range having higher populations, rates and more indoor staff compared to councils west of the range.

Figure 15. Council capacity scores



Conclusion

The Statewide Assessment of Flood Risk Factors (SAFRF) was Queensland's first ever comprehensive statewide assessment of flood risk management needs. The project was undertaken by QRA in consultation with councils, industry, and other state agencies, with the aim of identifying gaps and needs to support councils in their flood risk management responsibilities, defined in the Queensland Flood Risk Management Framework (2021).

The assessment considers twelve factors that relate to flood risk management. The scores on these factors revealed several trends, including:

- Aboriginal councils tended to score with a high need across many of the factors. Typically, a result of old, low-quality LiDAR, no flood studies, no floodplain management plans, a history of flooding and vulnerable roads to flooding.
- Along the eastern seaboard between Cairns to Brisbane the population in the floodplain is significantly higher than in the west and centre of Queensland by the tens of thousands. With these regions typically exhibiting a mix of flood studies, floodplain management plans and moderate council capacity.
- In the west and centre of Queensland low populations are coupled with a lack of contemporary flood studies, low LiDAR coverage and road networks that can be vulnerable to flooding damage.
- There is a widespread need for flood studies, with 67 of the 78 LGAs scoring a 5 (high need) in this factor.
- On average all the regions of Queensland have a moderate need to reduce the flood exposure and to improve the management of flooding. Specifically, the South West Region has the highest need to improve flood risk management, driven by the opportunity to move from local disaster management plans towards floodplain strategies and plans. This region has a low level of council capacity resulting from low rates (average $7.7 million, small population (average 3970) and small number of indoor staff (average 53). Moreover, this region has a need for new rain and water level stations as identified by the Bureau of Meteorology's scoping study (BOM, 2021).
- The Wet Tropics Regions was the highest in exposure. Driven by Cairn's high number of people in the floodplain (61k in the 1% AEP extents), high population growth rates and the significant portions of roads in the floodplain.

These highlights illustrate that the tool developed from the SAFRF can assist with understanding flood risk management at a LGA level and provide information on the investment needs and priority areas to ensure further progress of flood risk management in Queensland.

References

ABC, 2022, Emergency alerts were delayed during south-east Queensland's flood disaster, report finds, sourced from https://www.abc.net.au/news/2022-10-12/queensland-flood-report-emergency-management-brisbane-alerts/101512840

Australian Disaster Resilience Manual 21: Flood Warning, 2009, Australian Institute for Disaster Resilience CC BY-NC

Commonwealth of Australia (Bureau of Meteorology), 2021a, Queensland Flood warning observations network scoping study technical report #1 – Methodology, assumptions, and outcomes, Official – DRAFT

Commonwealth of Australia (Bureau of Meteorology), 2021b, Queensland Flood warning observations network scoping study summary report, Official – DRAFT

Commonwealth of Australia (Bureau of Meteorology), 2019, Flood Warning Infrastructure Standard, accessed from http://www.bom.gov.au/water/standards/documents/Flood_Warning_Infrastructure_Standard.pdf

Deloitte, 2022, The social, financial, and economic costs of the 2022 South East Queensland Rainfall and flooding event, for the Queensland reconstruction Authority June 2022

KBR, 2015, Performance Review of Flood Warning Gauge Network in Queensland Findings report, prepared for the Department of natural resources and mines. BEW553-TD-EV-REP-0011 Rev. 2

ICSM, 2008, ICSM Guidelines for Digital Elevation Data, Sourced from: https://www.icsm.gov.au/sites/default/files/2017-03/ICSM-GuidelinesDigitalElevationDataV1.pdf

Ipswich City Council, 2021, "Ipswich Integrated Catchment Plan Strategy and Action Plan", sourced from https://www.ipswich.qld.gov.au/__data/assets/pdf_file/0003/226623/Ipswich-Integrated-Catchment-Plan.pdf

MCR, 2022, Queensland Disaster Preparedness Research Wave 2 – 2022 Report, DOC/22/26529

RBA, 2022, Housing in the Endemic Phase, sourced from https://www.rba.gov.au/speeches/2022/sp-ag-2022-05-25.html

The State of Queensland (Queensland Reconstruction Authority), 2021a, Queensland Flood Risk Management Framework, DOC/21/23368 GD/0590

The State of Queensland (Queensland Reconstruction Authority), 2021b, Queensland Strategic Flood Warning Infrastructure Plan, DOC/21/23369 GD/0622

The State of Queensland (Queensland Reconstruction Authority), 2022, Queensland Strategy for Disaster Resilience 2022-2027, QRATF/21/3031 GD 0698

List of abbreviations

Table 19. List of abbreviations

The Framework	Queensland Flood Risk Management Framework
FRM	Flood Risk Management
QFAO	Queensland Floodplain Assessment Overlay
QRA	Queensland Reconstruction Authority
QFES	Queensland Fire and Emergency Services
BOM	Bureau of Meteorology
PMF	Probable Maximum Flood
AEP	Annual exceedance probability
SEQ	South East Queensland
QSDR	Queensland Strategy for Disaster Resilience

Frequently Asked Questions

Q. What is the *Statewide Assessment of Flood Risk Factors* (SAFRF)?

A. The SAFRF will deliver Queensland's first ever comprehensive statewide assessment of flood risk management in Queensland, based on analysis of key flood risk factors across every Queensland council.

Q. Why does Queensland need a SAFRF?

A. The SAFRF supports the implementation of the *Queensland Flood Risk Management Framework* through providing a state overview of our current strengths, needs, gaps and challenges. It will lead to stronger flood risk management capability statewide, as well as feed into the building a case for proactive investment in Flood Risk Management (FRM).

Q. Who is involved in the SAFRF?

A. This initiative is being coordinated by the Queensland Reconstruction Authority (QRA) in consultation with councils, industry and other state agencies.

Q. Who is responsible for the SAFRF?

A. The QRA is responsible for updating, analysing, reporting, and evaluating the SAFRF. We rely on Councils for some of the input data.

Q. How will the SAFRF benefit councils and state government?

A. The SAFRF will:

- identify flood risk factors and needs to facilitate effective FRM
- support proactive funding streams, rather than relying on reactive grants-based programs after events/activations
- enable streamlined funding applications in areas of high need
- provide avenues for the state to provide technical information to councils about statewide data availability/assessment results
- assist regions to understand their collective needs and opportunities for collaboration
- formalise an approach for data sharing and provide an avenue for councils to proactively inform the state of their FRM needs.

Q. How will SAFRF be used to inform investment?

A. Currently Queensland has no established system or data at a statewide level to inform pro-active short, medium, or long-term FRM programs of work and to guide prioritisation of funding.

The ultimate vision is an investment program setting out current and future planned flood risk management projects.

As FRM project needs are not currently well established across the state, a strategy will be developed to inform Flood Risk Management needs according to themes and proposed investment to fulfill these needs over the next 10 years. Themes may include:

- LiDAR and data capture
- flood studies
- flood risk management studies, strategies, and plans
- community awareness and resilience
- flood warning infrastructure
- flood warning systems
- road flood immunity upgrades
- physical flood mitigations
- property specific flood mitigations
- landscape and environmental mitigations.

Other sources of information, such as council Local Resilience Action Plans and Local Flood Risk Management Plans, will also be taken into consideration in developing this strategy, which is only in the very early stages of planning. Extensive stakeholder consultation to be undertaken in 2023 to help shape this document.

Q. How this will align with Queensland's Regional Resilience Strategies in considering flood related actions identified in the local action plans?

A. The local action plans developed under the Regional Resilience Strategies will be referred to when identifying eligible projects as funding opportunities become available. The approval of funding will still consider competing priorities, and the SAFRF will assist in informing these priorities.

Q. What won't the SAFRF do?

A. The SAFRF:

- **will not** rule out any applications for FRM funding, but may simplify process for higher needs councils

- **will not** replace or fulfill Queensland Emergency Risk Management Framework (QERMF) or State Natural Hazards Risk assessment

- **is not** a flood risk assessment in line with Queensland Flood Risk Management Framework process (drawn from the Australian Disaster Resilience Handbook 7: Managing the Floodplain).

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