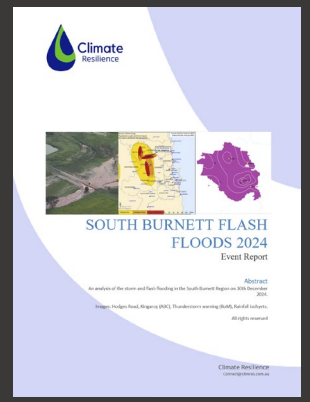


Climate
Resilience

South Burnett Flood Event Report Overview

Summary of December 30th Kingaroy Flood

Important - *The information in this document is general in nature and is for reference purposes only. It does not constitute weather, climate, or engineering advice. For access to the full 30-page report and analysis, please contact us at: connect@climres.com.au*

About Us

Climate Resilience is a Queensland small business, founded in 2022 by James Stuart, a former Bureau of Meteorology Queensland Flood Warning Manager, and Executive for Water Resources and Dam safety at Sunwater.

James is Chair of the International Commission on Large Dams Climate Change Committee, Fellow of Engineers Australia, a Registered Professional Engineer of Queensland (RPEQ), a non-executive Director of the USA National Hydrologic Warning Council, and a Company Director.

Climate Resilience helps organisations achieve better outcomes for decision making, and preparedness ,related to weather, climate, and hydrological risk for governance, critical infrastructure, business, and communities. We do this using a suite of tools that assist in fostering best practice, discharging director duties, facilitating data driven decisions, and global event learnings.

Climate Resilience helps organisations achieve better outcomes for decision making, risk management, and preparedness ,related to weather, climate, and floods for governance, critical infrastructure, business, and communities.

Climate Resilience

Executive Summary

During the afternoon of 30th December 2024, storms impacted the South Burnett Regional Council area with intense rainfall in, and around Kingaroy. This resulted in significant overland flow damaging businesses, infrastructure and homes. Kingaroy, received around 125-150mm within a two-hour period, with isolated totals more than 160mm.

Impacts in Kingaroy are largely attributable to the intensity of the rainfall. Across the council area, impacts were aggravated by the wet antecedent conditions. The location of the storm atop the catchment divide likely prevented life safety impacts that have been seen elsewhere in the area, notably at Cooyar in 1988.

The 'La-Nina like' conditions, in place since early November, were material to the event. Sea surface temperatures had been at record levels in November and December was notable in the historical record at many sites prior to he storm on 30th December leaving saturated catchments, regional dams spilling, and elevated river discharges Climate drivers, particularly the Madden Julien Oscillation (MJO), influenced significant convection through the month.

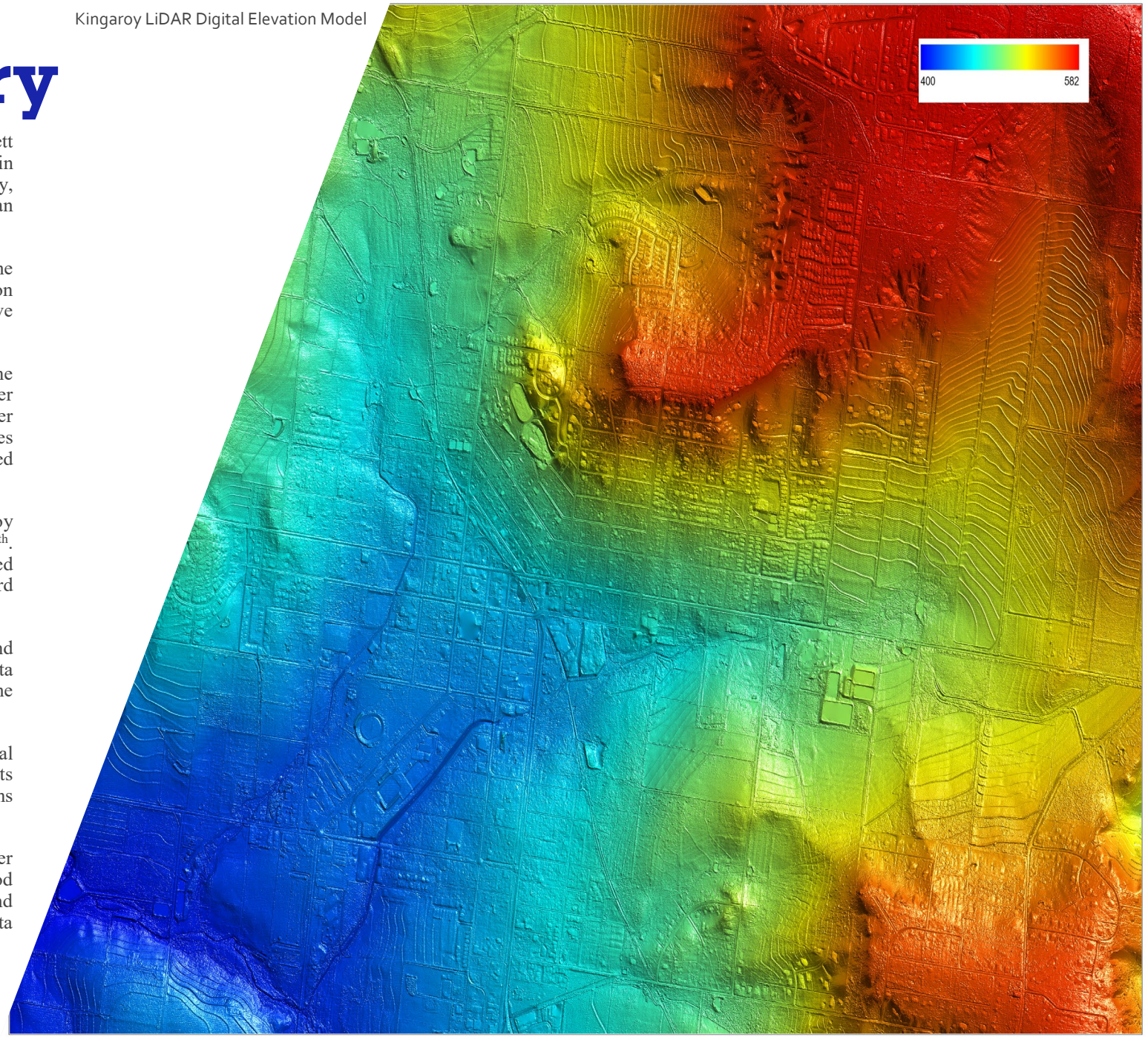
Historically, the daily rainfall to 9am on the 31st December ranked 3rd for Kingaroy and was of a similar magnitude to the 1942 Burnett flood event total ranking 4th. Considering runoff, when grouping by weather events, the Kingaroy Storm is ranked 7th for observed peak flood levels at Weens Bridge, along the Stuart River, a record going back to 1965.

Depth-area-duration analysis demonstrates over 75mm mm fell in 2 hours over around 665km^2. Intensity Frequency Duration (IFD) analysis of Bureau of Meteorology data at Kingaroy shows the probability in any given year was between 1:200 and 1:500, the rarity confirmed by a nearby Sunwater rain gauge.

Impacts included swift water rescues, car damage, significant erosion of agricultural land, inundated businesses and homes, and widespread road closures. Media reports listed over 50 calls for assistance from the State Emergency Service. Regional dams saw historically significant floods.

Warnings were provided by the Bureau of Meteorology and the Local Disaster Management Group, the latter issuing a watch and act for intense rainfall and flood impacts to mobiles within the area. Learnings from the event include those around forecasting severe storm impacts, the importance on antecedent conditions, and data availability.

Kingaroy LiDAR Digital Elevation Model



Site, Situation, and Data

Site and Situation

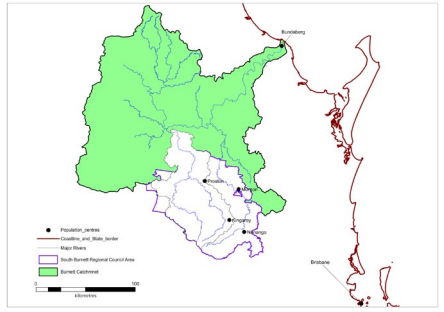


Figure S1: Kingaroy, South Burnett and Wide Bay area

Kingaroy (see Figure S1) is located 155km NW of Brisbane, and 200km SSW from Bundaberg. The 2021 census recorded a population of just over 10,000. The town site slopes in a southerly direction towards Kingaroy Creek. The climate at the town location is classed by the Bureau of Meteorology as temperate, although much of the surrounding area is classed as sub-tropical. The average rainfall is around 650mm annually, based on the Bureau record at Kingaroy Airport.

The topography of the Council area varies between 200mAHD and 1000mAHD (see Figure S2). Kingaroy is located around the catchment divide at around 450 to 500mAHD. Geological strata are largely Igneous hard rocks such as Basalt, and Granite, with a significant area of Coal beds to the west of Nanango, and areas of Quaternary Alluvium confined to river and creek valleys. The region has a GRP of about AUD $2.1 billion annually, with agriculture, coal, and power generation some of the more important sectors of the economy. The traditional custodians of the land are the Wakka Wakka people.

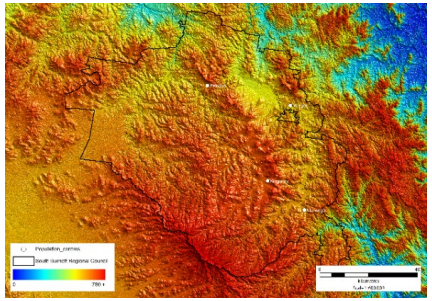


Figure S2: Topography of South Burnett Regional Council area (SRTM)

Data Availability

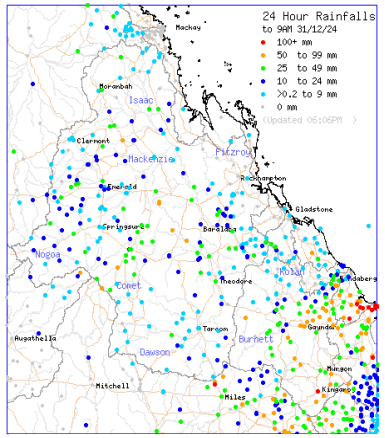


Figure D1: Bureau rainfall totals across region to 9am on 31st December 2024

Data for the event is available from a range of agencies including the Queensland Govt, Sunwater and the Bureau of Meteorology, who each provide quality-controlled data associated with surface water, ground water, and meteorological observations.

In Kingaroy, daily rainfall has been collected by the Bureau since 1905 with an Automatic Weather Station (AWS) replacing the daily observations in 2001. An unbroken composite record is therefore available at Kingaroy from 1905 to present, noting the location difference of around 2km.

Supplementing this, flood warning network data, and private weather stations provide a detailed snapshot of the event, noting these two sources are not quality controlled. 39 rain gauges were available in the area for the event analysis, 20 of which were in Kingaroy.

Climate Resilience

Climate and Meteorology

Climate

The macro climate set up relevant to the events of December 30th, 2024 centers on two key drivers, Sea Surface Temperatures (SST) and the Madden Julian Oscillation (MJO).

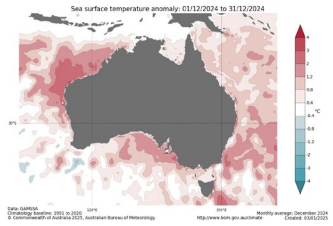


Figure C1: December SST anomaly (Bureau of Meteorology)

SST were at record levels around Australia in November and December 2024 (see Figure C1) with the Bureau advising of the likely influence for increased rainfall. While the El Nino-Southern Oscillation (ENSO) remained at neutral levels, high SST have produced a similar effect to La Nina conditions, leading to identification in early November 2024 of 'La-Nina like' conditions for the 2024-25 wet season.

The MJO was weakening and moving out of the area of influence towards the end of December 2024. However, earlier in the month, the amplitude of the convective energy pulse was strong (see Figure C2) and influenced the increased wet conditions through the month, with rainfall on 14 days, placing the month in the top 10% since 1906. Storms on the 11th , and the 20th resulted in historically important runoff in Barker Creek and the Stuart River.

Figure C2: MJO amplitude and influencing area during December 20204. (Bureau of Meteorology)

Other drivers such as Indian Ocean Dipole, and Southern Annular mode, were unfavourable for influencing wetter conditions in Southern Queensland. Broader indications of the favourable climate for above average rainfall in Southern Queensland include the third wettest November and December combined in Brisbane since 1840, and the Brisbane River exceeding minor flood level on the 17th of December, a relatively unusual event.

Meteorology

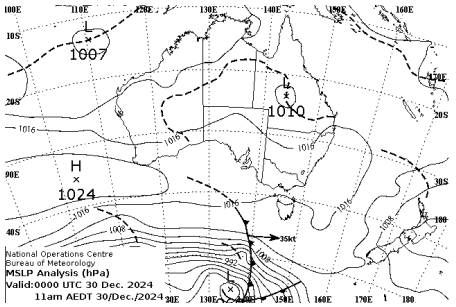


Figure M1 Mean Sea Level Pressure Analysis synoptic chart for December 30th, 2024. (Bureau of Meteorology)

Meteorological conditions were extremely favorable to storm activity on 30th December 2024. An upper trough, visible across Southern Queensland in the synoptic chart for the day (see Figure M1), was located across the Wide Bay forecast district, that includes Kingaroy. Combined with moist and unstable air, this provided all the ingredients necessary for severe storms. A forecast advising of their possibility was provided by the Bureau of Meteorology early on the 30th of December, 2024.

Total Precipitable Water (TPW) values, the moisture in the atmospheric water column, were at moderate levels in the South Burnett area on December 30th. Values of 45-55mm were estimated as shown in Figure M2. Such values are not unusual for Queensland, particularly in the wet season, and well short of TPW record values.

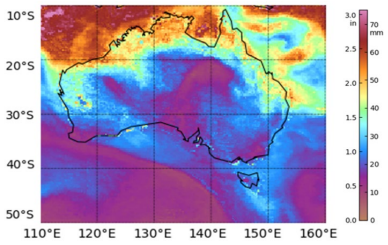


Figure M2: TPW values for December 30th, 2024. (CIMSS)

In forecasting severe impacts, identifying specific locations remain difficult, as noted in the Bureau report into the Cooyar flash flood, in 1988.

Climate Resilience

Event & Historical Context

Antecedent Conditions

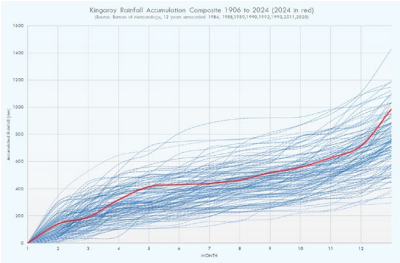


Figure A1: Accumulated rainfall by year 1906-2024 from both official Bureau gauges. 2024 shown in red. (Bureau of Meteorology)

Antecedent conditions were wet. Figure A1 shows the 2024 accumulated rainfall together with 111 years of combined data from both the official Kingaroy stations. August was wet with a rank of 17/111 (54.2mm) of monthly totals with September, October, and November seeing broadly average rainfall. Prior to the storm, December ranked 37/111 for an accumulated monthly total, and post event ranks 5th wettest December since 1906 as of the date of this report. In terms of rain days, Kingaroy observed 131 during 2024.

The wet nature of the region prior to the storm is demonstrated in Figure H1 that shows the peak levels recorded at Weens Bridge, along the Stuart River. Gauged since 1965, levels on the 11th and 19th reached rankings of 18 and 13 respectively (amber) in terms of days ranked, from over 21,000 days recorded.

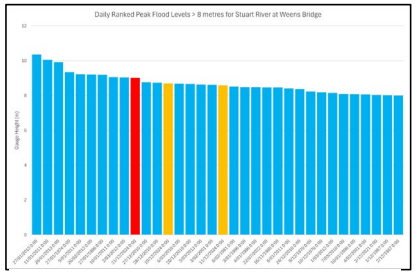


Figure A2: Daily peak levels above 8m on the Stuart River at Weens Bridge, ranked by height (Bureau of Meteorology)

The two major dams in the region, Boondooma and Bjelke Petersen, both filled and commenced spilling on 12th December. Spills at these dams are relatively infrequent events, and the rainfall on the 20th of December led to increased spillway discharges that rank 5th and 6th in the historical record at Boondooma, and Bjelke Petersen Dam respectively. This confirms the wet lead-up to the Kingaroy storm on December 30th ,and that it was a historical month prior to the events of the 30th December.

Historical Context

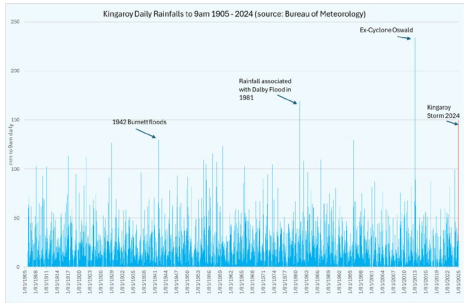
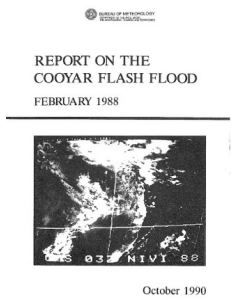


Figure H1: Daily Rainfall 1905 to 2024 from both Bureau gauges in Kingaroy. (Bureau of Meteorology)

At a daily scale, the event rainfall totals observed are historical, although not record breaking. Using a composite record of the Kingaroy official Bureau observations since 1905 (Figure H1), the 24-hour totals to 9am on the 31st December rank 3rd behind Ex-Cyclone Oswald in 2013, the Dalby event storm of 1981, and just ahead of the 1942 Burnett flood event. It should be noted that the 2011 flood data is missing from the record and there is good evidence that there were rainfalls more than 100mm in the 24 hours to 9am during that event.


REPORT ON THE
COOYAR FLASH FLOOD
FEBRUARY 1988

October 1990

Considering monthly totals, December ranks as one of the wettest months in the last 120 years in South Burnett. At one location, the monthly totals rank third in accumulated rainfall for any month since 1916. The region has experienced flash floods before, with the area to the south of Kingaroy seeing significant flash flood events at locations including Yarraman, Nanango, and Blackbutt, and with a notable event at Cooyar in 1988, 60km to the South of Kingaroy, that saw 225mm in 3 hours (Figure H2).

Figure H2: Cooyar Flash flood report

Climate Resilience

Flood Event

Kingaroy Rainfall and Flood

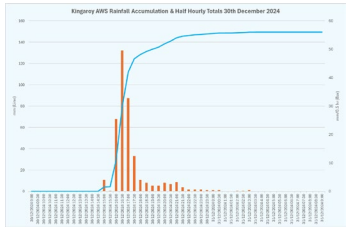


Figure E1: Event rainfall accumulation and half hourly totals recorded by the AWS at Kingaroy Airport.

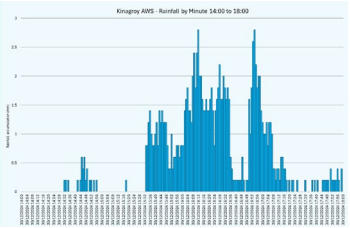


Figure E2Minute rainfall accumulations recorded by the AWS at Kingaroy Airport.

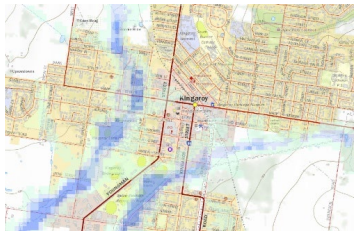


Figure E3: 1% Annual chance flow paths in Kingaroy (Qld Govt.)

The Bureau of Meteorology Automatic Weather Station (AWS) at Kingaroy Airport observations are available at a minute timescale throughout the storm. Continuous rain was observed between 14:30hrs (30th) and 00:30 on the 31st of December, a duration of 10 hours with 148.6mm. (Figure E1) during this period. 120.2mm fell between 15:30 and 17:30 with two intense bursts around 4pm and 5 pm, evident in minute data shown in Figure E2. Rainfall rates of 168mm per hour were recorded.

Similar observations of timing, and magnitude were recorded from a standalone rain gauge in the Booie area, owned by Sunwater, that observed 91mm in 60 minutes. Twenty unofficial gauges in and around Kingaroy recorded event totals as high as 188mm, with several exceeding 160mm.

The intensity of the rainfall was well in excess of the design capacity of the stormwater drainage system and a number of videos of the event confirm this, with significant overland flow evident that inundated businesses, prior to entering tributaries of Kingaroy Creek. A general guide from the 1% flood area, as provided by the Qld. Govt is outlined in Figure E3.

Regional Rainfall and Flood

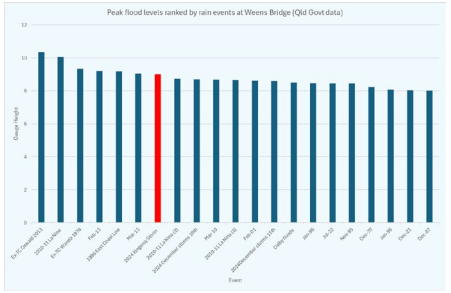


Figure R1: Peak flood levels at the Stuart River gauging station at Weens Bridge. (DLGWV)

In the broader region, critical infrastructure impacts occurred in both the Barker Creek, and Stuart River catchments with roads and bridges inundated. Analysis of historical peaks from the Qld Govt. gauging station at Weens Bridge, shows a significant rate of rise with the change in water level advancing from 0.8m below the bridge deck to inundation within 20 minutes, and with a time of closure of over 24 hours. The location saw the highest discharge since 2013.

Elsewhere, multiple roads were damaged or undermined with closures evident in the South Burnett emergency dashboard (see Figure R2)

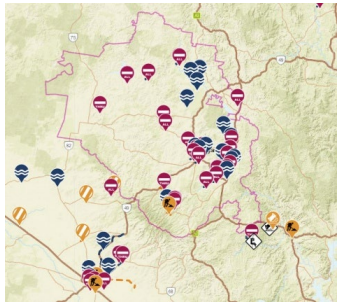


Figure R2: Road closure and flooding (South Burnett Regional Council Dashboard -31/12)

Social media videos show significant runoff from agricultural land with evident erosion, particularly in the locations of the most intense rainfall, an area that included Kingaroy, Booie, and Coolabunia.

The regions dams, already full, saw significant spills, with Boondooma seeing a peak that ranks 4th on the record since construction. Bjelke Petersen dam also spilled, and Gordonbrook Dam saw a flood 2.5 times the dam's volume pass through the spillway. Many weirs, such as Proston were drowned out.

Climate Resilience

Event Analysis

Depth, Area, Duration

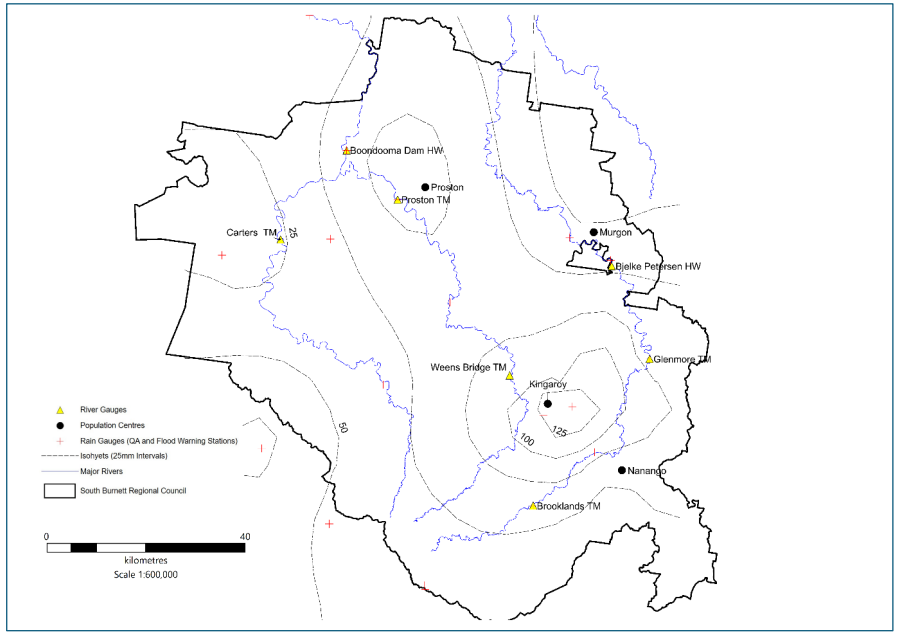


Figure AD1: Gauge location, major watercourses, and rainfall isohyets (24 hour totals) for 30th December 2024.

Analysis of the event totals sourced from official agencies demonstrate Kingaroy was at the centre of the storm cell on 30th December. Using Geographical Information Systems to estimate depth across areas, 122km² received more than 125mm with several totals locally reaching more than 160mm in 24 hours. 322km² is estimated to have received over 100mm, 665km² is estimated to have received over 75mm. Hourly depth-area values are estimated at 85mm over 122km², and 65mm over 322km². 24-hour isohyets are shown in Figure AD1.

Intensity, Frequency and Duration

Intensity, Frequency, Duration (IFD) analysis has been conducted using Australian Rainfall and Runoff (ARR) 2016. Assessment of the data shows that the storm duration with the most infrequent likelihood associated with the Kingaroy AWS data was 2 hours, during which 120mm was observed. The estimated frequency is between 0.5% (1:200) and 0.2% (1:500) chance annually. Whilst other durations also have a similar frequency assessment, the depth for the 2-hour duration exceeded the 1:200 chance depth by the largest margin. The hourly totals had a frequency of between 1% to 2% annually. More broadly, all durations greater than 25 minutes had a chance of occurrence rarer that a 10 annually.

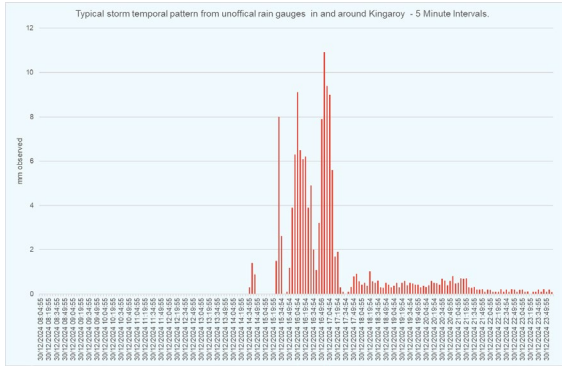


Figure I1: Typical storm intensity of 5-minute data from unofficial rain data

Assessment of the intensity data sourced from 20 informal gauges confirms two periods of very intense rainfall, observed at Kingaroy AWS, occurred across a much larger area. The two periods are clearly visible in Figure I1, a typical temporal pattern from Kingaroy.

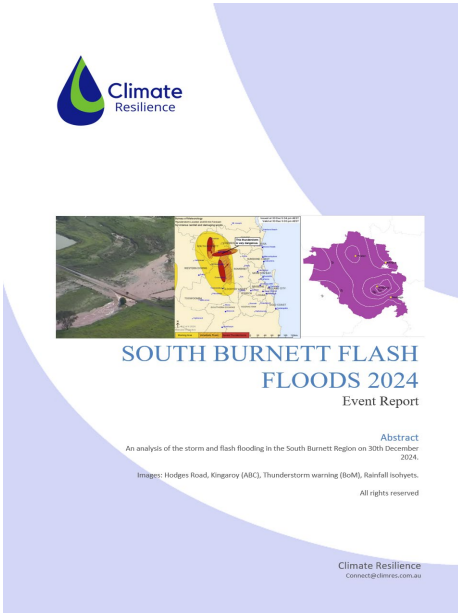
Climate Resilience

Flood Cause, and Mechanism

Flood Cause, Mechanism and Aggravating Factors

An assessment of the flood cause, mechanism, and any aggravating factors is contained within the full event report.

Full Report Access



Contents

The full , 30-page general event report includes detailed discussion, an event timeline, analysis of rainfall, river flows, critical infrastructure, and a full warning archive.

The report is available commercially ‘as is’, or can be modified with specific organisational additions, or questions, resolved.

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Climate Resilience

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