Australian Government
National Emergency Management Agency

Australian Institute for Disaster Resilience

Major Incidents Report 2021-22

AIDR is the National Institute for disaster risk reduction and resilience. We collaborate across sectors to strengthen the resilience of Australian communities to disasters.

AIDR creates, grows, and supports a range of networks; provides opportunities for learning, development, and innovation; shares knowledge and resources to enable informed decision making and action; and facilitates thought leadership through national conversations.

AIDR is a consortium managed by AFAC as a business unit and supported by its partners: the Australian Government National Emergency Management Agency and the Australian Red Cross.

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This report was compiled by Tony Murphy AFSM, former Chief Fire Officer of the Metropolitan Fire Brigade, Victoria, and Deputy Emergency Management Commissioner at Emergency Management Victoria.

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Image: Australian Defence Force

Foreword

The Major Incidents Report provides an annual record of major incidents from a national perspective that have been viewed as significant by the emergency management sector. This edition, the sixth Major Incidents Report commissioned by the Emergency Management and Response Group, National Emergency Management Agency and published by the Australian Institute for Disaster Resilience, outlines 36 significant events that impacted Australia across the 2021-22 financial year. Detailed overviews are provided for 9 of these incidents, selected based on factors including uniqueness, duration, impacts, resourcing demands, tiers of government involved, specialist equipment required and learnings.

The *Major Incidents Report 2021-22* includes a snapshot of the climate drivers that influenced the weather pattern across Australia and the impact this had on natural hazard events, including the second consecutive La Niña event which contributed to prolonged wet conditions on the east coast, and dry and hot conditions in the south west. It also includes an overview of the national resourcing arrangements that saw the sharing of personnel and equipment between Australian jurisdictions to provide surge capacity during major incidents, highlighting the strengths of Australia's tight-knit emergency management community.

Throughout the 2021-22 period the Australian emergency management landscape was dominated by consecutive, concurrent, compounding and complex natural hazards that have cascaded through communities and impacted on interconnected economic activities, technological services and natural environments. This report provides an overview of catastrophic flooding across Queensland and New South Wales in early 2022, affecting communities that have now been impacted by multiple flood events over several years. It details storm events in South Australia and Victoria in October 2021 and the impact of flooding from Tropical Cyclone Tiffany in Central Australia which disrupted national road and rail supply lines, impacting communities nationwide.

The 2021-22 period also saw the introduction of the National Coordination Mechanism (NCM), which has improved national arrangements. It was the catalyst for improved national coordination, collaboration and communication in stabilising and responding to the complexities that disasters impose on Australian communities. In addition to the NCM dealing with non–health impacts of COVID, supply chain issues, AdBlue shortages, food security and the flooding in South Australia the NCM has established a new way of including industry in problem definition and management when it comes to the consequences of disasters and crises.

The *Major Incidents Report 2021-22* demonstrates the capability of and necessity for the states and territories, Australian Government and industry to work together to minimise the impacts of the consecutive, concurrent, complex and compounding events that Australia faces. It highlights the important work and skills of our emergency service agencies and volunteers that help to keep communities safe.

I would like to acknowledge AIDR and the contribution of Tony Murphy AFSM in the development of this report, as well as the guidance and input provided by jurisdictional representatives from emergency service organisations, and the Bureau of Meteorology who formed the Major Incidents Report Steering Committee.

Joe Buffone PSM

Deputy Coordinator-General
Emergency Management and Response
National Emergency Management Agency

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The 2021–22 financial year (1 July 2021 - 30 June 2022) presented significant weather challenges for Australia, including above average rainfall due to a second successive La Niña, which resulted in widespread and significant flooding.


Image: NEMA

The concurrent, consecutive and compounding events of the season are not limited to the impacts of weather. The ongoing COVID-19 overlay remained a necessary consideration on emergency management responses across the country, as well as affecting access to critical supplies across a number of sectors.

Australia also faced several emerging health and biosecurity challenges including Japanese Encephalitis and Monkeypox, and the emergence of the agricultural Lumpy Skin Disease and Foot and Mouth Disease in our region. Fortunately, at the time of publication, Australia remains free of both these diseases.

The collaborative efforts of states and territories, the Australian Government, industry and non-government organisations in navigating these varied and complex issues – through crisis response to recovery – cannot be understated.

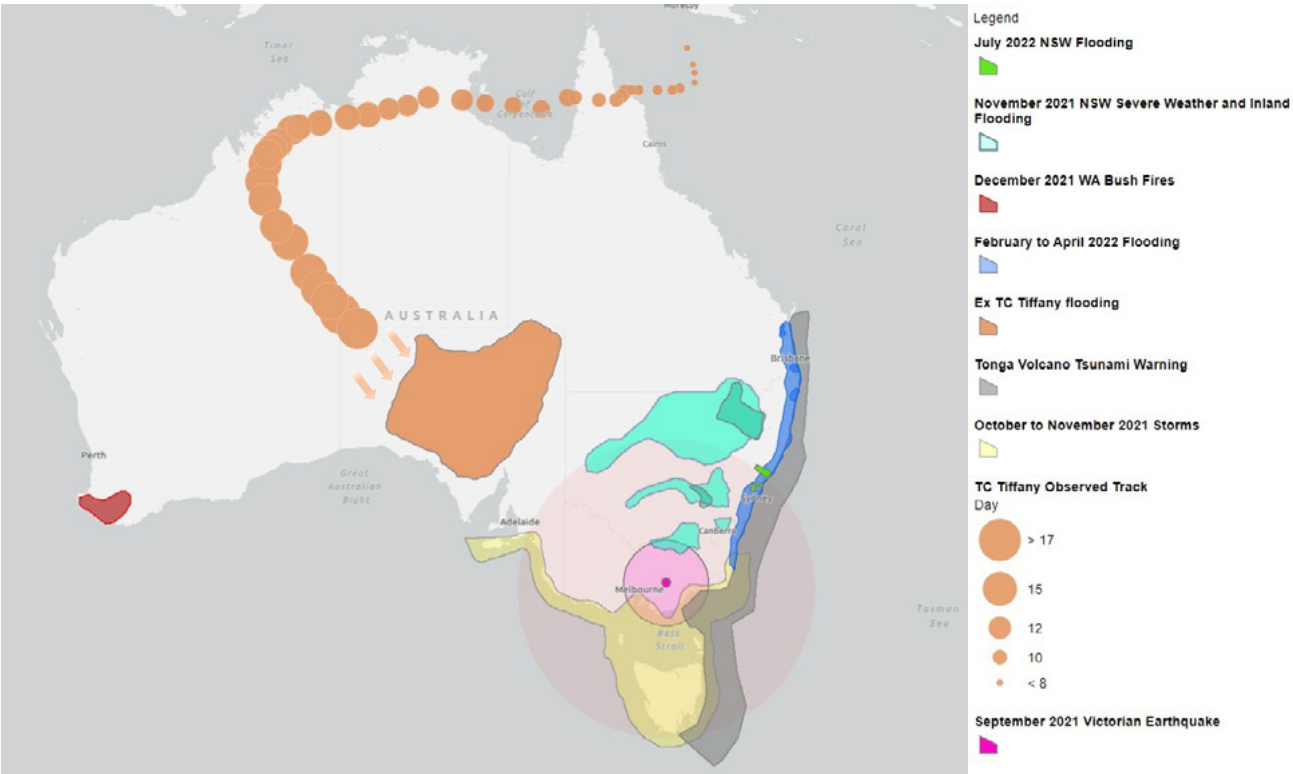

Figure 1: Map of major incidents described in the national overview

Weather Overview

July 2021 – June 2022 climate context:

- Australian rainfall +10%; New South Wales +39% (fifth highest on record, highest since 2011); Murray Darling Basin +26% (Preliminary data to the end July 2022).
- A weak to moderate strength negative Indian Ocean Dipole (IOD) became established in July, declared by the Bureau of Meteorology on 20 July. A negative IOD is typically associated with above-average rainfall across much of the eastern two-thirds of Australia in the winter-spring period.
- A weak-moderate strength La Niña became established in November, declared by the Bureau of Meteorology on 23 November (a late declaration based on previous history), following a La Niña watch issued in September and a La Niña alert issued in October. This was the second consecutive La Niña event following the La Niña of 2020-21 (back-to-back La Niña are not uncommon—about half of La Niña events on record return for a second year).
- The 2021-22 La Niña increased the likelihood of rain bearing weather patterns over eastern Australia and it reduced evaporation due to increased cloudiness and reduced temperatures. These conditions resulted in an increase in soil moisture during the spring and summer, meaning any heavy rainfall on the wet catchments saw less water soaked up by the ground and a tendency for rivers to respond more quickly and reach higher levels compared to dry catchments. La Niña conditions persisted through autumn, returning to neutral (neither La Niña nor El Niño) as of 21 June.
- A La Niña watch was issued in late June, indicating around a 50% chance of La Niña re-developing during the 2022-23 season.
- The Southern Annular Mode (SAM) was strongly positive from September through to April indicating weather systems were further south than normal, and hence directing moist onshore flow onto the east coast which was favourable for above-average seasonal and reinforced the La Niña impacts. The SAM value for the summer of 2020-21 was the third highest SAM since summer 1979-80.
- Waters around northern Australia were the third warmest on record for summer behind only 2015 (warmest) and 2019, further contributing to the increased likelihood of above-average rainfall.
- Nine tropical cyclones were observed across the Australian region, equal to the average since 2000 of 9 per season.
- The strongest tropical cyclones (TC) in 2021–22 were Vernon (February) and Charlotte (March). Both peaked at Category 4 intensity while well offshore of the Western Australia coast.
- Two TCs made landfall on Australian territories. Tiffany, which first crossed the east coast of Cape York Peninsula (at Category 2), and then tracked westwards and crossed the Arnhem coast of the Northern Territory (at Category 2, early January). Anika made landfall on the northern Kimberley coast (at Category 2) and then a second crossing of the Pilbara coast (at Category 2, late February-early March).
- Australia's wettest November on record (since 1900); 135% above long-term average. Previous wettest November was 1973. New South Wales had its wettest November on record, with more than 3 times its average November rainfall observed during the month.

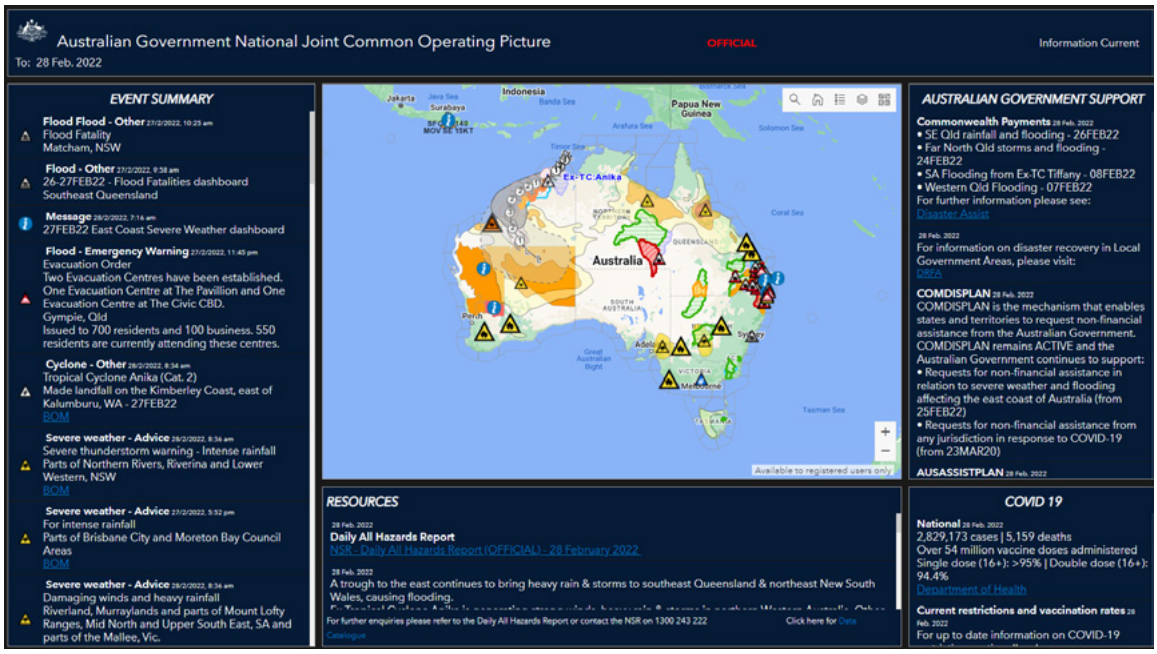

Figure 2: National Joint Common Operating Picture, 28 February 2022.

- The wet November led to Australia's lowest November mean monthly maximum temperature since 1999 and lowest mean minimum temperature since 2001.
- For Australia in autumn 2022, the mean minimum temperature was the second highest on record (behind only 2016), related to high rainfall and cloud cover (and resultant thermal blanket effect). New South Wales had its wettest Autumn since 1990 and seventh wettest on record.

High-impact weather:

- Severe thunderstorms on 14 October produced a tornado at Armidale, New South Wales, with reports of damage to buildings and cars.
- Severe thunderstorms with widespread large to giant hail occurred across parts of eastern Queensland. Hail up to 16 cm diameter was observed at Yalboroo (between Mackay and Proserpine) on 19 October, making it the largest verified hailstone measurement in Australia.
- On 20 October a severe thunderstorm moved through Coffs Harbour and Sawtellin New South Wales, resulting in extensive damage to homes and the Toormina shopping centre and leaving hail up to 30 cm deep on the ground.
- A weak tornado damaged buildings around the Port of Brisbane and Brisbane Airport on 21 October.
- Destructive winds associated with a severe thunderstorm hit Sydney's Northern Beaches on 19 December, with 2 fatalities reported.
- Heavy rainfall caused flooding to large areas of New South Wales and Queensland during November and December. The main areas affected were central/southern Queensland and central New South Wales.
- Major flooding affected parts of southeast Queensland in early January, associated with ex-TC Seth, including across the Bundaberg region.
- Ex-TC Tiffany contributed to record rainfall and flooding in parts of central and southern South Australia later in January, causing considerable damage to major arterial roads.
- Extreme to Catastrophic fire weather conditions in the Western Australia South West Land Division at the start of February, with multiple bushfires and some property loss.
- Persistent heavy rain led to flooding in February across southeast Queensland (including Brisbane metro, Sunshine Coast, and Ipswich) along with the Wide Bay and Burnett district, including Gympie. The heavy rain and flooding also affected northeast New South Wales, most notably around Lismore in late February.
- Heavy rainfall in early March, including that associated with an East Coast Low, continued the flooding event in northeast New South Wales while also leading to flooding around the Greater Sydney region.
- Later in March, very heavy rain around the Gold Coast, Queensland, led to major flooding and affected parts of northeast New South Wales, including Lismore (second township evacuation in a month).
- A deep low-pressure system off the southern coast of New South Wales at the start of April led to heavy rainfall and flooding over parts of East Gippsland, Victoria. The rainfall also caused renewed flooding across the Greater Sydney region.
- Storms and record heavy rainfall caused flash flooding in parts of southeast Tasmania early in May.
- In mid-May, more record rainfall affected parts of eastern and northern Queensland and parts of New South Wales, with flooding impacting parts of Queensland, from the coastal northern tropics to areas of the central west and the south east.
- Heavy rainfall at the end of May caused flooding and road damage across parts of the eastern Pilbara region of Western Australia.

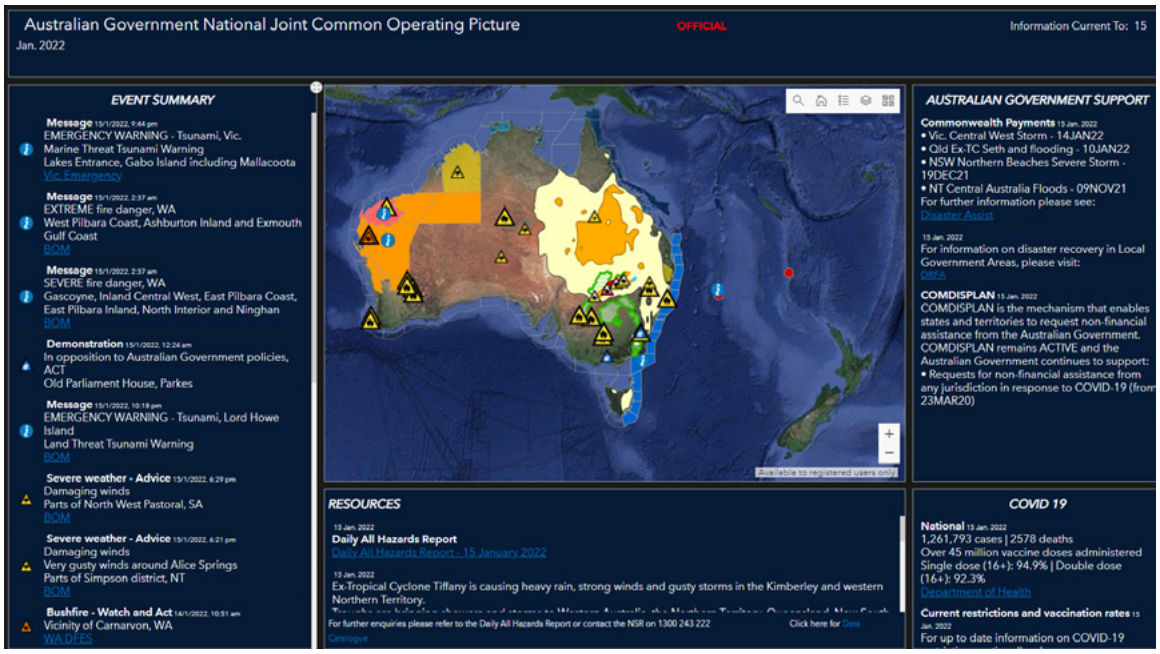

Figure 3: National Joint Common Operating Picture, 15 January 2022, depicting Tsunami warnings, heatwave and fire dangers.

National Emergency Management Agency

The Australian government, through the Emergency Management and Response Group of the National Emergency Management Agency (NEMA, formerly Emergency Management Australia), leads the Australian Government disaster and emergency management response, working with states and territories to build a disaster resilient Australia that prepares and responds to nationally significant disasters and emergencies. Through NEMA, the Australian Government maintains a forward leaning approach, coordinating disaster response support to states and territories during crisis events and the transition to disaster recovery.

The Australian Government National Situation Room (NSR) within NEMA provides 24/7 situational awareness, predictive analysis, impact and consequence assessment, and decision support to ensure rapid and appropriate assistance is provided to the states and territories when requested. The NSR issues short message services (SMS), verbal and written notifications on all-hazard emergency management events to key stakeholders where an event poses a potential risk to the Australian community or Australian interests.

During the period of 1 July 2021 to 30 June 2022, the NSR issued 2,281 reports, notifications, flash messages and dashboards to key stakeholders in Australian Government and state and territory agencies.

On 1 November, NEMA launched the National Joint Common Operating Picture (NJCOP), a web-based platform that provides decision makers with near-real-time automated situational awareness and decision support for nationally significant hazard events. As a trusted single source of truth, the NJCOP provides collective and common visibility of hazards across Australia, supporting unity of action and collective decision making in the best interests of those communities impacted by severe events. The NJCOP draws on data from Australian Government agencies including weather modelling from the Bureau of Meteorology, geospatial and earthquake modelling from Geoscience Australia and demographic data from the Australian Bureau of Statistics, along with hazard information from states and territories.

National Plan Activations

A NEMA Crisis Coordination Team (CCT) was established on 3 occasions for a total of 70 days to manage operational responses in relation to nationally significant events. In the reporting period, the Australian Government Disaster Response Plan (COMDISPLAN) was activated on 4 occasions and NEMA coordinated 386 non-financial requests for assistance (RFAs) from states and territories. In addition, the Australian Government Overseas Assistance Plan (AUSASSISTPLAN) was activated 9 times. The Australian Government Plan for the Reception of Australian Citizens and Approved Foreign Nationals Evacuated from Overseas (AUSRECEPLAN) was activated after the fall of Kabul, Afghanistan, in August, supporting the repatriation of over 4,100 people to Australia.

During the extensive flooding events of 2021-22, the Director General (DG) NEMA activated the European Commission's Copernicus Emergency Management Service mapping system 6 times, capturing 105 satellite images, which were shared with the Australian Government and state/territory stakeholders.

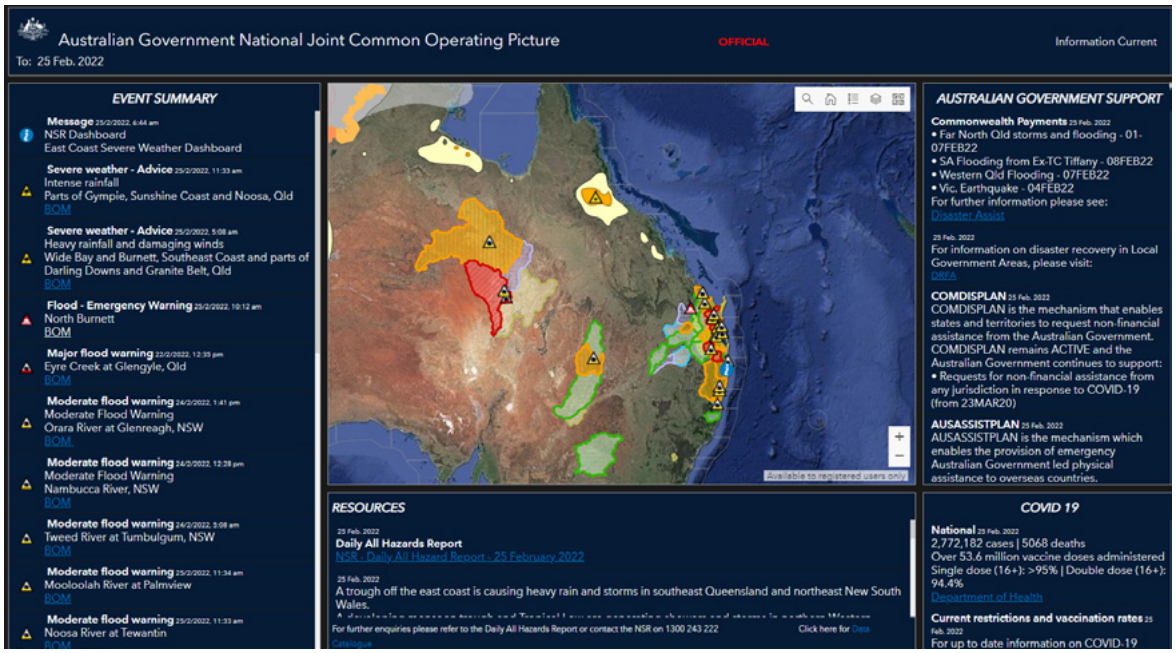

Figure 4: National Joint Common Operating Picture, 25 February 2022.

NEMA reported on, and where appropriate coordinated whole-of-Australian Government responses to several large scale crisis events in this period including:

Earthquake, VIC – September 2021

- On 22 September a magnitude 5.9 earthquake struck near the town of Rawson.
- It was the largest magnitude earthquake recorded onshore in Victoria in the modern instrumental era (post 1900).
- In total, 7 quakes were recorded, with tremors felt across Victoria, New South Wales, the Australian Capital Territory and as far away as Adelaide and Launceston.
- Geoscience Australia received more than 40,000 reports from people recording that they had felt the earthquake; a record since the agency started collecting felt reports.
- There were 46 reports of building damage, mainly in Melbourne and Mansfield.
- No Australian Government non-financial assistance was required.

Storm, SA/VIC/TAS – October-November 2021

- Severe thunderstorms brought torrential rainfall, destructive wind gusts and abundant hail to areas of South Australia and Victoria on 28-29 October, and Tasmania on 1 November.
- At its peak, the storm caused power outages at 518,000 properties in Victoria and at over 30,000 properties in Adelaide.
- The highest wind gust reported was 143km/h at Mount William in the Grampians, Victoria.
- The Bureau of Meteorology reported more than 500,000 lightning strikes in southeast Australia in the 24 hour period between 28-29 October.
- Fortunately, no injuries or fatalities were reported. The event was declared an insurance catastrophe by the Insurance Council of Australia, which has so far recorded 109,000 claims worth $839 million in relation to the damages caused by this event.

Tropical Cyclone Tiffany, QLD/SA – January 2022

- TC Tiffany was a Category 2 system that crossed the Queensland coast near Cape Melville on 9 January.
- COMDISPLAN was activated on 9 January, in anticipation of non-financial RFAs in relation to severe weather in southeast Queensland and forecast effects of TC Tiffany.
- On 10 January, the Coen River flooded following heavy rain from Tiffany, which continued to move west across the Gulf of Carpentaria, later impacting the Northern Territory as a Category 1 system.
- Tiffany weakened to an ex-TC in mid-January. Severe weather related to the system subsequently resulted in significant impacts in northern, central and western parts of South Australia.
- Some areas received as much as 200mm of rain, resulting in widespread flooding that caused extensive damage to South Australian transport infrastructure and freight routes, cutting direct rail and road freight access between Darwin, Adelaide and Perth for several weeks.
- The flooding caused major disruptions to the national supply chain and led to a shortage of fresh produce, groceries, medicines, fuel and water treatment chemicals for an extended period of time, especially in the Northern Territory, South Australia and Western Australia. During this period, industries also reported impacts on workforce absences.
- The disruptions were compounded by concurrent supply chain challenges across Australia, largely caused by the workforce shortage due to the spike in the Omicron variant of COVID-19 infections.
- The Supply Chain Taskforce (SCTF) National Coordination Mechanism (NCM) was established on 10 January in response to the compounding and consecutive pressures on Australia's supply chains and worked to identify and address the additional critical supply impacts caused by the flooding event.
- The NCM ran 10 meetings and multiple working groups to harness the full capabilities of the Australian and state and territory governments and the private sector in support of the whole-of-government response to the crisis, enabling emerging vulnerabilities and issues to be identified and addressed.
- The NCM facilitated the establishment of a 'land bridge', in collaboration with the National Heavy Vehicle Regulator and transport industry CEOs, providing greater road freight capacity between Adelaide and Kalgoorlie. Options for additional sea freight were considered and actioned.
- The NCM also coordinated with the South Australian Government and industry to enable the transport of supplies to the eastern states, in order to resolve the supply issues of water purification chemicals, an essential element to sanitising flood affected drinking-water reserves.
- Australian Defence Force (ADF) air support was also approved on 29 January to ensure the delivery of critical supplies in regional South Australia.

Hunga Tonga-Hunga Ha'apai volcanic eruption and tsunami – 15 January 2022

- On 15 January, the Hunga Tonga-Hunga Ha'apai underwater volcano erupted, triggering a tsunami and blanketing many of Tonga's islands in a thick layer of volcanic ash. Two Tongan and one British national sadly lost their lives.
- A tsunami wave measuring 1.2m was observed at Nuku'alofa, Tonga.
- Land warnings were issued for Lord Howe and Norfolk Islands, and marine warnings were issued for large parts of the Australian east coast including Queensland, New South Wales, Victoria and Tasmania. The NSR liaised extensively with the Bureau of Meteorology and Geoscience Australia to confirm modelling and potential impacts, and maintained close communications with the eastern states. Fortunately, no impacts were experienced in Australia.
- Tonga's main island of Tongatapu, including the capital Nuku'alofa, experienced significant ash fall and flooding. Infrastructure on several outer islands was largely destroyed and local phone and internet services were disrupted due to volcanic ash.

- The tsunami caused significant damage to Tonga's international and domestic undersea fibre-optic cables, temporarily severing communications with and within Tonga.
- In response to the event, the Australian Government Department of Defence (Defence) established Operation (OP) TONGA ASSIST 22, to manage humanitarian RFAs. This included equipment to re-establish telecommunications, desalination equipment, shelter and hygiene kits, personal protective equipment and tools and equipment for volcanic ash cleaning up.
- A Royal Australian Air Force (RAAF) aircraft conducted a reconnaissance on 17 January, ahead of the first flight (C-17) to deliver humanitarian supplies on 20 January. This and subsequent flights delivered over 130 tonnes of emergency relief supplies and equipment.
- Her Majesty's Australian Ship (HMAS) Adelaide, HMAS Supply and HMAS Canberra were deployed to Tonga from 26 January to 18 March. The ships carried over 250 tonnes of emergency relief, humanitarian, medical and construction supplies. Emergency response was delivered using the ships' embarked engineering and helicopters forces.

NSW and QLD flooding – February to April 2022

- From late February to early April, Australia's east coast endured 3 intense weather systems that led to record rains and flooding, causing significant damage to critical infrastructure (including rail, roads, power and telecommunications), property, the agricultural sector and numerous critical supply chains.
- The flood event was one of the most severe in Australia's history with over 14 million people living in New South Wales and Queensland impacted.
- The event's severity was underpinned by its concurrency, with New South Wales and Queensland suffering catastrophic flooding in quick succession, drawing significantly on the resources of each state.
- Sadly, 26 people lost their lives.
- More than 8,000 homes were damaged or destroyed, with the estimated value of insurance claims in New South Wales and Queensland being over $4.29 billion – the majority related to property damage.
- Essential services across both states were impacted, with widespread power and communications outages. A number of schools and childcare facilities closed, and some communities were without clean drinking water.
- Significant impacts occurred to key rail and road freight routes, isolating communities and affecting access to food, fuel and medical assistance. The disruptions extended far beyond the flood affected regions, with food and grocery shortages occurring in Far North Queensland and parts of the Northern Territory due to rail line damage north of Brisbane.

Australian Government support

- On 25 February, COMDISPLAN was activated in anticipation of non-financial RFAs from affected states in response to severe weather and flooding. NEMA established a dedicated CCT shortly after to facilitate RFAs across both New South Wales and Queensland, including the provision of rotary wing aircraft for search and rescue operations, aerial assets to conduct large scale aerial imagery and mapping. ADF assets were providing search and rescue helicopter assistance, with 2 successful rescue missions conducted that evening in Gatton and Jimboomba (Boonah) in Queensland.
- Aviation support to search and rescue missions in New South Wales began on 28 February, including the rescue and evacuation of 56 residents across the Northern Rivers Region including Lismore, Ballina, Gundurimba, Woodburn, Dunoon, Bungawalbin, Upper Wilsons Creek, Kyogle, Swan River and Upper Main Arm. Further information on the Defence's support to the east coast floods is available below.
- On 27 February, NEMA, through Geoscience Australia, activated the European Commission's Copernicus Emergency Management Service to provide satellite-based flood extent imagery for Australian Government and state authorities. A total of 62 images were captured across 16 locations. The service was deactivated on 11 March in consultation with the Queensland and New South Wales governments.
- NEMA deployed Liaison Officers to the New South Wales State Emergency Operations Centre and the Queensland State Disaster Coordination Centre for the duration of the event, who assisted with timely facilitation of support.
- Throughout the crisis, NEMA convened regular meetings of the Australian Government Crisis Recovery Committee bringing together Australian Government agencies to provide a coordinated Australian Government response in support of New South Wales and Queensland.
- The NCM also facilitated multiple discussions between jurisdictional governments, Australian Government agencies and relevant industries, including Banking and Finance, Food and Grocery, Agriculture, Telecommunications and Logistics to address and overcome nationally significant issues resulting from the event.
- DG NEMA also chaired several meetings of the Commissioner's and Chief Officer's Strategic Committee, to facilitate common national situational awareness and resource sharing offers across jurisdictions.
- Australian Government Disaster Recovery Payment (AGDRP) and the Disaster Recovery Allowance (DRA) were activated in response to the southeast Queensland and New South Wales severe weather and flooding (February – April).
- Over 1.3 million claims for AGDRP were approved.

National Emergency Declaration

- On 11 March, the Governor-General, his Excellency General David Hurley AC DSC, issued a National Emergency Declaration (the Declaration) for flood affected communities in New South Wales on the recommendation of the former Prime Minister, the Hon Scott Morrison MP.
- The National Emergency Declaration Act 2020 (the Act) was enshrined in legislation following recommendations from the *Royal Commission into National Natural Disaster Arrangements Report,* October 2020.
- The Declaration was made in response to the severe impact of the floods on communities in New South Wales, the significant mental and physical toll on individuals and communities, and in anticipation of the impact to national supply chains given the compounding challenges caused by COVID-19.
- This was the first time a declaration was made under the Act, and it was in place for 3 months, ending 10 June.

National Coordination Mechanism

The NCM is an Australian Government mechanism facilitated by NEMA and is a key tool for preparing for, responding to, and recovery from any crises. Established in 2020 in response to the spread of COVID-19, the mechanism has now been embedded as a permanent response tool in the Australian Government Crisis Management Framework ensuring the government can bring together the relevant representatives of both government and non-government organisations to coordinate, communicate and collaborate during responses to crisis.

The NCM met on 163 occasions across 2021-22 in response to various crises, some caused by natural hazards, including stabilising national supply chains impacted by severe weather in South Australia and subsequently in northern New South Wales and southern Queensland.

From 10 January, the NCM also formed the basis of the SCTF which facilitated engagement across industry and government to identify and stabilise under-pressure supply chains. Numerous national supply chains were impacted by COVID-19 based workforce absences and the subsequent consecutive and compounding severe weather events in south and eastern Australia.

Department of Defence

During 2021-22, in response to requests for Australian Government assistance under the COMDISPLAN, Defence provided substantial contributions to emergency response, relief and recovery efforts across the nation, especially during the New South Wales and Queensland Flood Emergency in early 2022. This support was in addition to ongoing support to Western Australia bushfire fighting efforts and the use of RAAF aircraft to resupply the town of Coober Pedy, South Australia when isolated by flood waters.

Defence also continued to provide COVID-19 related support such as quarantine compliance management, support to aged care facilities, non-emergency ambulance driving, planning, and logistics.

Defence's support to the east coast floods of February to March 2022 was particularly significant, peaking at over 7,100 personnel on OP FLOOD ASSIST 2022 duties across Queensland and New South Wales. Defence was involved in supporting preparation activities, such as door knocking and sandbagging, and acted early to position personnel and assets into affected regions to assist local response operations. Defence helicopters also rescued over 110 people and provided reconnaissance and logistic support to isolated areas. Defence conducted hydrographic and diving clearance tasks in the Brisbane River and in Moreton Bay, Queensland and provided detailed aerial reconnaissance to inform damage assessment and task prioritisation. As the flood waters receded, and response effort moved into relief and recovery operations, Defence undertook wide scale road clearance, debris removal, food distribution, welfare checks, and logistic support tasks for state agencies.

Disaster Recovery Funding

The jointly funded Australian Government state/territory Disaster Recovery Funding Arrangements (DRFA) was activated in response to 51 domestic disaster events that occurred in 2021-22 (14 in New South Wales, 3 in the Northern Territory, 9 in Queensland, 2 in South Australia, 3 in Tasmania, 12 in Victoria and 8 in Western Australia). There were 448 DRFA local government area (LGA) activations (noting some LGAs were activated more than once). In addition, the Australian Government provided over $2 billion directly to disaster affected individuals and families through the Australian Government Disaster Recovery Payment and Disaster Recovery Allowance.

Images: Australian Rail Track Corporation

Images: NSW SES

Map of major incidents 2021-22

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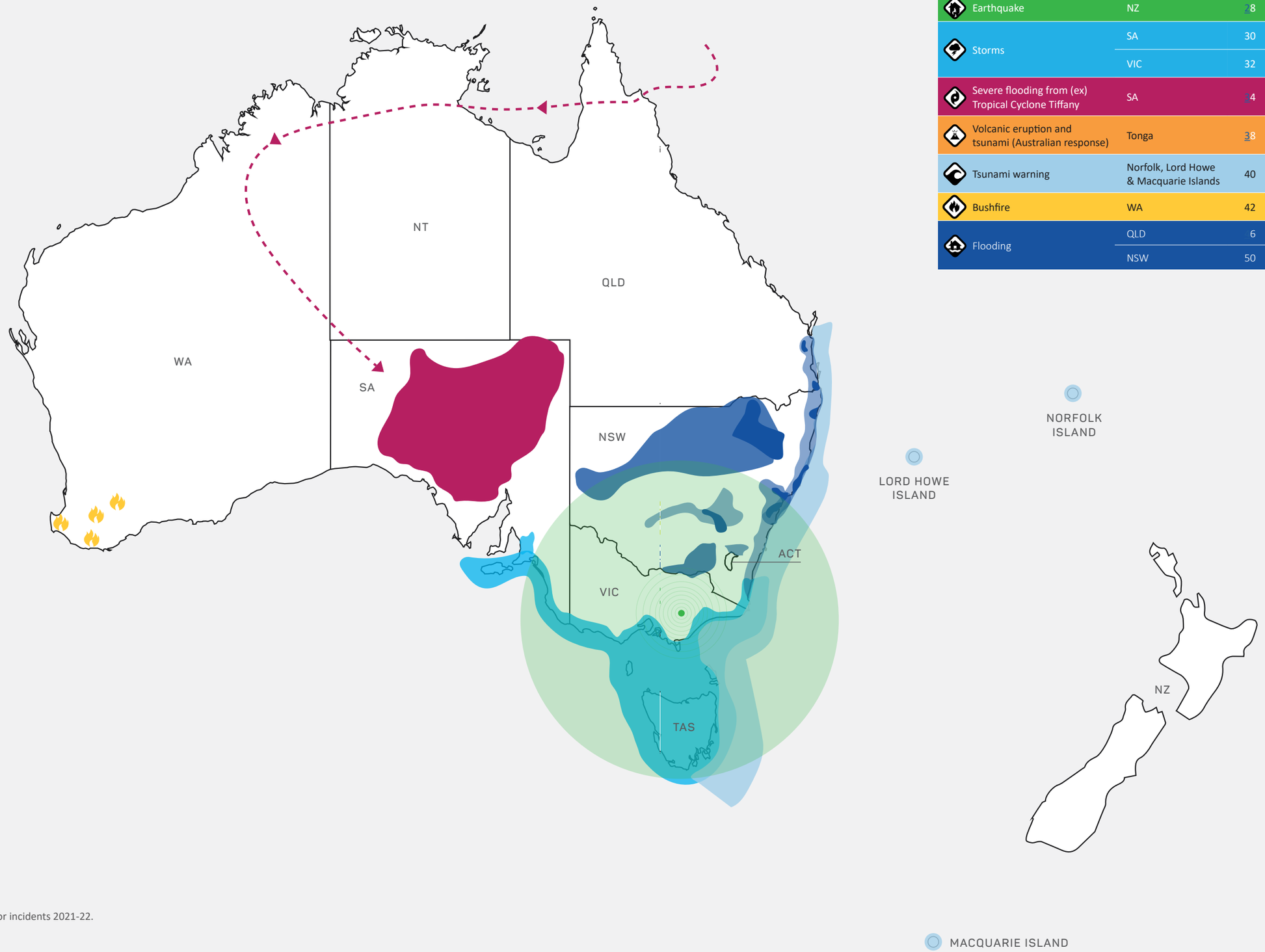


Figure 5: Map of major incidents 2021-22.

Consecutive, concurrent, compounding and complex incidents

The Australian emergency management landscape has been dominated by a diverse range of consecutive, concurrent, compounding and complex disasters across Australia during the 2021-22 period of the *Major Incidents Report*.

During this period there have been 36 significant events that required states, territories and the Australian government to enact measures in the before, during and after phases of these emergencies. Some of these large-scale incidents have impacted a considerable proportion of Australia's population, either directly or indirectly. Some communities have been impacted by multiple flood events over several years. Unfortunately, some of these major incidents resulted in the loss of life, injury, destruction and displacement of communities.

Almost 50% of the 36 major incidents occurred during the January and February 2022 period. The environment was one where there were consecutive, concurrent incidents occurring which added to the complexity facing response and recovery agencies at local, state, territory and federal government levels.

Of the 36 major incidents, 28 related to floods, storms and tropical cyclones. The vast majority of these rainfall events were on the east coast of Australia (Queensland, New South Wales and Victoria). The La Niña climatic conditions declared in November by the Bureau of Meteorology were a strong influencer on these events taking place with impacts amplified by the still saturated soils, catchments and near full reservoirs and dams that accompanied the La Niña event on the east coast during 2021.

The clustering in terms of the geographic and temporal dimensions of these events placed the emergency management system under stress over this period and are represented in Figure 6. The illustration reaffirms the consecutive and concurrent nature of incidents over the 2021-2022 period. The manner in which multiple responses occurred demonstrates the interconnectedness and interoperability of Australia's emergency management system. The consequences of consecutive, concurrent and compounding events cascading through communities have impacted highly on interconnected economic activities, technological services and natural environments. This compound risk effect puts communities, the environment, infrastructure, systems and services under enormous pressure. The complexity grows exponentially under these circumstances and creates difficulty to respond to and recover from a new crisis if you are still dealing with the impacts of the last one.

The COVID-19 pandemic has been determined and has become a factor in almost everything. Whether interference in supply chains, work environments, health impacts, family and community resilience – the circumstances of the pandemic as well as climate change, have become an amplifier in every problem or vulnerability that already existed. The Australian setting has also had to absorb the shocks that have reverberated from the war in Ukraine. This has further strained the resilience of Australian communities and manifested in many ways.

The major flooding of southeastern Queensland and northern New South Wales illustrate the direct and indirect impacts of these incidents on communities across Australia. The direct impact from these flood events has seen more than 225,000 insurance claims. A high proportion of these claims were from people who have seen serious damage done to their properties and businesses.

The indirect impacts associated with these floods touched many other Australian communities. People were unable to source various staples due to the disruption to supply chains from both the direct impact of the flooding and compounded by the impacts of COVID-19.

COVID-19 has added additional complexity for responders when supporting communities during operations throughout the 2021-2022 period. Fortunately the planning that had been previously undertaken to protect the health and safety of responders and the community assisted timely responses to deliver assistance.

Supplementary to the incidents occurring on Australian soil during the 2021-2022 period, there have been emergencies that have occurred outside Australian waters. These incidents, originating from seismic activity, have endangered Australia's coastline and required some Australian communities to act. Stemming from these events was a call from neighbouring countries for Australian support. Australian emergency management arrangements provided flexibility and agility to support neighbouring communities.

The compounding nature of the incidents and resourcing challenges caused by COVID-19 during this period added a layer of difficulty in synchronising resources required to respond to these events. A national resourcing approach combined with practiced COVID-19 policies, processes and procedures were fundamental in meeting the needs of each jurisdiction in managing incidents during the 2021-2022 period.

Timeline of major incidents 2021-22

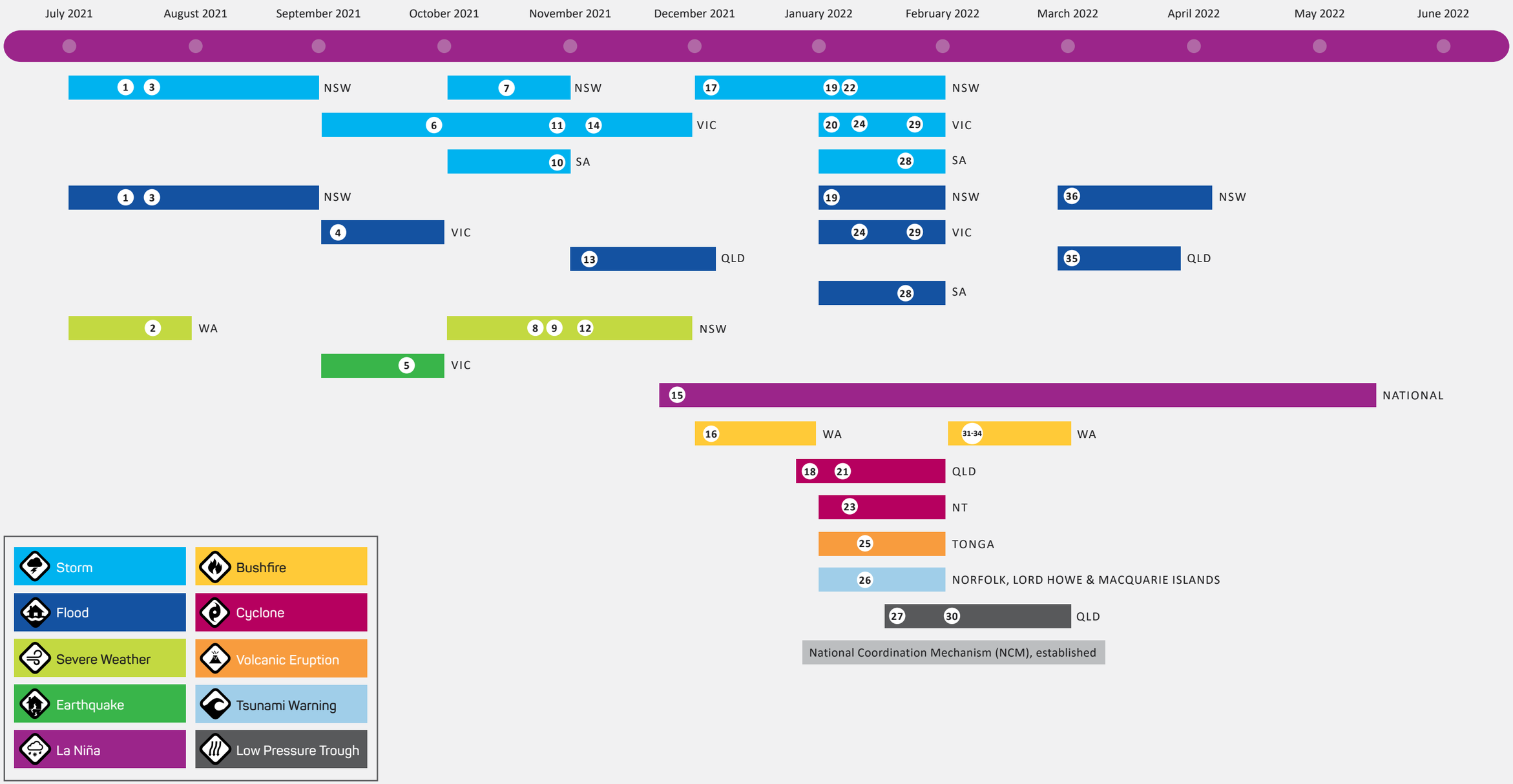


Figure 6: Timeline of major incidents 2021-22.

A table of all 36 major incidents in 2021-22 is provided on page 52.

Climate drivers and impact

There were a number of drivers that influenced the erratic weather patterns over the 2021-22 period.

La Niña

Following a period of cooler average ocean temperatures in spring 2021, a La Niña became established in November. This was a relatively late development based on the last 40 years of observational data. The Bureau of Meteorology declared the La Niña established on 23 November following a La Niña WATCH issued in September and a La Niña ALERT issued in October.

La Niña is part of a cycle known as the El Niño-Southern Oscillation (ENSO), a naturally occurring shift in ocean temperatures and weather patterns along the equator in the Pacific Ocean. During La Niña, waters in the central or eastern tropical Pacific become cooler than normal, persistent south-east to north-westerly winds strengthen in the tropical and equatorial Pacific become cooler than normal, and clouds shift to the west closer to Australia.

Characteristically this will result in rainfall becoming focused in the western tropical Pacific, leading to a wetter than normal period for eastern, northern and central parts of Australia.

In addition to rainfall, La Niña also increases the chance of cooler than average daytime temperatures for large parts of Australia and can increase the number of tropical cyclones that form. The last significant La Niña was 2010-12, which led to large impacts across Australia including Australia's wettest two-year period on record, and widespread flooding.

From a compounding perspective, La Niña also occurred during the spring and summer of 2020-21, which is not an unusual situation, with half of all past La Niña events returning for a second year. It is notable however, that there were a number of flooding events that occurred along the eastern seaboard during 2020-21 which were featured in the *Major Incidents Report 2020-21.*

During the 2020-21 La Niña period many of the catchment areas, dams, and reservoirs recorded high levels of rainfall. This resulted in elevated water storage levels along with high river levels and the soil moisture remained saturated as a consequence. The catchment systems were primed for further flooding with the 2021-22 La Niña.

The antecedent conditions from the La Niña period in 2020-21 and the declaration of another La Niña in November created an ideal environment for flooding to occur across eastern Australia again.

There were a number of other climate drivers in addition to an active La Niña in the Tropical Pacific Ocean that contributed to the development and maintenance of wetter conditions during 2021 which extended into summer 2022. These included a persistent and strong positive phase of the Southern Annular Mode, several active phases of the Madden Julian Oscillation, the negative phase at the start of the northern Australia wet season of the Indian Ocean Dipole and warmer oceans. These factors all played a part in the development and maintenance of wetter conditions, most notably during Australia's wettest November on record.

Southern Annular Mode (SAM)

The SAM was mostly in a positive phase from October to December, with the monthly SAM index value for December the second highest on record (since 1979) behind 2011. In combination with La Niña, positive phase SAM is associated with above average rainfall over southern parts of northern Australia during the wet season. At this time, the polar vortex over Antarctica was also particularly strong, likely contributing to the strongly positive SAM. From January to April, the weekly SAM index was closer to neutral values, with brief periods of positive and negative values. The SAM averaged over the northern wet season was the third highest since 1979–80.

Madden–Julian Oscillation (MJO)

The MJO is the major climate influence for tropical Australia on weekly to monthly timescales and likely influenced tropical Australia at a few key points during the season. The MJO was in the Australian region during much of October and November, potentially contributing to the wetter conditions across northern Australia during these months. However, MJO activity was almost completely absent from the Australian and Western Pacific regions between February and April, with MJO activity in or near the western Indian Ocean. When the MJO activity is closer to Africa than Australia, there is often reduced cloudiness over northern Australia, with reduced convection and rainfall.

The lack of local MJO activity in the second half of the wet season likely contributed to an overall lack of strong monsoon activity over northern Australia. There were only 4 main active events of the Australian monsoon: around early November, late in December, and during the second half of January. There were no further monsoon bursts until late in April.

Indian Ocean Dipole (IOD)

The IOD was in a negative phase at the start of the wet season, resulting in warmer than average sea surface temperatures in the eastern Indian Ocean. The negative IOD, and a warmer eastern Indian Ocean generally, was likely conducive to the above average rainfall observed in parts of northern Australia during October and November. The IOD returned to a neutral phase by December, in line with the typical life cycle of an IOD event. Above average sea surface temperatures across the eastern Indian Ocean may have contributed to cloud bands that brought rainfall to Western Australia, as well as inland parts of northern Australia.

Global Warming

In addition to the influence of natural climate drivers, Australia's climate is increasingly influenced by global warming. Australia's climate has warmed on average by 1.47 ± 0.24°C over the 1910–20 period, with most of the warming occurring since 1950. Rainfall across northern Australia has increased during the northern wet season since the 1970s, with more high intensity and short duration rain events.

As the climate warms, heavy rainfall events are expected to continue to become more intense. A warmer atmosphere can hold more water vapour than a cooler atmosphere, and this relationship alone can increase moisture in the atmosphere by 7% per 1°C of global warming. This can cause an increased likelihood of heavy rainfall events. Increased atmospheric moisture can also provide more energy for some processes that generate extreme rainfall events, which further increases the likelihood of heavy rainfall (State of the Climate 2020).

Impacts on weather conditions

One of the early weather events that set the tone for the events in this report involved severe thunderstorms across eastern New South Wales and southeast Queensland in October, with several tornadoes and multiple reports of giant hail resulting in extensive damage to homes.

The heavy rainfall experienced caused flooding to large areas of New South Wales and Queensland during November and December. The main areas impacted included central and southern Queensland and central New South Wales. The massive downpour set a new record and was Australia's wettest November on record (since 1900); 135% above the long-term average. The previous wettest November was 1973.

There was major flooding that affected parts of southern Queensland in early January, associated with ex Tropical Cyclone Seth, including across the Bundaberg region.

Ex Tropical Cyclone Tiffany contributed to record rainfall and flooding in parts of central and southern South Australia later in January, causing considerable damage to major arterial roads. This situation isolated road and rail transport routes requiring several states and the Australian Government to intervene to repair the damaged infrastructure and address resupply issues for isolated communities.

Nine tropical cyclones were observed across Australia during the tropical cyclone season from November to April. This is equal to the average since 2000 of 9 per season. More noteworthy is that only 2 systems (Tiffany and Anika) made Australian landfall with at least Category 1 strength. However, the impacts from Seth, for example, indicate that landfall is not a prerequisite for significant impact. Seth brought strong winds, rain and large waves to the Queensland coast with waves up to 6m.

A slow moving low-pressure system off the east coast in late February generated extremely heavy rain, resulting in further flash and riverine flooding across south eastern Queensland, which included Brisbane metro, Sunshine Coast, and Ipswich along with the Wide Bay and Burnett district, including Gympie. The heavy rain and flooding also affected northern New South Wales, most notably around Lismore in late February. To provide some context about the level of rainfall endured, more than 50 sites in south eastern Queensland and north east New South Wales recorded more than 1 m (1,000 mm) of rain in the week ending 1 March 2022.

The unrelenting heavy rain continued into early March, including that associated with an east coast low, which continued the flooding event in northeast New South Wales while also leading to flooding around the Greater Sydney Region. Later in March very heavy rain around Queensland's Gold Coast led to major flooding and affected parts of northeast New South Wales, including Lismore (second township evacuation in a month).

At the start of February, extreme to Catastrophic fire weather conditions were experienced in the Western Australia Southwest Land Division, with multiple bushfires resulting and some property loss.

The high impact weather was merciless and continued into the start of April where a deep low-pressure system off the southern coast of New South Wales led to heavy rainfall and flooding over parts of East Gippsland, Victoria. The rainfall also caused renewed flooding across the Greater Sydney Region.

In early May, storms and heavy rainfall caused flash flooding in parts of southeast Tasmania.

Moving into mid-May, a different weather system delivered more record rainfall affecting parts of eastern and northern Queensland and parts of New South Wales. Flooding impacted parts of Queensland, from the coastal northern tropics to areas of the central west and southeast Queensland.

At the end of May the climate delivered further heavy rainfall that caused flooding and road damage across parts of the eastern Pilbara region of Western Australia.

Effectively every state and territory of Australia received, and in some instances on several occasions, heavy rainfall resulting in extensive flooding which challenged and continues to challenge community resilience.

As of 21 June, ENSO-state has returned to neutral (neither La Niña nor El Niño), with a La Niña WATCH issued indicating an increased likelihood that La Niña will develop later in 2022. The Bureau of Meteorology will be monitoring this situation carefully.

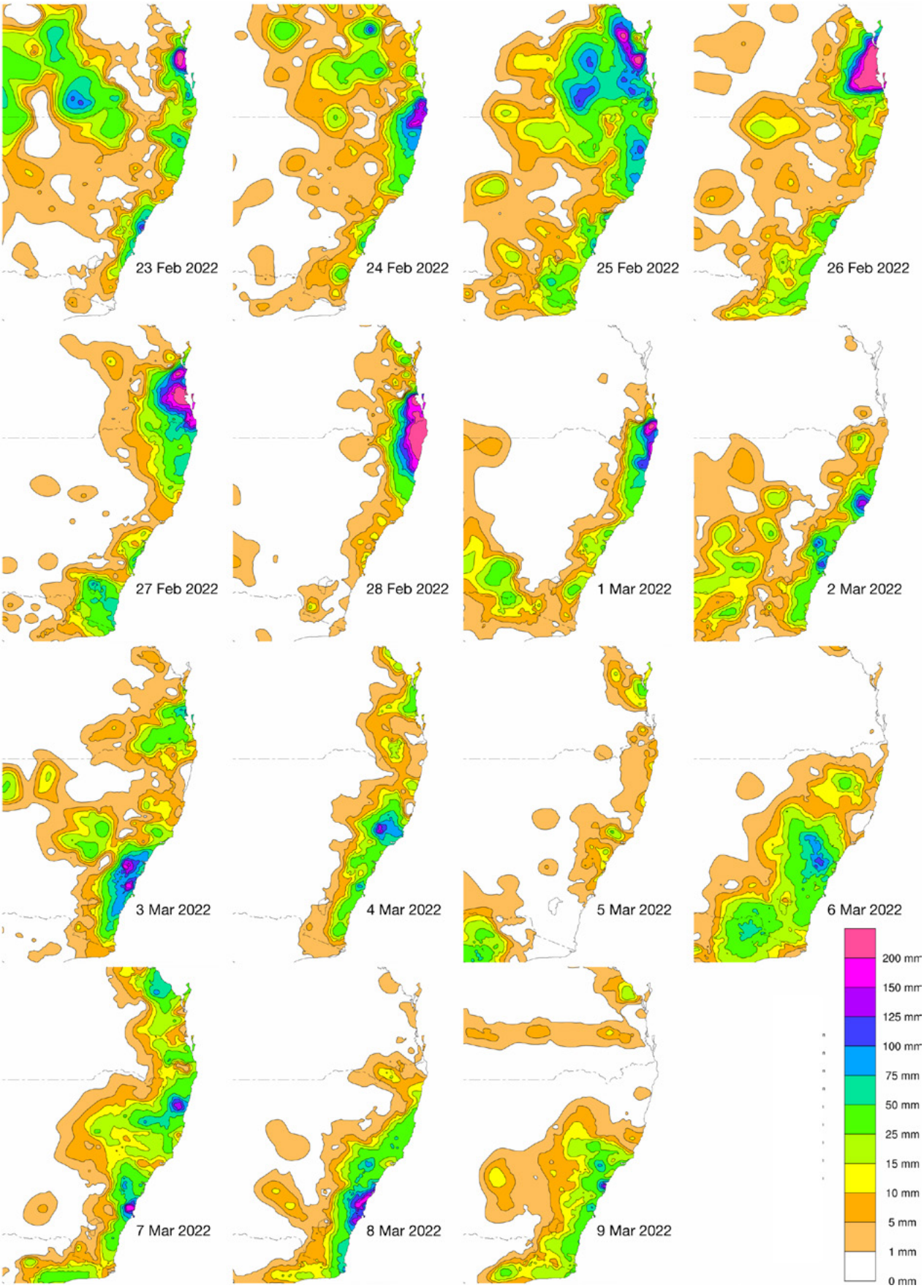
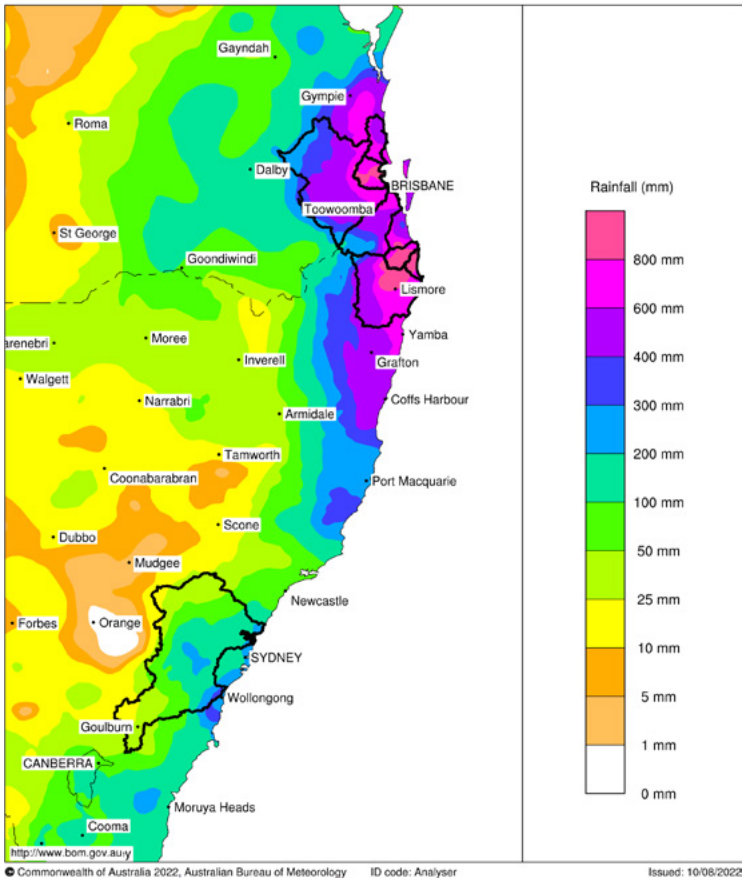


Figure 7: Maps of south-eastern Queensland and eastern New South Wales showing daily rainfall totals to 9am from 23 February to 9 March 2022.



Australian rainfall analysis (mm) Week ending 2 March 2022

Australian Bureau of Meteorology

Figure 8: Map of 7-day rainfall totals for south eastern Queensland and eastern New South Wales for the week ending **2 March 2022.** Black outlines show river catchments where 7-day catchment-average records were exceeded during the 22 February - 9 March period.

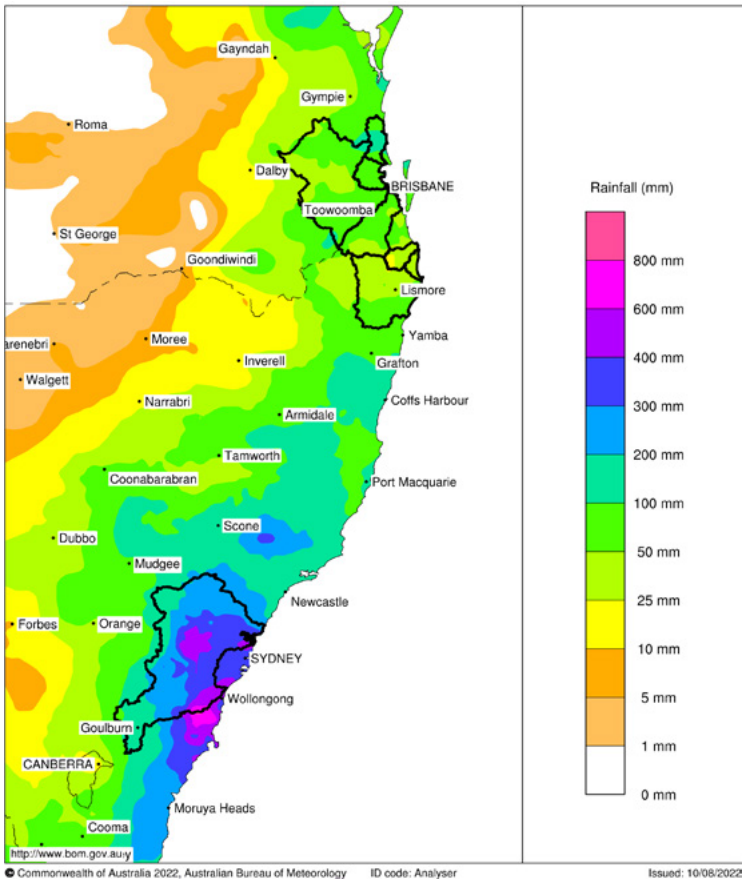
More details of river catchment regions are available at www.bom.gov.au/water/about/riverBasinAuxNav.shtml

Australian rainfall analysis (mm) Week ending 9 March 2022

Australian Bureau of Meteorology

Figure 9: Map of 7-day rainfall totals for south-eastern Queensland and eastern New South Wales for the week ending **9 March 2022.** Black outlines show river catchments where 7-day catchment-average records were exceeded during the 22 February - 9 March period.

More details of river catchment regions are available at www.bom.gov.au/water/about/riverBasinAuxNav.shtml



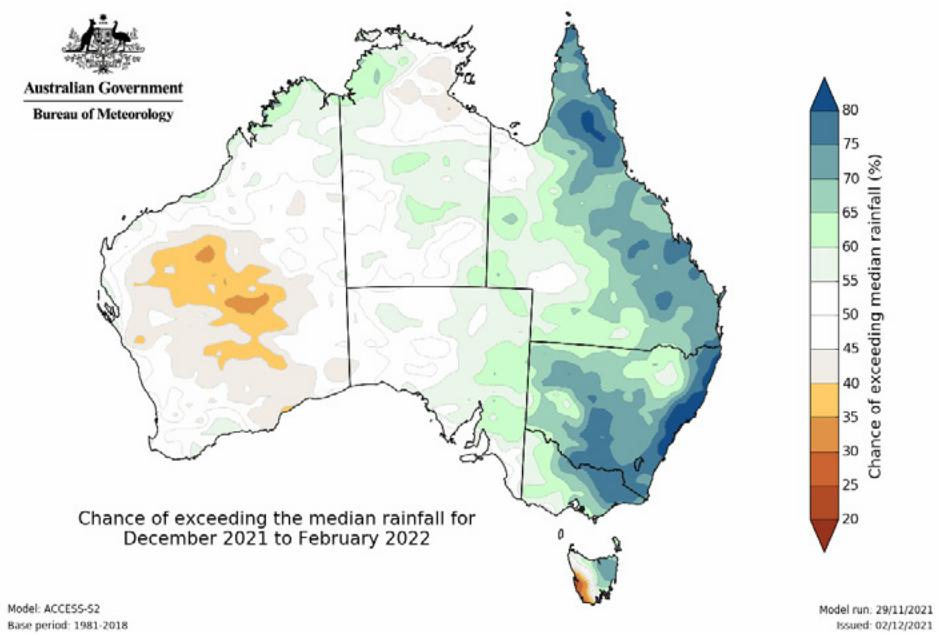


Figure 10: Map of Australia showing the chance of exceeding median rainfall for summer 2021-22 issued by the Bureau of Meteorology on 2 Dec 2021.

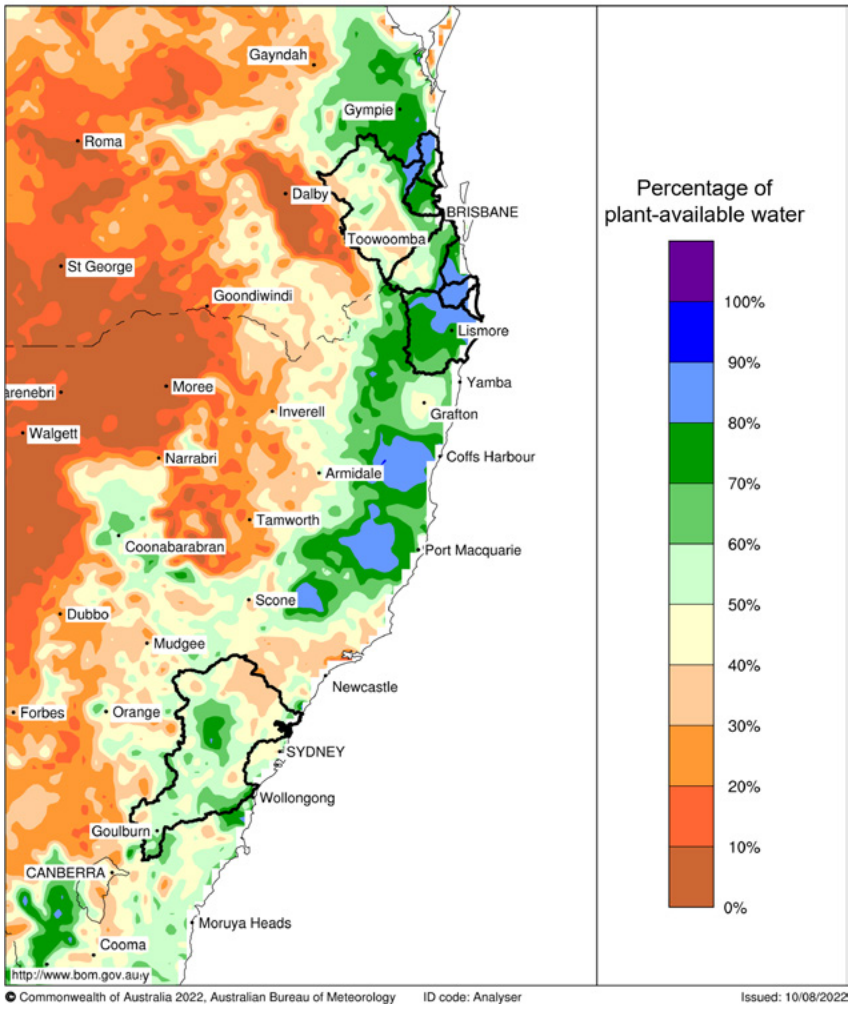


Figure 11: Map showing rootzone soil moisture prior to the start of the rain on 22 February 2022 for south east Queensland and eastern New South Wales. Shows the percentage of plant-available water content in the top 1m of soil as a percentage of the field capacity.

Tables of highest weekly rainfall totals

Week ending date	Station number	Station name	Rainfall (mm)
2022-03-01	040965	Clontarf	1097.0
2022-03-01	040550	Numinbah	1015.0
2022-03-01	040224	Alderley	1009.0
2022-03-01	040686	Beenham Valley Rd	1008.2
2022-03-01	040958	Redcliffe	968.8
2022-03-01	040607	Springbrook Road	930.0
2022-03-01	040141	Mount Cotton West	878.4
2022-02-28	040999	Landsborough	869.8
2022-03-01	040284	Beerburrum Forest Station	865.2
2022-03-01	040145	Mt Mee	864.8

Table 1: Ten highest **weekly** rainfall totals at **Queensland** sites in the Bureau of Meteorology's standard rain gauge network for the period 22 February – 9 March 2022.

Week ending date	Station number	Station name	Rainfall (mm)
2022-03-01	540400	Upper Springbrook Alert	1334
2022-03-01	540371	Bracken Ridge Res Alert	1164
2022-03-01	540417	Murrumba Downs Alert	1150
2022-02-28	540467	Albany Creek Al	1144
2022-03-01	540326	Cooran Alert	1132
2022-03-01	540414	Normanby Way Alert	1115
2022-03-01	540412	Youngs Crossing Alert	1105
2022-03-01	540562	Lawnton (Todds Rd) Alert	1099
2022-02-28	540121	Everton Hills Alert	1097
2022-03-01	540625	Strathpine (Gympie Rd) Alert	1095

Table 2: Ten highest **weekly** rainfall totals at **Queensland** sites that form part of the Flood Warning network of rain gauges operated by the Bureau of Meteorology and other organisations for the period 22 February – 9 March 2022.

Week ending date	Station number	Station name	Rainfall (mm)
2022-03-01	058019	Doon Doon (McCabes Road) (standard)	1631.0
2022-03-01	058165	Rosebank (Upper Coopers Creek)	1193.6
2022-03-01	058070	Rosebank (Repentance Creek)	1090.6
2022-03-01	058040	Mullumbimby (Fairview Farm)	1012.6
2022-03-01	058036	Chillingham (Limpinwood)	896.5
2022-03-08	068247	Beaumont (The Cedars)	816.2
2022-03-01	058127	Clunes (Flatley Drive)	813.0
2022-03-01	058020	Murwillumbah (Dungay (Taleswood))	772.2
2022-03-01	058023	Mcleans Ridges (Lascott Drive)	710.2
2022-03-01	058097	New Italy (Vineyard Haven)	685.2

Table 3: Ten highest **weekly** rainfall totals at **New South Wales** sites in the Bureau of Meteorology's standard rain gauge network for the period 22 February – 9 March 2022.

Week ending date	Station number	Station name	Rainfall (mm)
2022-03-01	058019	Doon Doon (McCabes Road) (Flood Warning)	1429
2022-03-01	058167	Uki (Tweed River)	1346
2022-03-01	558049	Huonbrook	1298
2022-03-01	558107	Burringar (Upper Burringbar Rd)	1297
2022-03-01	558033	Goonengerry	1283
2022-03-01	558031	Dunoon	1268
2022-03-01	558018	Terragon (Palmers Road)	1206
2022-03-01	058129	Kunghur (The Junction)	1170
2022-03-01	558094	Upper Crabbes Creek (Crabbes Creek Rd)	1116.5
2022-03-01	558079	Numinbah (Couchy Creek)	1088

Table 4: Ten highest **weekly** rainfall totals at **New South Wales** sites that form part of the Flood Warning network of rain gauges operated by the Bureau of Meteorology and other organisations for the period 22 February – 9 March 2022.

Notes

1. The tables exclude several sites where subsequent quality checks established that either the rain gauge had overflowed, or that the Flood Warning rain gauge was not reporting correctly.
2. The Bureau of Meteorology standard gauge at Doon Doon (McCabes Road) reported 758.0mm in the 24 hours to 9am on 28 February, the third-highest daily total at a Bureau of Meteorology standard rain gauge ever recorded in New South Wales. While the observer had noted that the gauge overflowed, the current assessment is that the daily total is a plausible estimate, and if anything would be on the low side.
3. The Doon Doon site is one of a number across the network, mostly in New South Wales, where there is a standard and Flood Network rain gauge with the same station number. In this situation, the Bureau of Meteorology standard rain gauge total is used in the climate record, while the Flood Network totals and intensities are used for hydrological applications such as streamflow and flood forecasts. Both are legitimate measurements of the observed rainfall that are fit-for-purpose.

National Resourcing Arrangements

There were an unparalleled number of major incidents that occurred across Australia during 2021-22. Several jurisdictions were dealing with multiple events simultaneously, placing response systems under pressure. This pattern compounded the impacts from these events along with other factors such as COVID-19.

The complexity in managing situations like this was challenging. Responder agencies in Australia have learnt important lessons and have developed an enabling mechanism to deploy national capability for fire and emergency services to address capability needs and maintain response efforts. There is an additional ability for federal resources to be accessed using longstanding and well-practiced national emergency management arrangements.

The AFAC National Resource Sharing Centre (NRSC) in partnership with NEMA coordinates and facilitates international and interstate deployments from fire and rescue agencies using partnerships and national arrangements. It is pertinent to recognise the resourcing extends to both people and equipment.

The ability to provide additional resources to deliver surge, sustaining, and/or relief can be a force multiplier. Australia has been regularly challenged by consecutive and concurrent emergencies, many have been overwhelming and to have this flexibility has enabled jurisdictions to maintain postures, structures and strategies in responding to protect communities.

During the 2021-22 period the NRSC coordinated resources for deployment to the fires in Western Australia in January and February and the floods that occurred in New South Wales and Queensland between February and April. An outline of the resources provided, and the functions performed are contained in table 5. These 2 events operated for an extensive period with resources from interstate rotating on a regular basis.

An additional benefit is that interstate deployments provide a great personal development opportunity for people who participate in them.

The key elements of note from these two deployments relate to the number of resources, the varied specialised skills possessed by those deployed, the duration of their deployment and the jurisdictions of the interstate teams.

The deployment of aviation resources (people and aviation assets) to Western Australia through the NRSC, assisted by the National Aerial Firefighting Centre, is a demonstration of the ability to implement a turnkey solution that was self-contained from other states and territories into another jurisdiction during a chaotic period. The risk environment changed considerably during the 2021-22 period. Eastern Australia was drenched, and Western Australia (experiencing severe to catastrophic fire weather) was dry and vulnerable to bushfire. The flexibility to reassign potent firefighting and intelligence gathering assets to where the risk existed delivered an effective and efficient outcome for the state, Australia and the community.

In all of these interstate deployments, managing COVID-19 was a priority when responding. The emergency management sector went to great lengths during the 2020-21 emergency season to develop policies, procedures and processes to minimise infections when responding to incidents. These COVID-19 guidelines were further improved using learnings from the 2020-21 period and implemented for the 2021-22 period.

The strength of this interoperable resourcing model is that an agency can request a range of specialised operatives to perform critical tactical roles (as an example swift water operators in a flood) and strategic roles (incident management team roles) in responding to an emergency. The continuity of effort from this intervention enables progress in managing an incident and brings an incident to a closure.

Resource type	VIC	ACT	NT	QLD	SA	TAS	WA	Total
Swift Water Rescue	15			42	30			**87**
Flood Boat Crews	21							**21**
Incident Management	56	5	6	7	59	10	43	**186**
Storm Damage Crews	124	33	8	41	56	9	21	**292**
Community Liaison Crews	80				36		12	**128**
Liaison Officers	12			3	7		6	**28**
Total	308	38	14	93	188	19	82	**742**

Table 5: Totals of people with specific skill sets deployed to Queensland and New South Wales floods.

Bushfire activity in Western Australia

In response to a series of significant fires during the recent summer in south western Western Australia, several deployments were made through the AFAC NRSC.

Throughout December 2021 and January 2022, NSW Rural Fire Service (RFS) cooperated with the WA Department of Fire and Emergency Services, deploying aircraft through the national aviation resource sharing arrangements administered by the NRSC and in consultation with the National aerial Firefighting Centre, including:

- a C130 Large Airtanker
- the RJ85 Large Airtanker
- two Bell 412s
- the NSW RFS Large Airtanker and Citation lead plane.

In early February, hot, dry, and windy conditions the South West land division in Western Australia created ongoing severe to catastrophic fire danger, and several major bushfires broke out. With Western Australian resources stretched, the NRSC responded to a request for assistance on 6 February and facilitated the deployment of 34 incident management specialists, together with a COVID-coordinator, from NSW RFS, Fire and Rescue NSW, NSW National Parks and Wildlife Service and Forestry corporation. Soon after their arrival, conditions eased in Western Australia and the deployment was demobilised early.

The NRSC also supported a long-term deployment for mechanical fleet technicians to Western Australia to assist with the servicing and repair of firefighting appliances.

DFES A/Executive Manager Plant and Equipment, Scott Hares, said that the technicians have been very beneficial in clearing a backlog of work: "Having visiting personnel work on smaller repairs enabled DFES technicians to concentrate on the longer duration tasks."

"Our technicians have enjoyed the opportunity to work with and share knowledge with personnel who bring different experiences from their respective jurisdictions", he said.

Personnel from Country Fire Authority Victoria; Department of Police, Fire and Emergency Management Tasmania; Fire and Rescue New South Wales; and New South Wales Rural Fire Service were deployed on rotation throughout February to April.

A case study of national aviation resource sharing arrangements, originally published in Fire Australia Magazine Issue 2, 2022.

Floods in Queensland and New South Wales

Extreme rainfall in late February and early March, resulted in widespread flooding across parts of the eastern seaboard.

The AFAC NRSC supported the response to these floods through one of its largest activations to date. On 27 February 2022, following severe weather and significant flooding across multiple catchments within south east Queensland, the NRSC responded to a request for assistance from Queensland Fire and Emergency Services (QFES). A total of 15 swift water rescue specialists from Fire Rescue Victoria, including command staff and swift water rescue operators, assisted flood response in the Beenleigh area between 28 February and 6 March.

Inspector Scott Beasley said the Victorian crew was received well and helped bolster the state's swift water capability:

"Having extra personnel meant that we could manage fatigue and rest some of our crews without diminishing our response capability. The crew were also able to assist for the first time with damage assessment, paving the way for future resource sharing in this area", he said.

On 1 March, deployments commenced to New South Wales following a request for assistance from NSW SES. Over the course of the following weeks, recurrent major flooding severely impacted communities across northern NSW. As of 7 April, NRSC supported deployments of 759 personnel from Victoria, South Australia, Tasmania, Western Australia, the Northern Territory, Queensland and the Australian Capital Territory. Resources included swift water rescue technicians and flood boat crews, incident management specialists, field crews, command and admin staff, storm crews, and community liaison officers.

A case study highlighting the use of the national resource sharing arrangements to Queensland and New South Wales floods, originally published in Fire Australia Magazine Issue 2, 2022.

Image: J. Quanine, VIC SES

Major incidents 2021-22

These 9 incidents below have been selected for inclusion in this report because of their impact and consequences, the uniqueness, the learnings and observations recorded, the resourcing requirements, the significance of the event and its duration.

A table of all 36 major incidents in 2021-22 is provided on page 52.

1

Earthquake
Victoria
22 September 2021

2

Storms
South Australia
28 - 29 October 2021

3

Storms
Victoria
28 October - 8 November 2021

4

Severe flooding from (ex) Tropical Cyclone Tiffany
South Australia
21 January - 3 February 2022

5

Volcanic eruption and tsunami (Australian response)
Tonga
15 January 2022

6

Tsunami warning
Norfolk, Lord Howe and Macquarie Islands
15 January 2022

7

Bushfire
Western Australia
5 - 15 February 2022

8

Rainfall and flooding
Queensland
22 February - 7 March 2022

9

Flooding
New South Wales
22 February - early April 2022

Earthquake

Victoria, 22 September 2021

At 9.15am on 22 September, an earthquake with a magnitude of 5.9 and a depth of 10 km was detected north east of Melbourne in the Alpine National Park, south east of Mansfield and north of Rawson.[1] The epicentre of the earthquake was in a largely unpopulated location approximately 130 km northeast of Melbourne,[2] and another nine aftershocks occurred within 24 hours.[3]

Over 40,000 reports of people feeling the earthquake were recorded; some of which were from the Australian Capital Territory, South Australia and Tasmania.[4] The first community messaging was a simple social media post by the Victorian State Emergency Service stating 'We felt it too. More to follow'. This was followed by an advice warning issued for Rawson, Mount Buller, Woods Point and their surrounding areas.[5]

Approximately 35,000 households and businesses experienced power outages and 90 sets of traffic lights were offline,[6] but triple zero communications were not disrupted.[7] Minor building damage occurred in the Melbournian areas of Kensington, Ascot Vale, Parkdale, Prahran, Balwyn, Elsternwick, Northcote and West Melbourne.[8] In Mansfield, an Ambulance Victoria dispatch bay reported some damage[9] and fallen trees were observed on roads.[10] In Prahran, one Coles supermarket was temporarily closed due to risks of falling facades,[11] parts of a tram line were briefly disrupted and a Betty's Burgers restaurant was shut for eight weeks due to building damage.[12]

Residential buildings up to 50 stories reported movement for a maximum of 20 seconds,[13] but only one person was reported as displaced and provided with accommodation by the City of Stonnington.[14] While major infrastructure was not damaged, there were instances of temporary closures to major infrastructure such as Melbourne Airport and the West Gate Bridge to allow for inspections. With COVID-19 lockdown orders having been in force at the time of the earthquake,[15] few people were walking on streets under the buildings that were damaged and no injuries or fatalities were identified.[16]

The reduced mobility of labour and production of materials due to COVID-19 restrictions was an added complication to the repair process. However, due to the limited damage the earthquake caused, this was of limited impact to Victorians.

This was the largest earthquake in Victoria since 1900[17] and was one of the biggest recorded in eastern Australia.[18] Usually, an earthquake of this size only occurs in Australia once every few years.[19] However, the south-east highlands where the earthquake occurred does have a higher than normal level of seismic activity.[20] The region often has small earthquakes with about 60 earthquakes of magnitude of 2.0 or higher having occurred since 2001.[21]

1 DJPR Emergency Situation Report, 23 September 2021
2 riskfrontiers.com/insights/mansfield-earthquake-22-september-2021-magnitude-5-9-what-caused-it-and-preliminary-impacts
3 www.ga.gov.au/news-events/news/latest-news/victorias-biggest-earthquake-on-record
4 DJPR Emergency Situation Report, 23 September 2021 and www.ga.gov.au/news-events/news/latest-news/victorias-biggest-earthquake-on-record
5 DJPR Emergency Situation Report, 23 September 2021
6 transport.vic.gov.au/about/transport-news/news-archive/transport-network-impacts-after-earthquake
7 DJPR Emergency Situation Report, 23 September 2021
8 DJPR Emergency Situation Report, 23 September 2021
9 riskfrontiers.com/insights/mansfield-earthquake-22-september-2021-magnitude-5-9-what-caused-it-and-preliminary-impacts
10 www.src.com.au/largest-earthquake-in-victorias-history
11 DJPR Emergency Situation Report, 23 September 2021
12 www.abc.net.au/news/2021-11-16/earthquake-damaged-store-reopens-for-first-time-melbourne/100624166 and transport.vic.gov.au/about/transport-news/news-archive/transport-network-impacts-after-earthquake
13 riskfrontiers.com/insights/mansfield-earthquake-22-september-2021-magnitude-5-9-what-caused-it-and-preliminary-impacts
14 www.abc.net.au/news/2021-11-16/earthquake-damaged-store-reopens-for-first-time-melbourne/100624166
15 lockdownstats.melbourne/timeline
16 DJPR Emergency Situation Report, 23 September 2021
17 www.ga.gov.au/news-events/news/latest-news/victorias-biggest-earthquake-on-record
18 DJPR Emergency Situation Report, 23 September 2021
19 www.ga.gov.au/news-events/news/latest-news/victorias-biggest-earthquake-on-record
20 www.ga.gov.au/news-events/news/latest-news/victorias-biggest-earthquake-on-record
21 earthresources.vic.gov.au/about-us/news/unpacking-victorias-earthquake-22-september-2021

Lessons

- Earthquake exercising had occurred with responder agencies, local government authorities and infrastructure owners in the lead up to this event. This resulted in agencies and departments implementing their plans and should be sustained for these rare but potential high consequence events.
- Relationships with Geoscience Australia and a clear understanding of expectations are critical. Geoscience Australia is a national service with limited personnel available or on duty at any point in time and agencies rely on Geoscience Australia for observations, analysis, predictions and warnings, as well as subject matter expertise and provision of spokespeople. Setting expectations early ensures the best opportunity for representation at meetings and for media opportunities.
- Due to geological variations, the event locality or epicentre is not necessarily reflective of the location of observed impacts. Where these locations cross emergency management regions, clear and consistent information dissemination and intelligence sharing is vital.
- Early (and continued) engagement with community is essential, particularly for hazards uncommon to many community members. Simple messaging and inclusive language further supports community understanding of safety messaging and response considerations.
- Further opportunities exist to streamline warning dissemination, from updated templates to improving warning drafting and approval processes. Works are continuing between VIC SES and Emergency Management Victoria in this space.

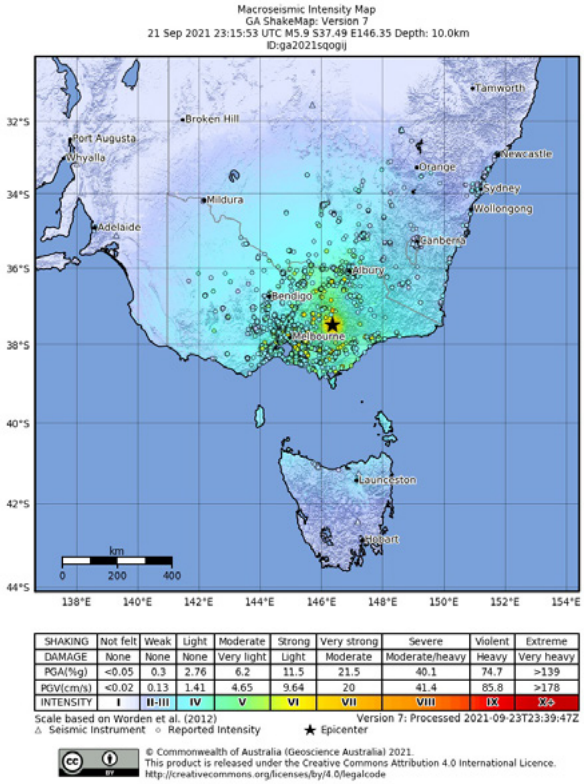


Figure 12: Map of macroseismic intensity on 21 September 2021 (Geoscience Australia).

Image: J. Quanine, VIC SES

Storms

South Australia, 28 - 29 October 2021

On 28 October a severe thunderstorm event impacted areas of South Australia including the Riverland and Adelaide northern and southern suburbs, resulting in significant damage from large hail and strong winds.

A trough of low pressure began tracking across South Australia on 27 October, producing gusty thunderstorms. Further south, a developing low-pressure system drove thunderstorms across the state overnight and during the morning of 28 October.

In what the Bureau of Meteorology described as 'waves of thunderstorms', large hail with thunderstorms initially impacted the Eyre Peninsula and moved across Yorke Peninsula, then over the northern suburbs of Adelaide and the Barossa Valley in the morning of 28 October and in the Murraylands, Riverland and southeast of the Northeast Pastoral in the afternoon.

Strong wind gusts of up to 124 km/h were reported with a thunderstorm at Wappika (west-north-west of Loxton) at 4.10pm. 98 km/h winds with a thunderstorm were reported at Loxton at 4.40pm.

The system brought wind, hail, lightning, and heavy rainfall resulting in minor flash flooding. Hail within the stronger cells was generally 1-3 cm, with local reports of 3-5 cm hail over the northern Adelaide area, focussed on the Elizabeth/Craigmore area.

Significant impacts were observed after multiple fronts crossed the state with reports of roof and skylight damage due to large hailstones, and property damage due to water ingress with many reports of collapsed ceilings.

Areas of thick raised dust with reduced visibility also occurred over the Pastoral and Flinders districts and parts of the northern agricultural area.

The City of Playford and Adelaide Plains councils reported horticulture and infrastructure damage. There were power outages and numerous school closures in the Adelaide northern suburbs due to the extreme weather.

Tornadic activity was reported in Waikerie, resulting in significant damage to roofs of homes and businesses, trees down, structural damage and downed powerlines.

As is common with large hail, there were many vehicles damaged, including some vehicles belonging to volunteers which were parked at South Australia State Emergency Service (SASES) units while volunteers attended requests for assistance (RFA).

The multi-agency approach to the response was excellent and unprecedented, particularly in the Riverland and Adelaide northern suburbs. SASES, Country Fire Service (CFS) and South Australia Metropolitan Fire Services (SAMFS) responded to RFAs with SASES undertaking many of the temporary repairs on roofs and technical tree down jobs and SAMFS providing strike teams on an ongoing basis until the RFAs were resolved. The CFS also attended RFAs, provided operational support and undertook reconnaissance.

The types of requests for assistance for large hail tend to take longer to attend to, and require specialist skills, compared to some other events. Crews were often required to assemble safe work systems prior to accessing roofs and then undertaking repairs.

It took several days to resolve the many outstanding RFAs, particularly in the northern Adelaide and Riverland districts of the state. Over 1,300 requests for assistance were received for this event.

Provision of operational consumables were provided at the Salisbury SASES which was central to a significant proportion of RFAs. This also enabled centralised provision of catering and logistics which was provided by the Paralowie Lions Club.

There were many complexities involved in this event due to its fast-impacting nature, which caused damage to many homes and buildings. There were also several geographic areas impacted in a short timeframe.

The SASES units in impacted areas, particularly in Adelaide's northern suburbs, continued to receive calls for assistance in the days and weeks after the incident when rain occurred. There were additional weather events that impacted homes in subsequent weeks. The COVID-19 situation and lack of resources in the building sector meant that some repairs were taking a very long time resulting in many re-attends. This impacted on the fatigue and morale of volunteers.

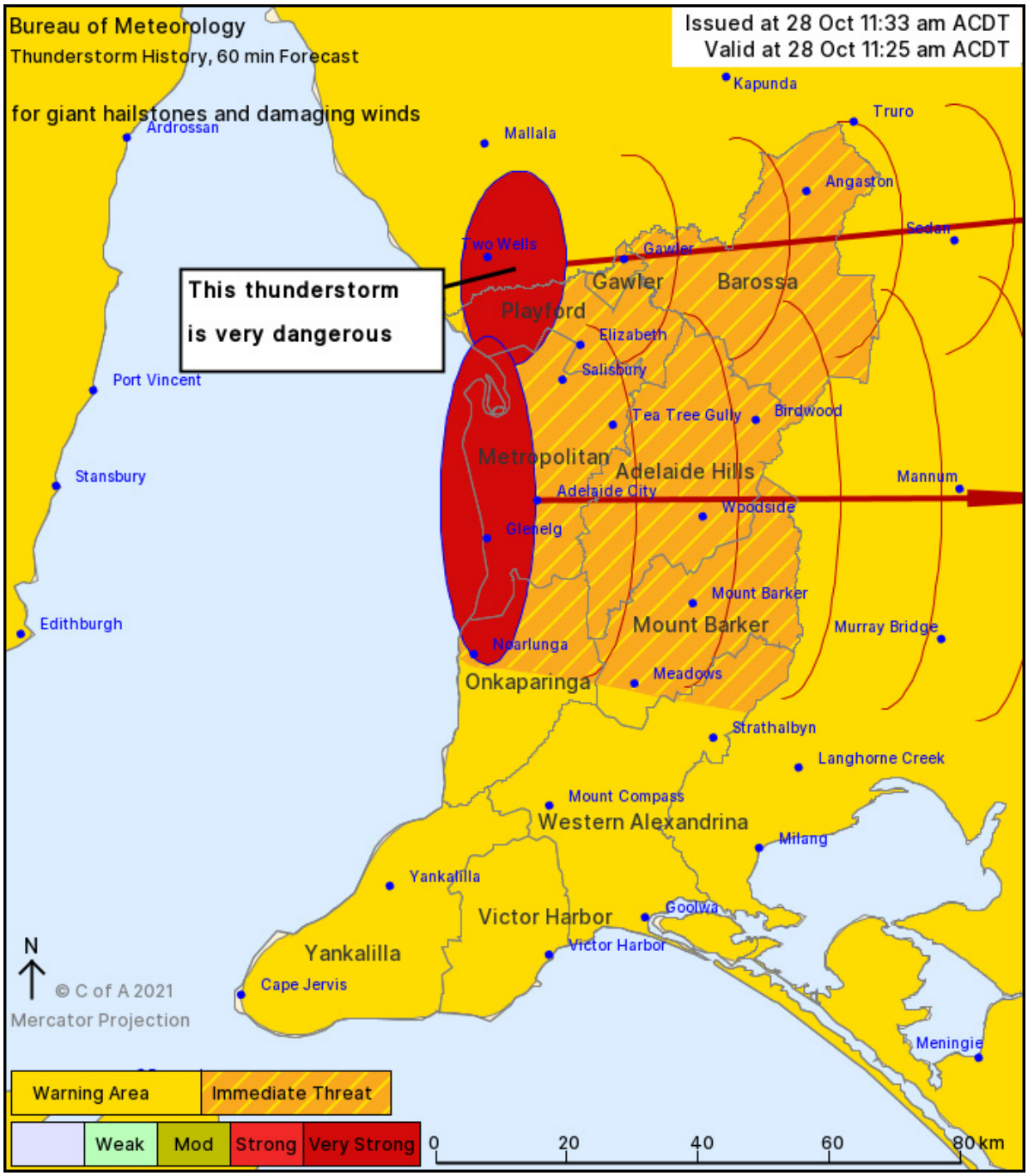


Figure 13: Severe thunderstorm warning issued by the Bureau of Meteorology on 28 October.

Storms

Victoria, 28 October - 8 November 2021

A strong front with associated damaging winds, accompanied by rain and hail, impacted western Victoria and was followed by additional strong fronts in the south-west and in Metropolitan Melbourne.

On 29 October, a severe weather advice level warning was issued for Dandenong, the Mornington Peninsula, the Bass Coast, Barwon Heads and Connewarre as well as community information for post-severe weather impacts in several areas including Melbourne's south eastern suburbs.

A health advice message for COVID-19 was current during the event and there was potential for thunderstorm asthma conditions during the initial stages of the event. An air quality advice message was issued for the southwest, Wimmera, Mallee and the Northern Country for 28 and 29 October.

Intense rainfall from 28 October led to flash flooding in the mid west and north west regions. Flash flood warnings were issued on 3 November for St Arnaud Creek, Castlemaine, Campbells Creek, Wycheproof, Charlton, Wedderburn, Warracknabeal and their surrounding areas including parts of the Calder Highway.

During the event, the Otway Coast, Barwon River, Leigh River, Moorabool River, Hopkins River, Lake Corangamite, Portland Coast and Glenelg River were under a flood watch and the Fitzroy River at Heywood was under a moderate flood warning. Many areas also had minor flood warnings.

Early on 29 October, there was heavy rainfall and wind gusts in excess of 100 km/h including 146 km/h being recorded at the exposed area of Wilsons Promontory, 143 km/h at Mt William and 119 km/h at Melbourne Airport. This led to widespread damage across the south west and metropolitan areas. In the southwest, flooding and fallen trees led to road closures and a rapid influx of requests for assistance. The Geelong, Bellarine and the Surf Coast municipalities were the most impacted. High winds and heavy rainfall in the metropolitan areas led to a considerable amount of building damage and fallen trees. Debris on tram and train lines and across roads also caused public transportation disruptions, which led to the temporary closure of many schools.

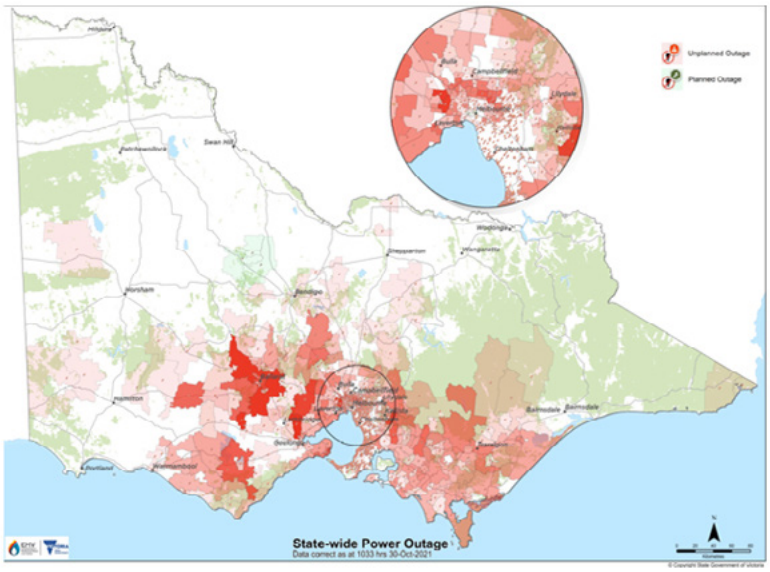


Figure 14: Areas of Victoria affected by the statewide power outage.

On 29 October, over 526,000 households (almost a quarter of all homes in Victoria) suffered power outages; the state's single biggest electricity outage. Outage areas were widespread across the state with some customers remaining off power for several days. Between 4.00am on 29 October and 4.00am on 8 November, there were 10,563 requests for assistance across the state including 3,899 requests for trees down and 2,238 requests for building damage. Incident control centres were established in Dandenong, Ferntree Gully and Geelong to manage the event. Five divisions were formed to assist the response, relief and recovery. All metropolitan Victoria State Emergency Service (VICSES) units were active for the response, along with many regional units.

New South Wales State Emergency Service (NSW SES) provided support to this event, with 44 NSW SES personnel deployed in the field across Frankston and Mornington Peninsula municipalities, and two NSW SES personnel positioned at the State Control Centre.

From swift deployment of NSW resources, effective integration of multiple agencies at Divisional Command Points and improved processes to activate generator rollout for power outages, many issues and potential improvements which were identified in the June 2021 extreme weather event were able to be applied to this event.

Lessons

After the extreme weather event in June 2021, Emergency Management Victoria established a learning review with VICSES. Its goal was to capture lessons of state-wide, multi-agency significance.

The review identified aspects of particular interest to affected communities. It includes lessons identifying areas of good practice and opportunities to improve. These lessons are being shared across the emergency management sector and with affected communities through the release of the *June 2021 Extreme Weather Event Learning Review - Community Report.*

Several themes emerged that highlight what has worked well and areas where there is room for improvement. Some affected communities expressed gratitude for the high levels of support they received in the initial response, relief, and recovery phases. This support came from agencies, departments and other community members.

Customers who were power-dependent or experienced prolonged outages received initial welfare calls from the Department of Families, Fairness and Housing and AusNet Services. These were greatly appreciated. This outreach was enhanced when Victoria Police began in-person welfare checks.

Extreme weather and significant impacts on critical infrastructure affected intelligence sharing and communication. Areas identified for improvement include:

- weather intelligence
- command and control arrangements during simultaneous emergencies
- clean-up processes for impacted areas
- financial support.

In response, the following has been implemented and was highlighted during the October 2021 storm:

- **Forecasting.** VICSES and the Bureau of Meteorology are continuously working and learning together to improve the communication and use of weather forecasting and potential impacts on communities. In particular, considering additional thresholds and antecedent conditions for issuing severe weather warnings for winds. The thresholds under consideration include wind direction, wind duration and preceding rainfall patterns.
- **Warning system.** Significant work has already been completed in late 2021 with Victoria the first to implement the new Australian Warning System that provides nationally consistent warning levels and warning icons. National implementation will be completed in 2023 providing a consistent framework for warning Australian communities for flood, severe storm, bushfire, cyclone and heat.
- **Warning protocol.** Streamlining and strengthening of the protocols for issuing severe weather messages using VicEmergency is underway. This work also considers observations from the storm events in June 2021, November 2021, December 2021 and January 2022.
- **Telecommunications.** The Victorian Government is pursuing a number of avenues to improve the resilience of telecommunications networks during emergencies. These initiatives are working to improve communications network coverage across the state and include:
  - Co-investing in and supporting the implementation of the Commonwealth Government's Strengthening Telecommunications Against Natural Disasters (STAND) package.
  - Delivering Victorian Government mobile programs and participating in the Commonwealth Government Mobile Black Spot program.
  - Delivering the $500 million Connecting Victoria program.

Severe Flooding from (ex) Tropical Cyclone Tiffany

South Australia, 21 January - 3 February 2022

A weather pattern influenced by ex-TC Tiffany, commencing early on 21 January and continuing until 3 February, resulted in record rainfall and flooding particularly in the north and west of South Australia. The flooding caused significant impacts on infrastructure, supply-chains, community, health and agricultural in northern, central, and western parts of the state.

On 20 January, the Bureau of Meteorology issued a severe weather warning for heavy rainfall and potential flash flooding across central and northern parts of the South Australia. Early on 21 January heavy rainfall began to fall on the western Eyre Peninsula with flooding and widespread damage reported. Isolated thunderstorms continued for the next few days.

Early the following week an upper low-pressure system and associated surface trough developed. There was an intensification of rainfall across the northwest of the state which moved slowly southwards to the northern parts of the Eyre Peninsula (including Kimba and Tarcoola) and eastwards to western Northeast Pastoral and Flinders. Much of the Eyre Peninsula, Yorke Peninsula and southern parts of the Pastoral districts recorded more than five times their January average rainfall.

As the control agency for flooding and severe weather, the South Australia State Emergency Service (SASES) was responsible for the control of the response to the emergency. The SASES State Control Centre (SCC) was activated on 21 January and on 28 January, supported by liaison officers from several agencies and functional support groups. The SCC remained activated for 17 days and a Major Emergency Declaration was signed by the State Coordinator, lasting for 14 days. Two SASES regional coordination centres were also activated.

Major damage was caused in 45 municipalities, the most extensive on the Eyre Peninsula and in the Northwest Pastoral area, including major disruptions to road and rail networks connecting the state to Western Australia and the Northern Territory.

The area of impact is comprised of vast empty space and farming land, low population including some isolated and vulnerable populations, mining and pastoral communities. The response was very complex due to the distances involved, lack of government resources in remote areas, reliance on private operators, access and remoteness making assessment of damage very difficult, large areas remaining under water for a protracted period and the overlay of the COVID-19 pandemic.

Damage, particularly to road and rail infrastructure, was arguably the most significant impact of the event, leading to critical consequences. Numerous highways, outback roads and tracks were closed due to flooding. The closure on 25 January of the Stuart Highway north of Glendambo, with large sections under water, had the most significant impact. The highway remained closed until 6 February, with a restricted reopening starting with essential heavy freight vehicles and emergency services. The highway was covered by approximately half a metre of water in some areas. The flood water at Glendambo was contained by high terrain, a 'natural bowl', and water levels were only dropping 40 mm per day. It was estimated that it would be 12 days minimum for restoration due to the time needed for water levels to subside, without human intervention such as high-volume pumping.

The feasibility of escorted heavy fleet along the closed Stuart Highway was assessed, however there were concerns about further damage to the road surface, which was already weakened and soft in places from inundation. An alternative Type II Network Route (for B Triples) was assessed for road transport to Darwin by the National Heavy Vehicle Regulator (NHVR). This route extended from Burra to Broken Hill, Bourke, Mount Isa and Darwin. The NHVR sought urgent approvals from South Australia and New South Wales to gazette the route, which was approved for a 28-day period for transporting essential foods and designated transport providers.

The route largely consisted of Type II approved roads and allowed road freight into Darwin and south to Alice Springs/ Coober Pedy, but the trip added two days of driving each way.

By 30 January the new heavy vehicle route had been compromised with floodwaters near Camooweal on the Queensland-Northern Territory border. Trucks continued to travel through shallow floodwaters over the road, whilst the NHVR investigated alternative options.

The east-west and north-south rail from Adelaide was closed for 24 days due to damage east of Tarcoola (18 washaway sites over 300 km) interrupting supply to both the Northern Territory and Western Australia. In excess of 50 return freight train trips (1.5 km long of rolling stock) normally move each week to Perth for one operator alone. The Australian Rail Track Corporation (ARTC) restored the rail line by 15 February.

Rail operators, One Rail Australia and Pacific Nation, collaborated to establish a land bridge from Port Adelaide and Alice Springs to Whyalla and Whyalla to Kalgoorlie, to manage a small proportion (5%) of the freight that would otherwise have been shipped via rail.

Consequences of the road and rail impacts were far-reaching. Supply chain disruption had significant flow-on effects

to communities and to the economy. Food security was significantly impacted in the north of South Australia and in the Northern Territory, and to a lesser extent in Western Australia.

Water security was also impacted as the majority of Australia's Alum (used in potable water and wastewater treatment) and other water treatment coagulants are sourced from Western Australia and supplied via rail. Disruption to the east-west supply route had significant implications for the eastern seaboard states and South Australia. South Australia Water reported that it generally utilises approximately 160 tonnes of coagulant per week and needed resupply within seven days before contingencies needed to be implemented. Options for contingencies included the use of the desalination plant at Port Stanvac, use of the reserve supply in South Australia, potential procurement of supply from New Zealand or India and alternative treatment options and reduction in water and wastewater treatment.

Potential and realised health consequences included sickness associated with mosquitoes from standing water, delays to medical supply deliveries and flood damaged airstrips compromising Royal Flying Doctor Service flights in and out of remote sites for emergencies and scheduled clinics.

Several tourists were stranded at Coober Pedy as well as Indigenous people seeking to return to Country (APY Lands). Of the stranded travellers, some had urgent medical appointments in Adelaide and were evacuated from Coober Pedy by the Royal Australian Air Force to the Edinburgh air base on a return food resupply flight.

Concerns for agriculture and animal welfare included the ability for pastoralists to provide access to shearers to enable them to shear sheep. February and March is shearing season and with so much water in the landscape the potential for large numbers of flies was high. The Department of Primary Industries and Regions (PIRSA) received requests for assistance from veterinarians and livestock owners to access properties in order to prevent and control blowfly strike in sheep.

PIRSA also reported the Dog Fence (built to keep dingoes out and runs 5,614 km from Darling Downs in Queensland to just above the Great Australian Bight on the Nullarbor Plain in South Australia) sustained considerable damage with 20 km of damage identified. Dogs had been confirmed as trespassing and baiting options were considered and implemented. PIRSA also had concerns regarding topsoil movement and loss on Eyre Peninsula with potential impacts on future grain yields.

The Department of Energy and Mines reported delays in mineral exports including iron ore, meaning deferred royalties into Treasury, and subsequent budget impacts. On 29 January it was reported that alternate transport routes were being explored.

Simec Mining (Middleback Ranges) looked to truck approximately 2,000 tonnes of iron ore daily, with approximately 11 trucks operating seven days per week on a 12-hour basis from 7am to 7pm, for two weeks to Whyalla whilst rail infrastructure repairs occurred.

At the strategic level, the emergency response was supported by the South Australia State Emergency Centre (SEC) and working groups including the Water Security Working Group, the SEC Supply Chain Consequence Management Group, and the SEC Remote Communities Food and Supply Group. The State Recovery Coordination and Planning Group was established and developed a recovery plan and funding submission to the Australian Government for funding under Disaster Recovery Funding Arrangements.

At the federal level, support was provided through the National Coordination Mechanism (NCM) which involved representatives of the transport sector and retail food suppliers. The NCM met with Trusted Information Sharing Network industry representatives seeking information on any industry specific supply chain issues.

Through the NCM there was a coordinated industry approach to support supply chain challenges across Australia. The NCM engaged directly with industry, rail owners and operators, Australian Government departments, state and territory governments, and other related peak bodies to keep essential supplies moving and repair infrastructure as soon as possible. Just-in-time regulations were facilitated to limit the application of anti-competition laws allowing collaboration/cooperation between industry competitors. The benefits of this forum were substantial and there is merit in South Australia considering the options for a domestic coordination capability for large scale events in the state.

The Australian Government National Situation Room monitored the situation across central and eastern Australia and coordinated imagery, forecasting and other support to the NCM.

The Australian Defence Force also provided significant support under Defence Assistance to the Civil Community arrangements for resupplying food to Coober Pedy which had been cut off from usual supply routes and other taskings.

Response to the severe weather and flooding event in South Australia and its impacts and consequences was wide-ranging. It involved the SASES, many South Australian government departments and NGOs, the Australian Government, commercial entities and infrastructure agencies. Given the unprecedented extent and scale of the impacts, there was a need for agencies to collaborate and innovate to support the community and minimise impacts.

Image: SA SES

Note: Abbreviated Council names used due to space constraints.

Legend

- Most Significantly Impacted
- Significantly Impacted

Figure 15: Areas in South Australia impacted by flooding from ex-TC Tiffany.

Image: Australian Defence Force

Volcanic eruption and tsunami (Australian response)

Tonga, 15 January 2022

There are many key elements of Australia's emergency management arrangements that are fundamental in responding to assist in an emergency. Flexibility and agility are vital foundational components of the response phase. There are many examples of how these arrangements have operated outside of Australia and the following case study provides an overview of the arrangements, systems and connections that Australian emergency management agencies have in place that underpin a timely response.

On 15 January, the volcano — known as Hunga Tonga-Hunga Ha'apai (Hunga) — which lies about 65 km northwest of the Tongan capital of Nuku'alofa and sits within a line of volcanoes called the Tonga-Kermadec volcanic arc – erupted. Hunga is an underwater (submarine) volcano between two small uninhabited islands at about 2,000 m high from the sea floor, with about 100 m of it visible above sea level and is about 20 km wide. The volcano had been active in the years preceding the January eruption.

The Kingdom of Tonga is a Polynesian country of more than 170 South Pacific coral and volcanic islands of which 36 are inhabited and home to about 106,000 people. Around 70% of the population live on the main island of Tongatapu. The islands are divided into four main groups — Tongatapu, Ha'apai, Vava'u and the Niuas. The capital Nuku'alofa is located on the main island of Tongatapu.

It's a remote archipelago that lies about 800 km east of Fiji, 2,380 km from New Zealand and 3,800 km from Australia.

The Hunga eruption sent a towering plume of gas and particles billowing into the mesosphere, part of the earth's atmosphere which extends from about 50 - 85 km above planet Earth. The plume reached 58 km in height at its highest point, making it the largest volcanic plume recorded by satellites.

The eruption is thought to be one of the world's largest in recent decades. Both atmospheric and tsunami wave impacts were felt in Samoa, Fiji, Vanuatu, Australia, New Zealand, Japan and the entire western seaboard of the American continent (from Alaska to Chile).

The official death toll from the volcanic eruption was three: two Tongan nationals and a British woman caught when the tsunami hit. The reasons for such a low death toll were considered to relate to an effective warning system and experience from previous disasters.

The eruption caused a tsunami on Tonga's largest island, Tongatapu, with waves recorded at 1.2 m near Nuku'alofa city flowing onto coastal roads and flooding properties on 15 January.

Tsunami warnings went into effect across Fiji, Samoa, Vanuatu and Australia. Footage from the ground in Fiji shows people fleeing to higher ground in the capital, Suva, as large waves hit the coast.

Authorities declared a state of emergency and estimated 84% of Tonga's population had been affected by the disaster. Impact assessments identified in excess of 300 houses were damaged and more than 1500 people displaced. Recovery efforts are ongoing.

The volcanic explosion caused power outages and cut off Tonga's undersea communications cable, limiting information into and out of the country. Power was quickly restored to the capital and limited satellite connectivity established, but communications across the country remained limited.

Ash pollution in drinking water raised immediate health concerns and ensuring clean water was an urgent priority. Local volunteers were among the first to distribute water supplies and other essential supplies to reduce the threat of water-borne diseases such as cholera and diarrhoea. Relief agencies reported that other priorities included telecommunications, logistics capacity, non-food items and support with further needs assessment, as assessment teams worked towards the harder-to-reach areas. Key challenges included ash clearance and ensuring food security.

COVID-19 complicated aid delivery, with the Tongan Government requesting donors to deliver supplies without any person-to-person contact to prevent the spread of COVID-19. The country had remained COVID-19 free for most of the pandemic — recording just one case over the two years to February 2022 — and had a strict border control policy that required all arrivals, including aid workers, to isolate for three weeks before entering the country, while cargo needed to complete 72 hours quarantine. The Tongan Government was initially cautious about allowing relief workers into the country, but as the magnitude of the disaster became clear, large numbers of international surge people supported the relief and recovery effort.

The volcanic explosion was another compounding event for the country. In addition to the 15 January event, Tonga had been impacted by a series of damaging severe tropical cyclones, Gita in 2018 and Harold in 2020. Layered on these events were the effects of COVID-19 which resulted in strict international and domestic travel restrictions since March 2020 that decimated Tonga's tourism, retail and construction sectors. Like other small Pacific Island states, Tonga is particularly vulnerable to environmental and economic shocks.

Australia's emergency management response

Australia responded swiftly and comprehensively to the events in Tonga, guided by the requests and priorities of the Tongan Government, and in close coordination with like-minded partners. Australia committed $3 million in initial humanitarian assistance and an additional $16 million to support Tonga's recovery and reconstruction and bolster its COVID-19 response.

The first Australian assistance to Tonga was provided by the Royal Australian Air Force (RAAF) in the form of reconnaissance flight, followed by delivery of emergency relief supplies. RAAF aircraft delivered over 130 tonnes of emergency relief supplies and equipment to Tonga.

One of Australia's biggest naval vessels, HMAS Adelaide, arrived in Tonga on 26 January carrying important materials and equipment. This included humanitarian and medical supplies, engineering equipment and helicopters to support logistics and distribution across the archipelago.

In addition to the efforts of HMAS Adelaide, HMAS Supply and HMAS Canberra brought fuel, construction materials and disaster relief supplies to Tonga. Australian naval vessels and air force flights delivered more than 390 tonnes of essential emergency relief supplies and equipment to Tonga, including: shelter kits and bedding, water containers, water purification tablets, water sanitation and hygiene kits, personal protective equipment, equipment to restore communications and engineering equipment and helicopters to support logistics and distribution.

The Australian contingent provided support to the Tongan government to understand the impact of the event across the Tongan kingdom on a regular basis to enable priority setting to occur. This information gathering enabled Australian resources to support Tongan personnel reinstating and reconstructing critical national infrastructure.

During the response effort the Australian contingent was a resolute partner in Tonga's fight in keeping COVID-19 at bay. Australia played a role in the provision of 73,990 vaccinations, testing equipment and support of the national vaccine rollout. With Australia's support, 98% of Tonga's eligible population had one dose of the COVID-19 vaccine, while over 90% had their second dose.

Fire and rescue agencies were involved in the preparedness and readiness arrangements associated with the eruption in January. Before reaching into the specific roles played it is important to understand the well-established governance mechanisms that are in place to create and nurture relationships between Pacific Island nations and Australian Fire and Rescue agencies.

Members of the National Council for Fire and Emergency Services, AFAC, have been working in cooperation with their Pacific counterparts to support capability development of fire and emergency agencies in the region for many years. Development activities have historically occurred where resources such as training and equipment become available through the twinning partnerships between AFAC members and Pacific Island Nations. Several twinning partners have been successful in supporting the set-up of Pacific Island Countries and Territories (PICT) services and creating capability plans and pathways for their PICT partners.

AFAC was integral in establishing the Pacific Island Fire and Emergency Services Association (PIFESA) as a formal committee, where heads of both PICTs and Australian and New Zealand agencies would come together to discuss priorities and share initiatives. AFAC members are well placed to contribute towards Australia and New Zealand Governments' humanitarian agendas and development programs in the Pacific.

Following the eruption in January 2022, the Australian Urban Search and Rescue (USAR) team with International Search and Rescue Advisory Group (INSARAG) accreditation and a Department of Foreign Affairs and Trade (DFAT) cohort commenced planning with a focus on initial reconnaissance.

As more information came to light on the event, DFAT requested a plan to provide pumping and hose kits for washdown of ash and other materials. A kit included a pump, hose and a nozzle with the kits being transported on the HMAS Adelaide to Tonga.

Following the successful deployment of this equipment, a further request was received from DFAT in March for a Damage Assessment Response Team to provide a capability to assess the volumetric capacity of asbestos debris from the rehabilitation and reconstruction effort. A team with a Remote Piloted Aircraft System and Geographic Information System technician along with officers capable of sampling the environment was deployed to provide this service.

The purpose of providing this overview is to demonstrate the important relationships that exist with critical neighbours, the enhancements that exist to emergency management arrangements and the joined up, interoperable systems that exist across Australian jurisdictions and the Pacific region.

This video by the Bureau of Meteorology provides excellent information on the Tongan volcano eruption.

Images: Australian Defence Force

Tsunami warning

Norfolk, Lord Howe and Macquarie Islands, 15 January 2022

The Joint Australian Tsunami Warning Centre (JATWC) is operated by the Australian Bureau of Meteorology and Geoscience Australia. Based in Melbourne and Canberra, it has been established so that Australia has an independent capability to detect, monitor, verify and warn the community of the existence of tsunamis in Australian coastal locations and offshore territories.

The aim of JATWC is providing the longest lead time of any potential tsunami threat. The major objective of the JATWC is to provide emergency managers with a minimum 90 minute warning of a likely tsunami impact on mainland Australia.

The JATWC provides warnings for Australia that identify affected coastal regions. It also identifies whether the tsunami has the potential to cause inundation to low lying coastal areas with the need for major evacuation (land threat), or if it is confined to dangerous rips and currents and some localised overflow onto the immediate foreshore with no need for major evacuation (marine threat).

The Bureau of Meteorology issues advice and warnings on any identified tsunami threat to emergency agencies, relevant authorities and the general community using the same systems and infrastructure used for warnings of other hazardous events such as severe weather.

While JATWC are the authoritative agency for tsunami warnings, local authorities and government agencies issue advice on tsunamis. Following the 2022 Hunga Tonga Hunga Ha'apai volcano eruption, the Australian Warning System was used to issue tsunami warnings.

The *Major Incident Report 2021-22* incorporates an overview of the actions taken by JATWC and includes the efforts of the New South Wales SES in the operational aspect of the tsunami following the volcanic eruption on the 15 January 2022. A land threat warning, the first in New South Wales with SES as the combat authority, was issued for Lord Howe Island on the 15 January 2022.

JATWC response

As a non-earthquake induced tsunami, the tsunami generated by the explosion of the Hunga Tonga-Hunga Ha'apai volcano on 15 January posed an unprecedented challenge to the JATWC and the global tsunami warning system that relies on seismic detection. While non-seismic sources from volcanic eruption and landslide have occurred in the past, this was the first non-seismic tsunami event since the 19th Century, with ocean-wide tsunami impact reaching Australia and many other Pacific countries.

Following the explosive volcanic eruption at 3.10pm AEDT, observations of a 1.2 m tsunami were made at the Bureau of Meteorology-operated Nuku Alofa (Tonga) tide gauge at 3.50pm. A record of the sea level observations detecting 1.27 m maximum tsunami waves from the Norfolk Island tide gauge station on 15 January is contained in Figure 16.

The JATWC immediately entered the heightened monitoring phase and liaised with the Darwin Volcanic Ash Advisory Centre for any volcanic development, as per pre-defined procedures. Upon detecting a 50 cm tsunami on the Norfolk Island tide gauge, JATWC issued marine warnings for Norfolk Island, Lord Howe Island, southern Queensland and the entire New South Wales coast.

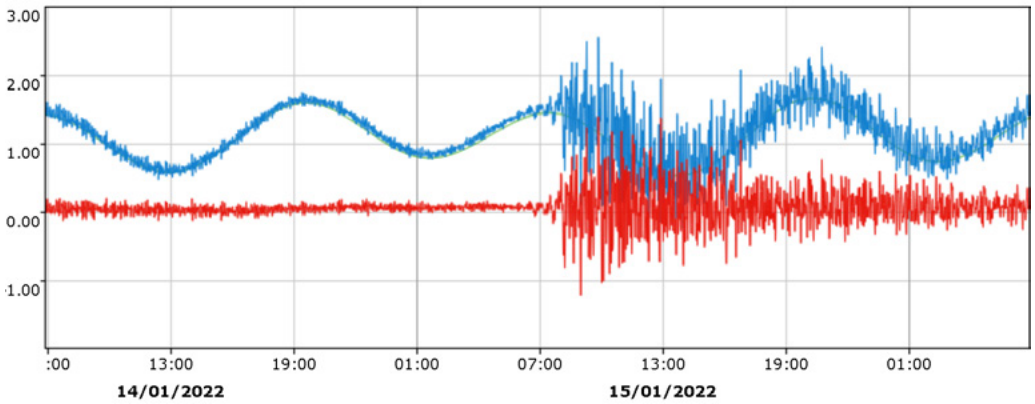


Figure 16: Plot of Sea Level Observations detecting 1.27 m maximum tsunami waves from Norfolk Island tide gauge station 15 January 2022.

As wave activity further increased across the southwest Pacific the JATWC upgraded warnings to Land Warning for both Norfolk and Lord Howe Islands. This prompted the New South Wales State Emergency Service (NSW SES) to issue an evacuation order for Lord Howe Island, with approximately 50 residents evacuated to higher ground. A Marine Warning was also extended to the east coasts of Victoria and Tasmania, as well as Macquarie and Wills Islands. See Figure 17 for a map of the tsunami warnings and travel time from the Tonga volcanic eruption.

These warnings were updated on an hourly basis until the warnings were cancelled approximately 30 hours later. The JATWC had assessed that the tsunami waves, while continuing, no longer posed serious threat to people in water or near the coast.

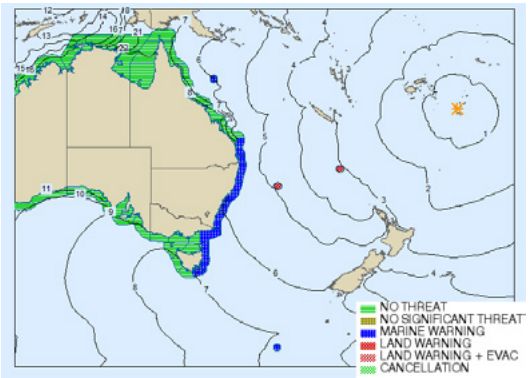


Figure 17: Map of Tsunami Warning and travel time (in hours) from the Tonga Volcanic Eruption.

NSW SES tsunami response

NSW SES is the combat agency for tsunami in New South Wales.

In NSW, a Marine Threat Warning was initially issued for Lord Howe Island at 8.00pm on 15 January, followed a short time later by a Marine Threat Warning for the entire NSW coastline at 8.36pm. At 9.18pm the warning for Lord Howe Island was upgraded to a Land Threat. This was the first land-based tsunami threat for NSW with the SES as the combat agency.

Lord Howe Island has a small SES Unit, which is supported by the Port Macquarie Unit on the mainland. The Island has a tsunami plan, and this was enacted by the SES and the Local Emergency Operations Controller on the island. The plan had been exercised in the previous 12 months.

NSW SES issued an evacuation order for low-lying parts of Lord Howe Island at 10.00pm 15 January. 50 residents were evacuated to higher ground on the island. At 10.17am on 16 January, the Land Threat Warning for Lord Howe Island was downgraded to a Marine Threat Warning and evacuated residents were allowed to return home. The Marine Threat Warning for Lord Howe Island was cancelled at 7.56pm on 16 January but remained in place for the remainder of NSW until 10.07pm.

With the tsunami threat warnings covering most of the east coast of Australia, NSW SES worked with agencies in Queensland, Victoria and Tasmania to ensure unified messaging to communities and a shared approach to the use of the Emergency Alert system.

NSW SES Units along the mainland coast were activated throughout this period to be ready to respond to any impact and to assist in warning the community of the marine based threat. The State Command Centre was opened to coordinate response activities and liaise with all other emergency management stakeholders.

The Bureau of Meteorology developed an informative video that provides an overview of the science behind the eruption of the undersea volcano, the impacts of the eruption, the extent of the warnings provided by JAWTC and the duration and the silver lining of the ash cloud on Australian sunrises and sunsets.

Observations

- When a tsunami threat covers multiple states and territories, it is important to liaise with the jurisdictions involved to ensure all communities receive relevant, unified and timely messages. This is particularly important with cross-border communities.
- The demand for the use of the Emergency Alert in a similar event will be extensive and will require joint risk assessment between jurisdictions to identify priority areas for messaging.
- Having an established and exercised tsunami plan was beneficial to the smooth and efficient response activities on Lord Howe Island.

Bushfire

Western Australia, 5 - 15 February 2022

The antecedent weather conditions that contributed to the severe weather event resulting in four simultaneous Level 3 bushfires across Western Australia provides the background to the behaviour of these incidents and the rapid escalation of these fires.

Seasonal outlooks produced by the Department of Fire and Emergency Service (DFES) in spring and summer identified that late winter rainfall had alleviated a prolonged drought over the southwest of Western Australia. This resulted in an environment which promoted good growth of vegetation and crops alike. This growth resulted in fuel loads which were above what would be considered normal for the time of year in many locations. Summer outlooks also identified above normal fire potential in large areas of the southwest amongst other areas of interest. During December, successive heatwaves ensured the curing of this fuel increased rapidly and left the landscape of the southwest primed in the event of any fire incidents.

Throughout January prolonged high temperatures and continuing heatwaves combined with a series of troughs ensured the southern half of Western Australia was set for an extended period of significantly elevated fire risk. The weather in Western Australia was in stark contrast to the eastern states where emergency services were responding to significant flooding events which would continue to for several months.

The development of a deep trough along the west coast on 3 February resulted in an environment with sustained winds above 40 km/h and temperatures well above 40°C. The passage of this trough inland would lead to risks elevating from coastal areas to inland areas over a period of several days. The consequential fire danger ratings were exceedingly unusual for many of the areas included in the forecast and resulted in Catastrophic ratings in areas which had never recorded these before. The instability of the atmosphere was also reflected in the C-Haines values exceeding 12 for much of the southwest on 5 February and 13 for large areas of the southwest by 6 February.

The weather system was forecast to rapidly change from the deep trough to a deep low-pressure system from late on 6 February and bring with it a much cooler environment with cold wet weather by 7 February. It was evident though that the passage of this trough would present significant challenges in preventing and responding to the ignition of fires in the landscape prior to any respite that the weather change presented.

The development of the significant fire weather in the southwest followed a sustained period of activity in the North West of the state with the passage of a Tropical Low which had impacted Broome and surrounding areas during the previous week.

Prior to the first incident, 6 of the 9 DFES regions had increased their forecast risk status to Moderate, and the State Operations Centre (SOC) pre-emptively triggered a major risk response across the state. This resulted in the activation of several predetermined processes which ensured broad coverage of the risk areas from both a staffing and resourcing perspective.

The development of the weather systems was closely monitored in the lead up by the DFES SOC, and ahead of the first ignition a range of measures to prevent and limit fires were implemented. The response to these emergencies required significant state-wide coordination involving numerous emergency management partner agencies.

Image: DFES WA

Recent breaching of the Transcontinental Railway by flooding had led to supply shortages across the state and reliance on road networks. The participation of parties involved in state freight supply planning was essential, in addition to traditional partners and stakeholders. The coordination of the involvement of external stakeholders was managed by the DFES SOC.

With the exemption of the far north of the state, the DFES SOC implemented Total Fire Bans (TFB) for most of the state in consultation with local governments and other stakeholders. Whilst many areas met TFB triggers, many others were included as preventative measures. These were supported by local governments implementing harvest and vehicle movement bans to complement the DFES preparations. These pre-emptive measures prior to the incidents no doubt played a significant role in ensuring that the number of potential incidents was minimised.

Bayview Rise bushfire

The first significant ignition began in the Shire of Denmark, approximately 400 km south of Perth, and became known as the Bayview Rise bushfire. The fire was reported at 9.28am on 4 February. Reports from initial crews indicated that the fire was escalating, and four aerial assets were mobilised to assist. Throughout the incident 80 appliances and 130 firefighters from various agencies were activated to bring the blaze under control. This was in line with directives from the Duty Assistant Commissioner to ensure an additional weight of response commensurate with the heighted fire danger risk. The fire was escalated to a Level 2 incident by 4.00pm that afternoon and subsequently Level 3 by 11.00pm. Numerous Emergency Warnings were issued to the community in the Shire of Denmark and evacuations of residents were facilitated.

At 6.00am on 5 February a Level 3 incident was declared, which triggered the mobilisation of a pre-formed Incident Management Team (IMT). Logistical support caches were also mobilised at this time to assist with mobile infrastructure for the IMT. The DFES SOC requested the mobilisation of a 36 person IMT from New South Wales to assist with further incidents should they occur due to the significant mobilisation to the Bayview Rise Bushfire. This was accomplished through the AFAC National Resource Sharing Centre (NRSC) and ensured Western Australia would remain able to respond accordingly to any further large-scale incidents.

The fire impacted an area of 2,200 ha as it rapidly spread through steep challenging forest and rural terrain to the West of Denmark. This resulted in the loss of 4 houses and 9 additional structures.

The fire remained a Level 3 incident until more favourable weather and light rain on 6 February assisted responders. The incident was downgraded to Level 2 on the morning of 7 February before being further downgraded on 10 February.

Bridgetown bushfire

Whilst the Denmark incident was still escalating, a second incident in the Shire of Bridgetown-Greenbushes commenced at 1.19pm on 5 February, 230 km south of Perth. The Bridgetown bushfire escalated very quickly to Level 2 by 3.05pm and Level 3 by 3.56pm. It was clear that this fire would also create significant disruption and losses. This was evident with the closure of the South Western Highway during the afternoon of the following day, causing transport disruptions throughout the southwest. This compounded the existing supply chain issues existing from the Transcontinental Railway outages in the previous months and shortages caused by the global pandemic.

This fire impacted an area of 2,206 ha through similar terrain to the Bayview Rise bushfire to the north of Bridgetown. Eight houses and 15 additional structures were reported as lost over the course of this incident. Many more properties were reported as saved, which is testament to the hard work of responders in difficult terrain and weather. Significantly, this fire resulted in the loss of a timber treatment facility which also created a hazardous materials risk to the surrounding communities. While the favourable weather on the evening of 6 February also assisted the responding crews at the Bridgetown Bushfire, the complexities of the incident's location and impact resulted in the incident remaining at Level 2 until 12 February.

Despite the area of this fire being smaller, the difficult terrain required more than 270 responding personnel and utilised in excess of 6000 hours of effort from both volunteer and career services to bring resolution to this incident.

Images: DFES WA

Shackleton Complex bushfire

While a Severe fire danger rating had been observed in many areas throughout 5 February, the most significant weather was observed on 6 February. Several locations throughout the Wheatbelt reported Catastrophic fire conditions very early and at 9.23am a fire, which became known as the Shackleton Complex bushfire, in the Shires of Bruce Rock, Quairading and Corrigin commenced 220 km East of Perth. Due to the forecast conditions, incident management personnel and aircraft consisting of a Level 3 team and five rotary wing aircraft had been pre-staged in the town of Northam, 100 km closer than normal operating bases. Additionally, a Large Air Tanker was staged in Kalgoorlie to the East. These resources were all sent to combat the incident.

The incident was declared Level 3 at 2.30pm and extreme fire behaviour resulted in emergency warnings being issued to many communities including the town of Corrigin.

Power outages resulted in communications challenges and a subsequent incident near Narrogin made evacuation planning challenging. Due to the extreme weather and fire behaviour the aerial assets were not as effective as in other incidents. These assets were reallocated by the DFES SOC State Operations Air Desk.

The Shackleton Complex Bushfire was similarly impacted by the favourable weather change late on 6 February, however it wasn't until 10 February that the incident was considered contained and controlled.

The Shackleton Complex Bushfire burned through an area of 44,600 ha and was comprised of two independent fires. The terrain was predominantly lightly undulating open farmland and woodland north of Corrigin. The Shackleton Complex contained the largest losses of the four incidents reporting 15 houses and 54 structures. In addition to the 54 other structures were the loss of significant amounts of breeding livestock and feed.

Narrogin East bushfire

Just over an hour after the ignition of Shackleton Complex incident another incident, known as the Narrogin East bushfire, was reported at 10.42am in the Shire of Narrogin, 170 km South East of Perth. Like the Shackleton Complex incident, it quickly escalated to catastrophic fire conditions reaching Level 3 by 5.20pm. The declaration of this incident brought a situation where DFES was now responding to Level 3 incidents in four separate locations across the state.

The Narrogin East Bushfire affected an area of 17,851 ha. It was located in a rural setting of the Wheatbelt similar to the Shackleton Complex and saw the loss of 31 buildings. The loss of a commercial piggery containing 5000 livestock and the closure of several significant transport routes were the most significant impacts of the Narrogin East incident.

Observations

These unprecedented events required the State Operations Centre to be particularly agile with the resourcing of IMT, ground assets and aerial appliances. There were several factors which contributed to the success with these incidents. While the change in weather late on 6 February had an obvious impact, had it not been for other strategic decisions made well prior to this, the incidents would not have been as well placed for a coordinated response.

The DFES SOC began preparation for the weather event well in advance of the impact of the system, which enabled responses to be rapid and appropriately scaled. While regions ordinarily report their forecast risk and ability to respond, the SOC undertook a more involved role earlier due to the number of regions reporting significant risks. This enabled the early identification of resources and a state-wide strategic planning process.

The pre-emptive positioning of resources across the state allowed for timely response to all incidents and ensured that the maximum effort was able to be applied early in each incident. This was particularly important given the large geographic spacing of the incidents.

New supplementary roles within the SOC enabled the production of a large range of intelligence products as additional support to incidents in the early phases. These included looking at worst case scenarios and forecasting much further than had been possible in previous incidents. These products included advanced predictions and modelling, but also staffing and resourcing assistance.

Early collaboration with the AFAC NRSC enabled a replacement Line Scanner and additional Large Air Tankers to be brought to Western Australia prior to the worst of the weather. This was also made possible due to the weather being experienced by other states being the opposite of what Western Australia was experiencing.

Utilising the State Operations Air Desk, aerial assets were strategically placed prior to impact and seamlessly moved to where they were best placed and reviewed on a regular basis. This strategic approach to aircraft usage ensured best utilisation of the assets available. Further consultation also ensured that the interstate IMT would arrive early during incidents.

While the process of recovery for any incident can be a protracted one, the early weight of response to these incidents ensured that the impacts were kept as small as possible. DFES continues to work with local governments through the Resilience and Recovery portfolio, offering support and coordination of recovery efforts throughout the state.

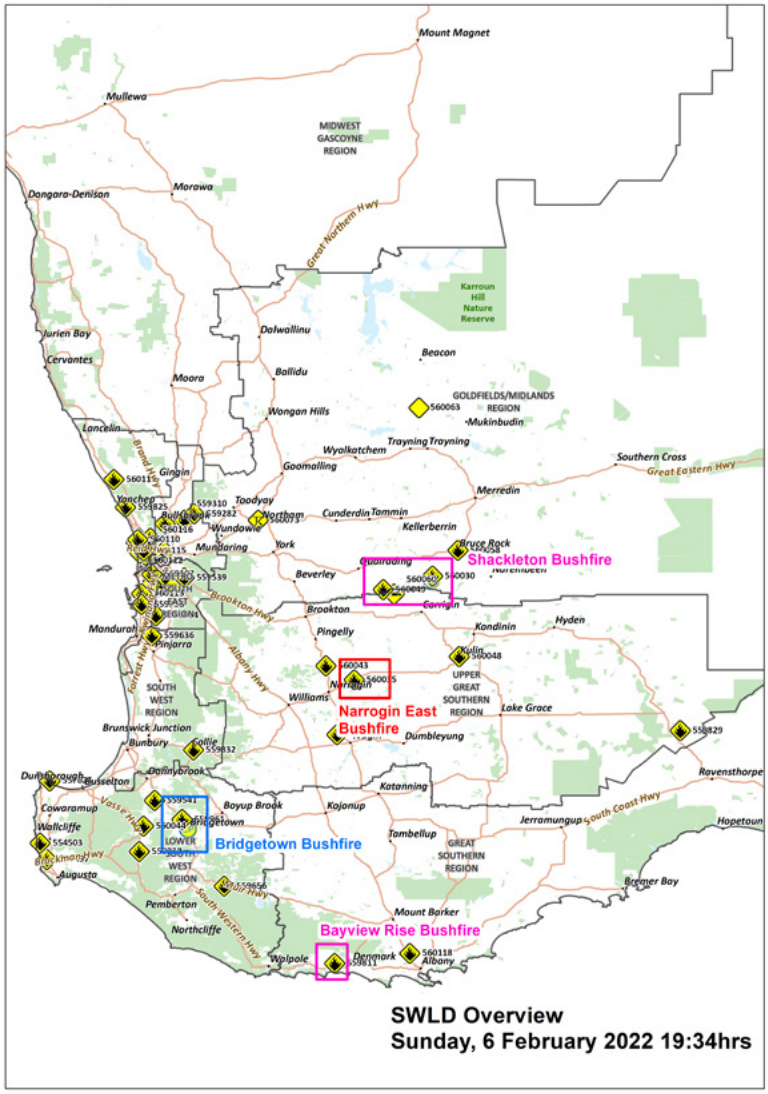
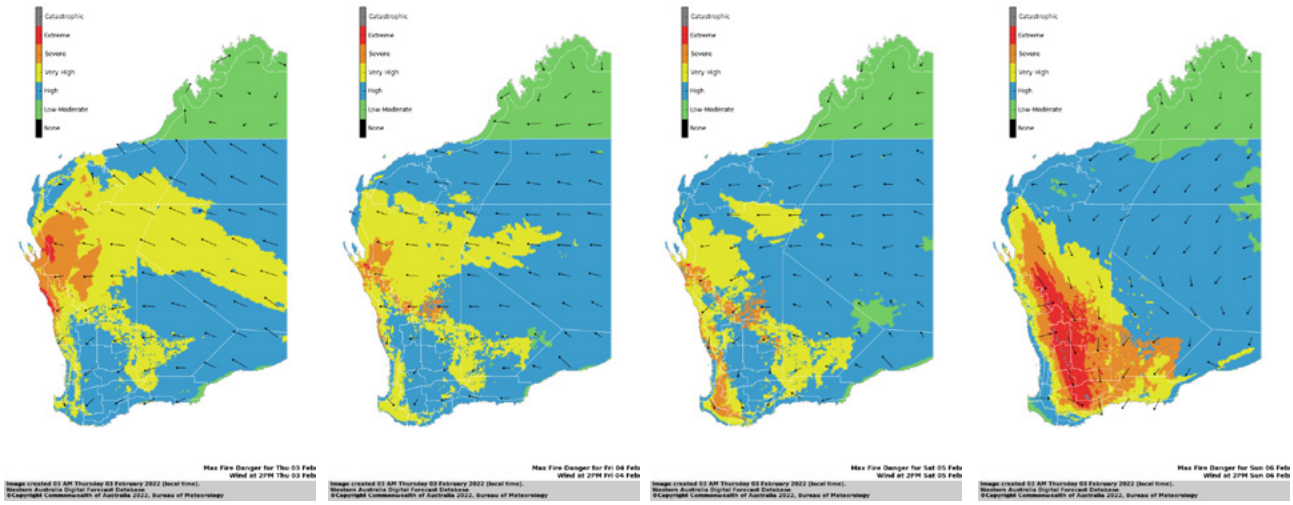


Figure 18: South West Land Division overview at 7.34pm, 6 February 2022.



Thursday Friday Saturday Sunday

Figure 19: Maximum fire danger and wind in Western Australia on 3-6 February 2022.

Rainfall and flooding

Queensland, 22 February - 7 March 2022

The Bureau of Meteorology forecasts for the 2021-22 storm and cyclone season indicated an increased chance of rain and widespread flooding, coastal flooding and erosion. Prior to the season, the Bureau of Meteorology modelling and evidence of cooling in the tropical Pacific Ocean raised the chance of a La Niña weather system forming in 2021. On 23 November, the Bureau of Meteorology declared that a La Niña weather system had developed in the Pacific Ocean.

The South East Queensland (SEQ) flood event was caused by a low pressure system over Queensland's southern coast that dragged moisture from the Coral Sea in the north. From 22 February to 7 March, the Brisbane, Maryborough, Gympie, Sunshine Coast, Caboolture, Toowoomba, Ipswich, Logan and Gold Coast areas suffered major flooding as a result of intense rainfall which led to flash flooding and riverine flooding across large areas of South East Queensland.

Resourcing

Disaster management in Queensland requires local, district and state groups, government agencies and non-government organisations to work effectively together under Queensland's disaster management arrangements. The multiple stakeholders have a range of diverse and significant responsibilities and the capacity and effectiveness of the system and its functioning is dependent on continuous maintenance of these relationships and associated functions.

During the SEQ flood event, a total of 23 local disaster management groups (LDMGs) and eight district disaster management groups (DDMGs) were activated, with Queensland Fire and Emergency Services (QFES) regional operational centres established in each of the impacted regions. The intensity and extended duration of the event resulted in a total of 1,623 State Emergency Service (SES) volunteers delivering and supporting emergency services activities which totalled over 36,200 hours of effort. The main focus of that effort was directed towards temporary repairs, sandbagging and flood boat operations. Fire and Rescue Service (FRS) swift water teams were also heavily involved in the event and in total, over 8,100 tasks were completed by QFES personnel.

A coordinated effort across the arrangements was maintained with effective online and in-person communications via online updates and daily briefings and debriefings. The inclusion of QFES emergency management coordinators and liaison officers was critical in supporting the coordinated effort from LDMGs and DDMGs to QFES incident command. This created the ability to extend situational awareness and communication which, in turn, supported an efficient and coordinated response to what was a large scale event.

The SEQ flood event evolved rapidly and placed considerable and complex demands on emergency services over a sustained period. From 24-27 February, Wivenhoe Dam capacity rose from 58.7% to 183.9%.[1] Peak flooding occurred from 25-27 February and the Bureau of Meteorology map issued on 27 February, five days into the event, provides an appreciation for the scale and areas impacted. Rainfall totals for the 6 days ending on 28 February were at least 2.5 times the February average rainfall across the South East Queensland area, with some parts of Queensland receiving more than 5 times their monthly average rainfall for February.

In response, FRS motorised swift water rescue teams were deployed throughout affected regions, supported by SES flood boat crews, who worked in collaboration with Queensland Police Service and Surf Life Saving Queensland personnel. All available assets and technology were used, with aircraft deployed on more than 40 occasions with operational response activities also supported by remotely piloted aircraft systems to provide tactical information for personnel.

Historically, this type of geographically isolating event hampers attendance to certain locations and some regional communities become increasingly isolated during the event. Consequently, the stakeholders in Queensland's disaster management arrangements continue to adopt a multi-modal approach to emergency communications through the utilisation of social media including Facebook, Twitter and Instagram, as well as websites that support the use of emergency alerts. A total of 182 emergency alerts were issued, with QFES social media contributing a total of 404 posts to the various platforms, with a reach of over 37 million and an engagement of 452,796.

27 February saw the peak of activity in relation to both the volume of triple zero and SES 132 500 calls tasked by both SES and QFES FRS, as well as the number of people evacuated. Rainfall in the Brisbane region was approximately 3 times that experienced the previous day.

On 28 February, the Brisbane River peaked at 3.85 m. In comparison, the Brisbane River's peak during the 2011 floods was 4.46 m. Once the intense rain across the state ceased, riverine flooding remained a concern for several days as the water slowly receded and water continued to be released from the dams.

Over 170 suburbs in the greater Brisbane region were impacted; almost double the impact of the 2011 floods.[2] In total, QFES received 16,243 requests for assistance either through calls to triple zero, SES 132 500 or through the SES Assistance QLD app, with 8,184 tasks completed.

Impact

From 22 February to 7 March, the sustained rainfall and subsequent flooding resulted in the loss of 13 lives, including the tragic death of SES volunteer Merryl Dray. The event also saw more than 90 rescues carried out by QFES with over 330 people evacuated. The Minister for Police and Corrective Services and Minister for Fire and Emergency Services declared disasters in the Disaster District of Gympie on 26 February and the Brisbane Local Government Area and Disaster District of Maryborough on 27 February.

During the event period QFES completed 16,485 damage assessments. The human and social impact of the event was significant, with more than 180,000 people losing power and 613 education facilities impacted, including 88 schools suffering damage. Over 1,700km of roads were closed or under restricted access. The economic cost resulted in over 98,000 insurance claims at a cost of $1.38 billion with an estimated impact on small business to be greater than $328 million.

Following the SEQ flood event, 23 local government areas were activated under the joint Commonwealth State Disaster Recovery Funding Arrangements (DRFA) to enable those impacted to have access to DRFA funding.[3] On 15 March, the Premier of Queensland announced that the Office of the Inspector General of Emergency Management (IGEM) would undertake a review of Queensland's response to the event. At the time of writing, the IGEM report is yet to be released.

Figure 20: Bureau of Meteorology Flood Map issued at 6.02am, Sunday 27 February 2022.

1 ABC News February 2022
2 Brisbane City Council 2022 Flood Review
3 2021-22 Southern Queensland Floods – State Recovery and Resilience Plan

Event Scale	
13 lives lost	Large commitment from staff from all agencies (5,664 QFES staff and volunteer shifts conducted) 15 fire rescue personnel deployed from Victoria
97 people rescued (63 rescues on 25 February 2022)	16,485 damage assessments completed
1 line of duty death (25 February 2022) 66 line of duty injuries	3,461 '000' calls received 12,782 '132 500' calls received
Multiple agencies - local, district and state level 23 LDMGs, 8 DDMGs, 1 SOC, 4 ROCs, 9 ICCs	Estimated $7.7 billion cost to Queensland Estimated $1.38 billion cost for private insurance claims Estimated $646 million uninsured losses
Multiple alerts / warnings issued 182 emergency alert campaigns 9,699,194 text messages delivered 1,931,446 failed deliveries	331 people evacuated
3 Disaster declarations (Gympie, Brisbane, Maryborough)	Tasks completed: 7,529 (SES) 655 (FRS)

Table 6: Event scale, rain and flooding, Queensland, 22 February - 7 March 2022.

Observations

An applied capability review of QFES' response to the SEQ flood event is currently underway. The review draws on the Observations–Insights–Lessons Identified–Lessons Learned model documented in the AIDR *Lessons Management Handbook*. To date, 1,309 observations have been gathered by QFES across all observation collection methods.

As part of the review process, after-action reviews, incident forms, debriefs and targeted surveys have been utilised to examine QFES' service delivery for the operational period 22 February to 7 March 2022.

Notes

1. The 2022 South East Queensland Rainfall and Flood Event (the SEQ Flood Event) which occurred in February - March 2022 amply demonstrated Queensland's status as the most disaster prone state in Australia. Comprehensive reviews on the SEQ Flood Event are currently being prepared by Queensland Fire and Emergency Services (QFES) and the Inspector-General Emergency Management (IGEM). However, as the reviews are still in progress, information provided in this report is necessarily high level and may be subject to change in the future.
2. Information and data provided in this report is largely based on QFES' response to the SEQ Flood Event.

Mudgeeraba, March 2022. Image: QFES

Newstead, February 2022. Image: QFES

Gympie, February 2022. Image: QFES

Dayboro, February 2022. Image: QFES

Flooding

New South Wales, 22 February - early April 2022

From late February to early April, New South Wales experienced catastrophic flooding. River systems from the Queensland border to the south coast as well as inland areas flooded. In some areas, flooding was to a scale that had never been seen before. The Wilsons River at Lismore reached a height of 14.4 m, which is 2 m above previous records.

The flooding was large scale and difficult to predict. For example, two days before the Wilsons River reached 14.4 m, the Bureau of Meteorology had forecast minor to moderate flooding.

In over 50 days of flood operations, New South Wales State Emergency Service (NSW SES) responded to 33,421 requests for assistance, including more than 2,200 flood rescue activations. Tragically, 13 lives were lost and 4,055 properties were deemed uninhabitable as a result of flooding. Over 5,600 members of the NSW SES responded to the event, supported by interagency, interstate and Australian Defence Force resources.

In March, the New South Wales Government commissioned an independent expert inquiry into the preparation for, causes of, response to and recovery from the catastrophic flood event across the state.

Situation/Weather Systems

Leading into 2022, many catchments in New South Wales were full and soils were saturated. This was due to a La Niña event in March 2021 that led to widespread flooding. The Bureau of Meteorology declared a second La Niña Event for Australia in September. Commencing in November, NSW SES responded to 109 consecutive days of flooding in large parts of western New South Wales resulting from rain in northwest New South Wales and inland Queensland.

From 22 February, a low-pressure system across northern NSW and southern Queensland produced heavy to torrential rainfall over the NSW coastline. This was followed by two more weeks of persistent coastal rainfall, including the development of two East Coast Lows (ECL), leading to flash and riverine flooding in numerous locations.

The heavy rainfall began in southeast Queensland and northeast New South Wales during the last week of February and continued further south into eastern New South Wales in March. Multi-day rainfall records were broken across south east Queensland and north east New South Wales, with multiple sites recording over 1 m (1,000 mm) of rainfall (Figure 21). For the last week of February, rainfall across parts of the region was at least 2.5 times the February average, with some parts experiencing more than 5 times the average. For north east New South Wales this was the wettest week since 1900. More than 50 locations in south east Queensland and north east New South Wales recorded more than 1 m of rain in the week ending 1 March.

In the first week of March, the rainfall system shifted south along the New South Wales coast, bringing further heavy rainfall to eastern parts of the state. The Hawkesbury-Nepean catchment recorded its wettest 9-day period on record to 9 March (Figure 22).

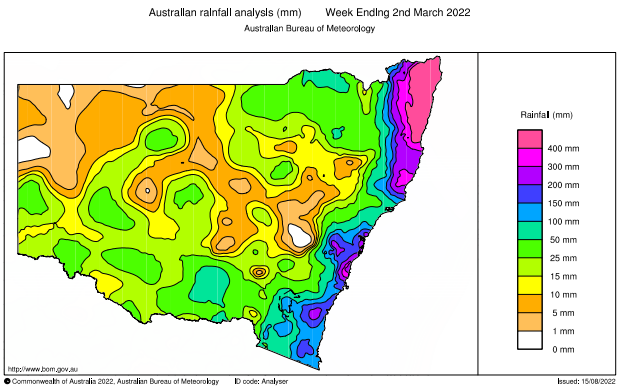


Figure 21: Map of 7-day rainfall totals for NSW for the week ending 2 March 2022 (Bureau of Meteorology).

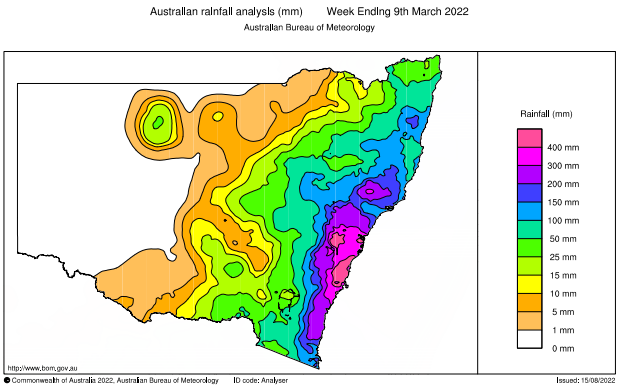


Figure 22: Map of 7-day rainfall totals for NSW for the week ending 9 March 2022 (Bureau of Meteorology).

Flooding

The intense and sustained rainfall across the region led to flash flooding and riverine flooding extending from Maryborough in Queensland to Grafton in New South Wales. Many of these communities also experienced flooding in 2021. With multiple weather systems impacting the state, some communities experienced two floods between February and April.

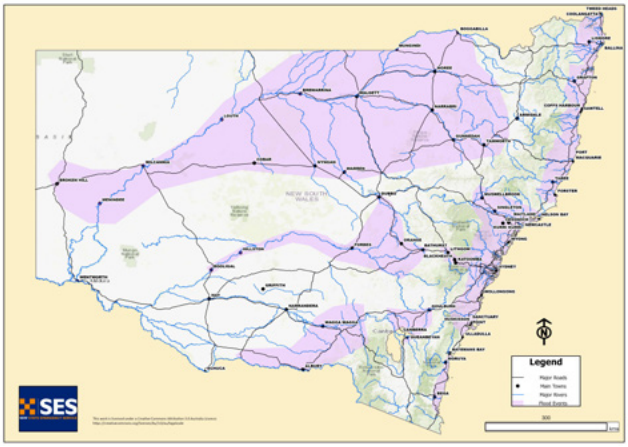


Figure 23: Map of flood affected areas in New South Wales.

Multiple communities in the Northern Rivers area experienced unprecedented flooding, with records broken by considerable margins. Devastating flooding occurred in Lismore, which experienced two floods in the space of a few weeks. The levee at Lismore overtopped both times, inundating the town on each occasion. The township of Woodburn was also inundated. Other towns experiencing significant flooding were Coraki, Murwillumbah and Tumbulgum.

In the Northern Rivers area several rivers reached a peak record height:

- Wilsons River in Lismore peaked at a height over 14.4 m, which is 2.12 m above the previous record set in 1890.
- Tweed River in Murwillumbah peaked at 6.51 m, which is 0.31 m higher than the previous record set in 2017.
- Tweed River in Tumbulgum peaked at 4.77 m, which is 0.86 m higher than the previous record set in 2017.
- Richmond River in Casino peaked at 16.49 m, which is 0.28 m higher than the previous record set in 2008.
- Richmond River in Coraki peaked at 7.65 m, which is 0.64 m higher than previous record set in 1974.
- Richmond River in the Bungawalyn Junction peaked at 7.23 m, which is 1.48 m higher than the previous record set in 1974.
- Richmond River in Woodburn peaked at 7.17 m which is almost 1.8 m higher than the previous record set in 1954.
- Brunswick River in Mullumbimby peaked at 4.98 m which is 0.30 m higher than the previous record set in 1987.

At the outset of this weather system the Warragamba Dam, Sydney's main water storage, was already at 98%. The heavy rain and spilling from the dam resulted in moderate to major flooding along the Hawkesbury-Nepean river system. With the ongoing rain over a number of weeks some areas experienced two peaks during the one flood. The 2022 flood levels on this river system exceeded those of March 2021 and were comparable to those of 1978. The Nepean River at Menangle Bridge peaked at 15.92 m, more than 3 m higher than March 2021. The Hawkesbury River at Windsor peaked at 13.8 m, nearly 1 m above the March 2021 level; while at Portland it peaked at 8.64 m, almost 1 m above the 2021, 1978 and 1964 flood levels.

During the same period, moderate to major flooding also occurred in the central and north coast areas of the state, including the Manning, Macleay, and Hunter rivers. Major flooding on the Hunter River at Singleton peaked at 13.15 m, exceeding March 2021 flood levels by nearly 1 m.

Response activities and resources

With the scale of the weather events and associated flooding, multiple areas of operations and Incident Management Teams (IMTs) were established to coordinate response activities. The State Command Centre was also activated to facilitate resourcing, planning, intelligence, and public information in support of the IMTs. The State Emergency Operations Centre and various other emergency operations centres were also operating.

Image: NSW SES

Over 50 days of flood operations, the NSW SES responded to 33,421 requests for assistance, including over 2,200 flood rescue activations. More than 72,000 calls were received at the State Operations Centre. More than 5,600 members of the NSW SES (staff and volunteers) responded to the event. This equates to over 489,000 personnel hours.

Communication with the public was a critical element of the NSW SES role during the floods. NSW SES issued over 500 evacuation related products and over 1,500 flood bulletins. The NSW SES webpage was visited 3.75 million times and the NSW SES Facebook page reached over four million people.

NSW SES was supported in response efforts by personnel from NSW Rural Fire Service, Fire and Rescue NSW, NSW Ambulance, NSW Volunteer Rescue Association, NSW Police Force, National Parks and Wildlife Service, Marine Rescue NSW, Surf Life Saving NSW, Service NSW, and Resilience NSW.

Over 785 personnel were sourced through the AFAC National Resource Sharing Centre to assist with flood operations in NSW. Assistance was provided from every state and territory. The Australian Defence Force supported response activities at a local level through Defence Assistance to the Civilian Community Level 1 (DACC1); and with wider support through DACC 2 requests. Support included aviation assets, high clearance vehicles and personnel.

Impacts on communities

The flooding significantly impacted multiple local government areas along the east coast of NSW, including Ballina, Kyogle, Bellingen, Lismore, Byron, Richmond Valley, Clarence Valley, Tweed, Singleton, Central Coast, Upper Hunter, Maitland, Port Stephens, Northern Beaches, Sutherland, Liverpool, Penrith, Fairfield, Hawkesbury, Canterbury Bankstown, Georges River, Bayside, Hornsby, Camden, Blacktown, The Hills, Wollondilly, Wollongong, and Shellharbour. Multiple communities in the Northern Rivers area experienced unprecedented flooding, with Lismore being one of the most heavily impacted communities. The township of Woodburn was also inundated.

During the Lismore flooding on 28 February, there were 2,823 properties impacted by flood waters. This resulted in 1,900 requests for assistance to NSW SES, including 862 flood rescue activations. Many flood rescues were carried out by the "Tinny Army" – the local community providing assistance to fellow residents.

All flooded communities experienced power and telecommunication outages, some lasting several days. Significant damage was caused to roads and other infrastructure in flooded communities across the state. For many residents and local governments, repairs for the damage that occurred as a result of the 2021 floods had only recently been completed. The second round of flooding in late March impacted many residents who had just completed the clean up from the flooding earlier in the month.

The 2022 flooding event tragically claimed the lives of 13 people. This included one person on the Central Coast, six people in the Northern Rivers area, four people in the Sydney area, one person in Broken Hill and one person near Grafton.

21,170 properties were impacted by the flooding. Of these, 8,108 were inundated, 10,849 damaged and 4,055 assessed as uninhabitable.

Relief and Recovery

Natural Disaster Declarations were made by the New South Wales Government for 62 local government areas impacted by flooding. This provided affected communities and individuals with a range of special assistance measures including access to financial assistance.

The Australian Defence Force provided a range of support services to the response and relief effort, assisting with damage assessments, helping householders and property owners to commence the recovery effort by cleaning out homes and businesses and moving debris in many locations.

Recovery centres were established in numerous communities. These centres provide residents with face-to-face access to a range of government services, support, and advice to assist with recovery from the flooding.

In early March 2022, the New South Wales Government appointed New South Wales Police Deputy Commissioner Mal Lanyon as Northern New South Wales Recovery Coordinator to coordinate the large-scale multi-agency clean up and recovery processes required to assist the many communities impacted by the unprecedented flooding in the Northern Rivers area.

On 1 June the Insurance Council of Australia (ICA) estimated that the catastrophic flooding that devastated southeast Queensland and northern NSW was the fourth most expensive disaster in Australia's history, with a total cost of $4.3 billion. However, the ICA estimated that the actual damage bill was likely to be significantly higher, with many residents not insured due to the cost of flood cover.

Lismore City Council, in its own report of the floods, estimated more than $350 million worth of damage to council assets, with a repair bill for roads and bridges alone of $200 million. The report indicated that the cost of rebuilding the broader community would be close to $1 billion.

Observations

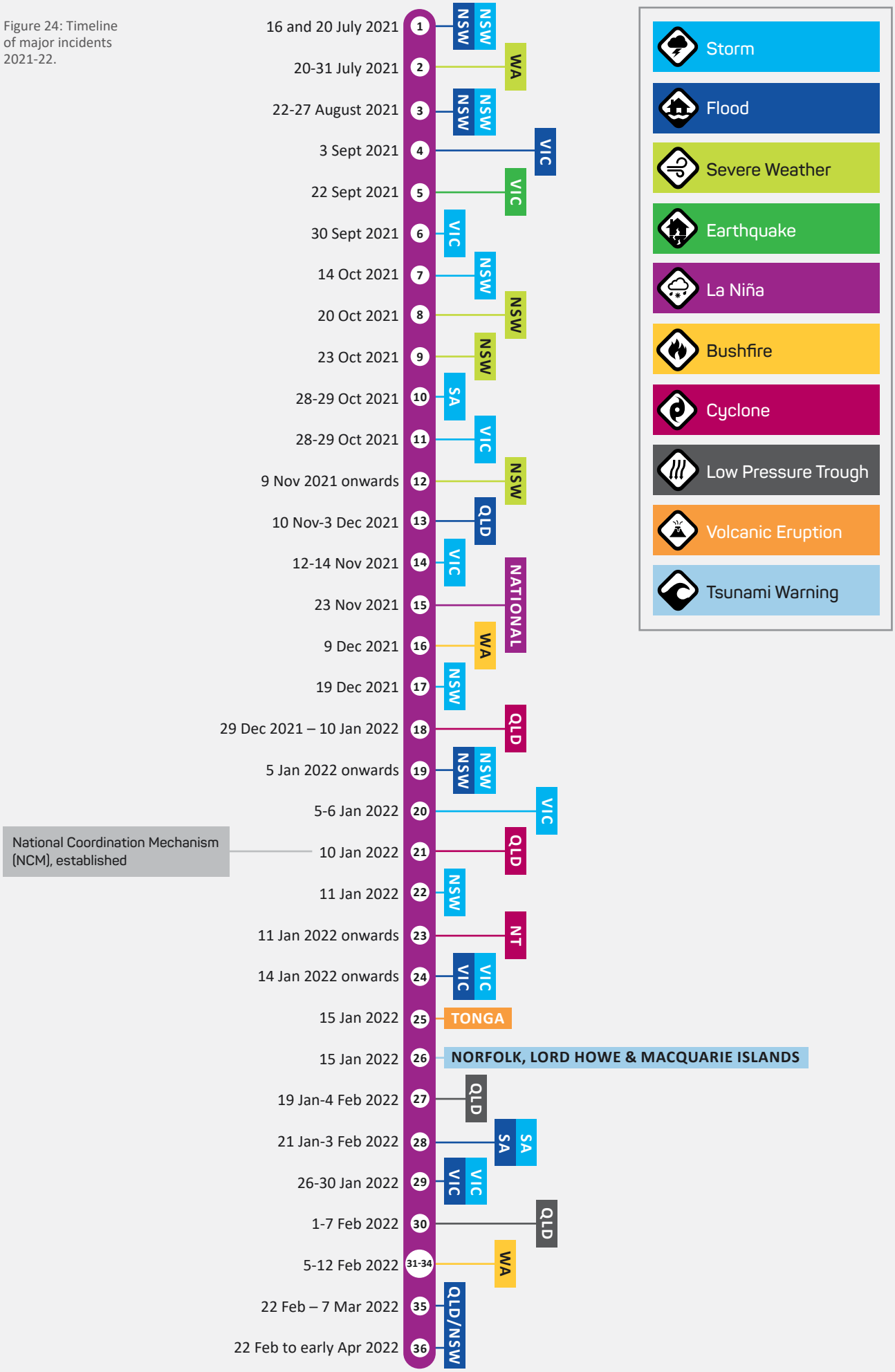
NSW SES has recorded a number of initial observations following these flood events:

- Partnering with other agencies and organisations is essential to joint preparedness and interoperability.
- As the complexity and frequency of severe weather events grow, the NSW SES preparedness and response capacity will also need to grow, as will the support to NSW SES volunteers.
- For NSW SES to prepare for the future, it is essential that the service has fit-for-purpose equipment and modern technology, and that partners' assets, such as gauges, are also maintained.

Further learnings will be identified through the extensive after action review program being completed and the independent inquiry into the floods commissioned by the New South Wales Government.

Image: NSW SES

Figure 24: Timeline of major incidents 2021-22.



Appendix

Shortlist of major incidents for consideration

Incidents and data included in this list are drawn from the Australian Government Disaster Assist portal and the Insurance Council of Australia (ICA), with supporting information from the Bureau of Meteorology and reputable news media sources.

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
1	16 and 20 July 2021	Storms and floods	New South Wales	Glen Innes, Severn, Inverell	New South Wales experienced strong north-westerly winds during the passage of a low-pressure trough, with some sites recording the strongest wind gusts in July for more than 10 years on 16 July. Strong and gusty winds affected the southern half of the state on 20 July. A Natural Disaster Declaration was issued by the New South Wales Government for this event.
2	20–31 July 2021	Severe weather	Western Australia	Augusta-Margaret River, Boddington, Busselton, Corrigin, Donnybrook-Balingup, Dumbleyung, Katanning, Narrogin, Pingelly, Serpentine-Jarrahdale, Wagin, Wandering, West Arthur	Strong winds and heavy rain occurred through July in Western Australia. A dozen cold fronts resulted in multiple severe weather events of damaging winds, heavy rainfall and flash flooding in Perth and the southwest of the state. Damaging winds with gusts in excess of 90 km/h were recorded in 13 of 31 days in the coastal locations of the southwest or in the Perth Hills. Cape Leeuwen recorded a destructive gust of 134 km/h on 27 July which was the highest since 2013. Heavy rainfall and strong winds caused flash flooding, damage to houses and properties across Perth and further south. There were close to 800 call outs to DFES for assistance in July.
3	22–27 Aug 2021	Storms and floods	New South Wales	Oberon	An east coast low caused rain, gales and cold temperatures on 24 August. Oberon in the Central Tablelands received 51 mm of rain in 24 hours. A storm lashed central western New South Wales overnight on 23 August, causing a house to lose its roof and a car was crushed by a downed tree in Orange. Flooding occurred in various inland New South Wales rivers from 23 August. Moderate flood warnings were issued for the Macquarie River at Bathurst and Belubula River at Canowindra. Renewed flood peaks developed downstream in the Lachlan River after flooding earlier in the month. A low-pressure system deepened along the New South Wales central coast on 24 August, producing hazardous surf and generating large waves and a storm surge seen only once every couple of decades. Widespread snowfalls were reported on 24 August across parts of New South Wales, including at Guyra, Cooma, and in the Blue Mountains and Central Tablelands. Snow settled in the Blue Mountains overnight on 25 August, with 7 cm recorded at Blackheath. Heavy falls were reported in higher parts of the Central Tablelands including 25-30 cm in the Jenolan area. Settled snow was also reported at Crookwell.

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
4	3 Sept 2021	Floods	Victoria	East Gippsland, Mansfield, South Gippsland	The Dandenong Ranges and East Gippsland were among the areas most impacted from rain and damaging winds. Flood warnings were issued and residents were reminded to be aware of potential hazards including falling trees and rising waters.
5	22 Sept 2021	Earthquake	Victoria	Rawson	The 5.9 magnitude earthquake could be felt across Victoria, New South Wales, South Australia and Tasmania. The epicentre was determined to have occurred at Woods Point, east of Melbourne. *More detail is provided in the body of this Major Incidents Report.*
6	30 Sept 2021	Storms	Victoria	Baw, Colac, Otway, South Gippsland	Flash flooding occurred in Victoria as rain lashed the state from a one in 20 year rainfall event in the Otways, West Gippsland and the Wimmera. 117 mm fell near Lorne on the Victorian southwest coast. The Bureau of Meteorology issued a severe weather warning for the event. Many towns in the affected LGAs received 20-40 mm of rain, causing flash flooding in some locations.
7	14 Oct 2021	Storm	New South Wales	Armidale	There were winds over 90 km/h and heavy rainfall experienced in the wild weather. Cars flipped, roofs were ripped off, power lines and trees fell, leaving thousands without power. A tornado was observed at Armidale, with reports of damage to buildings and cars. Large hail, up to 5 cm in diameter, was reported at multiple locations including Tenterfield, Lalor Park, Ropes Crossing and the Blue Mountains. NSW SES received more than 200 requests for assistance. The tornado was the second to hit the region over the past few weeks, the other was at Bathurst in September. Tornadoes are usually associated with supercell thunderstorms.
8	20 Oct 2021	Severe weather	New South Wales	Northeast NSW: Coffs Harbour	At around 2.00pm a severe thunderstorm moved through Coffs Harbour and Sawtell (described as a supercell) resulting in extensive damage to homes and the roof of the Toormina shopping centre and a local nursing home were extensively damaged. The storm left hail up to 30 cm deep on the ground. The incident required a large scale multi agency response. Over 1000 requests for assistance were received for the event which required operational effort for several days.
9	23 Oct 2021	Severe weather	New South Wales	Wollondilly	Severe thunderstorms (described as super cells) developed across NSW. One of the supercells developed southwest of Appin and Picton region. Some very severe microbursts were experienced with hail falling. There were wind gusts in excess of 120 km/h. The supercell lasted for about 15 minutes and was accompanied by large hailstones. A number of homes, motor vehicles and businesses were damaged by the wind and hail.
10	28–29 Oct 2021	Storms	South Australia	Statewide: Adelaide Hills, Adelaide Plains, Barossa, Barunga West, Berri Barmera, Clare And Gilbert Valleys, Cleve, Coorong, Elliston, Gawler, Karoonda East Murray, Light, Loxton Waikerie, Mid Murray, Mount Barker, Murray Bridge, Playford, Port Pirie, Renmark Paringa, Salisbury, Tea Tree Gully, Tumby Bay, Wakefield, Yorke Peninsula	Damaging wind gusts were recorded in southern South Australia on 28 October. The highest wind gust was 107 km/h at Mount Crawford. *More detail is provided in the body of this Major Incidents Report.*

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
11	28–29 Oct 2021	Storms	Victoria	Ararat Rural, Ballarat, Banyule, Bass Coast, Baw, Bayside, Boroondara, Brimbank, Cardinia, Casey, Colac Otway, East Gippsland, Frankston Glen Eira, Golden Plains, Greater Dandenong, Greater Geelong, Hepburn, Hobsons Bay, Kingston, Knox, Latrobe, Macedon Ranges, Manningham, Maroondah, Monash, Moonee Valley, Moorabool, Mornington Peninsula, Nillumbik, Northern Grampians, Port Phillip, Pyrenees, Queenscliff Borough, South Gippsland, Surf Coast, Wellington, Whittlesea, Yarra Ranges	Damaging winds affected Victoria due to a low-pressure system and the associated cold front. The strongest wind gust of 146 km/h was recorded at the Wilsons Promontory lighthouse on the 29 October. VIC SES received more than 2000 calls for assistance, mostly for fallen trees and building damage. Parts of Victoria were left without power.
12	9 Nov 2021–onwards	Severe weather	New South Wales	Bathurst, Bega Valley, Blayney, Blue Mountains, Bourke, Brewarrina, Broken Hill, Cabonne, Cobar, Coonamble, Cowra, Dubbo, Eurobodalla, Forbes, Gilgandra, Glen Innes Severn, Goulburn-Mulwaree, Gunnedah, Gwydir, Kyogle, Lachlan, Lithgow, Liverpool Plains, Lockhart, Mid-Western, Moree Plains, Muswellbrook, Narrabri, Narromine, Oberon, Orange, Parkes, Port Macquarie-Hastings, Queanbeyan-Palerang, Richmond Valley, Shoalhaven, Singleton, Snowy Monaro, Snowy Valleys, Tamworth, Tenterfield, Upper Hunter, Walcha, Walgett, Warren, Warrumbungle, Weddin, Wentworth	**Note: Incidents 12 and 13 are concurrent.** Troughs crossing New South Wales brought heavy rain on several occasions in November. This caused flooding on several inland rivers and many water storages were at full capacity. Daily totals of 25 to 50 mm were recorded across the Central and Southern Tablelands in the 24 hours to 9.00 am on 12 November, with totals up to 70 mm around Orange and Bathurst. This resulted in moderate to major flooding along the Lower Lachlan River, particularly affecting Forbes. On the 12 November, a complex inland low passed over the coast and intensified, bringing widespread rainfall totals of 20 to 40 mm to Greater Sydney. 40-70 mm of rain fell across the Northern Tablelands in the 24 hours to 9.00am on 21 November, with the highest totals reported around Inverell. Totals of more than 50 mm in the 24 hours to 9.00am on 22 November were recorded further south around Gunnedah and Coonabarabran, and up to 100 mm in the Dividing Range, resulting in major flooding along the Namoi River at Gunnedah. Most inland areas west of the Dividing Range had daily totals of over 25 mm in the 24 hours to 9.00am on 25 and 26 November. Over 100 mm was recorded across the Upper Hunter, west of Scone, in the 24 hours to 9.00am on 26 November, with major flood levels forecast for the Hunter River at Singleton. The highest daily total for November was 150 mm on 26 November at Blackville (Krui Vale) in the Upper Hunter, the highest daily November total in 137 years of site data. The November rain follows above average rainfall already in 2021, including that during the March 2021 floods. This had saturated soils and filled catchments across the state, increasing the risk of further flash flooding and riverine flooding. A significant amount of the monthly rainfall as well as the coolest temperatures were associated with coastal lows and low-pressure troughs encountered on the 5, 11, 12, 21, 22, 26 and 27 November. NSW SES responded to over 4,800 requests for assistance since the beginning of the November weather event and attended to 153 Flood Rescues.

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
					NSW SES personnel were deployed across the state to assist in areas of concern with the help of interagency support. As at 1 December 2021 there were almost 400 SES members in the field assisting the community with storm and water damage, flood rescues, resupplies and some completing rapid damage assessments. The Australian Government and New South Wales Government announced extended Disaster Assistance following the severe weather and flooding in the state.
13	10 Nov –3 Dec 2021	Heavy Rainfall and Flooding	Queensland	Banana, Barcaldine, Barcoo, Blackall-Tambo, Boulia, Central Highlands, Diamantina, Goondiwindi, Lockyer Valley, Longreach, Maranoa, Murweh, Scenic Rim, South Burnett, Southern Downs. Toowoomba, Western Downs	The wet November was the result of multiple rain events during the month which affected large parts of Australia. November 2021 was Australia's wettest November since national records began in 1900. With soil moisture and water storage levels already high, the heavy November rains contributed to substantial flooding, especially in inland New South Wales and southern Queensland. River systems which experienced major flooding included the Lachlan, Namoi, Macquarie, Barwon, Macintyre-Weir and Condamine-Balonne. In Queensland, the most extreme flooding occurred in the Macintyre-Weir catchment. The Macintyre Brook at Inglewood had its second-highest flood on record, with a peak of 11.2 m on 1 December ranking only behind 11.7 m in February 1976. There was also major flooding at Goondiwindi and various other locations downstream. The Condamine-Balonne system also reached major flood levels at a number of locations. In response to the damage sustained by residential and businesses the Queensland State and Commonwealth Governments provided a range of assistance through the Disaster Recovery Funding Arrangements.
14	12–14 Nov 2021	Storms	Victoria	Baw, East Gippsland, Macedon Ranges, Wellington	A low-pressure system brought heavy rain across Melbourne on the 13 November and resulted in flooding in Melbourne's south-west that left drivers stranded along Kororoit Creek Road in Williamstown North. Snow on the Victorian Alps was recorded on the 14 November following the passage of a strong cold front. Strong and gusty winds were observed both ahead of and behind the cold front that crossed Victoria on 14 November. VIC SES responded to more than 300 calls, mostly for fallen trees, and hundreds of homes were left without power. The strongest wind gust in the state for November, 130 km/ h, was recorded at the Wilsons Promontory lighthouse on 14 and 15 November.
15	23 Nov 2021	La Niña declared	National		A La Niña was declared by the Bureau of Meteorology and its influence on Australia's weather pattern is discussed at length in the main report. November 2021 was Australia's wettest November on record and the coolest since 1999. Nationally, rainfall for the month was well over double the amount of rainfall typical for a November. Multiple rain events throughout the November affected large parts of Australia. The heavy rains contributed to substantial flooding especially in inland New South Wales and southern Queensland, along with the Lachlan, Namoi, Macquarie, Barwon, Macintyre-Weir and Condamine-Balonne rivers. The extremely wet conditions were associated with a developing La Niña in the Pacific Ocean. *More detail is provided in the body of this Major Incidents Report.*

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
16	9 Dec 2021	Bushfire	Western Australia	Margaret River -Boranup	Mean maximum temperatures for December were warmer or very much warmer than average for Western Australia. These antecedent weather conditions provided the setting for severe fire conditions. The fire behaviour at Boranup was intense and spread rapidly. The fire scarred more than 8,000 ha of land- there were no houses lost and no loss of life. There were concerns of the environmental impacts from the fire given the unique landscape, part of which makes the area such a drawcard for tourists. Fire crews were wary about bringing in heavy machinery due to the cave system throughout the area. There were up to 150 firefighters on the fire line in the early stage of the fire. Major tourist routes were closed to keep the community safe and reopened after safety inspections concluded. One of the priorities adopted by fire crews was to protect campgrounds and tourism attractions. Schools in the area were closed because of the fire, evacuation centres were established, and road closures were put in place.
17	19 Dec 2021	Severe storm	New South Wales	Northern Beaches	Wind damaged houses and uprooted trees in a number of towns including Lithgow. In Sydney's Northern Beaches a severe thunderstorm with strong winds damaged houses and brought down trees. One woman died and three people were injured when a tree fell in a carpark from the storm. A 100 km/h gust was recorded at Mount Boyce. NSW SES received almost 600 requests for assistance due the damage caused by the storm.
18	29 Dec 2021–10 Jan 2022	Ex-Tropical Cyclone Seth	Queensland	Bundaberg, Carpentaria, Cherbourg, Gold Coast, Gympie, Fraser Coast, Kowanyama, North Burnett, South Burnett	Tropical cyclone Seth was a Category 1 system that formed in the Coral Sea east-north-east of Mackay in Queensland's Central Coast. It remained offshore but generated dangerous surf and contributed to abnormally high tides along the coast of Queensland and New South Wales. In Queensland, extremely heavy rain fell around Gympie in the Wide Bay and Burnett region on the 7 January following landfall of ex-tropical cyclone Seth, with more than 400 mm recorded in Bureau gauges in the hills to the north-west of Gympie. At a number of sites in the region, totals for the 24 hours to 9.00am on 8 January set daily rainfall records for January, and in some cases for any month of the year, although mostly at sites with less than 30 years of observations. Major flood warnings were issued for the Mary River, moderate flood levels were reported on the Burnett River, and flooding affected parts of the Bundaberg CBD and parts of Bundaberg South. Ex-tropical cyclone Seth also contributed to significant rainfall over parts of southeast Australia as a low-pressure trough and cold front crossed Tasmania. Most notable were 50-100 mm two-day totals for 7-8 January over inland New South Wales. A number of sites in south-eastern New South Wales, north-eastern Victoria and East Gippsland, and eastern Tasmania observed daily rainfall records for January, mostly for the 24 hours to 9.00am on the 7 January.
19	5 Jan 2022 onwards	Storm and Floods	New South Wales	Southern New South Wales: Albury, Bland, Goulburn Mulwaree, Greater Hume, Griffith, Hilltops, Narrandera, Temora	The flash flooding left roads damaged from the scouring effects of the rain leaving behind a large trail of debris. The weather station in Albury revealed that at peak intensity 9 mm of rain fell in 10 minutes.

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
20	5–6 Jan 2022	Storms	Victoria	Central West Victoria: Ballarat, East Gippsland, Glenelg, Hepburn, Moorabool	Severe thunderstorms on 5-6 January brought large hail and heavy rain to parts of Victoria around Ballarat, damaging potato and other crops. The SES received in excess of 180 calls for assistance in Ballarat from the damage and flash flooding from the severe thunderstorms. Campers and holidaymakers were urged to be cautious and take care during these storms.
21	10–11 Jan 2022	Tropical Cyclone Tiffany	Queensland	Aurkun, Cook, Douglas, Hope Vale	Tropical cyclone Tiffany was a Category 2 system that crossed the coast near Cape Melville on the Cape York Peninsula, with cyclone warnings extending across much of the peninsula as it tracked from east to west. Tiffany made a later landfall on the eastern side of the Gulf of Carpentaria as a Category 1 system before weakening below cyclone strength over land near the base of the Top End.
22	11 Jan 2022	Severe storm	New South Wales	Lithgow	Storms in Lithgow triggered flash flooding, swamping homes and business. Almost a month's worth of rain fell in 1 hour (72 mm). The NSW SES responded to more than 50 calls for assistance.
23	11 Jan 2022 onwards	Tropical Cyclone Tiffany	Northern Territory	East Arnhem, Katherine, Roper Gulf, Victoria-Daly, West Daly	Tropical cyclone Tiffany was a category 2 system that crossed the coast near Cape Melville on Cape York Peninsula, with cyclone warnings extending across much of the Cape York Peninsula as it tracked from east to west. Tiffany made a later landfall on the eastern side of the Gulf of Carpentaria as a Category 1 system before weakening below cyclone strength over land near the base of the Top End.
24	14 Jan 2022 onwards	Floods and storms	Victoria	Northeast Victoria: Towong, Wodonga	Air-conditioners were blown clear off roofs, swimming pools turned black and felled trees across Albury Wodonga leading to a significant clean-up effort. One resident had a tree fall on their roof. Over 69 mm of rain fell at Albury Airport in a short burst between 11.30pm and 12.30am on 14-15 January.
25	15 Jan 2022	Hunga Tonga-Hunga Ha'apai Volcanic Eruption and Tsunami (Australian response)		Tonga	The volcanic eruption of the Hunga Tonga-Hunga Ha'apai is covered in the body of this report.
26	15 Jan 2022	Tsunami warning		Norfolk, Lord Howe and Macquarie Islands	A detailed analysis of the tsunami warnings generated following the Hunga Tonga-Hunga Ha'apai Volcanic Eruption is covered in the body of this report.
27	19 Jan – 4 Feb 2022	Low Pressure Trough	Queensland	Western Queensland: Barcoo, Boulia, Bulloo, Burke, Cloncurry, Diamantina, Flinders, Longreach, McKinlay, Mount Isa, Paroo, Quilpie, Winton	The monsoon trough extended eastwards across northwest Queensland on 25 January, with heavy rainfall across the Townsville region on 26 and 27 January resulting in flash flooding, with dozens of calls to the SES for assistance. Townsville Aero had a 2-day rainfall total of 257 mm on 27 January, the highest 2-day total since 4 February 2019. Disaster relief payments were announced for householders, business and local government.
28	21 Jan – 3 Feb 2022	Severe weather and flooding	South Australia		From mid-January, the remnants of ex-Tropical Cyclone Tiffany brought heavy rain to central Australia as it moved south, forming a complex low-pressure system. Widespread moderate to heavy rainfall caused ponding and overland flow, together with rises in local creeks, impacting local transport networks and necessitating lengthy detours on some transport routes. *More detail is provided in the body of this Major Incidents Report.*

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
29	26–30 Jan 2022	Floods and storms	Victoria	Indigo, Macedon, Mildura, Mt Alexander, Towong, Wellington, Wodonga, Wangaratta	During the period of 26-30 January, a slow-moving weather system was responsible for a sustained and consistent outbreak of afternoon storms and showers across Victoria. This caused property damage which is typical of these events. The more significant thunderstorms impacted Mildura, Horsham, Swan Hill and an area across northeast Victoria into southern New South Wales. The storms cells brought heavy rain with parts of Victoria recording more than 50 mm of rain in the space of one hour. The thunderstorms and rain lashed parts of the state for several days. The weather pattern was most severe in western and central Victoria where wind gusts reached 139 km/h in Horsham. Mildura recorded its wettest January day in history (80.2 mm). Lightning sparked hundreds of small fires across the state.
30	1–7 Feb 2022	Low Pressure Trough	Queensland	Far North Queensland: Carpentaria, Croydon, Etheridge, Mareeba	There was a deluge across Far North Queensland that caused a lot of damage to households, businesses and community infrastructure (roads and bridges). A number of communities were isolated by the floods including Burketown, Dimbulah and Mutchilba, with some community members being airlifted to safety.
31	4–10 Feb 2022	Bushfire	Western Australia	Shire of Denmark	There were four separate fires that required an interstate and Australian Government response. *More detail on events 31-34 is provided in the body of this Major Incidents Report.*
32	5–12 Feb 2022	Bushfire	Western Australia	Shire of Bridgetown-Greenbushes	There were four separate fires that required an interstate and Australian Government response. *More detail on events 31-34 is provided in the body of this Major Incidents Report.*
33	6–10 Feb 2022	Bushfire	Western Australia	Shires of Bruce Rock, Quairading, Corrigin	There were four separate fires that required an interstate and Australian Government response. *More detail on events 31-34 is provided in the body of this Major Incidents Report.*
34	6–10 Feb 2022	Bushfire	Western Australia	Shire of Narrogin	There were four separate fires that required an interstate and Australian Government response. *More detail on events 31-34 is provided in the body of this Major Incidents Report.*
35	22 Feb –7 Mar 2022	Rainfall and flooding	Queensland	Southeast Queensland: Balonne, Brisbane, Bundaberg, Cherbourg, Fraser Coast, Gladstone, Gold Coast, Goondiwindi, Gympie, Ipswich, Lockyer Valley, Logan, Moreton Bay, Noosa, North Burnett, Redland, Scenic Rim, Somerset, South Burnett, Southern Downs, Sunshine Coast, Toowoomba, Western Downs	There was exceptional rainfall and flooding over southeast Queensland. *More detail is provided in the body of this Major Incidents Report.* *Note: Incidents 35 and 36 are influenced by the same weather event.*

	Date	Incident	Where (State)	Where (LGA/Region)	Summary of Incident
36	22 Feb–early Apr 2022	Flooding	New South Wales	Armidale, Ballina, Bayside, Bega Valley, Bellingen, Blacktown, Blue Mountains, Byron, Camden, Campbelltown, Canterbury, Central Coast, Cessnock, Clarence Valley, Coffs Harbour, Cumberland, Dungog, Eurobodalla, Fairfield, Georges River, Glen Innes Severn, Goulburn Mulwaree, Hawkesbury, Hornsby, Inner West, Kempsey, Kiama, Ku-ring-gai, Kyogle, Lismore, Lithgow, Liverpool, Maitland, Mid-Coast, Mid-Western, Muswellbrook, Nambucca, Newcastle, Northern Beaches, Parramatta, Penrith, Port Macquarie-Hastings, Port Stephens, Queanbeyan-Palerang, Richmond Valley, Ryde, Shellharbour, Shoalhaven, Singleton, Snowy Monaro, Sutherland, Tenterfield, The Hills, Tweed, Upper Hunter, Wingecarribee, Wollondilly	There was catastrophic flooding across the Northern Rivers and Mid North Coast. *More detail is provided in the body of this Major Incidents Report.* *Note: Incidents 35 and 36 are influenced by the same weather event.*

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