Australian Government

### Bureau of Meteorology submission to the 2022 New South Wales Independent Flood Inquiry



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#### **Executive summary**

Following two years of well above average rainfall and intermittent flooding, an exceptional weather event in late February and early March 2022 delivered extreme multi-day rainfall and flooding to eastern New South Wales. Multi-day rainfall records were broken across north-east New South Wales, with multiple sites recording more than one metre of rainfall. For central parts of the NSW coast, this rainfall was comparable to that of February 2020 - the last time that central-eastern New South Wales averaged greater than 220 mm over a 7-day period.

The heavy rainfall was the result of a persistent coastal trough that was cradled by a blocking high pressure system in the southern Tasman Sea. These systems combined to direct a flow of very warm, moist tropical air from the Coral and Tasman seas onto the eastern seaboard, where it was lifted further as it met the Great Dividing Range, enhancing condensation and rainfall.

The extreme rainfall led to major riverine flooding and extensive flash flooding in the catchments of north-east and central-east New South Wales. Major flood levels were reached in rivers across the region, including the Wilsons River at Lismore, the Richmond River at Coraki and Woodburn on Monday 28 February, and along the Hawkesbury-Nepean River at Menangle, Wallacia, North Richmond, Windsor, Sackville, Upper Colo, Wiseman's Ferry and Lower Portland on 8 and 9 March. The Wilsons River at Lismore peaked at a record height of 14.4 metres at around 2 pm on Monday 28 February. This peak was more than two metres above the previous record of 12.1 metres observed in both 1954 and 1974.

During this period, widespread major riverine flooding also occurred in the Tweed, Brunswick, Clarence, Lower Hunter, Paterson-Williams and Wollombi Creek catchments.

In the months preceding February 2022, the Bureau of Meteorology actively communicated the risk of wetter than normal conditions for New South Wales during the summer of 2021-22. The Bureau first advised of the likelihood of a La Niña event for the summer of 2021-2022 on 14 September 2021 and again on 12 October 2021.

During La Niña there is a heightened risk of heavy rainfall and major flooding in New South Wales. Federal, state and local governments received dedicated briefings and the community was informed via comprehensive traditional and social media engagement.

A La Niña was formally declared by the Bureau on 23 November 2021. In early October 2021, the Bureau publicly released its outlook for the 2021-22 severe weather season. This included the risk of above average flooding for eastern and northern regions of Australia.

In the immediate lead up to and during the floods the Bureau explicitly forecast and communicated to the New South Wales Government and the community the specific risk of very heavy rainfall for eastern New South Wales. Flood watches and warnings were issued two days in advance of major flood levels being reached. The Bureau clearly identified the risk for intense rainfall, life threatening flash flooding and the potential for rapid river rises in its communications with its partners and the community.

The first forecast for potentially heavy rainfall and flooding for north-east New South Wales was issued on Wednesday 23 February. On the morning of Saturday 26 February, the forecast was updated to advise of the potential for life threatening flooding. An updated Severe Weather Warning and Flood Watch was issued, and this was followed on the afternoon of Saturday 26 February with a flood warning for moderate to major flooding at Lismore for late Sunday 27 February into Monday 28 February. Initial forecasts were made with estimated river heights and included advice that higher flood levels and river heights were possible with further heavy rain. The Bureau continued to update its forecasts and warnings for the Northern Rivers as new information came to hand during a rapidly evolving and dynamic weather event.

The first Severe Weather Warning and Flood Watch for central-east New South Wales was issued on Monday 28 February. Flood warnings were issued late on 1 March and continued to be updated through until 14 March as many rivers responded to rainfall emanating from two East CoastLows (ECL). Rainfall arising from the first ECL brought flooding to the region on 3 and 4 March and the second increased flood levels further between 7 and 9 March.

In support of these updates, the Bureau's briefings to state and federal government customers, partners and stakeholders increased in frequency. The effectiveness of the response was enhanced through specialist Bureau staff being embedded with the New South Wales State Emergency Service in Wollongong and the New South Wales State Emergency Operations Centre at Sydney Olympic Park.

The many hundreds of outlooks, forecasts, watches, warnings, stakeholder and partner briefings, press conferences, radio and television crosses and social media posts that were delivered over a sustained period and over significant geographical areas, were based on the very best available science, technology and engineering capability; capability that benchmarks with that available in the US, UK and the European Union.

The weather along the eastern seaboard of Australia is complex: arguably more complex than most other places in the world. This is due to the influence of both tropical and sub-tropical weather systems, the abundance of moist air over the warm East Australian Current that flows offshore, and the proximity of the Great Dividing Range to the coast, which acts to enhance lifting of air during onshore flow. Most people in New South Wales live on the coast, adjacent to rivers that flood and often flood quickly.

Weather is highly dynamic and can change rapidly over small distances in short time frames. Despite a high overall reliability of meteorological predictions, weather forecasts carry an inherent uncertainty, particularly at local scales. Even small changes in the timing or location of high-intensity rainfall can significantly alter the magnitude of flooding impacts at local scale. The weather doesn't operate during business hours and every severe weather event is different. This is why the Bureau asks that communities closely monitor the Bureau's updates to forecasts and warnings on its website and app.

The Bureau considers that the impacts of the floods were significantly reduced because of the preparedness of emergency management agencies and the level of cooperation, collaboration and coordination across the emergency management "ecosystem". However, there remain opportunities to further reduce impacts on the community when similar circumstances arise in the future.

Like all of those involved in the response to the floods, whether they be elected leaders, emergency managers, businesses operators or members of the community, we at the Bureau will continue to learn and improve. While the Bureau drew upon the very best available capability to produce its forecasts and warnings during this period, scientific, technological, engineering and communications advances will continue, as they have done for decades.

Our submission highlights several opportunities in this regard. Accordingly, the Bureau looks forward to working with the New South Wales community to bring to bear the benefits that these advances will confer as soon as practicable.

#### Response to the Terms of Reference of the Inquiry

The Bureau wishes to make the following comments in relation to the published terms of reference.

# **1**. a. the causes of, and factors contributing to, the frequency, intensity, timing and location of floods in New South Wales in the 2022 catastrophic flood event, including consideration of any role of weather, climate change, and human activity;

There were several interconnected factors that contributed to the frequency, intensity, timing and location of the floods in New South Wales.

Successive La Niña events in the Pacific Ocean during the 2020/21 and 2021/22 Australian summers created conditions conducive to flooding over eastern New South Wales in late February and early March 2022. La Niña increases the chance of above-average rainfall for northern and eastern Australia during spring, summer and autumn.

Both 2020 and 2021 were unusually wet years for New South Wales, with numerous catchments experiencing major flooding. The Hawkesbury-Nepean River had significant floods in February 2020 and again in March 2021, and the Clarence River and many other locations in northern New South Wales experienced major flooding in March 2021. The very much above average rainfall over eastern New South Wales in the two years leading into February 2022 meant that antecedent soil moisture, runoff, water storage and river levels were high, and that river systems were primed for further flooding.

Several climate drivers contributed to the development and maintenance of wetter conditions over 2021 and into summer 2021–2022. These included an active La Niña in the tropical Pacific Ocean, a persistent and strong positive phase of the Southern Annular Mode (SAM), and warm oceans surrounding northern Australia. In 1974 and 2011, similar climate driver combinations, in particular similar or stronger La Niña events, contributed to periods of significant and widespread flooding across the region.

The high intensity rainfall and flooding was caused by the convergence and lifting of warm, moist winds from the Coral and Tasman seas into a persistent low-pressure trough along the New South Wales coast. The rainfall was further enhanced by mountainous terrain near the coast. While this combination of factors is quite common it was very unusual for this synoptic pattern to persist over the same region for such a significant length of time.

The 643 mm rainfall recorded from 22 February to 1 March 2022 was more than 30% higher than the previous area-average 7-day rainfall record (compared with all data since 1900) for north-east New South Wales (known as the Upper North Coast rainfall district); 480 mm of rain, set in March 1974. Between 1 and 9 March the Hawkesbury-Nepean catchment recorded its wettest 8 and 9-day periods on record (since 1900), while the Nepean River catchment upstream of Wallacia Weir recorded its highest rainfall totals on record for durations of 1 to 6 days.

Between 23 February and 9 March 2022, a series of low-pressure centres formed within the coastal trough, which served to focus heavy rainfall over north-east New South Wales initially, then over central parts of the New South Wales coast and adjacent ranges. Heavy rainfall intensified on Sunday 27 February and overnight into Monday 28 February in response to the development of an East Coast Low (ECL) within the coastal trough. The torrential rain resulted in extensive flash flooding along creeks and tributaries of the Northern Rivers catchments, leading to rapid rises in the major river systems. The ECL moved south and brought moderate to major flooding to central New South Wales coast catchments during Wednesday 2 and Thursday 3 March, including the Hunter, Paterson and Upper Nepean rivers, before weakening on Friday 4 March.

A second low-pressure system within the coastal trough developed into an ECL during Monday 7 and Tuesday 8 March. Heavy rain fell on catchments with already elevated water levels, and this resulted

in even higher peaks for the Hawkesbury-Nepean Valley in New South Wales and surrounding catchments. River levels were similar or exceeded the March 2021 flood at Menangle and all forecast locations downstream along the Hawkesbury River.

The high-intensity rainfall seen during this summer is consistent with the trend, observed in recent decades, towards a greater proportion of high-intensity, short-duration rainfall, especially across northern Australia<sup>1</sup>.

The Bureau's Special Climate Statement 76 – extreme rainfall and flooding in south-east Queensland and north-east New South Wales<sup>2</sup> provides a comprehensive summary of the climatic and weather settings for the floods, the historical context of the flooding, further details of rainfall and river heights that were recorded and trends in extreme rainfall in Australia.

#### b. the preparation and planning by agencies, government, other entities and the community for floods in New South Wales, including the accuracy and timing of weather forecasts, current laws, emergency management plans, practices and mitigation strategies, their application and effect;

The Bureau is Australia's national weather, climate, oceans and water agency, providing a wide range of products and services to support preparation and planning by governments, emergency services, industry and the community. The Bureau's products and services include a range of observations, forecasts, warnings, analyses and advice covering Australia's atmosphere, water, ocean and space environments.

The Meteorology Act 1955 outlines the functions of the Bureau including the issuing of warnings of gales, storms and other weather conditions likely to endanger life or property, including weather conditions likely to give rise to floods or bushfires.

The roles and responsibilities of governments in delivering forecasts and warnings to the Australian community are specified in the Intergovernmental Agreement (IGA) on the provision of Bureau of Meteorology Hazard Services to the States and Territories<sup>3</sup>. Under Section 6 of the IGA, the Bureau has responsibility for warnings of riverine flooding (defined as flooding that occurs when the time between the rain and the onset of flooding is 6 hours or more). Warning services for flash flooding (defined as flooding that occurs when the time between rain and the onset of flooding is less than 6 hours) are the responsibility of state and local governments.

The Bureau's flood warning services are provided within the context of the national Total Flood Warning System<sup>4</sup> and the arrangements for flood warning in Australia are documented in the National Arrangements for Flood Forecasting and Warning<sup>5</sup>.

Year round, the Bureau works to engage, inform and educate Australians about the weather and climate, and encourages the community to prepare accordingly. The Bureau's 'Know your weather. Know your risk' public safety campaign informs and educates Australians about the impacts of severe weather, with a focus on tropical cyclones, bushfire weather, heatwaves, floods and severe thunderstorms. The campaign directly encourages members of the community to prepare in accordance with these risks.

The Bureau works very closely with emergency services partners and across all levels of government. The strong relationships built across emergency management through participation on state and national level disaster preparedness and resilience building groups, facilitate strong inter-agency

<sup>&</sup>lt;sup>1</sup> <u>http://www.bom.gov.au/climate/current/statements/scs76.pdf?20220525</u>

<sup>&</sup>lt;sup>2</sup> http://www.bom.gov.au/climate/current/statements/scs76.pdf?20220525

<sup>&</sup>lt;sup>3</sup> <u>https://federation.gov.au/sites/default/files/about/agreements/intergovernmental-agreement-provision-bureau-meteorology\_0.pdf</u>

<sup>&</sup>lt;sup>4</sup> https://knowledge.aidr.org.au/media/9243/aidr\_flood\_warning\_companion\_2022.pdf

understanding and cooperation during preparation and planning activities, as well as during weather and flood events. During 2021 and early 2022, the Bureau directly supported a range of New South Wales agencies and communities to prepare for the severe weather season:

- Bureau climate advice reflected an increasing flood risk for the 2021-2022 summer. Climate Outlooks from as early as September 2021 reflected an increasing likelihood of a La Niña, and increased risk of above average rainfall and flooding over eastern and northern Australia for the summer of 2021-2022.
- The Bureau utilised a broad range of channels in the months and weeks ahead of the flooding to raise awareness of the increased flood risk and preparedness actions that the community could take. For example, on 11 October 2021 the Bureau released a video explaining the Bureau's Severe Weather Outlook and the heightened risk of widespread flooding over the east.
- Every year, to support preparedness and response activities, the Bureau provides season outlook briefings. Between August and December 2021, the Bureau's decision support specialists delivered more than one hundred individual briefings to local, state and federal government stakeholders, relevant partner agencies and industry. These briefings highlighted the risk of major flooding in New South Wales during the 2021-2022 severe weather season.
- Briefings were provided to:
  - The New South Wales Flood Warning Consultative Committee, which includes representatives from Department of Planning and Environment, WaterNSW, Sydney Water and New South Wales State Emergency Service (SES), in August 2021 and February 2022.
  - New South Wales SES pre-season briefing on 31 August 2021.
  - New South Wales Resilience and local councils in September 2021.
  - New South Wales State Emergency Management Committee in November 2021.
  - National Cabinet in November 2021.
- In late February and early March 2022, the Bureau actively warned of the potential for major riverine and flash flooding across a large part of the New South Wales coast and adjacent ranges.

Regarding the timeliness and accuracy of the Bureau's forecasts and warnings it is important to understand the wider scientific and technological context within which the Bureau operates. The weather, especially along Australia's eastern seaboard, is highly dynamic and can change rapidly over small distances in short timeframes.

For example, East Coast Lows (ECL), a core feature of the events that led to flooding on 27 and 28 February, are characterised by a distinctive asymmetric structure with sharp boundaries between intense rain and clear conditions. Widespread heavy rain is typically confined to southern quadrants of an ECL. Particularly dangerous weather can occur close to the centre of the low where strong convergence and uplift along narrow bands can cause localised torrential rain and thunderstorms. Orientation of the airflow across steep topography can further intensify rainfall at a local scale.

Predicting the precise position of an ECL, the sharp rainfall boundaries, and the position of localised torrential rain bands and thunderstorms remains a forecasting challenge. Important information about very intense rainfall can be provided at longer lead times, but with less certainty in its timing, spatial extent and intensity than possible at shorter lead times. The Bureau conveys this uncertainty by describing credible, but lower likelihood, alternate scenarios. Only through radar nowcasting at timeframes of an hour or less can the zones of very intense rainfall be accurately identified and tracked.

Between 23 February and 9 March, the Bureau's weather and flood forecasts and warnings performed well given these inherent uncertainties. Warnings highlighted an unfolding flood risk early and were updated and communicated 24/7 throughout the event. Due to the dynamic nature and severity of this event, many warnings were updated every hour or half hour as new information came to hand. For example:

- The first severe weather warnings, flood watches, flood scenarios and flood warnings for the Northern Rivers and Mid North Coast catchments were issued on Wednesday 23 February.
- Severe weather warnings, flood watches and flood scenarios were renewed on Saturday 26 February ahead of the trough and developing low that was forming near the south-east Queensland coast and expected to move southward and bring heavy rain to the Northern Rivers late on Sunday 27 February. The words "life threatening", in relation to flash flooding, were included in warnings from Saturday 26 February to convey the potential for very significant community impacts. The *Flood Scenarios* product issued on 26 February highlighted that the levee at Lismore may be breached on 28 February.
- The first *Flood Watch* for flooding for the Hawkesbury Nepean Valley was issued on Monday 28 February, two days ahead of the flooding that occurred on Wednesday 2 March at Menangle, Camden, Wallacia, Penrith, North Richmond and Windsor.
- The renewed *Flood* Watch issued on Friday 4 March (which advised of potential major flooding) provided a lead-time of 4 days before the commencement of major flooding in the Hawkesbury-Nepean and other rivers.
- The Bureau updated its flood warnings as new information came to hand during what was, for many catchments, a rapidly evolving and dynamic riverine and flash flood event. For example, flood warnings for the Wilsons River were updated 9 times between midday Sunday 27 February and midday Monday 28 February:
  - at 2.15 pm on Sunday 27 February, the Bureau highlighted river rises to 10.6 metres at Lismore, equivalent to the levee height and at 5.56 am Monday 28 February, the Bureau highlighted that river heights were forecast up to 14 metres by Monday afternoon.
  - The Wilsons River at Lismore reached the levee height at 3 am Monday morning, and the Wilsons River at Lismore is estimated to have peaked near 14.4 metres around 2 pm Monday afternoon, with major record flooding.

The Bureau's rainfall forecasts emphasized a high likelihood of eastern New South Wales experiencing very heavy rain between 23 February and 9 March. Observed rainfall totals were often at the lower end of forecast probabilities, underscoring the unusual nature of these weather systems and the challenging nature of forecasting detailed rainfall amounts for a location. For example:

- On Saturday 26 February, the Bureau forecast for the Northern Rivers on 27 February to be "Very high (near 100%) chance of rain. The chance of a thunderstorm, possibly severe with heavy rain which may lead to flash flooding".
- On Saturday 26 February, the Bureau forecast a 25% chance of rainfall exceeding 224 mm and a 10% chance of rainfall exceeding 322 mm at Lismore on Sunday 27 February. The Bureau's automatic weather station at Lismore recorded 360 mm in the 24 hours up until midnight on Monday 28 February.
- On Sunday 27 February, the Bureau forecast a 25% chance of rainfall exceeding 73 mm and a 10% chance of rainfall exceeding 99 mm at Casino on Monday 28 February. The Bureau's automatic weather station at Casino recorded 161 mm. In the same period much heavier rainfall totals were observed in the headwaters of the Wilsons river, highlighting the importance of topography in locally enhancing rainfall. On Sunday 27 February, the Bureau forecast a 25% chance of rainfall

exceeding 69 mm and a 10% chance of rainfall exceeding 113 mm at Dunoon on Monday 28 February. The closest flood warning observation site to Dunoon recorded 485 mm.

• On Sunday 6 March, the Bureau forecast a 25% chance of rainfall exceeding 58 mm and a 10% chance of rainfall exceeding 76 mm at Penrith on Monday 7 March. The Bureau's automatic weather station at Penrith recorded 127 mm.

As part of the continuous improvement of forecast and warning services, the Bureau is working to:

- Provide more frequent forecast updates.
- Enable emergency managers and the community to better understand the risk and uncertainty associated with forecasts and warnings
- Continuously improve the use of the available data and the quality of numerical weather and hydrological prediction systems. For example, the Bureau is currently improving the flood modelling capability in the upstream reaches of the Hawkesbury-Nepean river system. This has been aided by the incorporation of a hydraulic model developed by NSW State Government. There is the opportunity to explore the application of this approach to other areas of complex river behaviour such as the Wilsons, Richmond and Tweed river catchments.
- Apply suitable elaboration to the model outputs, known as post-processing, to further increase accuracy.
- Enhance rainfall and hydrological forecasts with probabilistic outputs and to make these outputs available to emergency managers. Tailored probabilistic rainfall and flood forecasting tools provide the means by which emergency managers can better envisage the timing, behaviour and potential extent of flooding. These outputs are particularly useful in dynamic situations with high levels of uncertainty, such as those experienced during the February-March 2022 floods. The Bureau is operationalising a probabilistic flood forecasting service for New South Wales Government in the Hawkesbury-Nepean catchment. There is an opportunity to explore the application of this service to other high flood risk catchments in New South Wales.

## c. responses to floods, particularly measures to protect life, property and the environment, including i. immediate management, including the issuing and response to public warnings;

The Bureau provides a wide range of products and services, including a comprehensive range of observations, forecasts, warnings, analyses and advice that are used to support decision-making by governments, emergency services, industry and the community during the response to flood and other severe weather events. The Bureau's warnings also inform emergency warnings and alerts issued by emergency services agencies to communities under threat.

Meteorologists, hydrologists, communication specialists, technicians and support staff were all dedicated to the task of ensuring this information was provided in a timely and robust manner.

- Technicians were available around the clock, monitoring for any technical outages or incidents affecting the Bureau's observational network and ensuring good data flow and quality of the flood warning observational network.
- Specialist meteorologists were dedicated to rainfall analysis and providing updated warnings for severe weather and storms which were conducive to flash flooding at a local level, acknowledging that specific flash flood warnings are the responsibility of local government.
- Specialist meteorologists provided frequent and catchment-specific updates to rainfall forecasts used to determine river level predictions.

• Specialist hydrologists monitored river conditions across New South Wales around the clock, providing updated riverine flood warnings and worked closely with the New South Wales State Emergency Services and WaterNSW.

In total, the Bureau issued 59 severe weather warnings for New South Wales between Wednesday 23 February and Wednesday 9 March, as well as 725 flood warnings, which gave detailed information about river levels in catchments across eastern New South Wales. In addition, 30 severe thunderstorm warnings were issued which provided detailed information about the intensity of storm cells at a suburb scale over the Sydney area. A full list of warnings issued by the Bureau, their timing and geographic application is available upon request.

The Bureau's critical flood and severe weather information was enhanced by extensive direct engagement with emergency managers in New South Wales. For example:

- The Bureau's decision support specialists participated in over 80 tailored briefings with the New South Wales State Emergency Service (SES) and State Emergency Operations Centre (SEOC) throughout the floods, which provided detailed information on the weather and its expected impacts.
- In addition to its core flood warning services, the Bureau provided content to support emergency managers' decision making. For example, the Bureau prepared daily briefing packs that were disseminated across New South Wale State Government by the New South Wales State Emergency Operations Centre.
- Opportunities exist for emergency managers to procure customised services from the Bureau to support their preparedness and decision making. These include the provision of real-time model data feeds or engaging Bureau staff to provide dedicated briefings, training and other knowledge sharing and communication activities.

In the Hawkesbury-Nepean River catchment, decisions made regarding the operations of the Warragamba Dam can have a significant impact on river flows. The Bureau and WaterNSW have a strong and long-standing working relationship to ensure that decisions affecting dam operations inform and are informed by Bureau rainfall and river height forecasts. For example, and in relation to the floods:

- WaterNSW provided the Bureau with water data, which the Bureau consolidated and used to deliver a range of water information and data services. The Bureau provided WaterNSW with observations, forecasts and model data to inform operations, seasonal and long-term planning.
- From Tuesday 24 February to Wednesday 7 March, the Bureau chaired 9 technical meetings held with WaterNSW. The standard agenda for these meetings included an update from the Bureau's decision support meteorologists, a technical discussion by a senior hydrologist on the river forecasts for the New South Wales rivers, and updates from water managers from WaterNSW.
- A substantial number of officer-to-officer communications occurred between the Bureau and WaterNSW throughout this period to ensure consistent forecast strategies.
- Hydrological model data were regularly exchanged between the Bureau and WaterNSW during the development of the Bureau's flood forecasts. This included ingestion of the WaterNSW dam release strategy.

The communication of Bureau warnings is critical to effective response to the warnings. Bureau communication experts ensured that consistent and clear messaging about the increased flood risk was shared with stakeholders and the community in a timely manner through multiple channels

including the Bureau's website, BOM Weather app, broadcast media (including engagement with ABC emergency broadcasting) and social media. For example, between 23 February and 9 March:

- The Bureau participated with SES and New South Wales government officials in 12 press conferences where they delivered the latest weather and flood advice to the community and reinforced emergency management messaging around safety actions. The Bureau issued 16 media releases (including audio news releases).
- In addition to sharing details of forecasts and warnings via approximately 19 routine public information crosses with radio networks across New South Wales every day, the Bureau collaborated with the ABC to stand up an emergency broadcasting service. Subject matter experts from the Bureau provided up-to-date forecast and warnings information to impacted communities.
- The Bureau coordinated responses to hundreds of media enquiries. Across New South Wales and south-east Queensland, the Bureau received more than 1,000 mentions across traditional media, reaching a potential cumulative audience of 30.5 million. The Bureau issued 1,090 social media posts about the severe weather event via the Bureau's Facebook and Twitter accounts, including local messages for New South Wales.
- Fifteen severe weather videos were produced between Tuesday 22 February and Wednesday 9 March, focussing on New South Wales and south-east Queensland. These were shared via the Bureau's social media channels and were amplified through on-sharing by members of the community, media and partner agencies.

Across Australia the Bureau provides communities and emergency managers with the flood forecasts and warnings used to support disaster preparedness, response, and recovery. The *Intergovernmental Agreement on the Provision of Bureau of Meteorology Hazard Services (IGA)*<sup>6</sup> mandates responsibility to the Bureau for providing riverine flood warnings while local government has responsibility for providing flash flood warnings. There are opportunities to review the existing institutional agreements and to explore how flash flood forecasting and warnings services might be delivered in the future. The Bureau considers that any such review should evaluate whether an integrated flood warning service for all sources of flooding would better support emergency managers and the community to understand and respond to flood risk.

The information that links the Bureau's forecast river heights to the impact at local level such as flood extent, town inundation and evacuation route information is managed, where it exists, by organisations across all three levels of government. In many instances, emergency managers and community members do not have timely access to information that provides critical actionable information such as "flood waters are expected at [place], by [time]". A geographically and methodologically consistent and coordinated approach to converting flood river heights to community impacts would assist all levels of emergency management to better plan for and respond to floods, and to help community members to determine whether, when and how to take individual and/or collective action.

Real-time information on the impact of severe weather on communities is often captured by local managers working on the ground or by the community, and shared through a variety of channels, ranging from operational briefs to social media. Currently, there is no coordinated, widely accessible and responsive platform to report or view observed impacts. This means that, in many instances, emergency managers and community members do not have timely access to information that provides critical actionable information such as "flood waters are being observed at [place]". A

<sup>&</sup>lt;sup>6</sup> <u>https://federation.gov.au/sites/default/files/about/agreements/intergovernmental-agreement-provision-bureau-meteorology\_0.pdf</u>

geographically and methodologically consistent and coordinated approach to capturing and sharing on the ground observations of impact would assist all levels of emergency management to better respond to floods, and to help community members to determine whether, when and how to take individual and/or collective action. The Bureau would welcome the opportunity to discuss these matters with the New South Wales Government.

#### *ii. resourcing, coordination and deployment, including with respect to the Australian* Defence Force

The extreme nature of the flood called for an enterprise-wide response from the Bureau, with technicians, meteorologists, hydrologists, communication specialists and support staff from across Australia engaged in the Bureau's response to flooding in New South Wales. The Bureau's National Operations Coordination Team managed the Bureau's operational response, which included coordinating national capability and activating additional delivery functions to meet increased demands.

The Bureau works very closely with customers, partners and stakeholders during responses to weather and flood events. The strong relationships built across emergency management through participation on state and national level disaster preparedness and resilience building groups facilitate the strong inter-agency cooperation that is relied upon during floods of this scale.

Between Wednesday 23 February and Wednesday 9 March, the Bureau's specialist staff were available around the clock to provide weather and flood intelligence to emergency managers across state and federal governments. New South Wales and federal government emergency managers had a direct link to the Bureau's management and 24/7 operational centres that provided, and from where they were able to seek, additional weather and flood intelligence and provide feedback to the Bureau around impacts.

To further support the response to the floods,

- the Bureau tripled the number of staff that would usually be outposted to the New South Wales SES. The additional Bureau meteorologists and hydrologists worked with incident management teams from the State Operations Centre at the New South Wales SES headquarters, where they delivered frequent and tailored weather and flood briefings. The Bureau embedded a community engagement officer in SES public information units between Thursday 3 March and Wednesday 9 March to ensure that both agencies had a common and consistent understanding of impacts.
- a Bureau meteorologist was deployed into the State Emergency Operations Centre (SEOC) at Sydney Olympic Park from Monday 28 February to Friday 4 March, and again from Monday 7 March to Friday 9 March, as a Bureau spokesperson for press conferences and to provide briefings to the SEOC.
- Bureau meteorologists were outposted in the National Situation Room in Canberra, to support Emergency Management Australia with frequent weather and flood updates.
- the Bureau's Meteorological Intelligence Support Team (MIST) are embedded in the Australian Defence Force Headquarters of Joint Operations Command to provide services supporting operations and planning with 24/7 support. To further support the provision of services to the ADF, the Bureau increased its staffing at Oakey Airport to 7 days a week between Saturday 25 February and Saturday 5 March. Defence operations from Oakey including supporting the NSW response, in particular around the Northern Rivers.

The Bureau's communications specialists coordinated closely with relevant communications representatives within the New South Wales Government including the New South Wales Premier's

office, Department of Premier and Cabinet, New South Wales SES and the Police Information Functional Area Command at SEOC, to ensure the best targeting and consistency of messaging.

#### *iii. equipment and communication systems;*

Across Australia, the Bureau provides communities and emergency managers with the flood forecasts and warnings used to support disaster preparedness, response, and recovery. Flood warning infrastructure, which includes the communications systems that relay data from the field into the Bureau's systems, is a critical enabler of these flood services. The national network of warning infrastructure captures and relays rainfall and river level data to the Bureau's flood models, to enable forecasting of water levels within a particular catchment. This enables the provision of timely and accurate flood forecasts and warnings. The data are published on the Bureau's website and used for situational awareness and local decision making by the public, emergency services, water users, agriculture and other industries.

During the period Wednesday 23 February to Wednesday 9 March, there was very heavy demand for the Bureau's website and app platforms. Throughout this period all Bureau communications referenced the website and app as the single source of truth. During the period Wednesday 23 February to Wednesday 9 March, traffic to the Bureau's website and mobile app from New South Wales users increased three-fold compared to the same period in 2021. The daily number of visits to the website and mobile sessions reached a maximum on Thursday 3 March when 7.6 million individual users visited the website and 5.7 million app sessions were conducted.

The Bureau's radars, automatic weather stations (AWS), flood warning networks and the Bureau's website operated at a very high standard of quality and continuity during the floods. There were a small number of sites that experienced outages. For example, the Bureau's Lismore Airport AWS was rendered inoperable by the flood at around 3:30 am on Monday 28 February. The Bureau's weather forecasts and warnings were not impacted by this outage because the Bureau draws upon a wide range of observational technologies to inform its forecasts and warnings; redundancy is built into the observation system to protect the integrity of forecasts.

The primary flood level gauge on the Wilsons River at Lismore (Lismore Rowing Club) is owned by the local council with data used by the Bureau for monitoring and issuing flood warnings at Lismore. This gauge failed at around 1.00pm on Monday 28 February. After this time readings taken from the secondary Browns Creek gauge were used to inform river height forecasts. This gauge is also council-owned and is located in the middle of the town next to the levee gates on the Wilsons River.

In New South Wales, the Bureau owns and manages 885 of the more than 1,500 flood infrastructure assets, with the remainder owned and managed by local councils, state government and non-government agencies. In 2018, the Council of Australian Governments (COAG) endorsed the *Intergovernmental Agreement on the Provision of Bureau of Meteorology Hazard Services (IGA)*<sup>7</sup>. This requires asset owners (e.g. local councils) to be responsible for maintaining flood warning assets. Many non-Bureau asset owners are unable to maintain their assets to an appropriate standard<sup>8</sup>. In recognition of the difficulties faced by some asset owners, the Bureau has, for a number of years, performed some of the maintenance for non-Bureau assets.

There are opportunities to improve the reliability of the flood infrastructure network by considering the location and design of the flood network and consolidating ownership and maintenance

<sup>&</sup>lt;sup>7</sup> <u>https://federation.gov.au/sites/default/files/about/agreements/intergovernmental-agreement-provision-bureau-meteorology\_0.pdf</u>

<sup>&</sup>lt;sup>8</sup> <u>http://www.bom.gov.au/water/standards/documents/Flood Warning Infrastructure Standard.pdf</u>

arrangements. This has been discussed through the Australian-New Zealand Emergency Management Committee (ANZEMC)<sup>9</sup>. Further, the Bureau, Local Government Association of Queensland (LGAQ) and Queensland Reconstruction Authority (QRA) have jointly undertaken additional work to outline the benefits of, and what is required to, establish common information sharing processes, maintenance standards, automation of observations and automation of data quality control. There are opportunities to progress this work, which would result in improved data for flood forecasting and greater resilience of the flood warning network.

### d. the transition from incident response to recovery, including the roles, structure and procedures of agencies, government, other entities and the community;

The Bureau continued to deliver its full range of products and services during the transition from incident response to recovery operations. Details of the Bureau's services in the recovery phase, which began in early March, are outlined in TOR e(i).

#### e. recovery from floods, including:

#### *i. immediate housing, clean-up, financial support and community engagement measures;*

The Bureau continues to provide support to state and federal government during the recovery to floods, through the continued provision of observations, forecasts and warnings and through targeted briefings, analyses and advice on past and future weather and flood. For example:

- In New South Wales, many stakeholders and partners involved in the recovery effort attend the SES' weekly strategic operational briefing, where the Bureau's SES-embedded meteorologist provides a weather and flood briefing and is available for additional context following these briefings.
- At the federal level, recovery efforts undertaken by the Australian Government are coordinated through the Australian Government Crisis and Recovery Committee (AGCRC) and the National Coordination Mechanism. The Bureau attends briefings and provides weather updates and outlooks to the National Situation Room.
- The Bureau's Meteorological Intelligence Support Team (MIST), embedded in the Australian Defence Force Headquarters of Joint Operations Command, continue to provide services 24/7 to supporting ADF operations and planning.

The Australian Climate Service (ACS) is a partnership between the Bureau of Meteorology, CSIRO, Geoscience Australia and the Australian Bureau of Statistics and was created in 2021 to improve data and intelligence on climate and natural disasters. In its first year of operation, the ACS has been focusing on supporting Emergency Management Australia (EMA) and the National Recovery and Resilience Agency (NRRA). During the floods, the Australian Climate Service pro-actively provided data and intelligence to Emergency Management Australia (EMA) and the National Recovery and Resilience Agency (NRRA) via the National Situation Room to support decision making by the Commonwealth.

Combining the efforts of these partners, the following data and intelligence were provided:

- Information on relevant historical floods including their impact and any known recovery challenges to assist NRRA and EMA to understand the relative scale of the unfolding event.
- The extent of flooding at key points in time, derived from international satellite sources requested by Emergency Management Australia.

<sup>&</sup>lt;sup>9</sup> <u>https://recovery.gov.au/sites/default/files/files/aus-nz-emergency-management-committee-communique-27082019(1).pdf</u>

- Information on a range of impacts that may occur across the built environment, community and economy as well as known recovery challenges.
- Information on community demographics, vulnerability information (such as age, welfare support, culture and income) for relevant local government areas.
- Advice on the current and expected supply chain impacts associated with road closures during the floods.

#### *ii. longer-term community rebuilding support; and*

Nil response

f. any other matters that the inquiry deems appropriate in relation to floods.

Nil response