Australian Government
Bureau of Meteorology

Tasmanian Calibration Rain Events

Analysis of 13 significant rain events across Tasmania for the **Tasmania Flood Map Project**

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Cover: Flooding of the Mersey River, driven by an east coast low with a deep tropical moisture in-feed, June 7th, 2016. Photo reproduced with permission, credit Cordell Richardson / Fairfax Syndication (.com) (Age twitter feed).

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List of Acronyms

Term	Definition
AEP	Annual Exceedance Probability
AWAP	Australian Water Availability Project
AWRA-L	Australian Water Resource Assessment Landscape
AWS	Automatic Weather Station
BARRA-TA	The Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia - Tasmania
BoM	Bureau of Meteorology
IFD	Intensity-Frequency-Duration design rainfall
MSLP (L/H)	Mean Sea Level Pressure
OMD	One Minute Data
Pluvio	Pluviograph
SDI	Soil Dryness Index
SES	State Emergency Service
TBRG	Tipping Bucket Rain Gauge
TFMP	Tasmania Flood Map Project

Contents

Purpose

During 2019, the Tasmania State Emergency Service commissioned the Bureau of Meteorology to compile a report providing them with a meteorological analysis of thirteen significant rain events across Tasmania. Along with this report, the Bureau also provided rainfall data, soil moisture data, radar data and 'reanalysis' rainfall data. This report and data will be used by the SES for calibration of a hydrological model as part of the Tasmania Flood Map Project.

The term 'rain event' is loosely defined as a period of time (usually several days) where significantly heavy rainfall occurred across a part, or multiple parts, of Tasmania. For example, if heavy rain occurred across northwest Tasmania over a two-day period, then the heavy rain shifted to southeast Tasmania during the following two days, the entire four-day period is considered one event.

The thirteen rain events were selected using several criteria:

- Rainfall rates within an event should have an Annual Exceedance Probably (AEP) of less than 2% at durations of 2 hours or longer (that is, the probability of the observed rainfall rate occurring at that location in a year should be less than 2%)
- There must be at least one event for each Tasmanian forecast district (Figure 1)
- A list of historically significant events provided by the SES must be included
- A combination of short-duration (flash flood) and longer-duration (riverine flood) events must constitute the list of events

Another consideration when selecting events was to ensure that a broad array of different synoptic situations was selected. Every effort was made to ensure this, however most heavy rain events across Tasmania are related to east coast lows, periods of prolonged northeasterly airstream, or periods of prolonged moisture-rich westerly airstreams. It is important to note that observed flood levels or reported flood impacts were not a consideration when selecting an event. It should also be noted that the list of events was biased towards more recent years (post 2000), as significantly more rainfall data is available for those events, including high temporal resolution rainfall observations.

Once the Bureau had collated a rain event list that satisfied the above criteria, the list was provided to the SES who confirmed that it was adequate. The events are listed in Table 2.

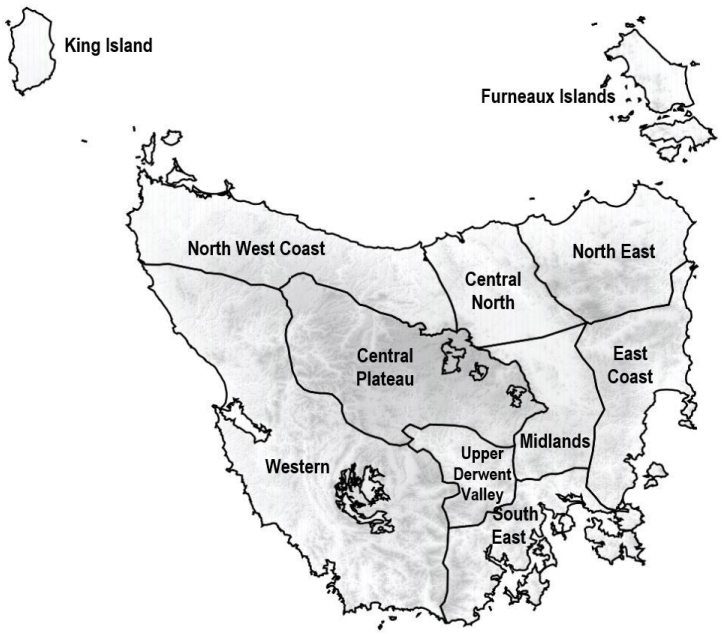


Figure 1: Tasmanian forecast districts.

Data

The Bureau of Meteorology has provided the Tasmania SES with a broad array of data for each event. This section outlines each data source including data format and quality control.

Most of the data provided is daily and sub-daily rainfall observations. The rainfall data provided is operational data and has a very limited or no data quality control. Use of the data is at your own risk. This data comes from a range of different rain gauge networks, including manually read observations from observers, rain gauges that make up the Bureau's flood warning network, rain gauge data-loggers from volunteer rain observers, Automatic Weather Stations and data from 3rd parties such as Hydro Tasmania, local councils or the Department of Primary Industries, Parks, Water and Environment. As such, data has been provided in a range of different formats. It is important to note that the various datasets provided may contain the same data. The Bureau has provided the SES with all observed rainfall data available. However, other agencies may hold furth rainfall datasets that may be of use to the SES.

Daily rainfall observations, 24 hours to 9 am

This dataset provides 24-hour rainfall to 9 am at dozens or hundreds of locations across Tasmania each day. The data comes from several sources, including automatic weather stations, manually read observations and other tipping bucket rain gauges. This data is provided for all events.

Due to the highly labour-intensive process of quality control, this dataset has only limited quality control. Manually read observations are quality controlled, however automatic observations are rarely quality controlled. Quality control information is provided in the data file.

This data is provided in a compressed file entitled 'Daily_YEAR_MONTH'. Within the compressed file is a single .txt file containing all observations, a notes file describing how to interpret the data and a station details file.

AWAP rainfall,

This dataset provides gridded, observed 24-hour to 9 am rainfall across Australia. It is derived from observed rainfall data, with a sophisticated analysis technique applied to interpolate the data between observation points. The data has a 5 km spatial resolution. Note that the quality of the data degrades across data-sparse areas such as western and southwestern Tasmania. AWAP data is also used to build climatological data such as rainfall anomalies and deciles.

Quality control has been undertaken on this dataset. However, in the data-sparse areas, errors may enter the analyses because they cannot be detected by comparison with other reports. More information about this dataset is available here:
http://www.bom.gov.au/climate/austmaps/about-rain-maps.shtml

This data is contained within a directory entitled AWAP for each event. A single NetCDF file is provided for each day of data.

AWS (Automatic Weather Station)

This dataset provides one-minute accumulated rainfall at all Bureau Automatic Weather Stations. Data is provided for events from 2007 onwards, with more recent events having more AWS data. This data is rarely quality controlled.

The data is provided in a compressed file entitled 'AWS_YEAR_MONTH'. Within the compressed file is a single .txt file containing all observations, a notes file describing how to

interpret the data and a station details file.

Pluvio

This dataset provides five-minute rainfall accumulations. The data comes from two sources: tipping bucket rain gauge data-loggers that have been provided to the Bureau, and older mechanical pluviograph data that has been digitised. Although data is provided for all events, data is very sparse until 1970 and may not be applicable to the event. Very limited quality control has been applied to this data. From 1970 onwards, there are generally dozens of observation points provided.

The data is provided in a compressed file entitled 'Pluvio_YEAR_MONTH'. Within the compressed file is a single .txt file listing all stations that data is provided for, a metadata file for each station and a rainfall data file for each station

Rain_accum

This dataset provides a rolling rainfall accumulation as well as the exact time (to the second) that a bucket tip is reported. The data comes from the Bureau's flood warning tipping bucket rain gauge network as well as 3rd party sources. The dataset is essentially not quality controlled, however a 'void flag' is present for each observation. A flag of 'Y' means that a hydrologist deemed the data suspect. However, this judgment was made (under pressure) during real-time operations and may be an erroneous decision. A flag of N does not mean the data is not suspect. This data is provided for events in 2007 and beyond.

One .csv data file is provided per event entitled 'rain_accum_FromDate_ToDate'. The data can be interpreted using the following format:

> *station_num, sensor_num, station_name, latitude, longitude, obs_time_UTC, obs_time_local, rainfall_accumulation (mm), void_flag*

Rain_event

This dataset generally provides a 10-minute accumulation from tipping bucket rain gauges that make up the Bureau's flood warning network as well as 3rd party sources. The dataset is essentially not quality controlled, however a 'void flag' is present for each observation. A flag of 'Y' means that a hydrologist deemed the data suspect. However, this judgment was made (under pressure) during real-time operations and may be an erroneous decision. A flag of N does not mean the data is not suspect. This data is provided for events in 2011 and beyond.

One .csv data file is provided per event entitled 'rain_event_FromDate_ToDate'. The data file provides an accumulation in mm at an exact time over a defined interval of time at each gauge. If the interval is zero, the accumulation is from last observation. The data can be interpreted using the following format:

> *station _num, sensor_num, station_name, latitude, longitude, obs_time_UTC, obs_time_local, rainfall_accumulation (mm), rainfall_accumulation_interval (in seconds), void_flag*

BARRA-TA

The Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia – Tasmania domain (BARRA-TA) is an approximate reconstruction of the atmosphere in the past. It is constructed by taking all available observations and using a weather model to 'reanalyse' the atmosphere. 10-minute rainfall accumulation has been provided with a spatial resolution of 1.5 km in the form of NetCDF files. Note that although the BARRA-TA dataset is highly valuable, it has limitations. BARRA-TA data is usually not appropriate to use for short-duration rainfall events involving thunderstorms or convection. This is because the

exact location of the thunderstorm is often slightly displaced and this has a significant ramification for hydrological modelling. This data is only available for events after 1990. More information about the BARRA dataset is available here:
http://www.bom.gov.au/research/projects/reanalysis/

AWRA-L

Historic soil moisture data has been provided for each event using the Bureau's operational Australian Water Resources Assessment Landscape model (AWRA-L). The total amount of water (in mm) has been provided for the rootzone layer – the top 1 m of the soil profile. Daily rootzone soil moisture data is provided for the entire year for each event. The data is in NetCDF format. More information about the AWRA-L dataset is available here:
http://www.bom.gov.au/water/landscape/

Rainfields

Rainfields data uses radar information in combination with rain gauge measurements to provide rainfall accumulation estimates around the Mt Koonya radar, southeast Tasmania. This is accomplished by adjusting, or calibrating, radar-rainfall data with data from rain gauges situated within the radar boundary. No quality control of the data has taken place.

30-minute accumulated rainfall data is provided for the January 2016 event, and 6-minute accumulated rainfall data is provided for the May 2018 event. More information about this dataset is available here:
http://www.bom.gov.au/australia/radar/about/using_rainfall_accumulations.shtml

Report structure

The thirteen event analyses within this report are ordered chronologically and titled by the month and year they occurred, followed by the broad area that was impacted. Each analysis is designed to provide the user with a clear picture of the location, timing and significance of each rain event, as well as the antecedent conditions, soil moisture, meteorological causes and an understanding of the nature and intensity of the rainfall. Every event analysis is laid out identically so that the user can quickly and efficiently extract the information they require. All times stated within the report are local unless otherwise stated. The standard format is outlined below:

Summary

Users can read this section to gain a quick understanding of the event, including when and where it occurred, how much rain fell, what meteorological conditions drove the event and a summary of some of the known impacts. Also included in this section is a map showing the observed rainfall amounts accumulated over the event. This graphic is derived from the AWAP dataset.

Antecedent Conditions

This section starts by summarising the long-term rainfall trend across Tasmania. A map showing the rainfall deciles over the 6 to 12 months leading up to the event gives the user quick insight into how wet or dry conditions were leading up to the event. Following this, a map is provided showing how much rain fell across Tasmania in the month or weeks before the event, along with a map showing the rainfall anomaly (in mm) for this period. This provides the user with precise information about rainfall conditions immediately before the event. These maps are derived from the AWAP dataset.

With knowledge of the preceding rainfall conditions, soil moisture is then discussed. A map

displaying modelled 'rootzone' soil moisture is displayed. This represents the total amount of water (in mm) in the top 100 cm soil layer. Also provided for events after the year 2000 is a map of the Soil Dryness Index. This is generated using observed rainfall and temperature data and *roughly* represents the amount of rainfall (in mm) required to bring the top layer of soil to saturation where no more rainfall can be absorbed.

Meteorological Discussion

This section outlines the broad meteorological conditions that generated the event. Mean Sea Level Pressure synoptic charts are provided to indicate the position of high- and low-pressure systems as well as the strength, direction and origin of airstreams over Tasmania. For later events, radar data is also shown to help illustrate the exact nature of the rainfall. It is assumed that the user has a basic understanding of interpreting radar and synoptic charts.

Rainfall Maps

This section describes the daily rainfall accumulation and distribution during the event. Daily rainfall maps are provided for each day so that the user can quickly see how the event unfolded. The rainfall maps are derived from the AWAP dataset.

Point Rainfall Probability Analysis

This section conveys information about the intensity and duration of the rainfall event, as well as how significant and rare it was. Two or three significant rainfall observation locations are chosen and analysed. Rainfall accumulation at these points are shown on a rainfall accumulation graph – these graphs show one-minute accumulations for many events. From this data, the user can ascertain if the event was a short duration thunderstorm event or a longer duration, multi-day rain event.

Storm envelope graphs are also provided for the same significant rainfall locations as above. At each of these locations, rainfall rates for every measured duration are calculated throughout the entire event. The highest rainfall rate at each duration is plotted on the graph as the storm envelope (see example below). Also plotted on the graph are the Annual Exceedance Probability (AEP) curves for that location. The AEP values tell us the probability of a rainfall rate at that location being exceeded within a year. For example, the below storm envelope at Upper Esk tells us that the highest observed 2-hour rainfall rate during this event has a 50% probability of occurring each year, whereas the highest observed 24-hour rainfall rate has a 1% probability of occurring each year. In this case, this graph is telling us that the short duration rainfall rates were not significant, however the longer daily rainfall rates were highly significant.

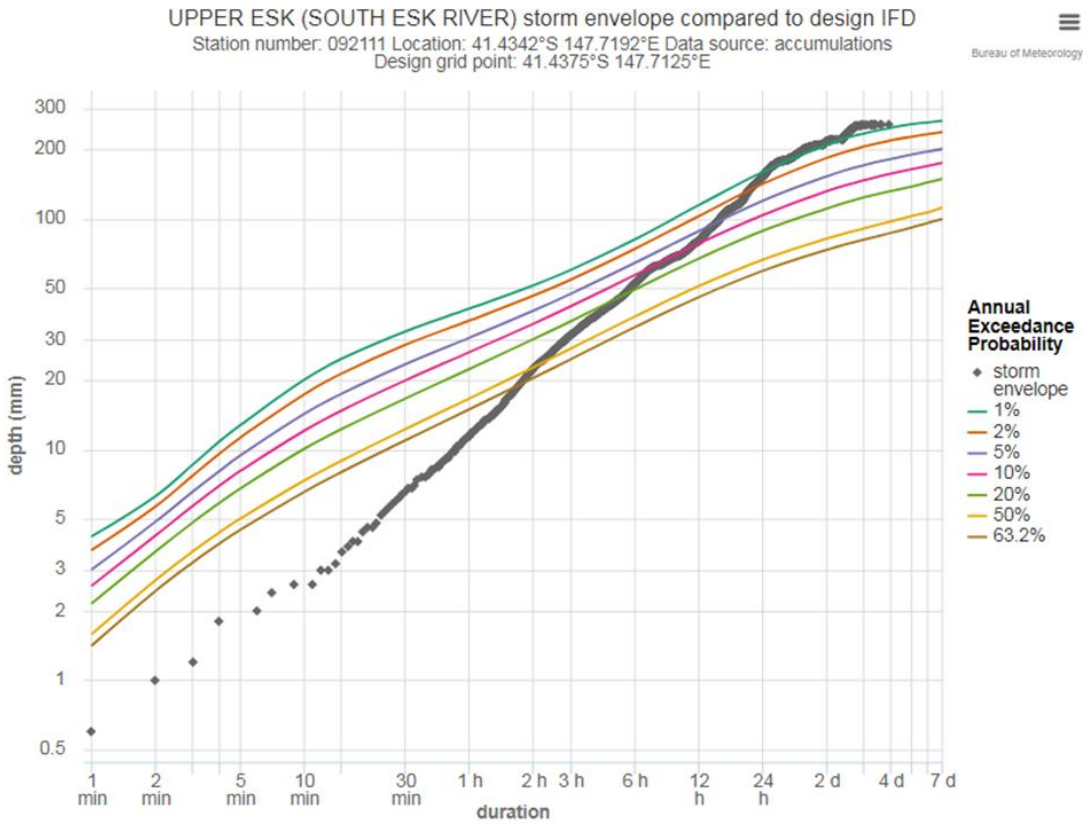


Figure 2: Example storm envelope.

At locations where only daily rainfall is available, a 'restricted' 24-hour rainfall rate is provided. This is the 24-hour rainfall rate from 9 am to 9 am. It is likely that the highest 24-hour rainfall rate occurred outside these hours. Table 1 below provides the conversion factors to convert the restricted 24-hour rainfall rate to an approximation of the unrestricted rate. The AEP data comes from the Bureau's Intensity-Frequency-Duration design rainfalls database - more information is available here: http://www.bom.gov.au/water/designRainfalls/ifd/.

Duration	1 Day	2 Days	3 Days	4 Days	5 Days	6 Days	7 Days
Factor	1.15	1.11	1.07	1.05	1.04	1.03	1.02

Table 1: Restricted to unrestricted conversion factors.

BARRA-TA Analysis

Here, 24-hour rainfall data from the Bureau's high-resolution reanalysis dataset, BARRA-TA, is displayed for two key days of the event. A brief discussion about the quality of the data follows as well as a recommendation of whether the data can be used for hydrological modelling. BARRA-TA data is usually not appropriate to use for short-duration rainfall events involving thunderstorms or convection. This is because the exact location of the thunderstorm is often slightly displaced, and this would have significant ramifications for hydrological modelling. This data is only available for events after 1990.

Data Provided

Finally, a list of all the provided event data is specified.

List of rain events

Event No.	Date	Description	Synoptic Situation	Forecast Districts affected	Flooding type	Ranking of the river height	Why event chosen
1	4th – 6th April 1929	Widespread rainfall of 200 to 300 mm across much of northern Tasmania over three days, with elevated areas in the north and northeast receiving in excess of 400 mm.	Complex cut-off low slow moving over SE and a stationary high over NZ draws a NE'ly airstream over TAS with a long fetch	NW, CN, NE, E, MID	Riverine, probable flash flooding	Fingal 9.52m (1st), Longford 9.33m (1st)	Historically significant event (22 killed). Widespread, multi-day rainfall over multiple catchments.
2	19th February 1946	Significant rain event over King Island - 170mm/24h	Large low centre close the W Tas coast on the 19th	King Island	Possible flash flooding	1 in 200 and 1 in 500 AEP for the restricted 24-hour duration	One of the most significant recorded events for King Island.
3	23 April 1960	Between 20th & 23rd, widespread flooding of most Tasmanian rivers, with the Derwent, Macquarie, Elizabeth, Lake and Liffey rivers particularly affected. The greatest damage occurred in the New Norfolk area when over 250 mm of rain fell in less than 48 hours. At Macquarie Plains, 12 homes were destroyed. In Hobart, record losses were sustained through flooding of the Hobart Rivulet, with flooding a metre deep through some city streets. Flooding also extended throughout the East Coast and Midlands.	Large, slow-moving low-pressure centre remaining close the east of Tasmania from the 21st to the 23rd. Continuous heavy rainfall affecting much of Tasmania. Generally, 100 to 300 mm of across much of the east, south, west and inland areas.	E, SE, MID, UDV, CP, W	Riverine	Campbell Town 2.29m (3rd), Hamilton [1/4/60] 5m (1st)	Historically significant, widespread event. Hobart Rain AEP <2% for durations of 6hrs and greater
4	30th – 31st May 1969	Flooding about the East Coast and Midland areas. 100 to 300 mm of rainfall about eastern Tasmania over the two days (50 to 100mm elsewhere).The most severe flooding in Launceston since April 1929. At Longford, 250 people were evacuated and 65 homes were inundated by rising floodwaters.	Intense low centre develops close to the NE of Tas, with a NE'ly airstream gradually tending E to SE'ly as the low slowly moving towards northeastwards by early June	NE, E, CN, MID	Mostly riverine	Fingal 8.59m (2nd), Llewellyn 10.82m (2nd), Killymoon 3.71 (8th), Longford 7.95m (2nd), Perth 10.25m (1st), Hamilton 3.59m (3rd)	Historically significant event.

5	24th – 25th August 1970	Significant rainfall about the north with Mersey/Forth/Meander major flood, major flood in Ouse and Lake rivers.	N/NE flow ahead of trough, crossing on the 24th. Low develops close to the NE on the 24th, moves down east Tas coast on 25th.	CN, NW	Riverine		Historically significant event.
6	8th – 11th August 2007	A significant multiday West Coast and Derwent event - high river flows in central western catchments like the Pieman	Prolonged strong W'lies as deep lows pass to the south. A significant cold front crosses on the 10th.	W, SE, UDV	Riverine	2% AEP rainfall for Strathgordon for 2 - 3 day totals	A good western district event
7	12th – 14th January 2011	Very heavy rain about the northwest and the northeast caused flash flooding and major damage.		NW, CN, NE	Flash		
8	24th – 25th March 2011	Generally 200 to 400 mm of rain about the upper east and north east, with 100 to 200 mm about parts of the north. Significant flooding of the South Esk and Macquarie rivers.	A trough and series of lows lie along the SE and E coast of Australia. A long NE'ly flows over Tasmania for a number of days, then a small low moves down the E Tas coast on the 24th.	NE, E	Riverine and flash	Fingal 7.82m (3rd), Llewellyn 11.02m (1st), Killymoon 3.9m (4th), Longford 6.4m (3rd), Perth 9.87m (2nd)	A significant event with a reasonably 'typical' East Coast Low setup. Quality data available.
9	10th – 11th February 2012	Heavy rainfall on Flinders Island with shorter embedded storms	Ridging over much of Tasmania, trough slowly moves over Flinders Island	Flinders Island		Near 5% AEP for durations of 24 hrs	A reasonably significant event for Flinders with quality data.
10	29th – 30th January 2016	Highly significant/localised flash flooding occurred across Eastern Tasmania, with significant rain also in the N/NW. Between 100 to 300 mm fell in those areas, with rainfall generally very intense over short durations.	A slow moving, complex area of low pressure develops to the W of TAS and slowly moves over SE Aus, with a number of associated troughs moving over TAS.	NW, CN, NE, E	Flash Flooding	Grindstone, near Orford, recorded 73mm in an hour <<< 1% AEP	A significant convective, intense rain event with quality data.

11	4th – 6th June 2016	Major riverine flooding and flash flooding occurred across all river basins in northern Tasmania, and some rivers in the south, as a persistent and very moist northeasterly airstream delivered exceptionally heavy rain over several days across northern districts, with daily totals in excess of 200 mm in the 24 hours to 9 am on the 6th. Some sites broke long-standing flood records from 1929 and 1970 and there was extensive damage to infrastructure. Two people were confirmed dead and one missing.	During the first week of June an East Coast Low developed over the Tasman Sea, coinciding with record-high sea surface temperatures. The East Coast Low interacted with an extensive upper level trough over eastern Australia and a high-pressure system over New Zealand, and extended its influence from southern Queensland to northern Tasmania	NW,CN,NE,E,UDV	Riverine/Flash flooding		Highly significant event with high quality data
12	12th – 15th July 2016	Major flooding of the Huon due to heavy rain in the west/southwest and snowmelt.	Strong, moist westerlies with snowmelt	W, SE	Riverine		Significant event and quality data, different synoptic set up to other situations.
13	10th – 11th May 2018	Hobart and parts of SE Tas experience extremely intense, short duration rainfall in storms on the night of the 10th of May. Extensive flash flooding and damage was recorded.	Severe thunderstorms associated with the passage of a complex low close to the east coast of Tasmania.	E, SE	Flash flooding		Highly significant flash flood event with quality data.

Table 2 List of selected rain events with summary information. Note that the ranking of the river height is current to June 2019.

1. April 1929 – Northern Tasmania

Summary

Between the 3rd and 6th of April 1929, exceptionally heavy rainfall was observed about much of the north of Tasmania. The most extreme rainfall occurred during the 48 hours from 9 am of the 3rd to 9am of the 5th of April when up to 400 to 500 mm of fell on the Northeast, Central North and Northwest slopes of Tasmania.

Floods caused by this rainfall were disastrous in many areas. More than 22 deaths, bursting of a large mine dam and destruction of many bridges etc. were reported. The floodwater carved a path across the region, destroying everything in its path, including vehicles, buildings and railroad tracks. It inflicted huge stock losses, the evacuation of 3500 people, while damaging 35 bridges and 1000 homes.

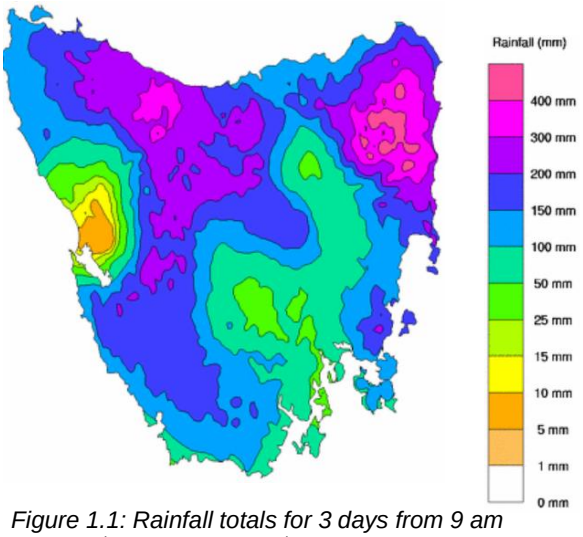


Figure 1.1: Rainfall totals for 3 days from 9 am of the 3rd to 9 am of the 6th April 1929

Antecedent Conditions

During the six months leading up to the event, above average rainfall had been reported about north and west Tasmania with very much above average rainfall in the northwest (Figure 1.2).

During the two months leading up to the rain event, Tasmania experienced generally average rainfall. However, parts of the northwest and northeast, particularly elevated areas, recorded 50 to 200mm of rainfall above the February/March average (Figure 1.3).

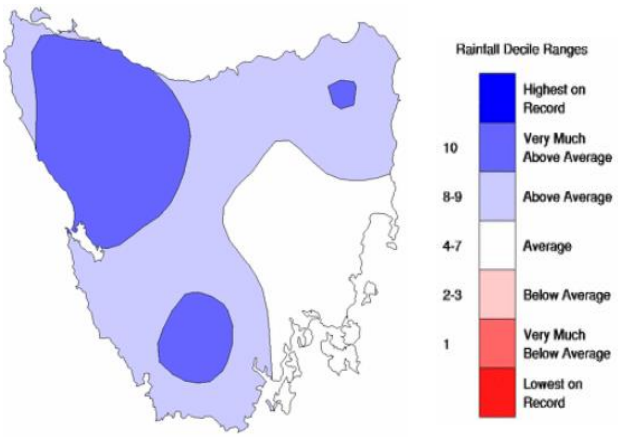


Figure 1.2: Rainfall deciles from 1st October 1928 to 31st March 1929

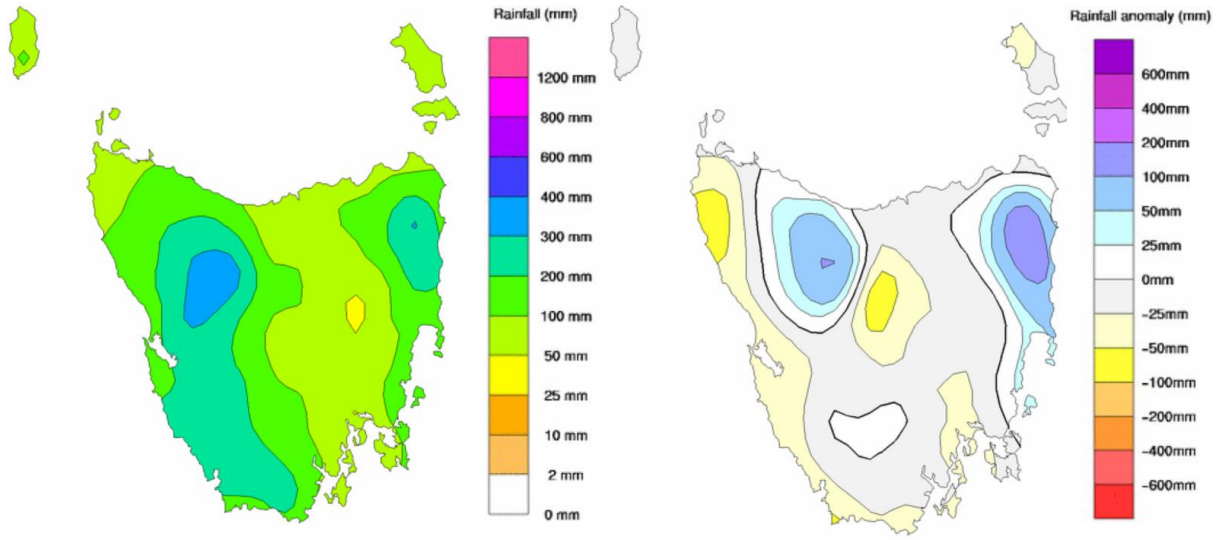


Figure 1.3: The left map shows recorded rainfall across Tasmania over the months of February and March 1929. The right map shows the deviation of the observed rainfall from the February and March mean (in mm).

As the six months leading up to the event were reasonably wet, soils in elevated areas of the north and west had high soil moisture. Figure 1.4 shows the Bureau's AWRA-L rootzone soil moisture model. Here, elevated areas in the north and west have soil moisture of around 200 mm whereas lower elevations have soil moisture near 100 mm.

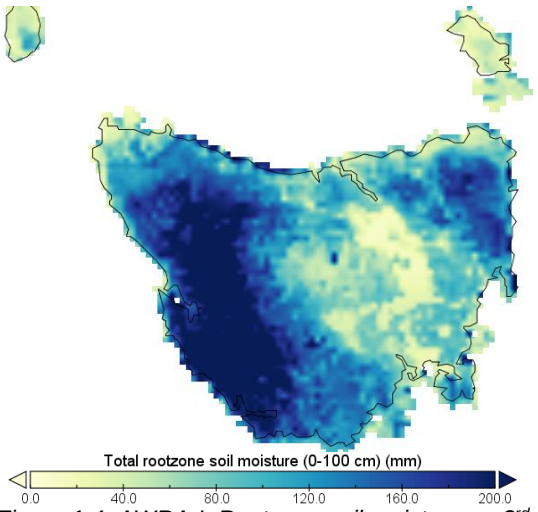


Figure 1.4: AWRA-L Rootzone soil moisture on 3rd April 1929.

Meteorological Discussion

During the 3rd of April 1929, a near-stationary 'blocking' high was established over the eastern Tasman Sea near New Zealand. A ridge of high pressure extended northwards from the high towards New Caledonia. A low of monsoonal origin was present over Queensland and extended a deep trough over Victoria toward an area of low pressure to the south of Tasmania (Figure 1.5).

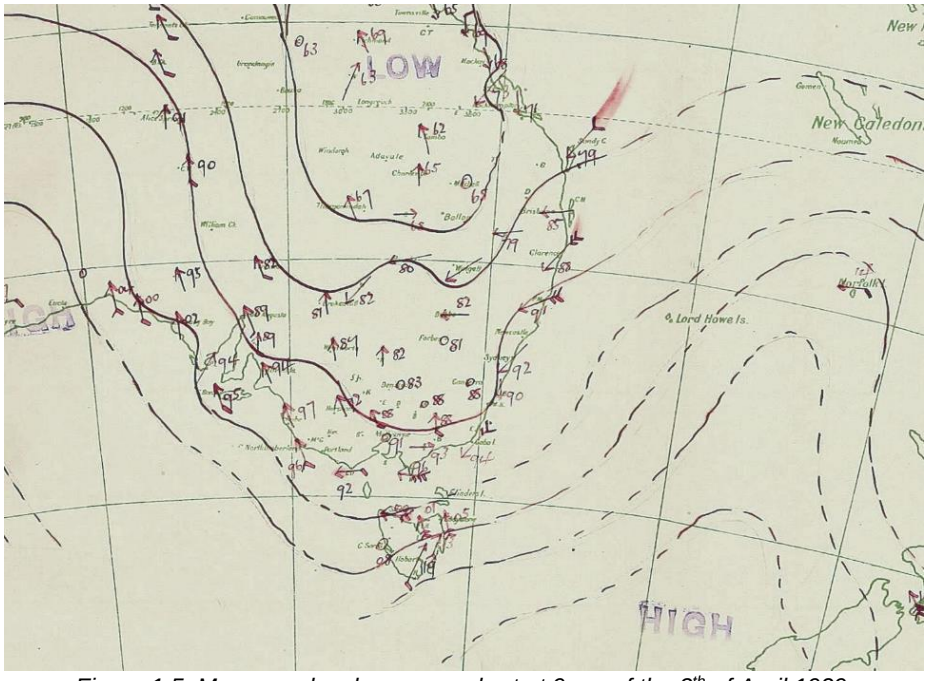


Figure 1.5: Mean sea level pressure chart at 9 am of the 3th of April 1929.

This pressure distribution (with a large pressure gradient over the western Tasman Sea and Bass Strait) caused inflow of very warm and very moist air from the Coral Sea/New Caledonia region to Bass Strait and Northern Tasmania. Heavy rain began to develop about the north during this time. Rainfall was influenced heavily by topography with elevated, windward slopes in the north and northeast seeing the highest totals.

An area of high pressure over the Bight and low pressure to the south of Tasmania acted to bring a cold pool of air from the Southern Ocean to western Victoria.

The pressure field (with high pressure to the east and west of Victoria and low pressure to the north and south) was extremely favourable for low pressure development over southern Victoria. This was only increased by the injection of cold air into Victoria and a warm sector moving over northeast Tasmania. During the 3rd of April, a deep low rapidly developed near Melbourne. Pressure fell about 20 hPa in less than 24 hours over Melbourne and at 9 am on the 4th of April the fully developed intense low was centred near Melbourne (Figure 1.6). This brought stronger northeasterlies to Tasmania with a much increased moisture inflow and very heavy rain into northern Tasmania.

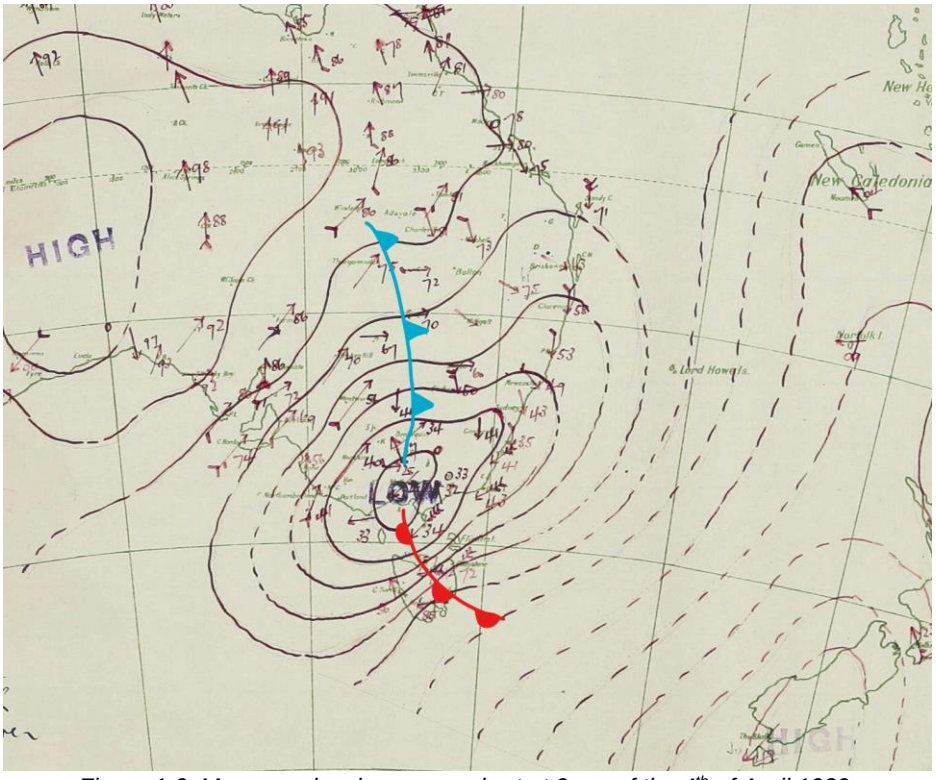


Figure 1.6: Mean sea level pressure chart at 9 am of the 4th of April 1929.

The low slowly moved south to southwest (near western Tasmania) over the next 24 hours and by 9am 5th April, the rain and moist northeasterlies had eased as a cold front crossed from the north (Figure 1.7). On 6th April, the low slowly moved towards the southeast and by the 7th, a ridge was approaching Tasmania from the west, cold air covered Tasmania and the rain had mostly cleared.

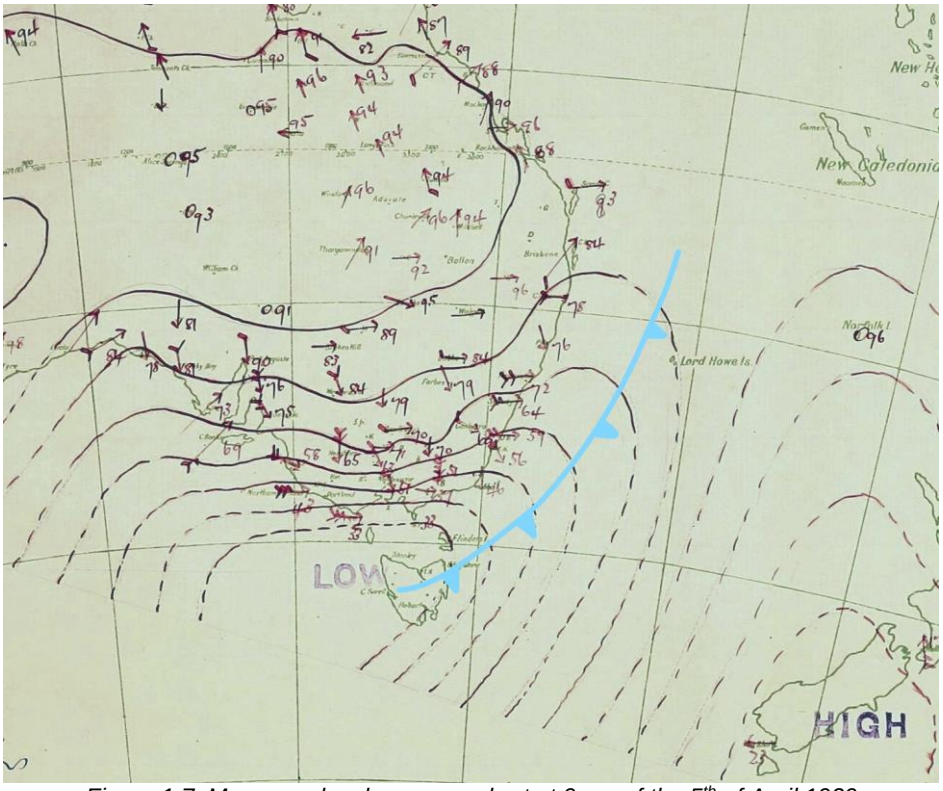


Figure 1.7: Mean sea level pressure chart at 9 am of the 5th of April 1929

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 1.8). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. As can be seen, this was a multi-day rain event with heavy rain developing about the north on the 3rd of April (as the northeasterly flow becomes established), increasing on the 4th of April (as the low deepens to the north), and beginning to ease on the 5th and 6th of April.

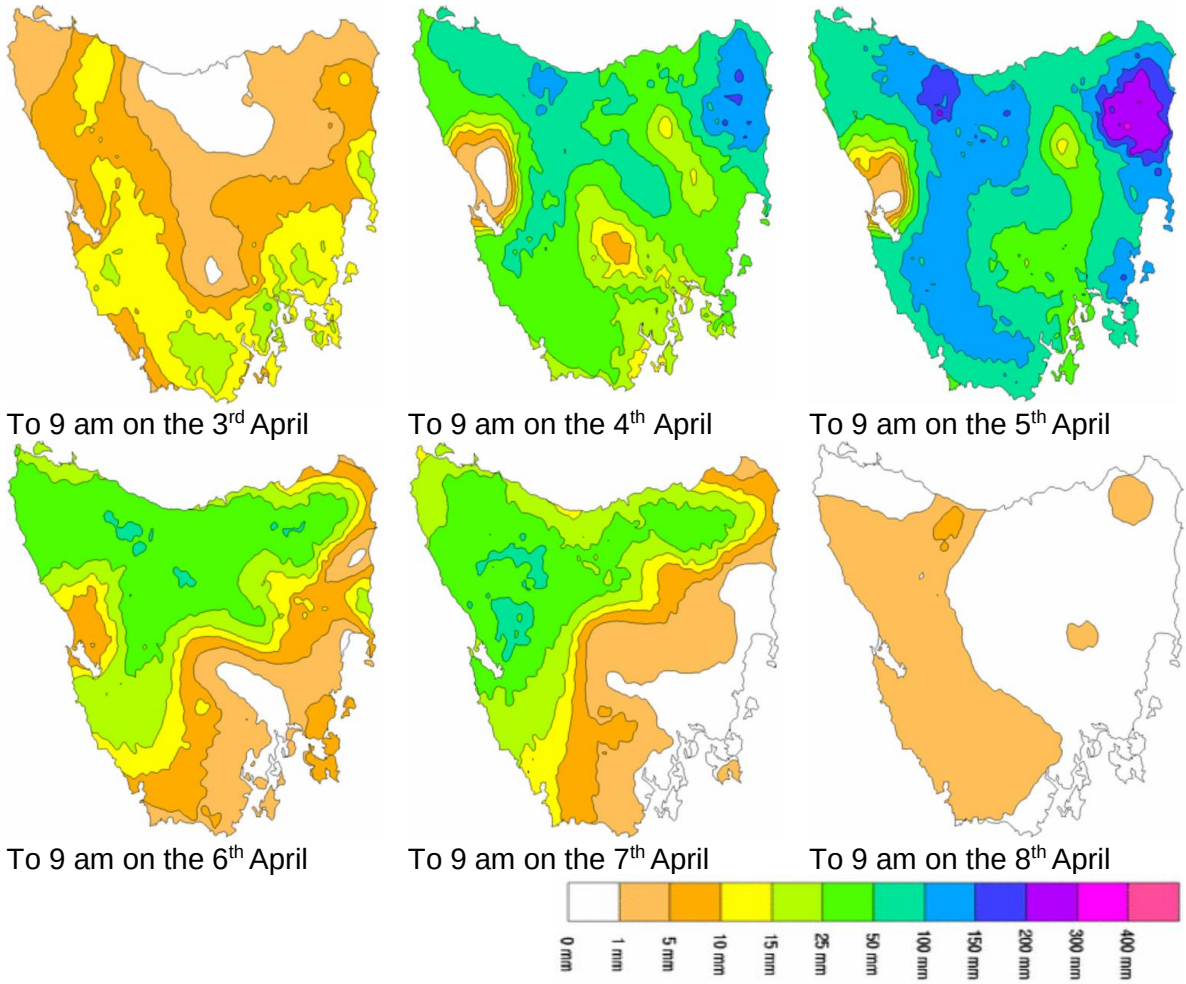
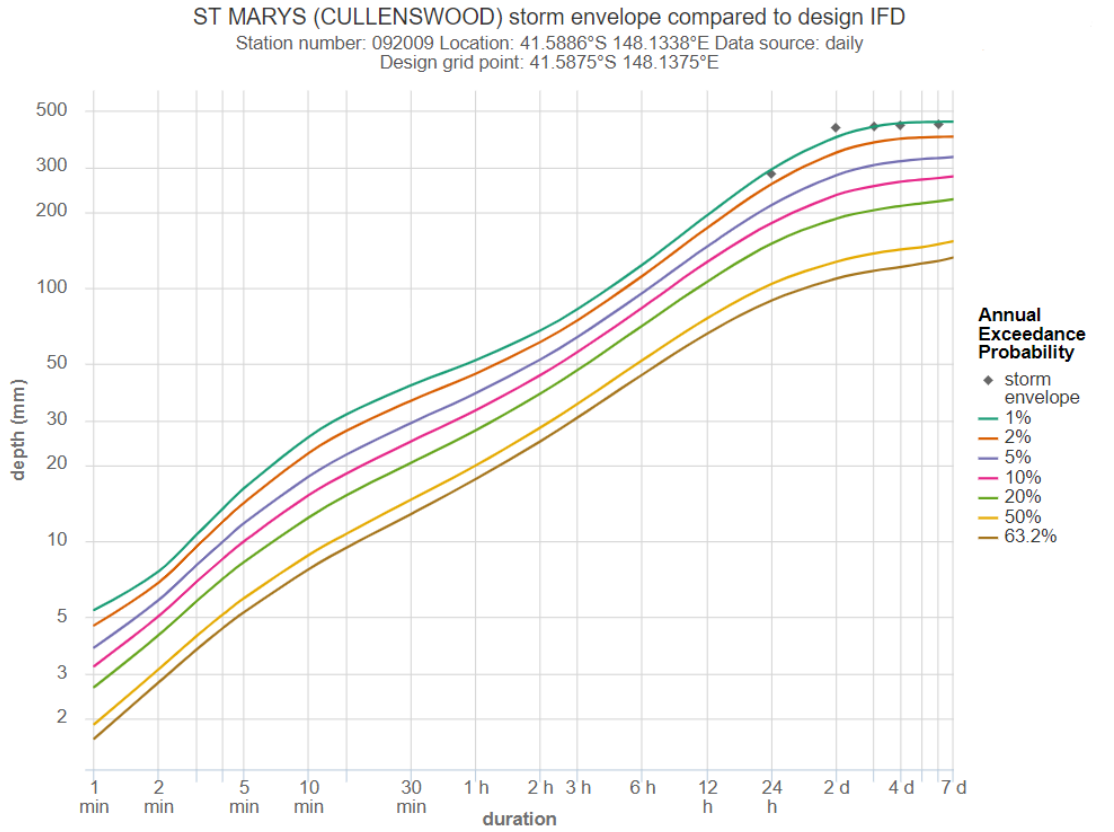


Figure 1.8: 24 hour rainfall to 9 am of the designated date for six days around the event during April 1929.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to Annual Exceedance Probability (AEP) thresholds for St Marys (in the northeast district) and Sheffield (in the northwest district). Note that only restricted 24-hour rainfall rates are available. It can be seen that at both locations, 24 hour rainfall rates from 9 am to 9 am were between 2% and 1%, with 2 to 4 day rates less than 1%.



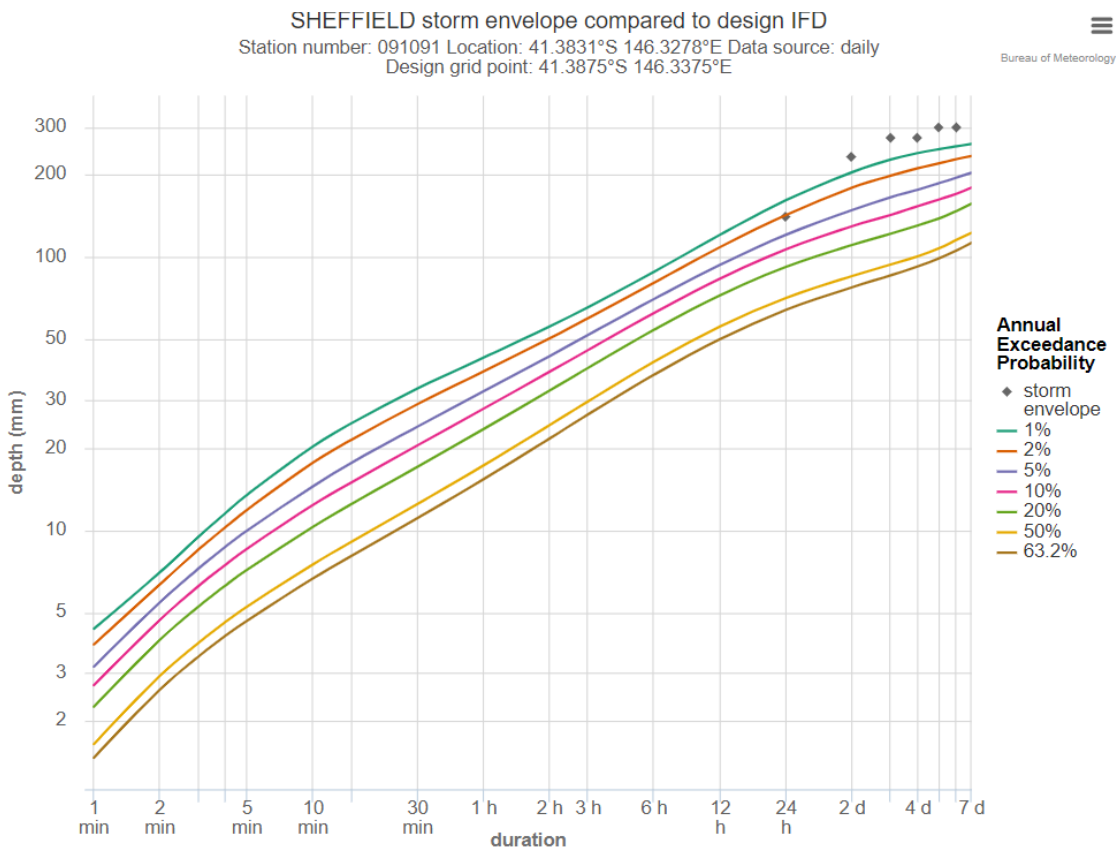


Figure 1.9: Storm envelopes from the 2nd to the 8th for St Marys (top) and Sheffield (bottom).

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- Pluvio, five-minute rainfall accumulation
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

2. February 1946 – King Island

Summary

The most significant recorded rain event on King Island occurred on the 19th of February 1946. Rainfall totals around 150 mm were observed across the island (Figure 2.1). Impacts from the event are unknown. Unfortunately, limited data exists for this event and mean sea level charts cannot be found, however heavy rain at King Island (and across Tasmania more broadly) coincided with a significant flood event at Cowell, South Australia, in the Eyre Peninsula region

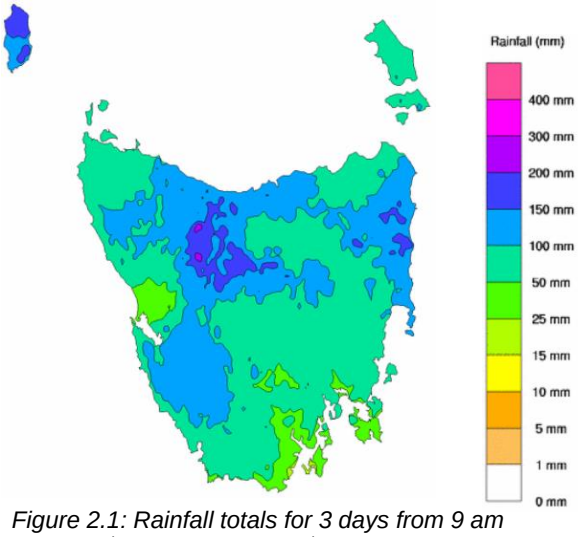


Figure 2.1: Rainfall totals for 3 days from 9 am of the 17th to 9 am of the 19th of February, 1946

Antecedent Conditions

Antecedent rainfall was not particularly unusual. During the six months leading up to the event above average rainfall was recorded across King Island (Figure 2.2).

From the 1st to the 17th of February, King Island had received near half of its average February rainfall (Figure 2.3) with around 10 to 25 mm falling across the island.

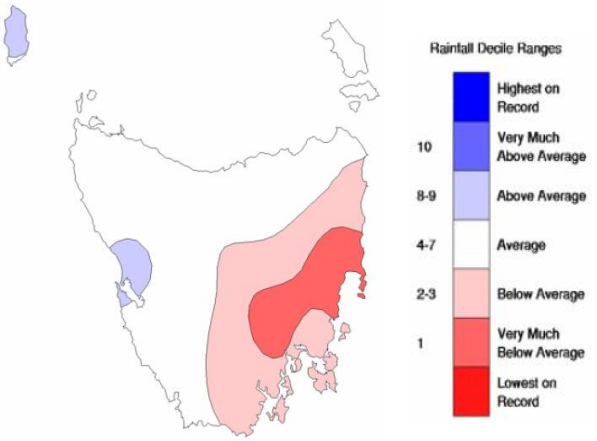


Figure 2.2: Rainfall deciles from 1st July 1945 to 31st January 1946

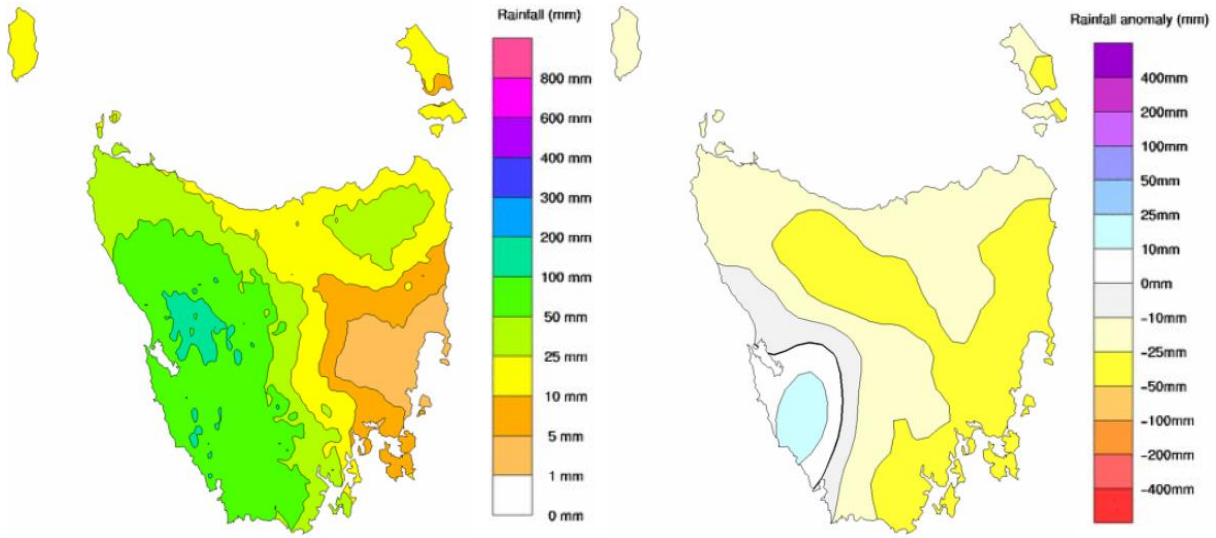


Figure 2.3: The left map shows recorded rainfall across Tasmania from the 1st to 9am of the 17th of February 1946. The right map shows the deviation of the observed rainfall from the February mean (in mm).

Across King Island, the six months leading up to the event were a little wetter than average, however the recent longer days, warmer months and near average rainfall would have acted to reduce soil moisture. Figure 2.4 shows the Bureau's AWRA-L rootzone soil moisture model. Soil moisture values of 60 to 90 mm exist across much of the island.

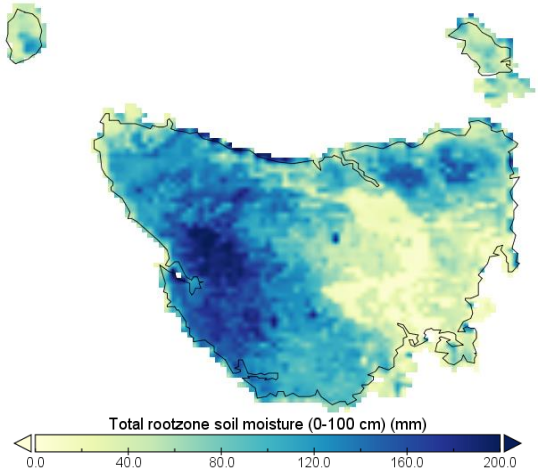


Figure 2.4: AWRA-L Rootzone soil moisture on 18th February 1946.

Meteorological Discussion

No synoptic charts could be found for this event so there is little that can be said for how this event unfolded. However, based on the observed rainfall across Tasmania on the 19th of February 1946, the heaviest rain occurred across the northern and northeastern slopes of north and northeast Tasmania, so it is very likely that a moist northeasterly airstream prevailed during this time. It is quite likely that the rainfall over King Island occurred quite rapidly as a trough of low pressure or a line of thunderstorms crossed.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9 am of the date stated below (Figure 2.5). The three days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. Although around 20 mm of rainfall was observed across the island on 18th February 1946, the bulk of the rain (100 to 150 mm) occurred on 19th February. Note that this was an isolated rain event during the month of February 1946, with little rainfall before or after the event - 10 to 25 mm was recorded for the remainder of the month.

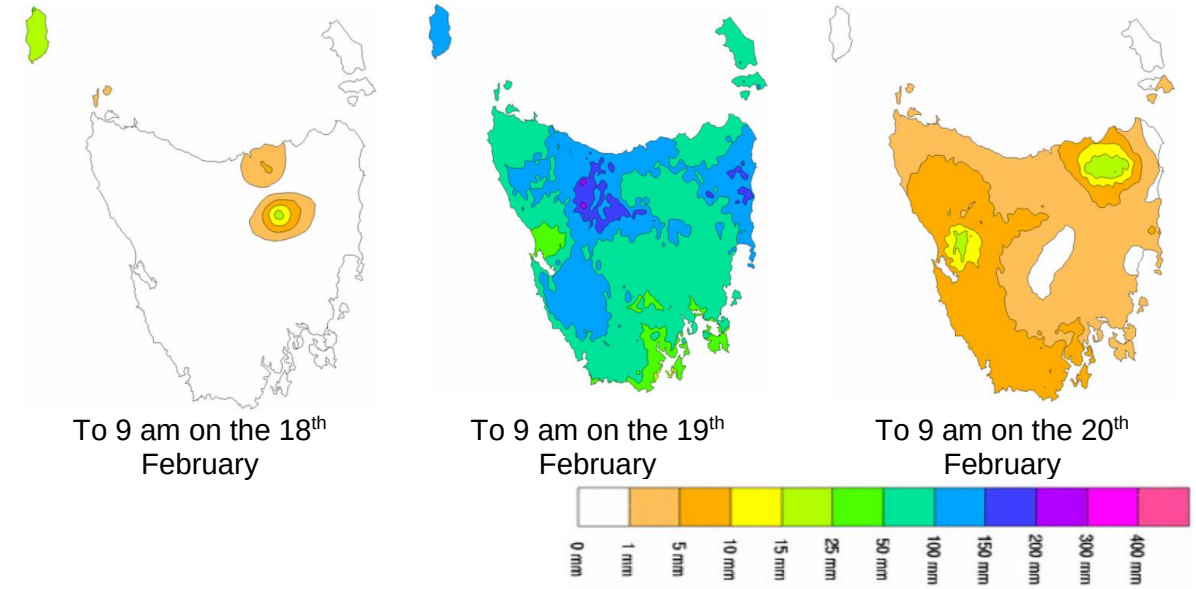


Figure 2.5: 24 hour rainfall to 9 am of the designated date for three days around the event during February 1946.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Naracoopa, eastern King Island (Figure 2.6). Naracoopa received 148.8 mm in the 24 hours to 9am on 19th February 1946. Note that only restricted 24-hour rainfall rates are available. These rainfall rates were less than 1%.

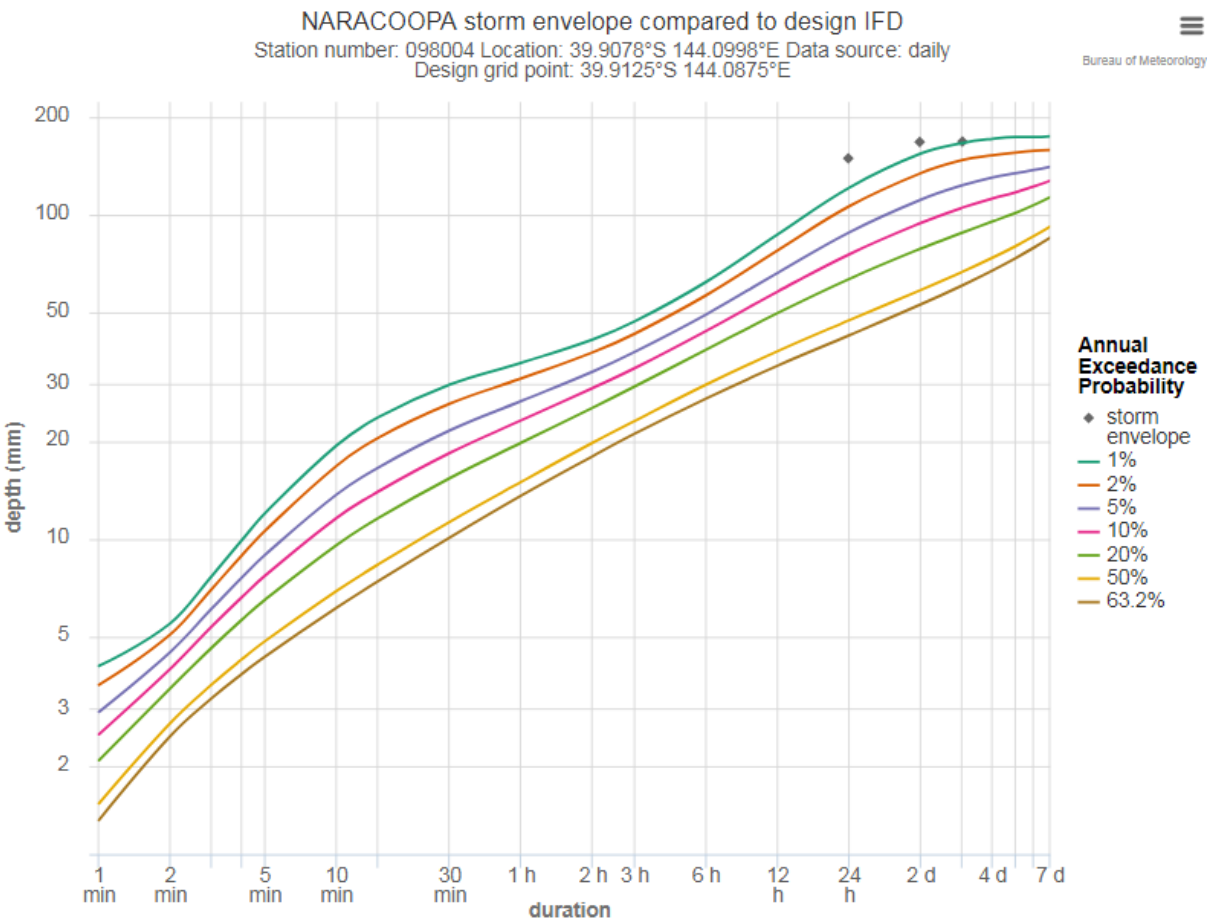


Figure 2.6: Storm envelope for Naracoopa, eastern King Island.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- Pluvio, five-minute rainfall accumulation
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

3. April 1960 – Southeast

Summary

Between the 20th and 23rd of April 1960, very heavy rain across eastern, southern and inland Tasmania resulted in widespread flooding of all Tasmanian rivers, with the Derwent, Macquarie, Elizabeth, Lake and Liffey rivers particularly affected.

According to the DIPEPWE Derwent flood book, the greatest damage occurred in the New Norfolk area where over 250 mm of rain fell in less than 48 hours. At Macquarie Plains, 12 homes were destroyed. In Hobart, rainfall rates of less the 2% AEP were observed for durations of 6 hours and longer. The Hobart Rivulet flooded and there was flooding a metre deep through some city streets. Flooding also extended throughout the East Coast and Midlands.

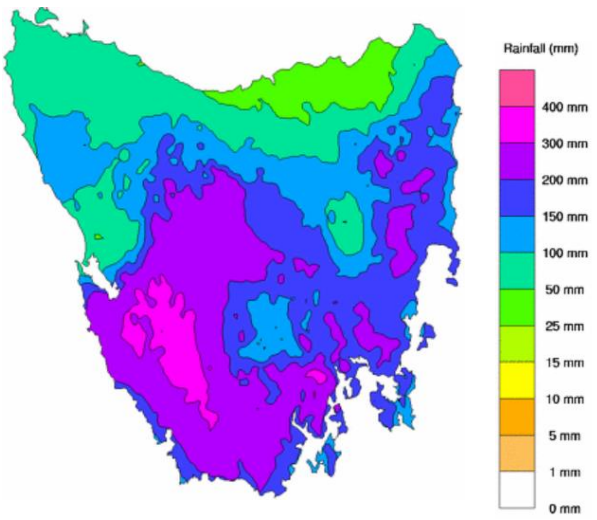


Figure 3.1: Rainfall totals for 2 days from 9 am of the 21st to 9 am of the 23rd of April 1960

Antecedent Conditions

The year leading up to the event had been particularly dry across much of the state, especially across the western half (Figure 3.2).

February and March 1960 were very dry across the east, south and inland areas, with rainfall generally 50 to 100mm below average for those months (Figure 3.3). Below average rainfall continued throughout April until the event occurred, particularly in the east.

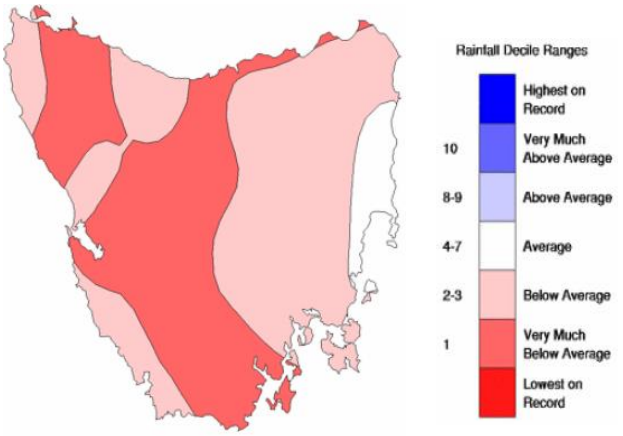


Figure 3.2: Rainfall deciles from 1 April 1959 to 31 March 1960

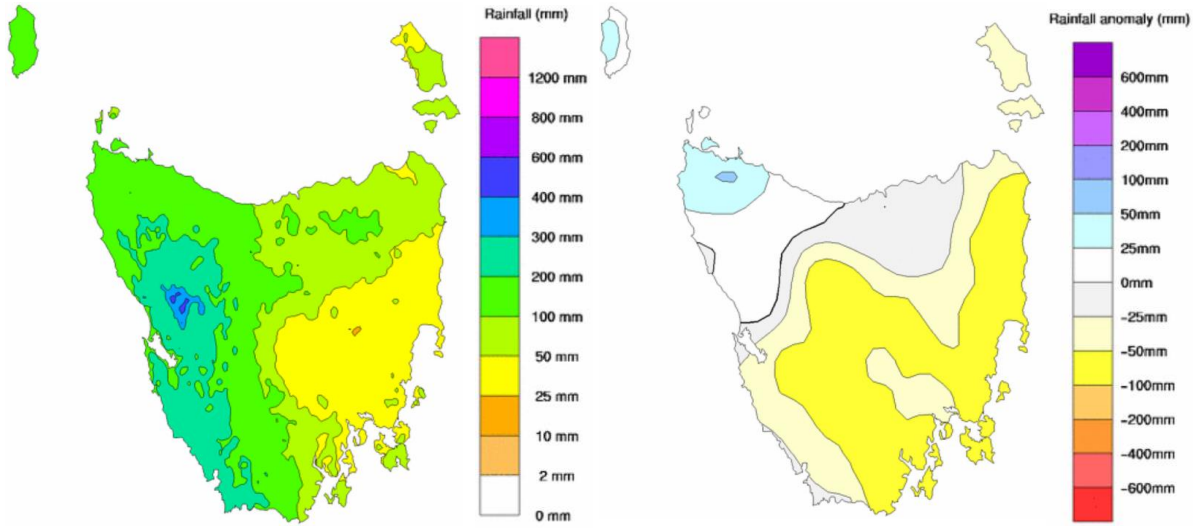


Figure 3.3: The left map shows recorded rainfall across Tasmania over the months of February and March 1960. The right map shows the deviation of the observed rainfall from the February and March mean (in mm).

The year proceeding the event was dry across most of Tasmania, particularly in the west, so rootzone soil moisture was relatively low across areas of lower elevations. Figure 3.4 shows the Bureau's AWRA-L rootzone soil moisture model. Here, areas of lower elevation have soil moisture of less than 40 mm. Despite dry conditions soil moisture in the west is generally above 150 mm.

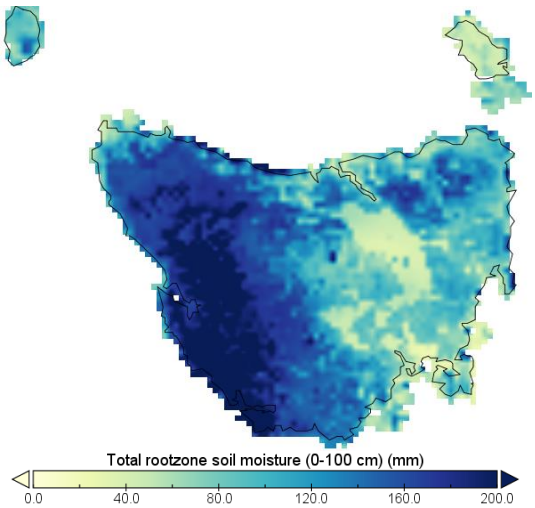


Figure 3.4: AWRA-L Rootzone moisture on 21st April 1960

Meteorological Discussion

During the 20th of April 1960, a high-pressure centre had established near New Zealand and had extended a ridge well north towards the Queensland coast (Figure 3.5). This, in conjunction with a trough that extended down interior parts of Queensland and New South Wales to a low over Victoria, directed a very moist, tropical airstream toward southeast Australia and the western Tasman Sea. Meanwhile, a high over the Bight brought a cold pool of air to western Victoria and South Australia.

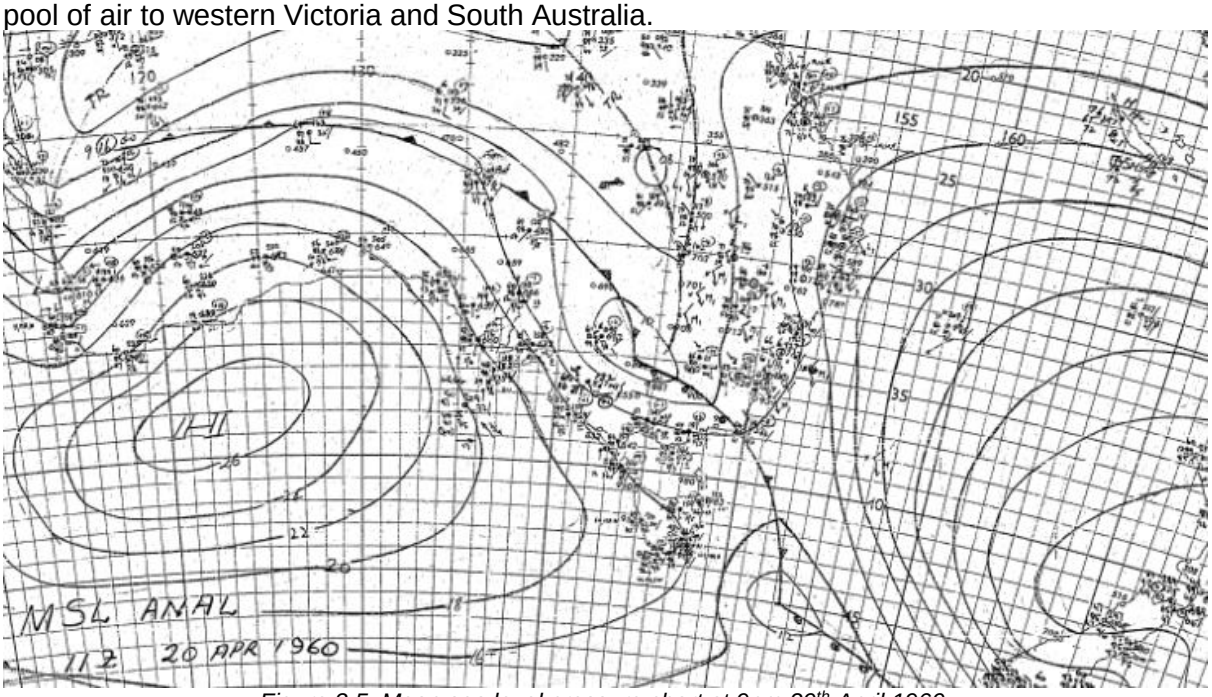


Figure 3.5: Mean sea level pressure chart at 9pm 20th April 1960.

Late on the 20th, the low over Victoria began to move toward Bass Strait. The general pressure field during this time was highly conducive to the development of the low and with cold air wrapping into the low from the northwest flank, and a warm, moist infeed into the low from the east, the low began to rapidly intensify. By 9 pm on the 21st, a deep low centre had established over Bass Strait (Figure 3.6). This low directed a very moist and strong east to southeasterly airstream over Tasmania, bringing heavy rain to much of the State. Rainfall was particularly heavy across the upper east coast where the moist, onshore flow interacted with the topography and helped to extract rainfall from the flow. 100 to 200 mm was recorded across the upper east coast during this time.

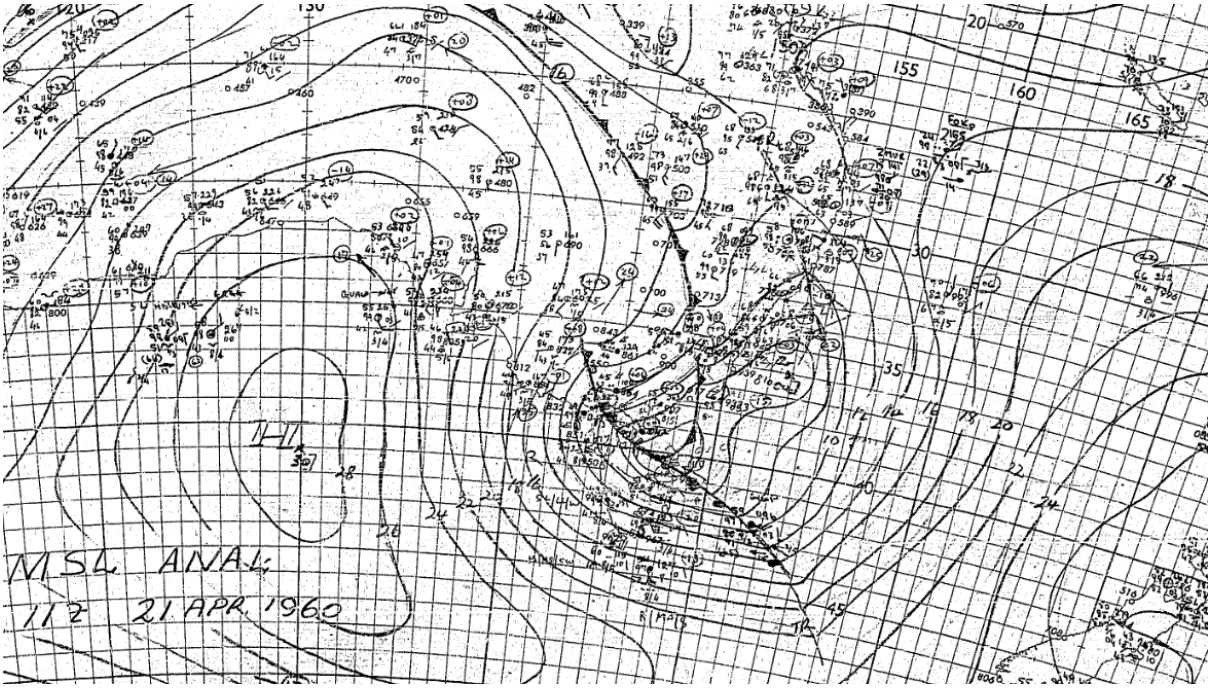


Figure 3.6: Mean sea level pressure chart at 9pm 21st April 1960.

During the 22nd of April, the low had moved to the east of Tasmania with the airstream tending to a strong and moist southeasterly (Figure 3.7). This shifted the heaviest rainfall toward the south and southeastern areas of the State, where generally 100 to 200 mm was recorded in the 24 hours to 9am on the 23rd.

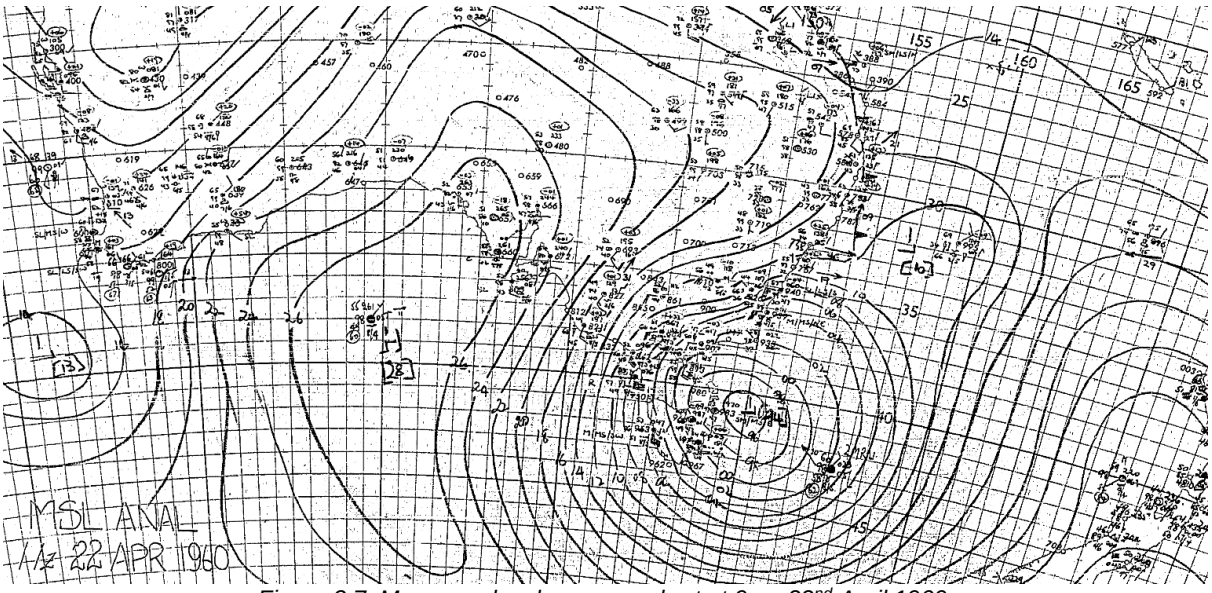


Figure 3.7: Mean sea level pressure chart at 9pm 22nd April 1960.

Finally, by the morning of the 23rd rainfall had eased as the low had begun to retreat toward the east and a ridge of high pressure advanced over southern Tasmania, bringing a drier southerly across the State (Figure 3.8).

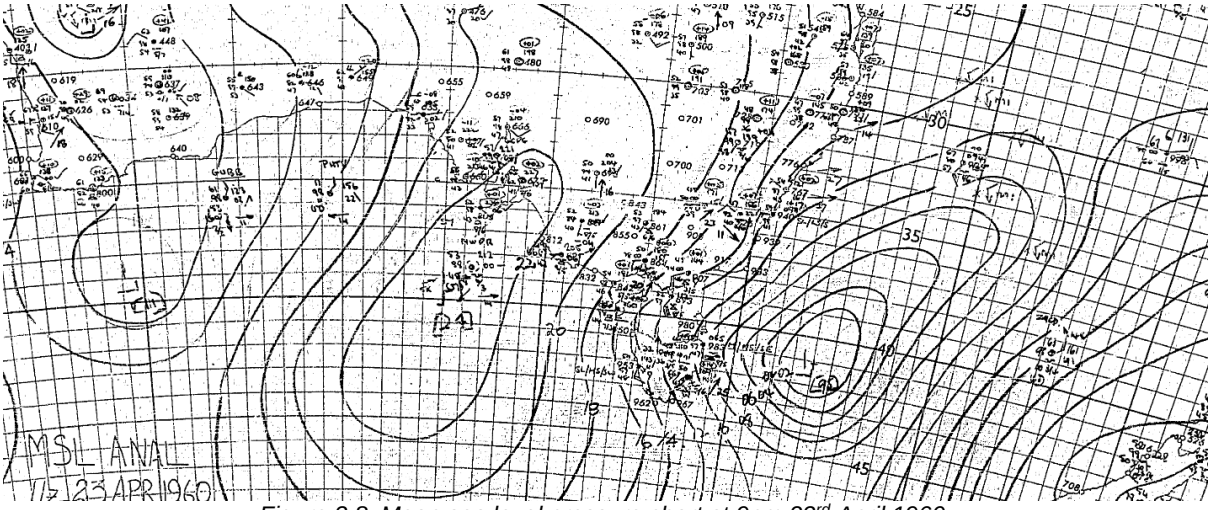


Figure 3.8: Mean sea level pressure chart at 9pm 23rd April 1960.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9 am of the date stated below (Figure 3.9). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. As can be seen, heavy rain occurred across much of the State during the 48 hours from 9 am 21st to 9 am 23rd April. The heaviest rain occurs across the upper east during the 21st when the airstream is easterly, then the focus shifts to the south on the 22nd when the airstream tends southeasterly.

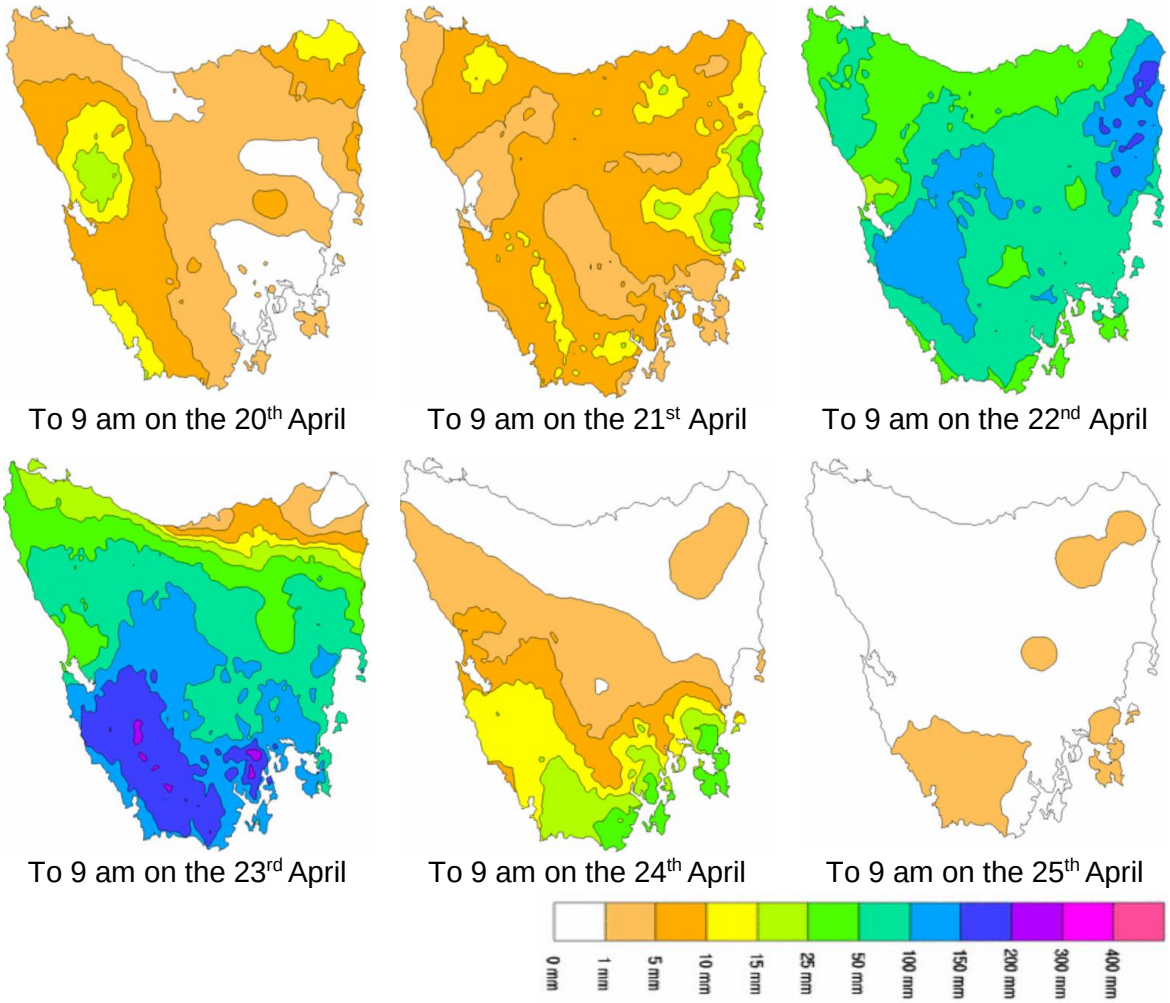


Figure 3.9: 24 hour rainfall to 9 am of the designated date for six days around the event during April 1960.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Hobart and Butlers Gorge. Also shown are the rainfall accumulations for these sites. A pluviometer at Hobart provides 6-minute accumulation data, however only restricted 24-hour accumulations are available at Butlers Gorge. The storm envelope at Hobart (Figure 3.10) shows that rainfall rates reach the 2% AEP threshold at durations of 6 hours, with rainfall rates near or less than 1% at durations of 9 hours and beyond. The accumulated rainfall at Hobart (Figure 3.11) shows that continuously heavy rainfall began on the evening of the 21st of April 1960, then became exceptionally heavy on the afternoon of the 22nd, easing during the morning of the 23rd. At Butlers Gorge, rain rates were near or less than 1% AEPs for durations of one to three days. Note that these are restricted 24-hour rainfall rates.

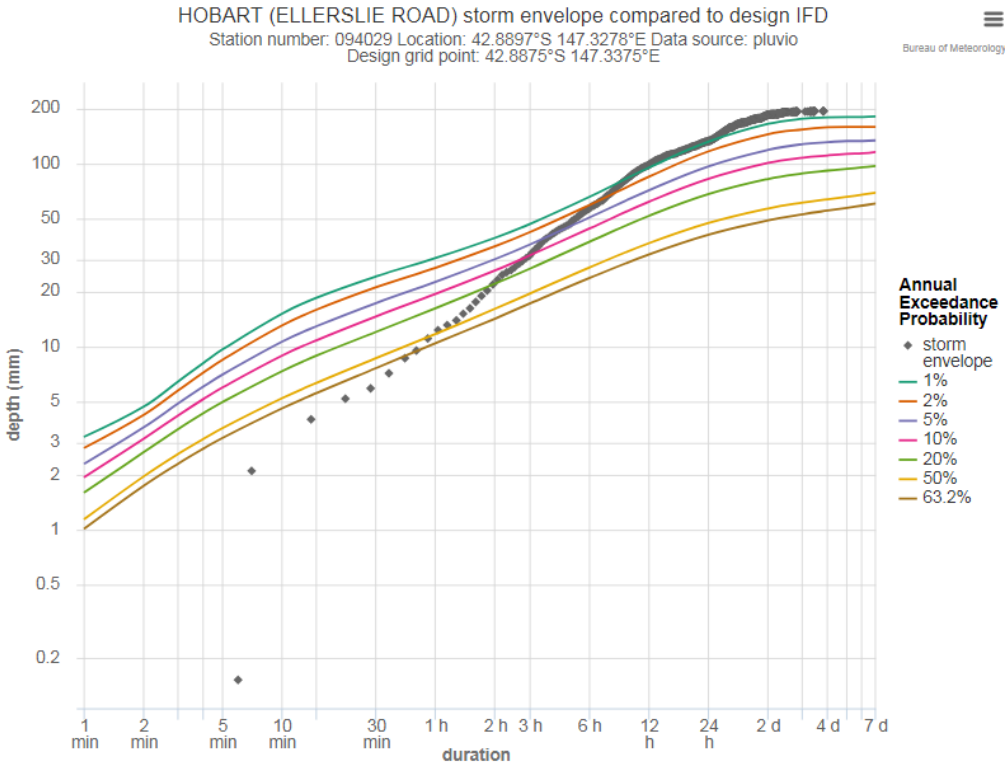


Figure 3.10: Storm envelope for Hobart (Ellerslie Road)

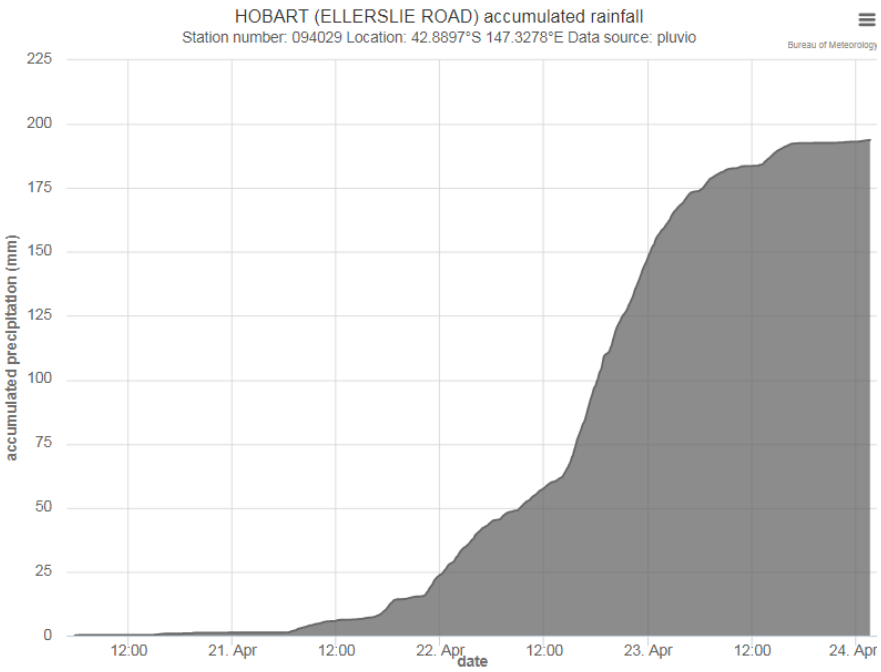


Figure 3.11: Rainfall accumulation at Hobart (Ellerslie Road)

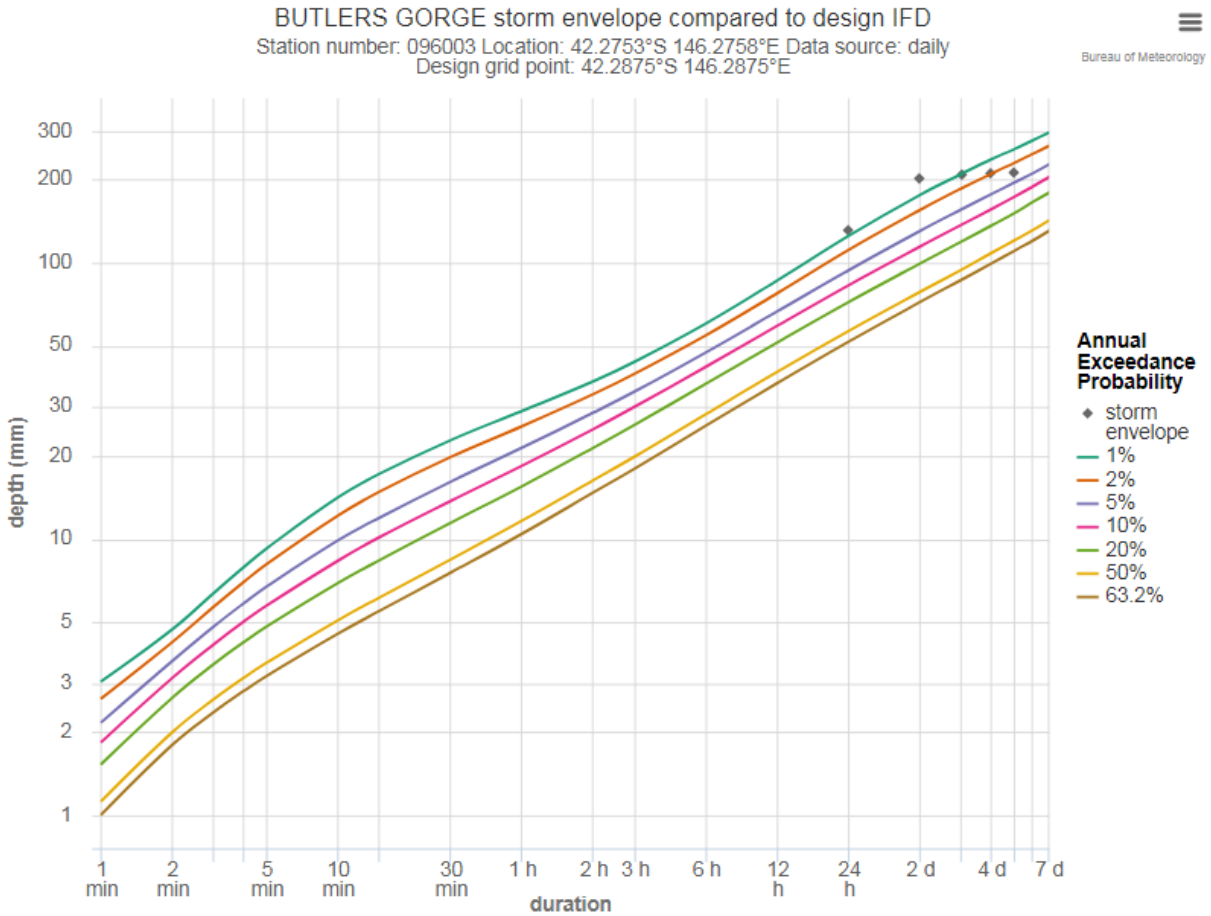


Figure 3.12: Storm envelope for Butlers Gorge

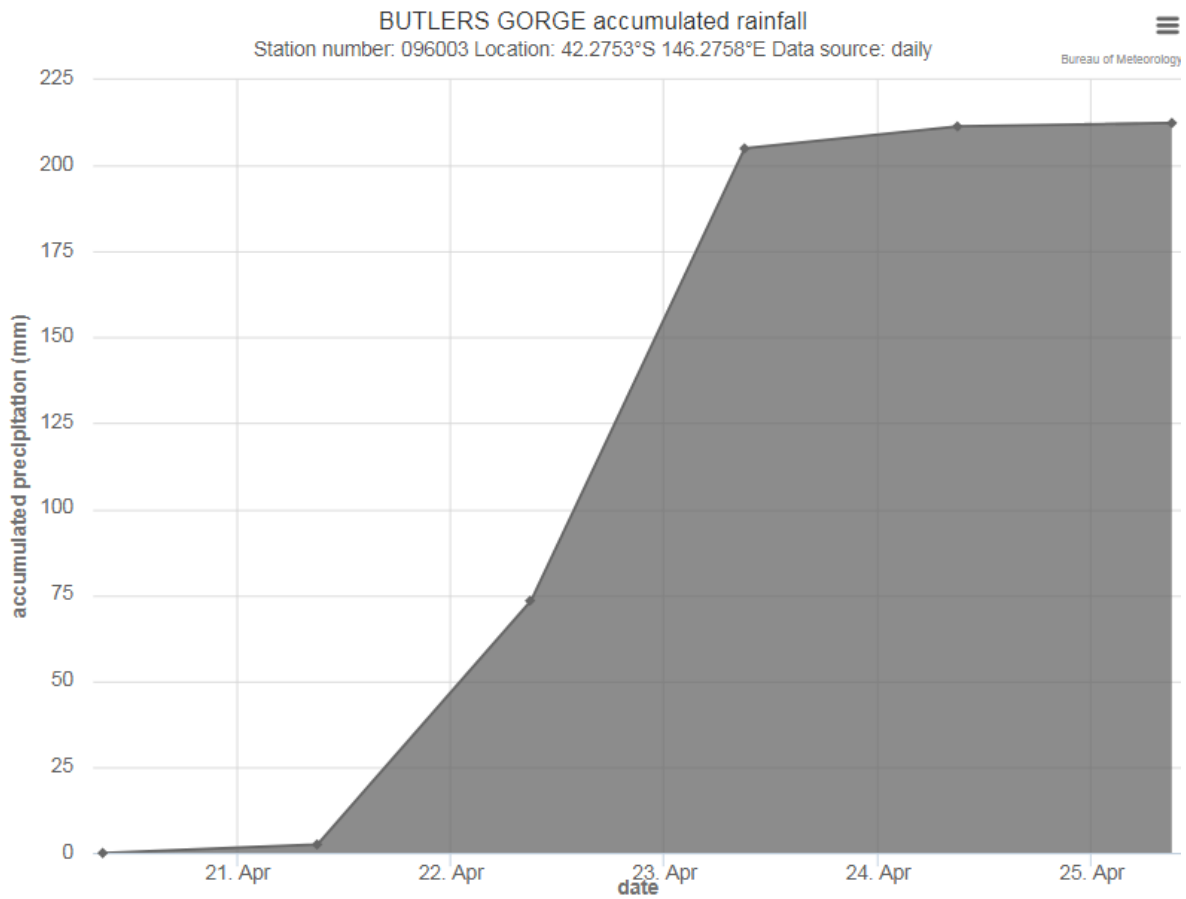


Figure 3.13: Storm envelope for Butlers Gorge

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- Pluvio, five-minute rainfall accumulation
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

4. May 1969 – East Coast

Summary

During May 1969, a series of heavy rain events occurred across eastern Tasmania. In mid-May, 50 to 200 mm of rainfall was recorded about the east. This is not too atypical of rainfall behavior in the east, however it was enough to dramatically increase soil moisture ahead of a more significant rain event.

On the 29th of May 1969, an East Coast Low passed to the northeast of Tasmania, bringing generally 200 to 300 mm of rainfall to northeastern elevated areas over a two day period (Figure 4.1). The highest observed rainfall rate was at St Marys (Cullenswood) with 211mm over 24 hours. It was reported that this event resulted in the biggest South Esk flood since 1929.

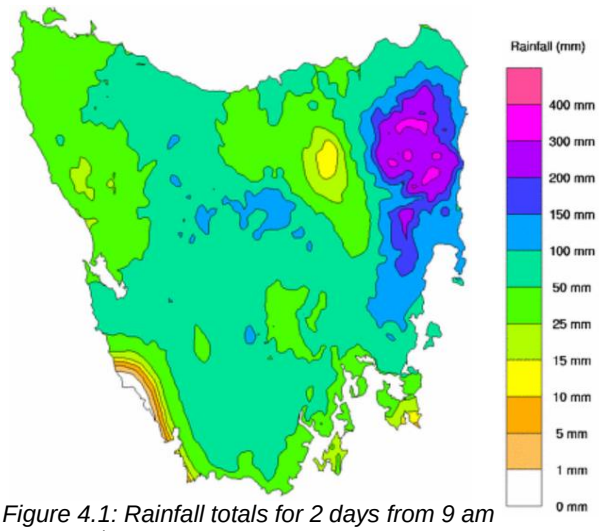


Figure 4.1: Rainfall totals for 2 days from 9 am of the 29th to 9 am of the 31st May 1969

Antecedent Conditions

During the eight months leading up to May 1969, very wet conditions had persisted across the western half of Tasmania, with near average conditions about the east (Figure 4.2).

Throughout April 1969, conditions were drier than average in the north and east, but wetter than average about the west and south.

During the first half of May, generally dry conditions prevailed about the State, particularly in the west (Figure 4.3).

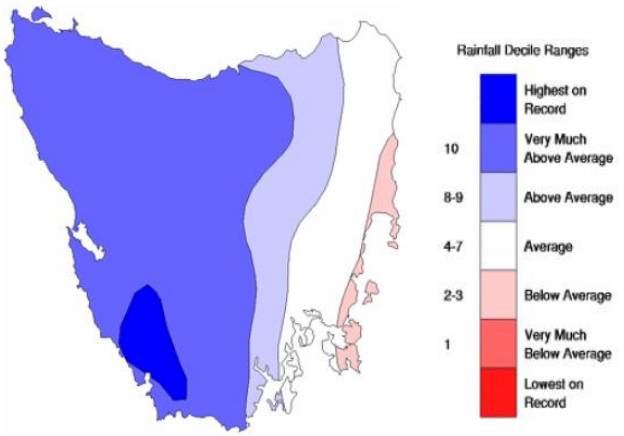


Figure 4.2: Rainfall deciles from 1 August 1968 to 30 April 1969

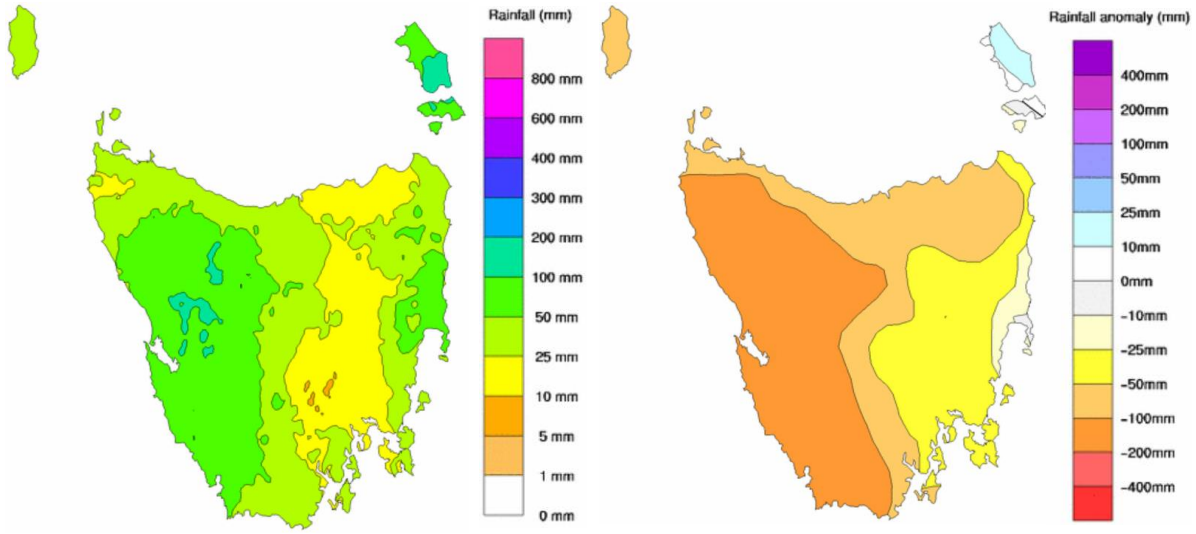


Figure 4.3: The left map shows recorded rainfall across Tasmania from the 1st to the 16th of May, 1969, with the right map showing the deviation from the May mean (in mm)

However, the second half of May became increasingly wet in the east of Tasmania with a significant rain event bringing 50 to 200 mm to much of the east in the 24 hours to 9 am on 17th May, so that leading into the major rain event at the end of May much of eastern Tasmania had already received 50 to 100 mm of rainfall above the May average (Figure 4.4).

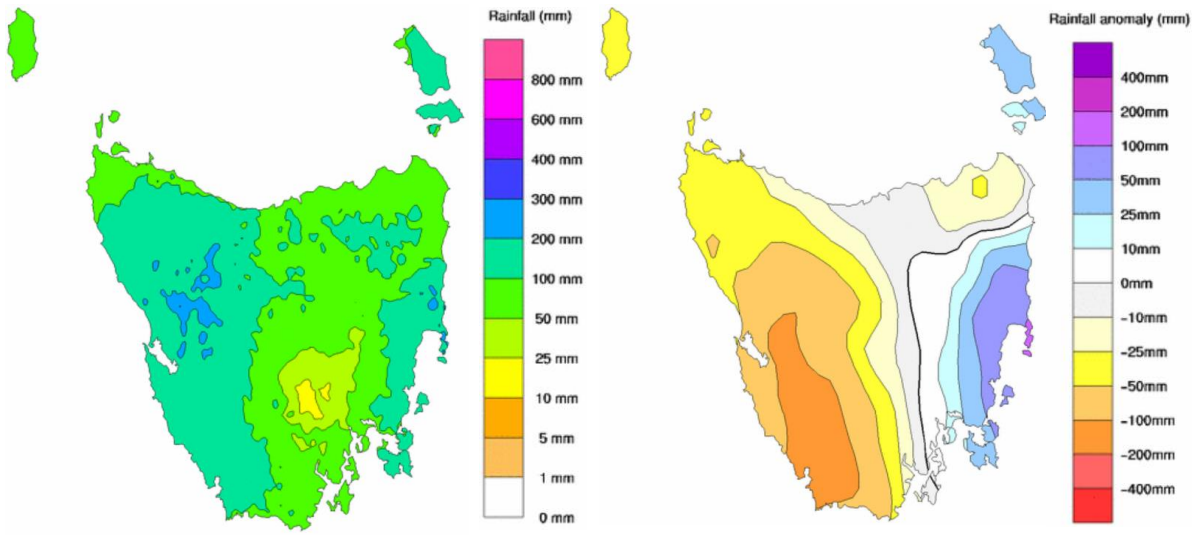


Figure 4.4: The left map shows recorded rainfall across Tasmania from the 1st to the 28th of May, 1969, with the right map showing the deviation from the May mean (in mm)

Although rainfall about the east had been below average during the eight months to the end of April 1969, a rain event in mid-May brought high levels of rootzone soil moisture to much of the east just ahead of the major rain event. Figure 4.5 shows the Bureau's AWRA-L rootzone soil moisture model. Here, much of the east has soil moisture of around 100 to 150 mm whereas soil moisture throughout the Midlands is still quite low – near 55 mm. Soil moisture throughout the north and west is high due to the wet antecedent conditions.

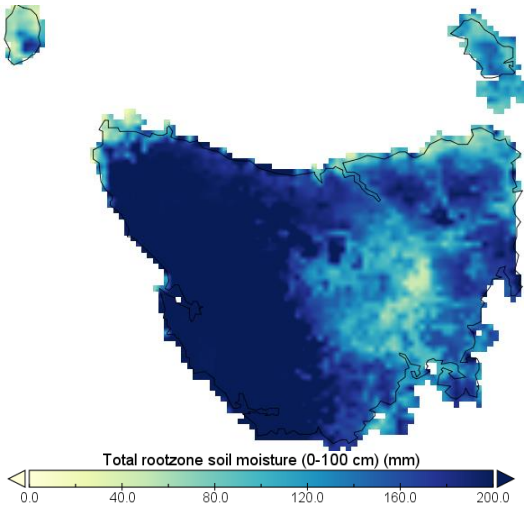


Figure 4.5: AWRA-L Rootzone soil moisture on 28th May 1969

Meteorological Discussion

This heavy rain event was generated by an East Coast Low; a meteorological setup that is very typical of most other heavy rain events across eastern Tasmania. During the 28th and 29th of May 1969, a cold front swept across southeastern Australia and ran into a ridge of high pressure that extended northwards across the Tasman Sea (Figure 4.6 and Figure 4.7). The ridge 'cradled' the cold pool of air, holding it in place to the northeast of Tasmania. This resulted in the rapid deepening of a low-pressure centre along the eastern Victorian coast during the 29th of May (Figure 4.7).

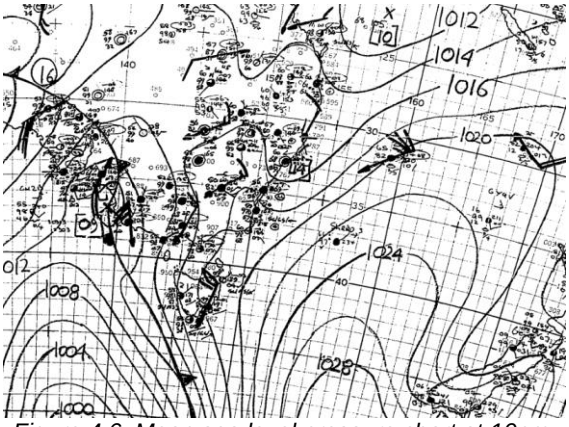


Figure 4.6: Mean sea level pressure chart at 10pm 28th May 1969

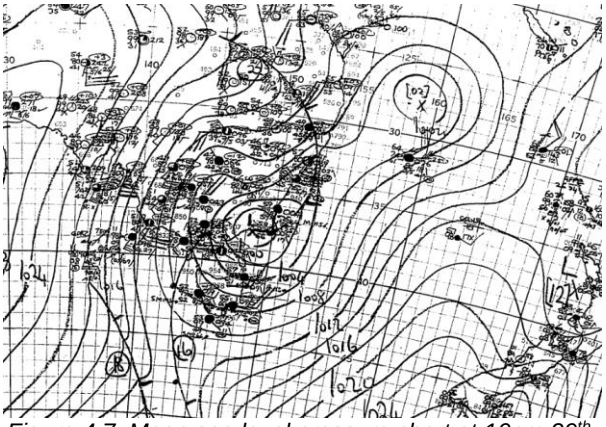


Figure 4.7: Mean sea level pressure chart at 10pm 29th May 1969

The low then slowly moved to the east of Flinders Island during the 30th of May and was held in place there by the high-pressure ridge now positioned over New Zealand and to the south of Tasmania (Figure 4.8). The combination of the low centre and the ridge of high-pressure resulted in a very strong pressure gradient across the northern half of Tasmania on the 30th of April, as can be seen by the very close isobars on the synoptic chart (Figure 4.8). This strong pressure gradient generated strong and moist east to northeasterly winds over the northern half of Tasmania, resulting in rain across Tasmania with exceptionally heavy rainfall about windward elevated terrain in the northeast as the airstream interacted with topography. Note that strong airstreams generally result in higher rainfall than weak airstreams as more total moisture is being directed onto the land. The airstream tended more southeasterly and began to ease during the 31st of May (Figure 4.9).

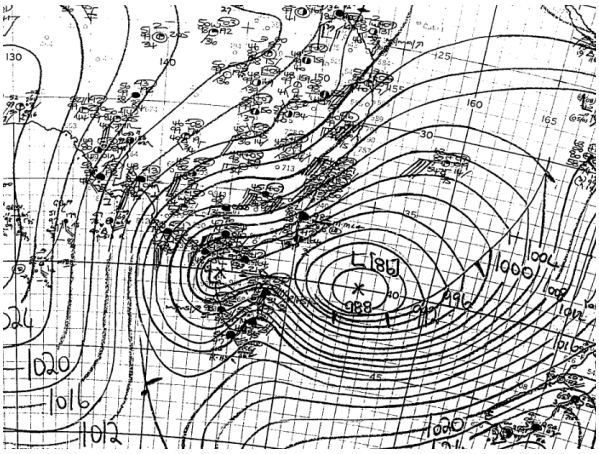


Figure 4.8: Mean sea level pressure chart at 10pm 30th May 1969

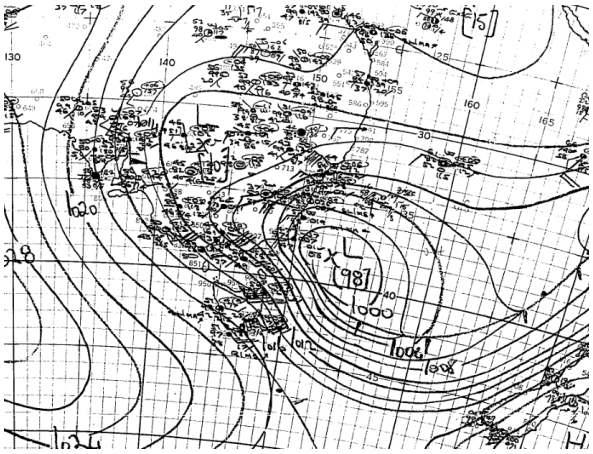


Figure 4.9: Mean sea level pressure chart at 10pm 31st May 1969

The low then moved off to the east-northeast and over the next few days and rainfall rapidly eased.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 4.10). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. Rainfall began about windward, elevated parts of northern and northeastern Tasmania during 28th and early 29th of May 1969 as the northeasterly airstream established. Then continuous and very heavy rainfall developed about elevated areas in the northeast later on the 29th as the low centre drew close and directed a very strong east to northeasterly airstream. Rain then eased early on the 31st as the low moved away.

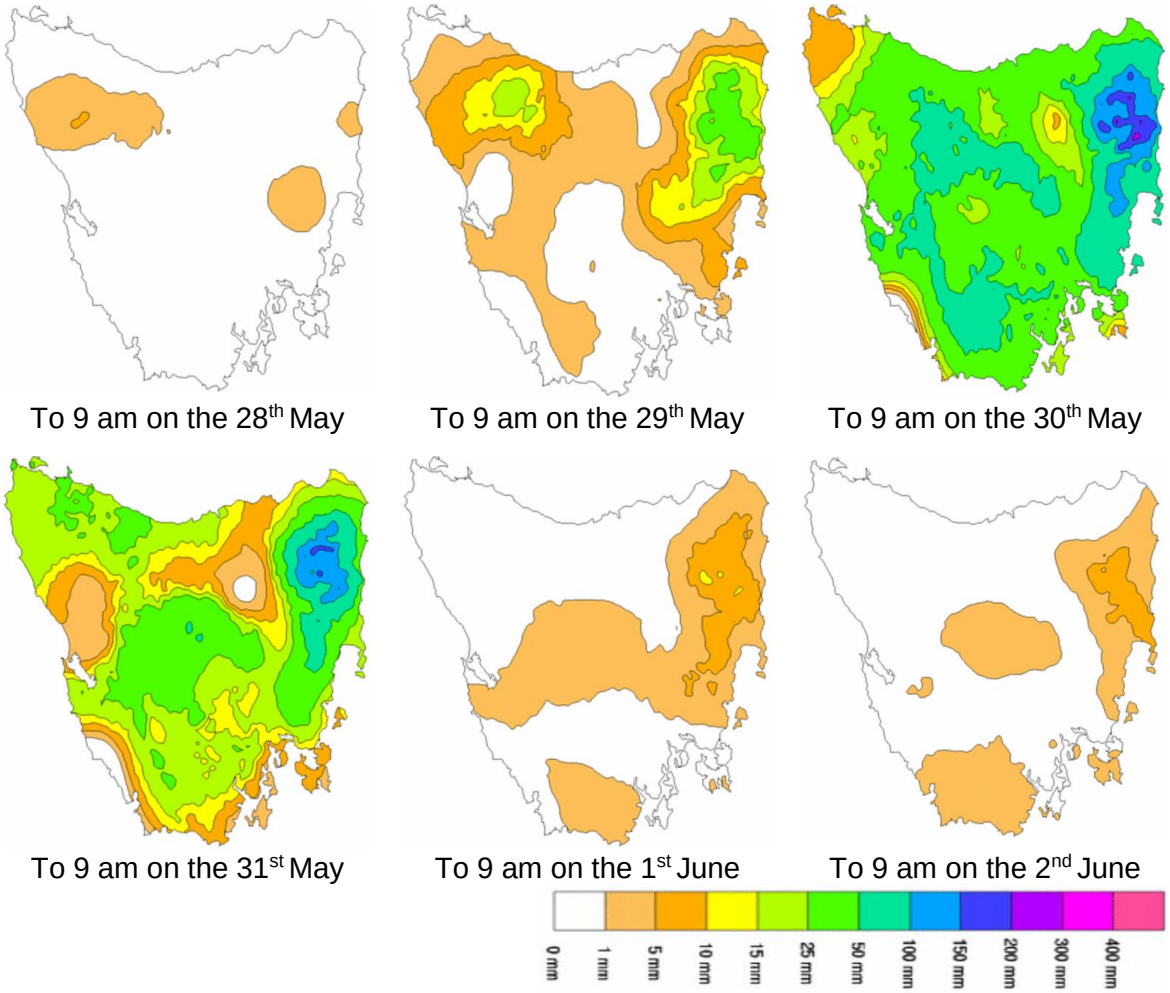


Figure 4.10: 24 hour rainfall to 9 am of the designated date for six days around the event during May and June 1969

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Mount Victoria and St Marys (Cullenswood). Also shown are the rainfall accumulations for these sites. A pluviometer at Mount Victoria provides 6-minute accumulation data, however only restricted 24-hour accumulations are available at St Marys. The storm envelope and accumulation graph at Mount Victoria (Figure 4.11 and Figure 4.12) show that heavy rain began on the of the 29th of May and maintained a near continuous high rainfall rate until the morning of the 31st. Rainfall rates reach a 2% AEP at durations of around 36 hours and beyond.

St Marys (Cullenswood) recorded 211 mm in the 24 hours to 9 am of the 30th of May 1969, however this restricted rainfall rate only corresponds to an AEP of near 5% (Figure 4.13 and Figure 4.14).

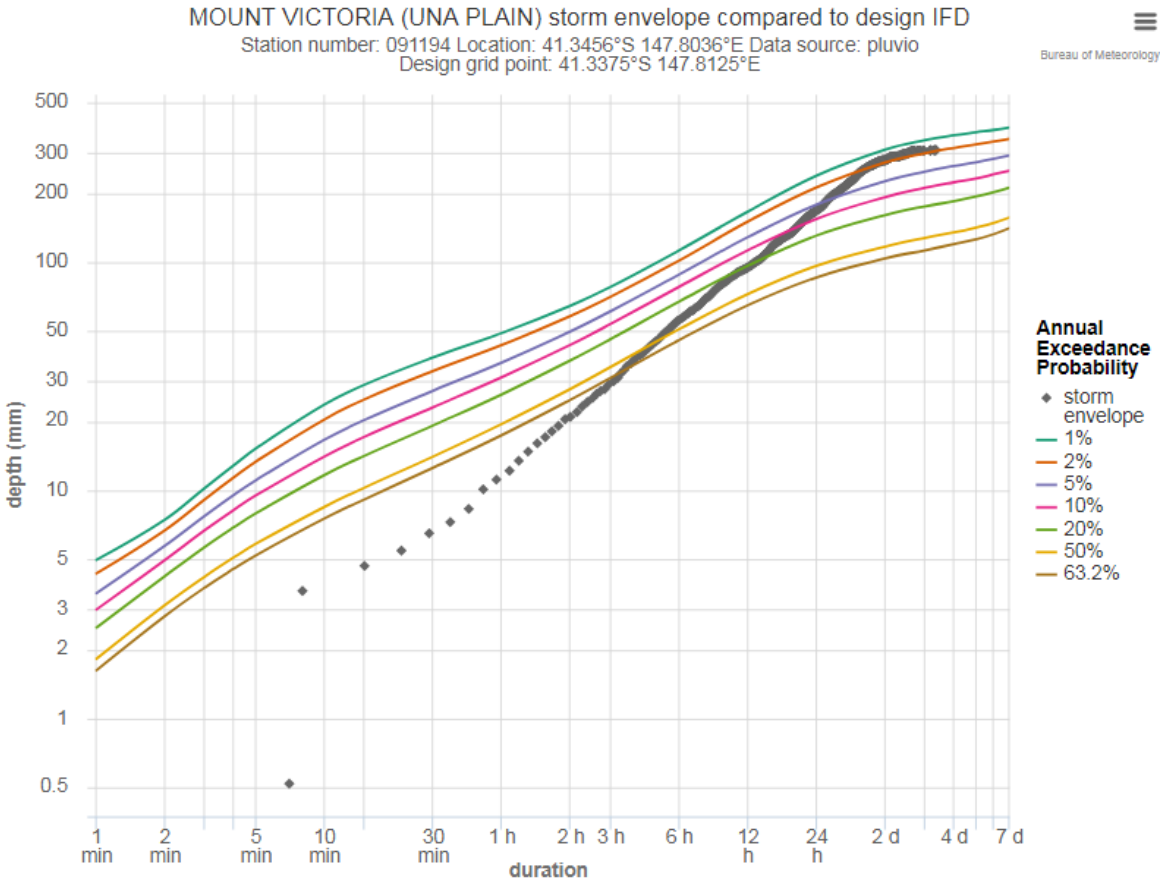


Figure 4.11: Storm envelope for Mount Victoria

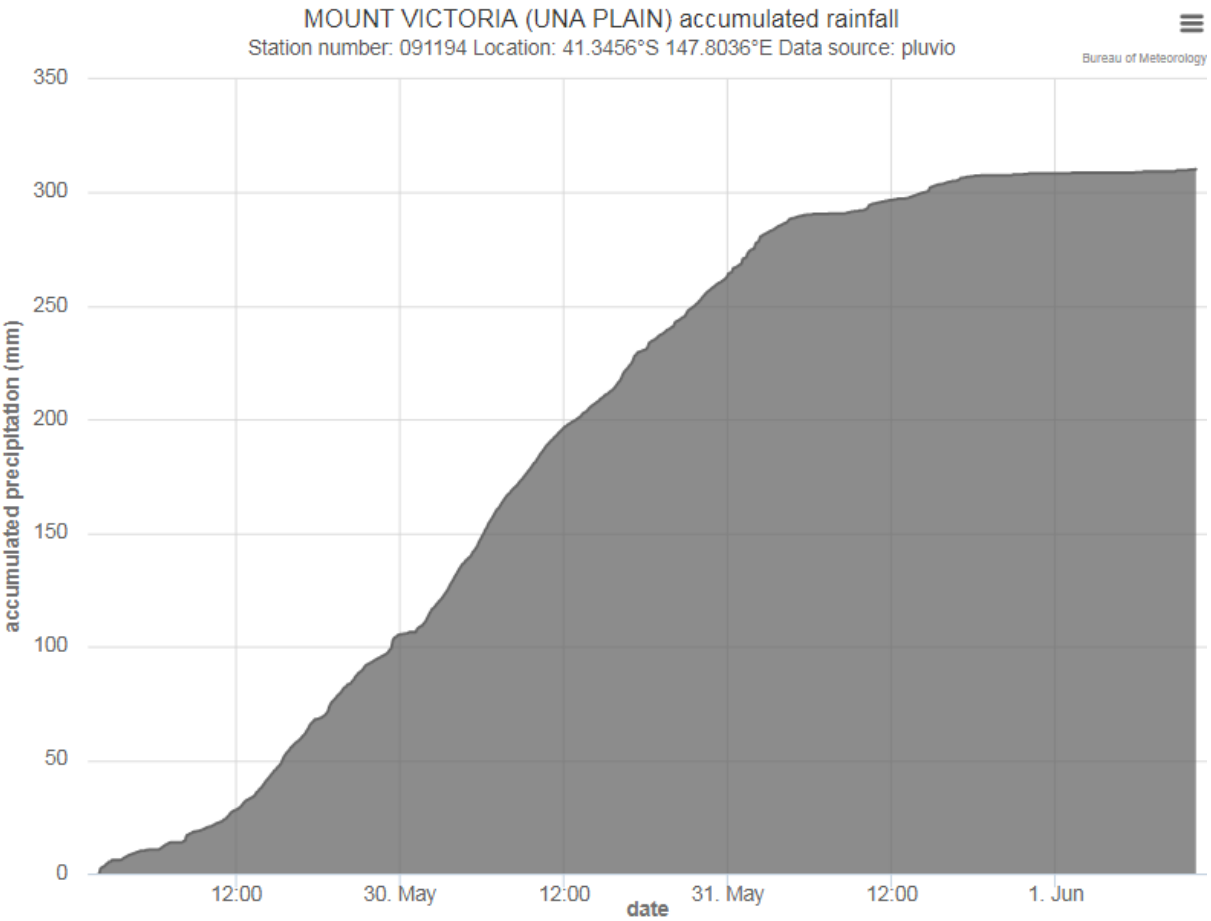


Figure 4.12: Rainfall accumulation at Mount Victoria

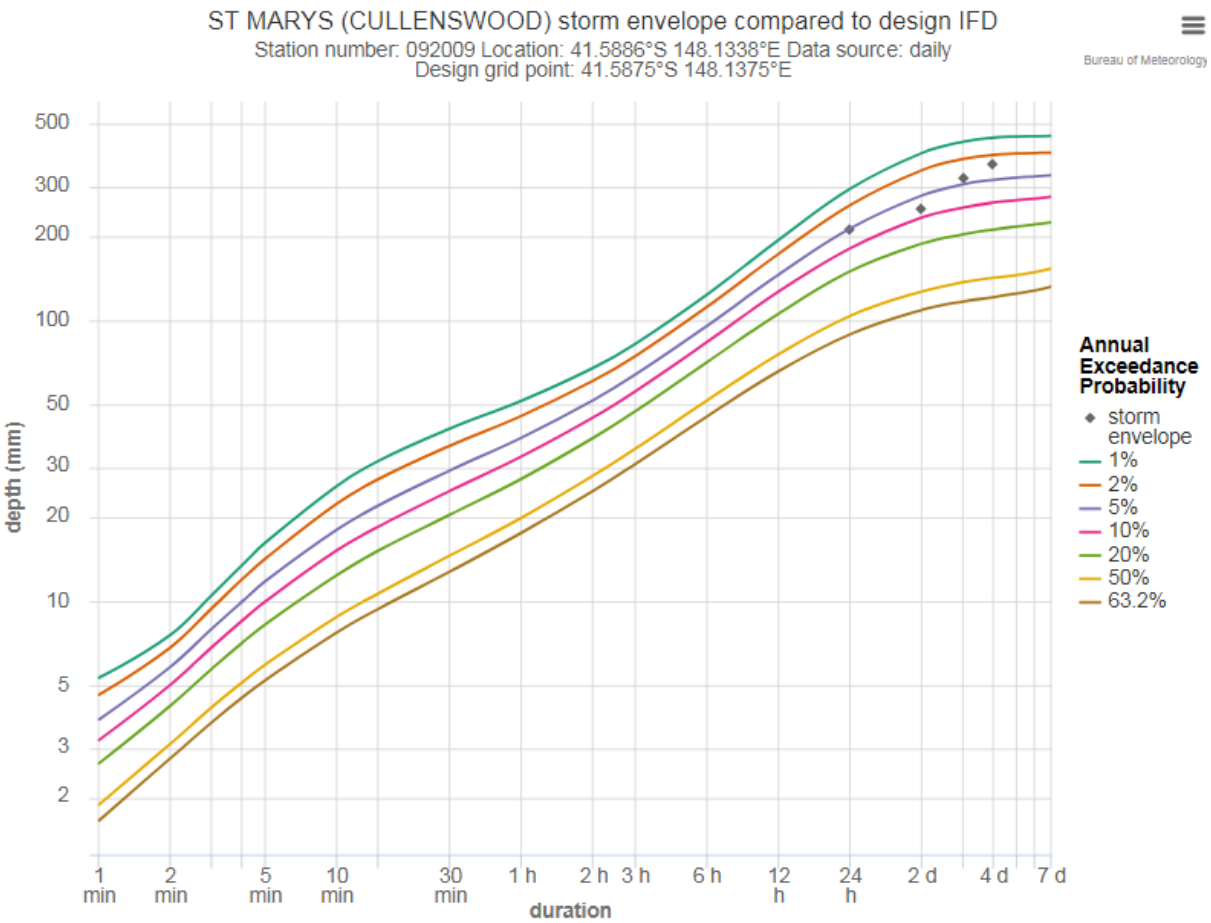


Figure 4.13: Storm envelope for St Marys (Cullenswood)

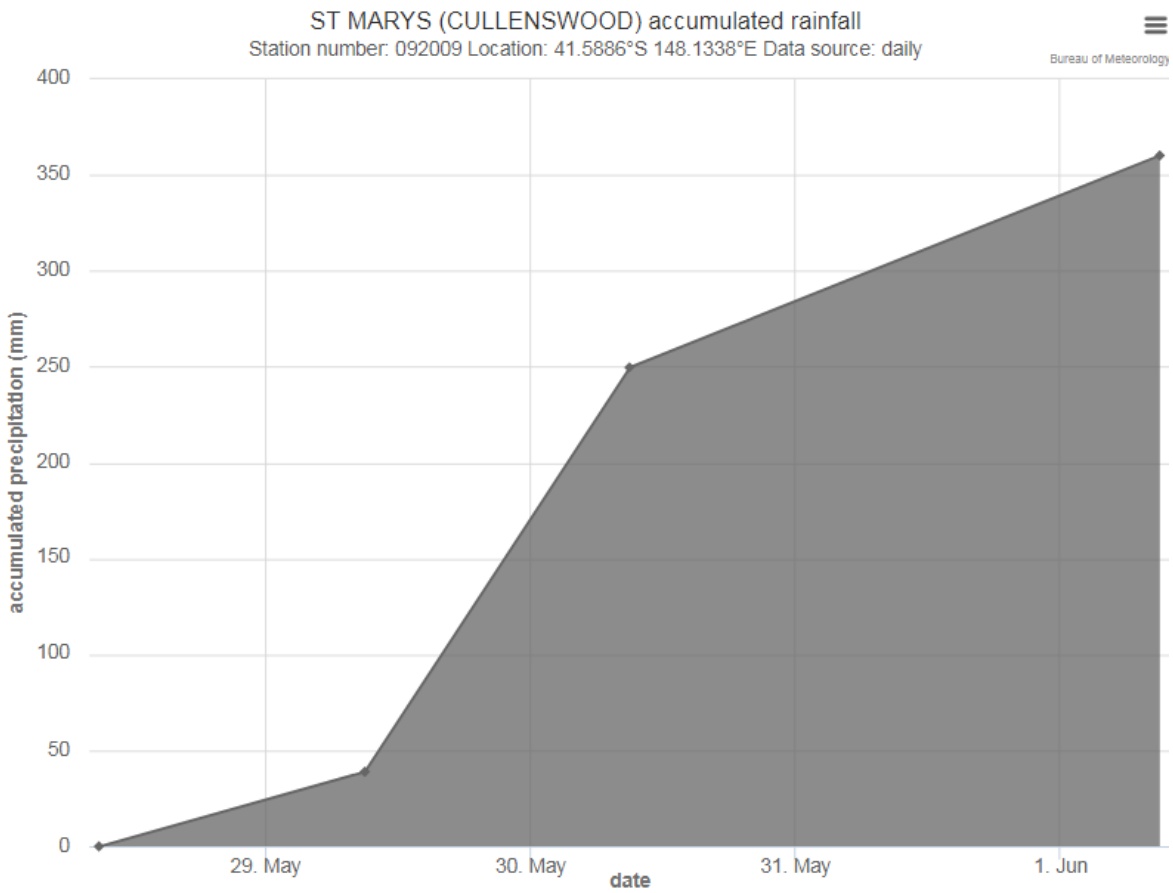


Figure 4.14: Rainfall accumulation at St Marys (Cullenswood)

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- Pluvio, five-minute rainfall accumulation
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

5. August 1970 – North

Summary

During August 1970, a prolonged period of moist north to northeasterly winds, amplified by a low-pressure complex to the northwest of Tasmania, brought significant rain to much of the north. Heavy rain developed about the northwest of Tasmania during the 22nd of August 1970 and prevailed until the morning of the 25th of August. During this time, 150 to 300 mm of rain fell across windward, elevated terrain in the northwest (Figure 5.1). Although 24-hour rainfall rates were not highly significant (generally less than 10% AEP), the multi-day accumulations were exceptional. Soils across north, west and inland Tasmania were very moist leading up to the event. It was reported that the Mersey, Forth, Meander, Ouse and Lake rivers experienced major flooding.

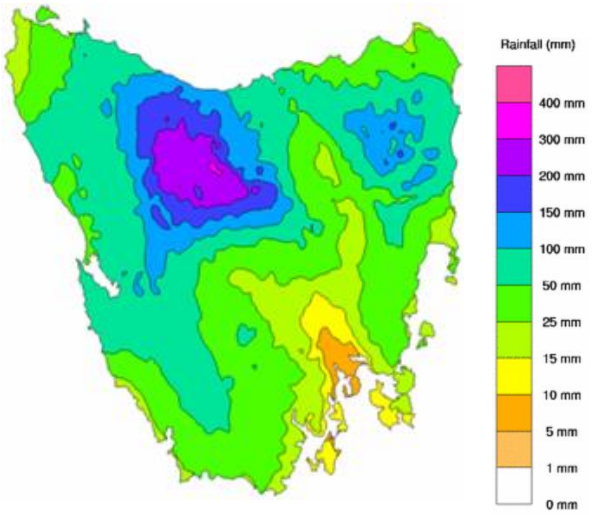


Figure 5.1: Rainfall totals for the 3 days from 9 am of the 22nd to 9 am of the 25th August 1970.

Antecedent Conditions

During the six months leading up to the end of July 1970, generally wetter than average conditions had persisted across much of Tasmania. However, near average rainfall was recorded across much of the northwest (Figure 5.2).

However, very wet conditions developed during July 1970 with generally 200 to 400 mm of rain falling across much of the northwest – about 50 to 200 mm more than the July mean (Figure 5.3).

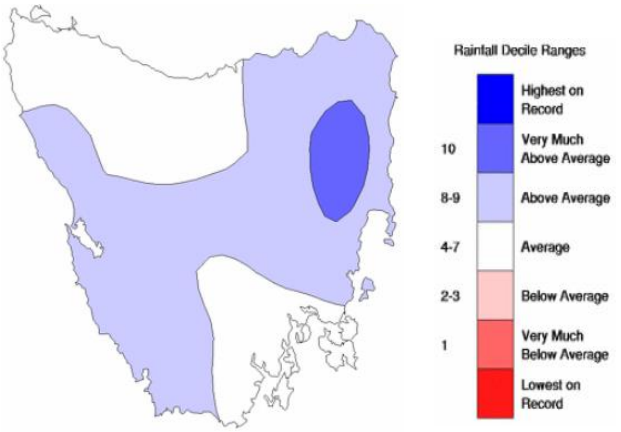


Figure 5.2: Rainfall deciles from 1 February to 31 July 1970.

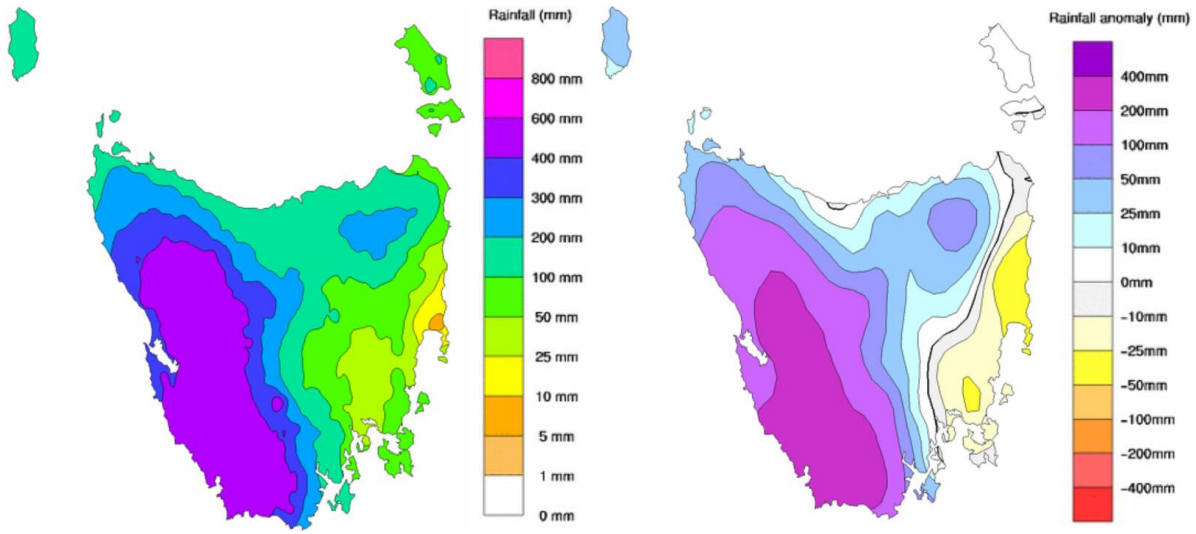


Figure 5.3: The left map shows recorded rainfall across Tasmania over the month of July 1970. The right map shows the deviation of the observed rainfall from the July mean (in mm).

During the first three weeks of August 1970, the northwest received a further 50 to 200 mm (mainly in the west and elevated areas) – about half the average August rainfall (Figure 5.4).

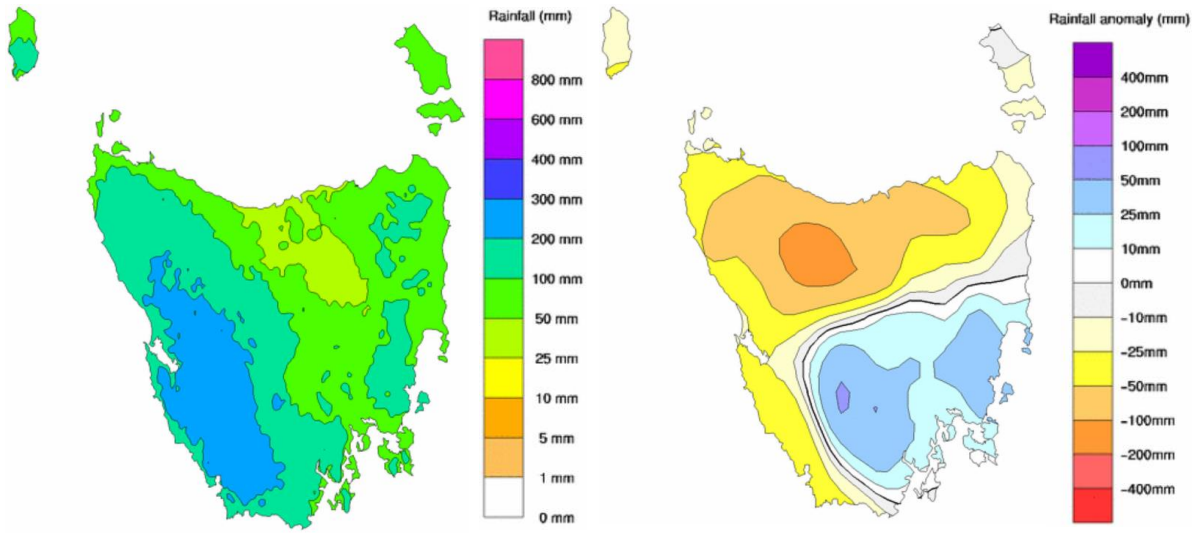


Figure 5.4: The left map shows recorded rainfall across Tasmania from the 1st to the 22nd of August, 1970, with the right map showing the deviation from the August mean (in mm).

The recent rainfall, as well as the shorter days and lower temperatures during this time of year, resulted in high levels of rootzone soil moisture. Figure 5.5 shows the Bureau's AWRA-L rootzone soil moisture model. Areas of low elevation in the north generally had soil moisture in excess of 160 mm, however elevated areas in the west, north and central parts have soil moisture near and in excess of 200 mm.

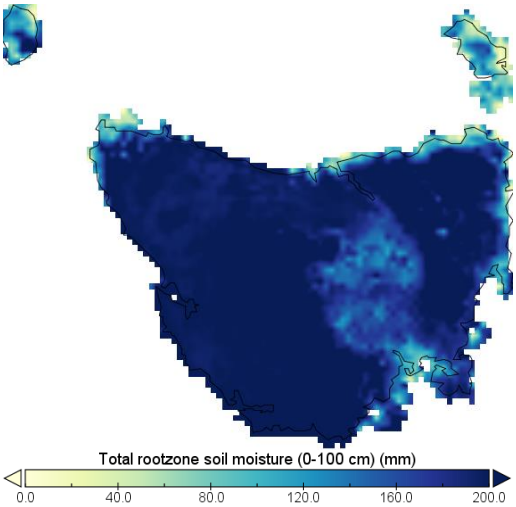


Figure 5.5: AWRA-L Rootzone soil moisture on 22nd August 1970.

Meteorological Discussion

During the 22nd of August 1970, a ridge of high pressure extended along the east Australian coast from a high centre well to the southeast of Tasmania (Figure 5.6). A warm front approached Tasmania from the north and crossed during the day with a moist north to northeasterly airstream following. An area of low-pressure had developed over the Great Australian Bight and was held in place by the high-pressure ridge to the east. By the evening of 23rd of August, the low-pressure complex had slowly moved toward the west coast of Tasmania (Figure 5.7). The interaction of the low and high pressure resulted in a relatively strong pressure gradient and moist north to northeasterly airstream prevailing over Tasmania during this period, with heavy rain developing about the northwest.

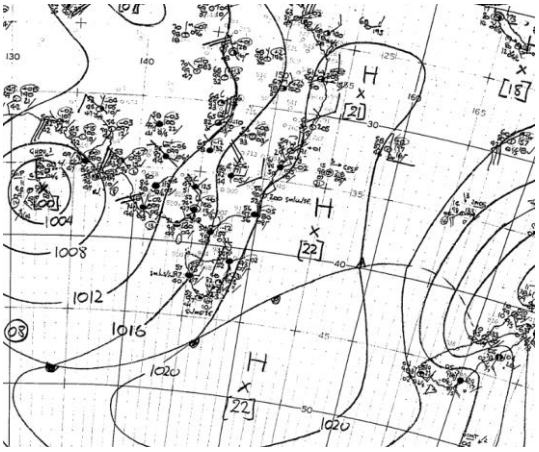


Figure 5.6: Mean sea level pressure chart at 10pm 22nd August 1970

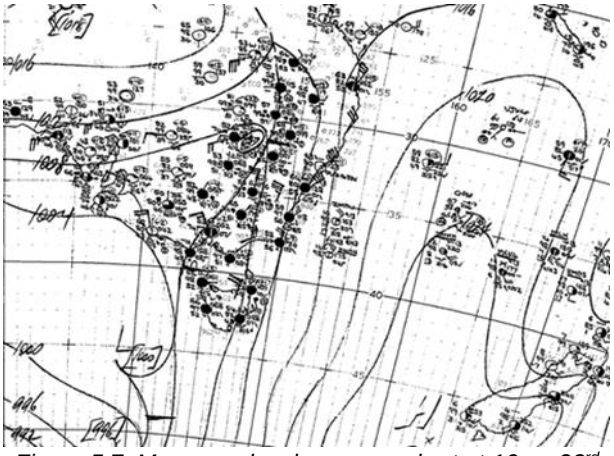


Figure 5.7: Mean sea level pressure chart at 10pm 23rd August 1970

By the evening of the 24th of August, the low-pressure complex had moved over Bass Strait and Northwest Tasmania (Figure 5.8), with the northeasterly airstream being briefly directed over eastern Tasmania. During the 25th of August, the low moved over Tasmania, bringing light to moderate rainfall across the state (Figure 5.9).

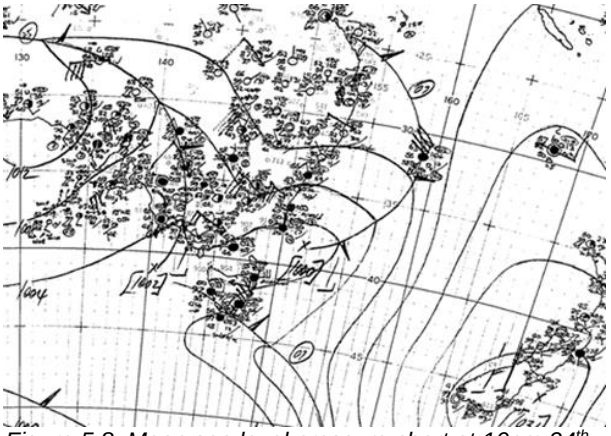


Figure 5.8: Mean sea level pressure chart at 10pm 24th August 1970

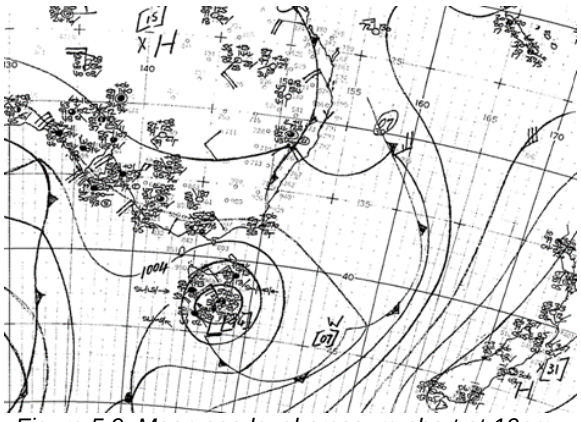


Figure 5.9: Mean sea level pressure chart at 10pm 25th August 1970

The low centre then moved away to the southeast as a cold front approached, crossing Tasmania during the 26th of August and bringing a further 25 to 50 mm of rainfall to much of the north and west.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 5.10). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied.

The most significant rainfall driver throughout this event was the moist north to northeasterly airstream interacting with topography. As the moist air ascended over elevated terrain, it cooled with embedded water vapour condensing into rainfall. As such, the highest rainfall totals are found across windward elevated terrain throughout the north with a 'rain-shadow' evident in the lee of the topography (i.e. west and south Tasmania, Tamar Valley and Midlands).

Moderate rainfall began about northwestern Tasmania on the 22nd of August, increased on the 23rd and prevailed until the morning of the 25th. As can be seen, no highly exceptional rainfall was recorded on any single day, rather this was a highly significant multiday event.

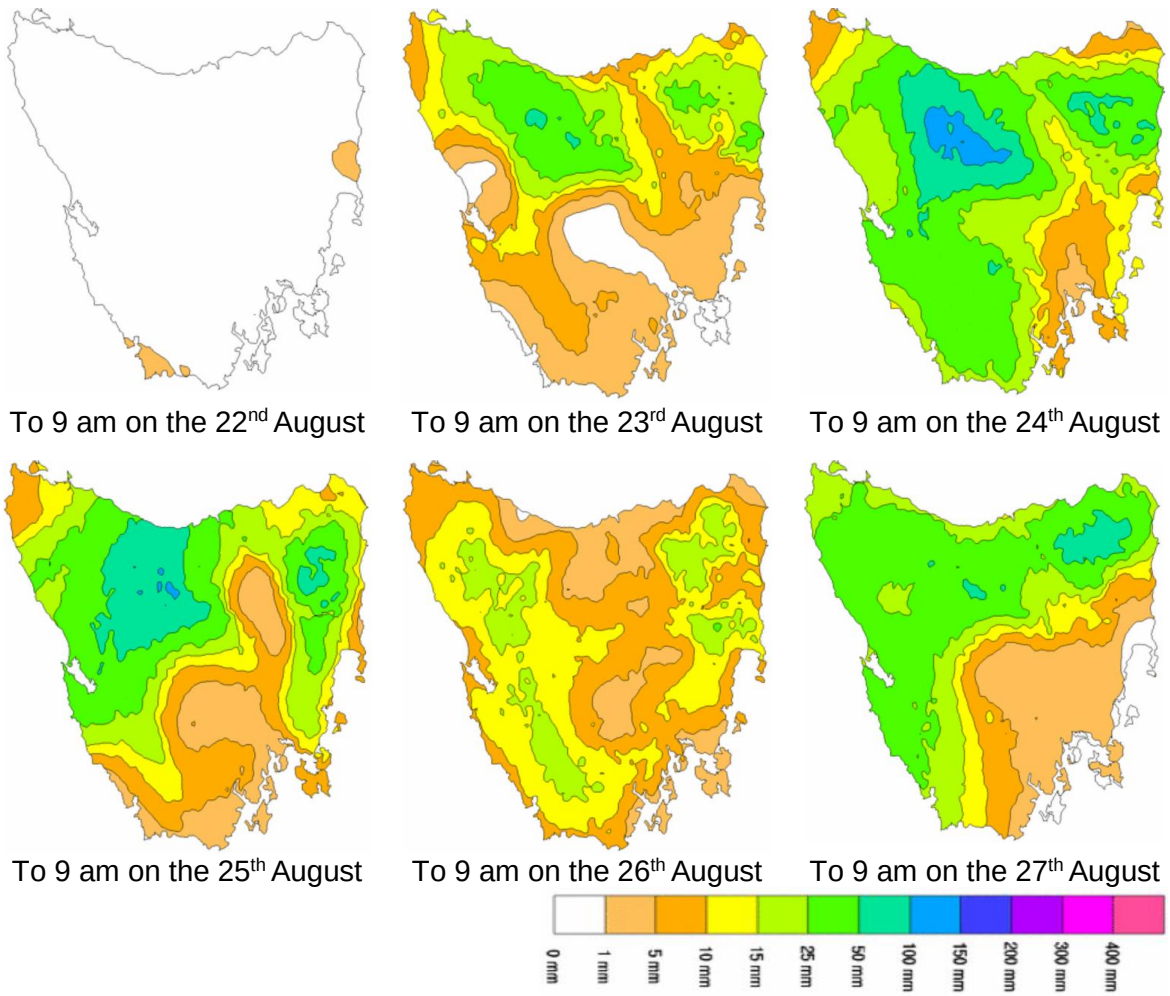


Figure 5.10: 24 hour rainfall to 9 am of the designated date for six days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Lake Mackenzie and Burnie. Also shown are the rainfall accumulations for these sites. A pluviometer at Burnie provides 6-minute accumulation data, however only restricted 24-hour accumulations are available at Lake Mackenzie.

The storm envelope at Lake Mackenzie (Figure 5.11) shows that restricted rainfall rates reach near the 2% AEP threshold only after prolonged durations of two days or more. The restricted 24-hour duration rainfall rate is less than 10% AEP. The accumulated rainfall at Lake Mackenzie (Figure 5.12) shows that heavy rain maintained for the three-day period from 9am on the 23rd of August to 9am on the 25th.

Similarly, the storm envelope at Burnie (Figure 5.13) shows that rainfall rates reach the significant values only after a prolonged duration. However, rainfall rates were not as significant at Burnie as they were at Lake Mackenzie, with the highest rainfall rates reaching 10% AEP at around the five-day duration. The accumulated rainfall at Burnie (Figure 5.14) shows that apart from a pause in rainfall during the afternoon and evening of the 23rd and 24th of August, the rainfall rate was fairly continuous. Rainfall rates at elevated locations like Lake Mackenzie would likely have been more, however there would probably have been lulls in the rain similar to those seen at Burnie.

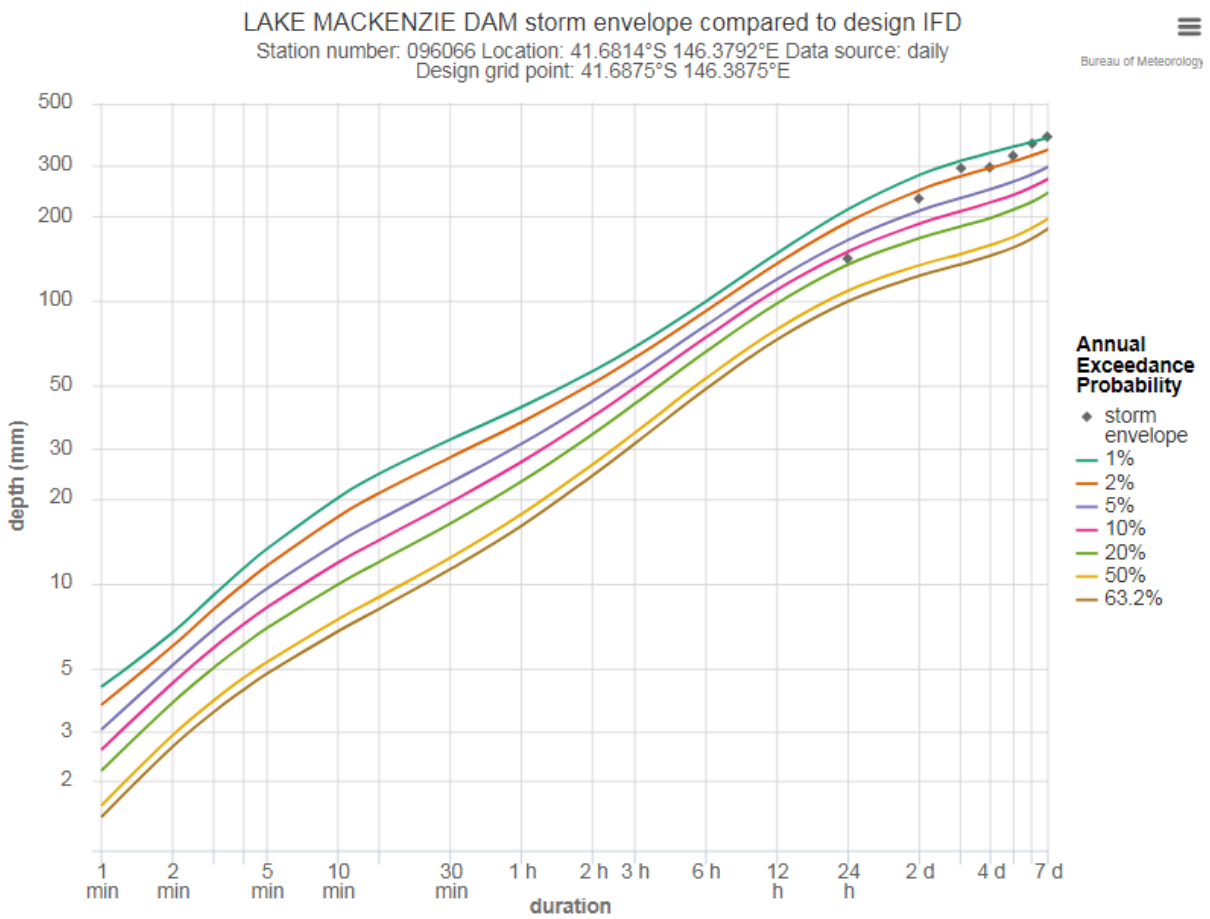


Figure 5.11: Storm envelope for Lake Mackenzie Dam

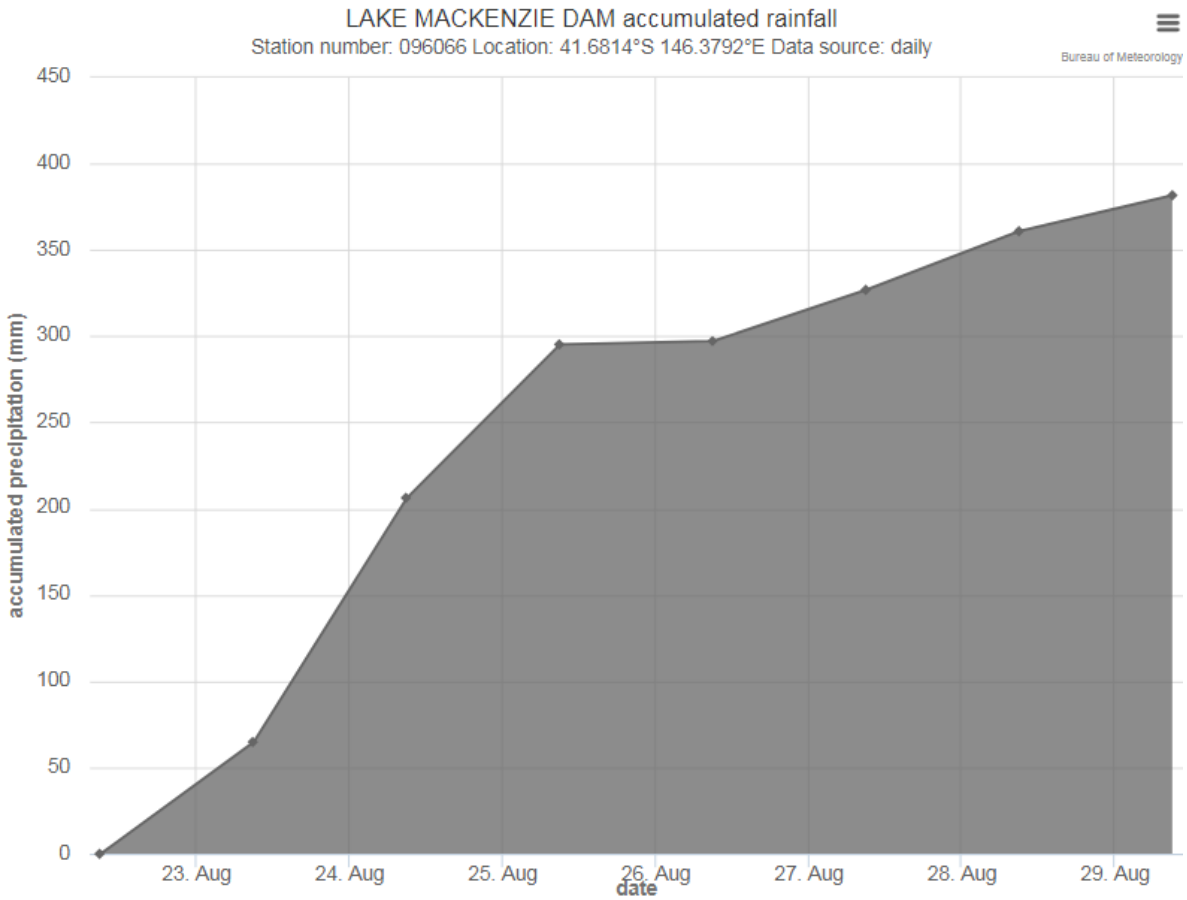


Figure 5.12: Rainfall accumulation at Lake Mackenzie Dam

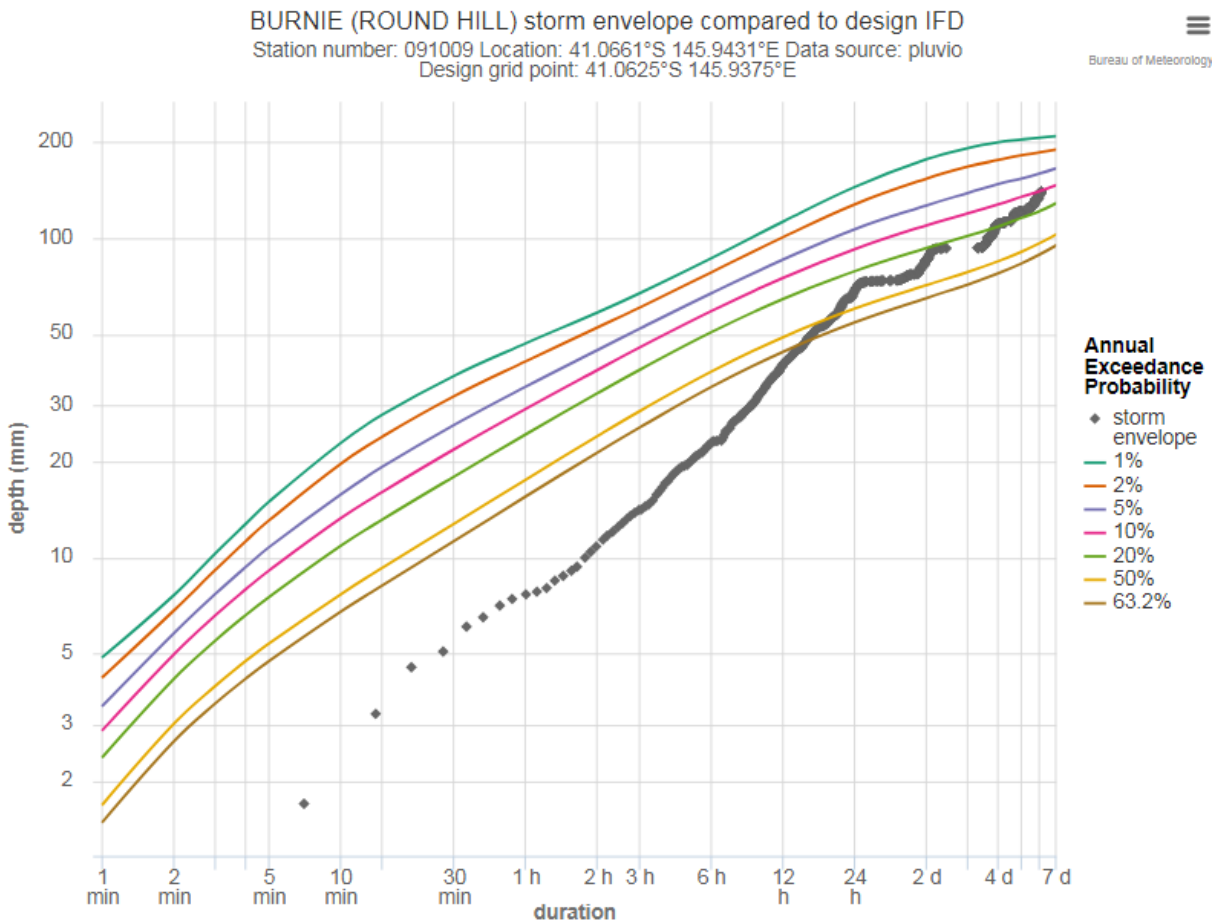


Figure 5.13: Storm envelope for Burnie (Round Hill)

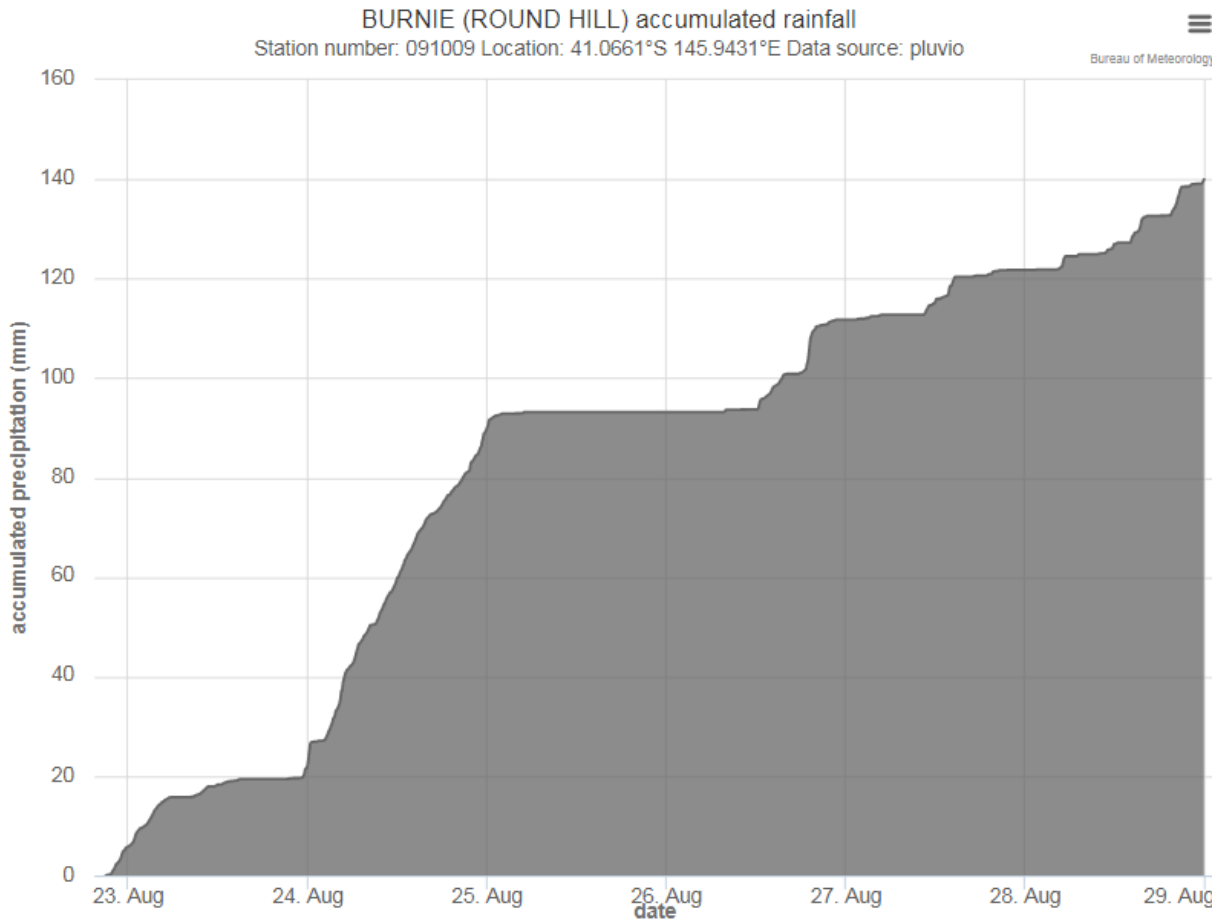


Figure 5.14: Rainfall accumulation at Burnie (Round Hill)

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- Pluvio, five-minute rainfall accumulation
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

6. August 2007 – West

Summary

August 2007 was a period of strong, persistent westerlies with the passage of frequent cold fronts. This persistent airstream delivered an almost continuous infeed of moisture into western Tasmania during the period of the 8th and the 10th, with generally 150 to 200 mm of rainfall into the west (in-excess of 200 mm in the southwest) (Figure 6.1). Major flooding was recorded in the Forth and Derwent rivers, moderate flooding in Huon and South Esk and minor flooding in the Meander. There was also significant flooding of the Ringarooma River at Branxholm. Abnormally high tides caused complications on flooded rivers.

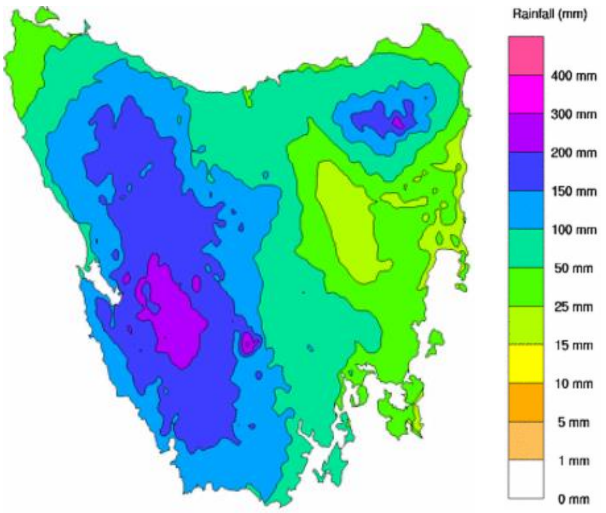


Figure 6.1: Rainfall totals for the 3 days from 9 am of the 8th to 9 am of the 11th of August 2007.

Antecedent Conditions

The year leading up to the end of July 2007 was very dry across Tasmania, with rainfall deciles very much below average across the State (first decile). However, much of the northwest, central north and northern Midlands had recorded its driest year on record (Figure 6.2).

July 2007 remained relatively dry and although much of the west received 100 to 200 mm during this month, this was generally 50 to 150 mm below the July average (Figure 6.3).

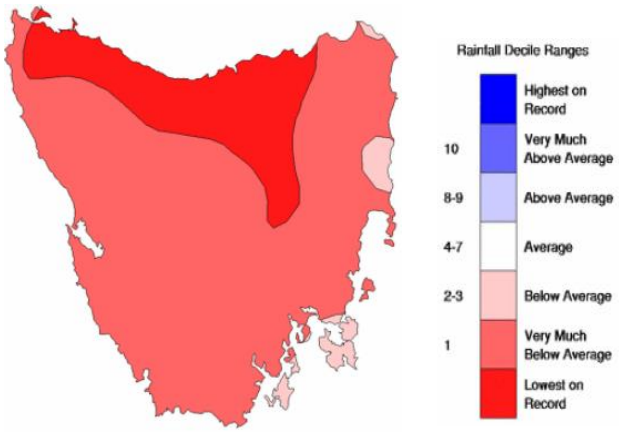


Figure 6.2: Rainfall deciles for the year leading up to 31 July 2007.

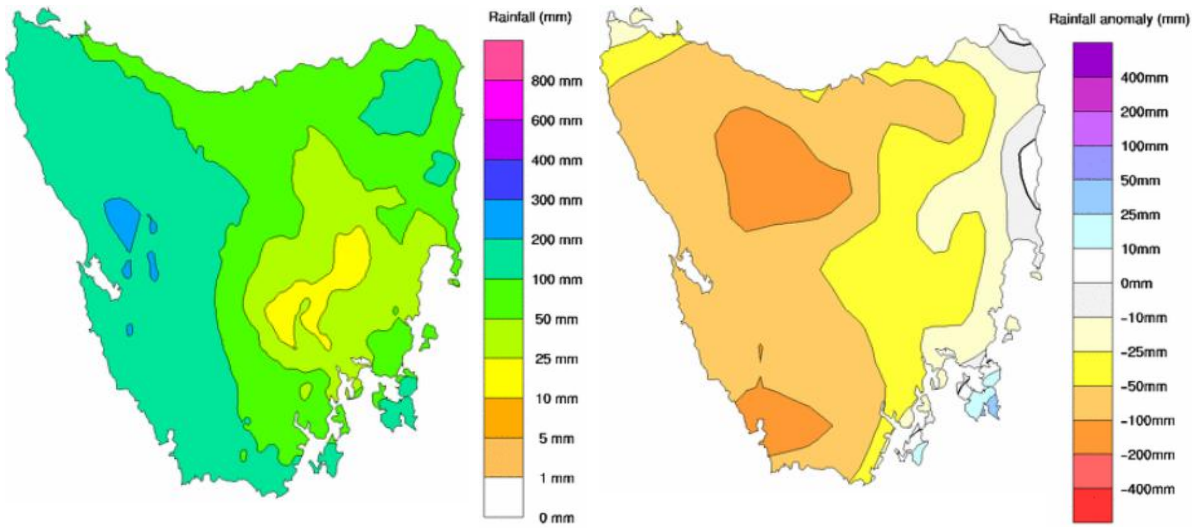


Figure 6.3: The left map shows recorded rainfall across Tasmania during July 2007, with the right map showing the deviation from the July mean (in mm).

Although rainfall across Tasmania had been well below average during the antecedent months, rainfall patterns dramatically changed at the beginning of August 2007. During the first eight days of the month, around 100 to 200 mm of rainfall was recorded about the west (Figure 6.4).

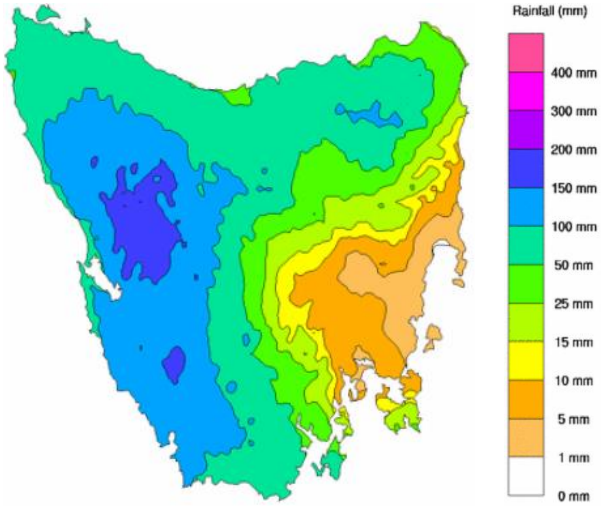


Figure 6.4: Rainfall totals from 9 am 31st July to 9 am August 8th 2007.

Despite the preceding dry conditions, recent rainfall resulted in high levels of rootzone soil moisture across much of the west just ahead of the significant rainfall event. Figure 6.5 shows the Bureau's AWRA-L rootzone soil moisture model. Much of western Tasmania has near or above 200 mm, whereas the east, southeast and low inland areas have low soil moisture. Similarly, the Soil Dryness Index (Figure 6.6) shows that near saturated soils are prevalent across much of the west, northwest and elevated inland areas.

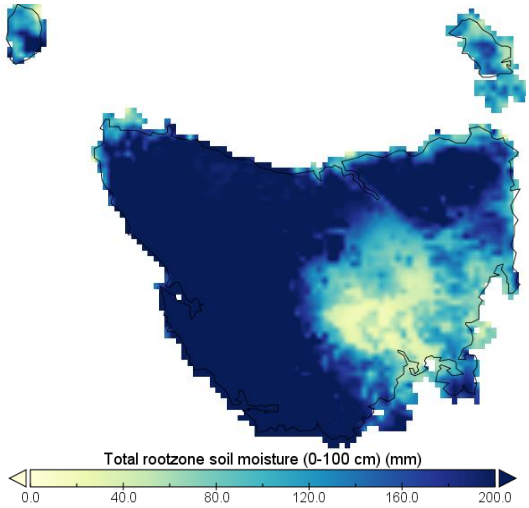


Figure 6.5: AWRA-L Rootzone soil moisture on 7th August 2007.

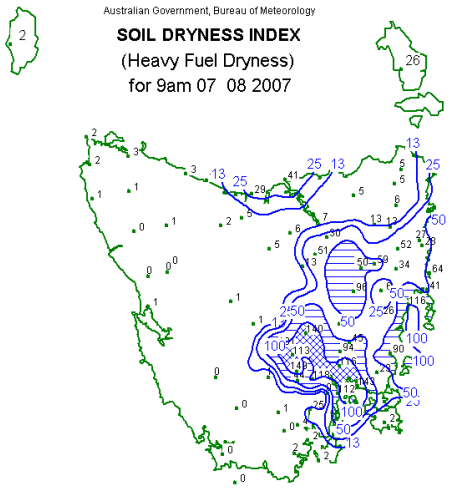


Figure 6.6: SDI on 7th August 2007.

Meteorological Discussion

August 2007 was marked as a period of strong, persistent westerlies with the passage of frequent cold fronts. This persistent airstream delivered an almost continuous infeed of moisture into the west during this rain event. The continuously heavy rain began on the evening of the 8th of August 2007. A rain bearing cold front crossed the state in the early hours of 8th, with a strong west to northwesterly airstream to follow (Figure 6.7). This airstream had its origins from over the Indian Ocean (as can be seen by the isobars over Tasmania tracking back to the west of Western Australia) and was relatively mild and moisture rich. The airstream strength was enhanced by another rain bearing cold front approaching Tasmania from the southwest. This second front reached the west Tasmanian coast on the evening of the 8th and crossed the State early on the 9th (Figure 6.8). High pressure over the Mainland and a deep, broad area of low pressure over the Southern Ocean maintained a strong westerly airstream (and moisture infeed) into the west behind the front. This maintained heavy rain into the west throughout the 9th of August.

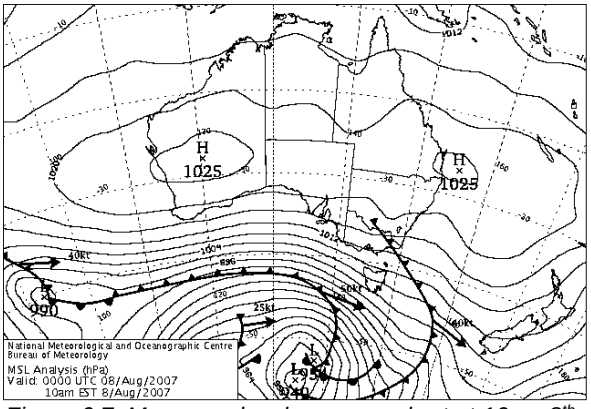


Figure 6.7: Mean sea level pressure chart at 10am 8th August 2007

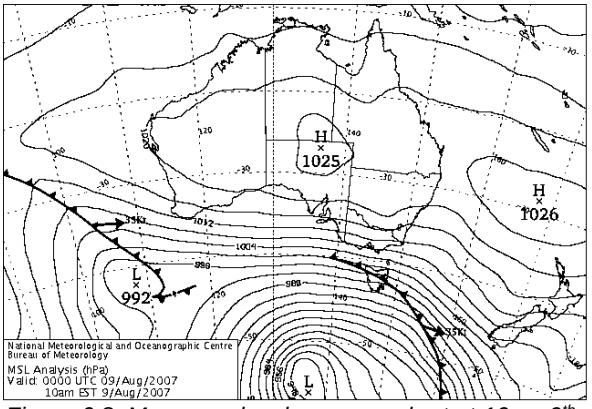


Figure 6.8: Mean sea level pressure chart at 10am 9th August 2007

Yet another cold front crossed Tasmania on the 10th of August, clearing to the north of the State during the evening (Figure 6.9). Ahead of the front, a strong, moisture rich airstream was maintained into the west during the day. However, rain rates decayed rapidly later during the 10th of August as the cold front crossed and the strong westerly airstream was abruptly replaced with a weaker, cooler and drier southwesterly airstream. This airstream prevailed throughout the 11th of August (Figure 6.10).

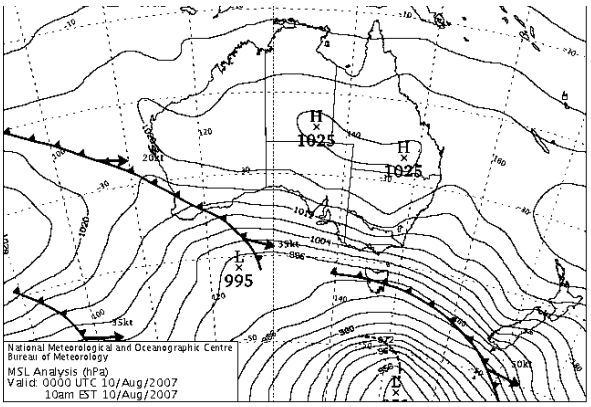


Figure 6.9: Mean sea level pressure chart at 10am 10th August 2007

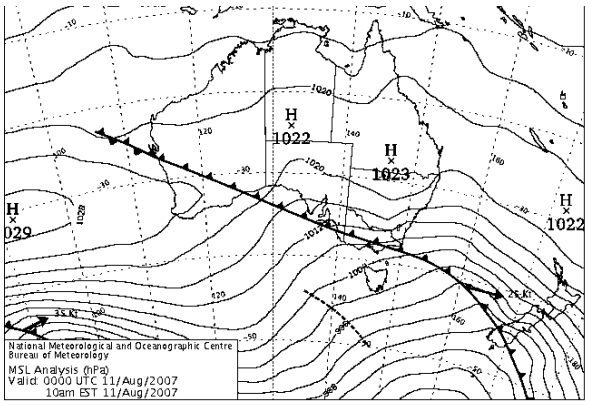
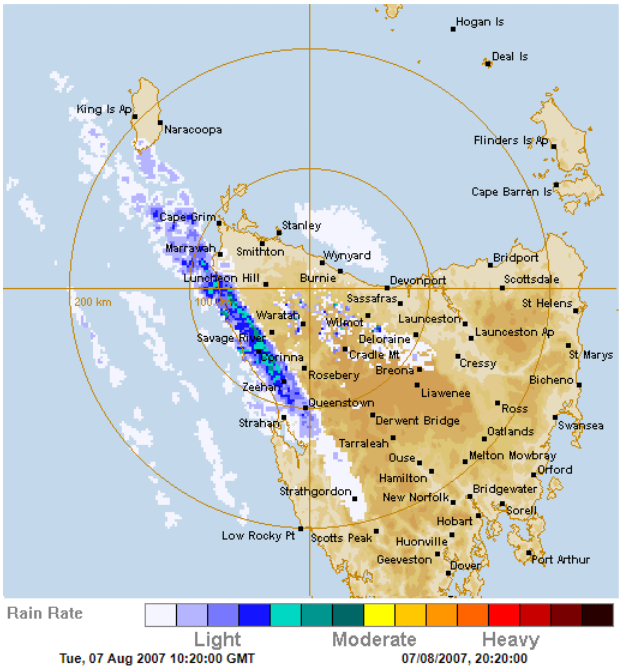
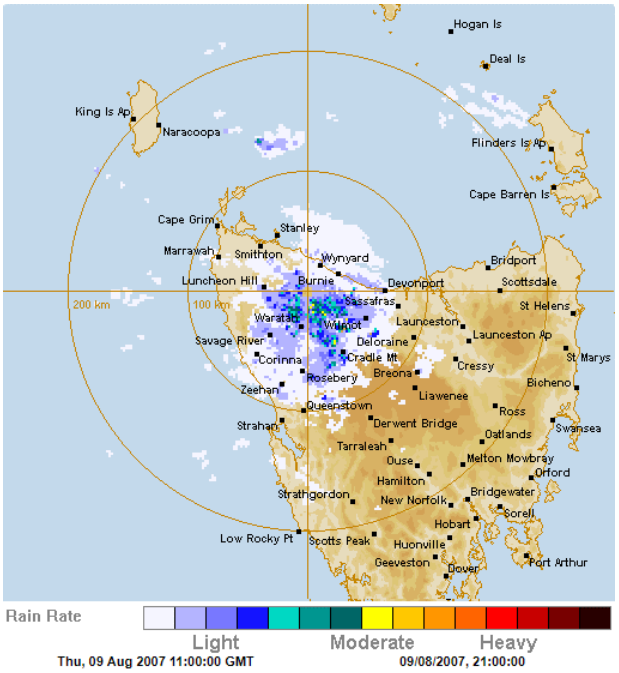


Figure 6.10: Mean sea level pressure chart at 10am 11th August 2007

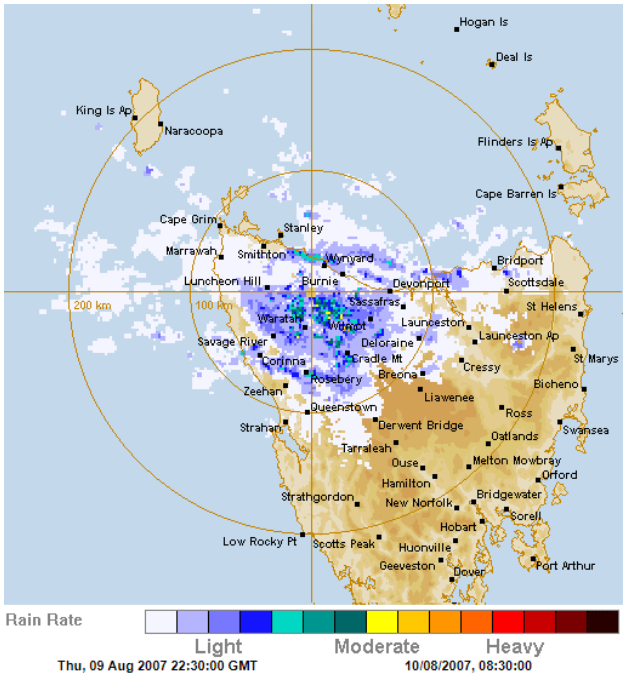
Radar reflectivity imagery from the West Takone radar is shown below (Figure 6.11). The image at 20:20 on the 8th shows a vigorous frontal band crossing the west, heralding the beginning of the persistently heavy rain in the west. The images from 21:00 of the 9th and 08:30 of the 10th show mostly uniform and continuous rain into the northwest. This rain was mostly generated by the interaction of the airstream with the topography and as such, would have fallen from low-level cloud throughout the west. The northwest Radar would not have been able to detect this low cloud and rainfall into the west and southwest, however it is highly likely that the uniform and continuous rainfall detected in the northwest would have prevailed throughout all of the west and would have been stronger (or heavier) in the southwest where the airstream was stronger. The radar image from 19:50 of the 10th shows a cold front to the north of Tasmania with rain rates quickly easing behind the front.



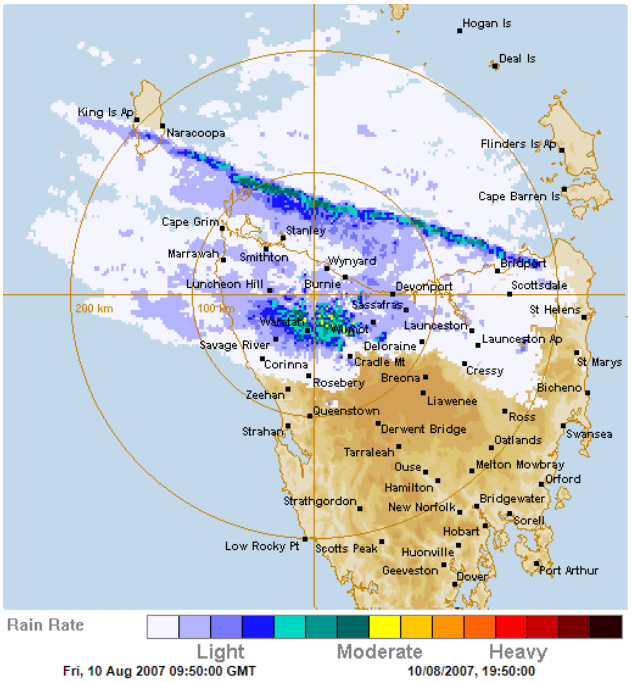
20:20, 8th of August



21:00, 9th of August



08:30, 10th of August



19:50, 10th of August

Figure 6.11: Radar reflectivity images during the event at the designated time and date.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 6.12). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. No significant rain fell in the west in the few days leading up to the 8th of August 2007. Heavy rain then fell on the 8th, 9th and 10th, with the bulk of the rain falling during the 24 hours to 9 am of the 10th.

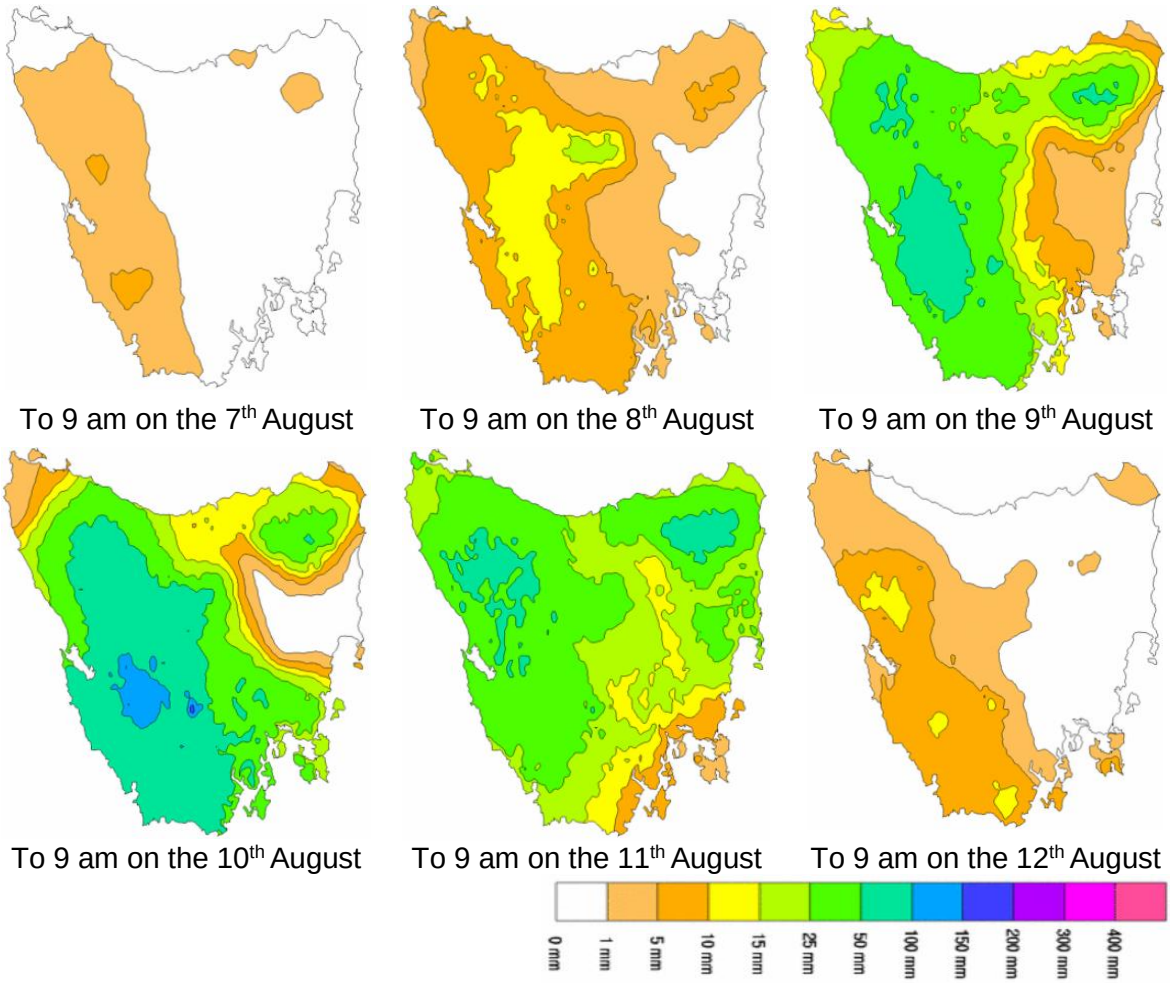


Figure 6.12: 24 hour rainfall to 9 am of the designated date for six days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Strathgordon and Tarraleah Villages. Also shown are the rainfall accumulation graphs for these sites. The pluviometers at both locations report rainfall accumulations at one-minute increments.

Looking at the rainfall accumulation graphs at both locations shows persistent rain beginning during the afternoon and evening of the 8th of August (Figure 6.14 and Figure 6.16). Once the rainfall begins it remains relatively steady until it dramatically eases on the afternoon of the 10th of August.

The storm envelopes show that this was a multiday event with highly significant rainfall rates at durations of around two days, and generally insignificant rainfall rates at durations less than 12 hours. Rainfall rates at Strathgordon are at their most significant around the two-day duration with an AEP near 1% (Figure 6.13). Rainfall rates were less significant at Tarraleah, peaking at 10% AEP at the two-day duration (Figure 6.15). As Tarraleah is further north and inland of Strathgordon, it was less exposed to the westerly stream and received less rainfall.

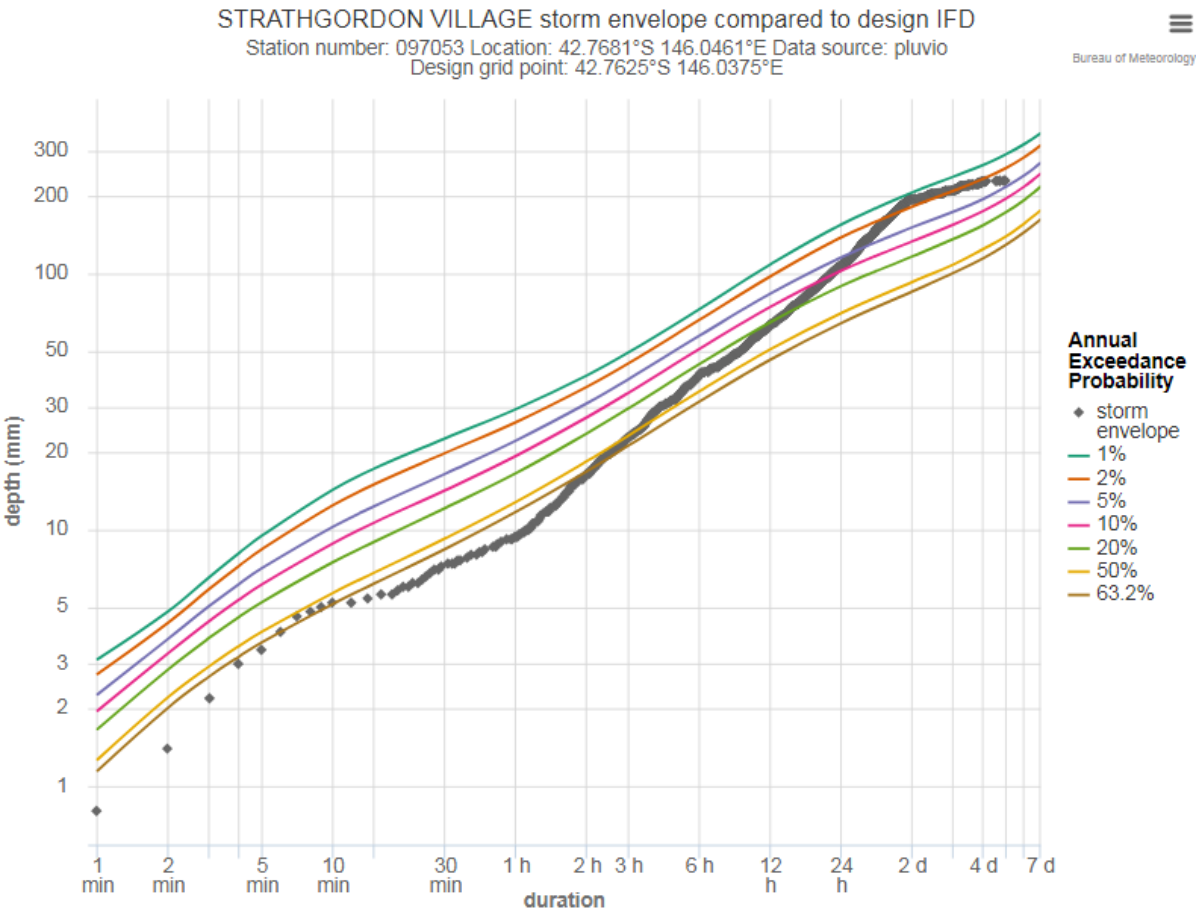


Figure 6.13: Storm envelope for Strathgordon Village

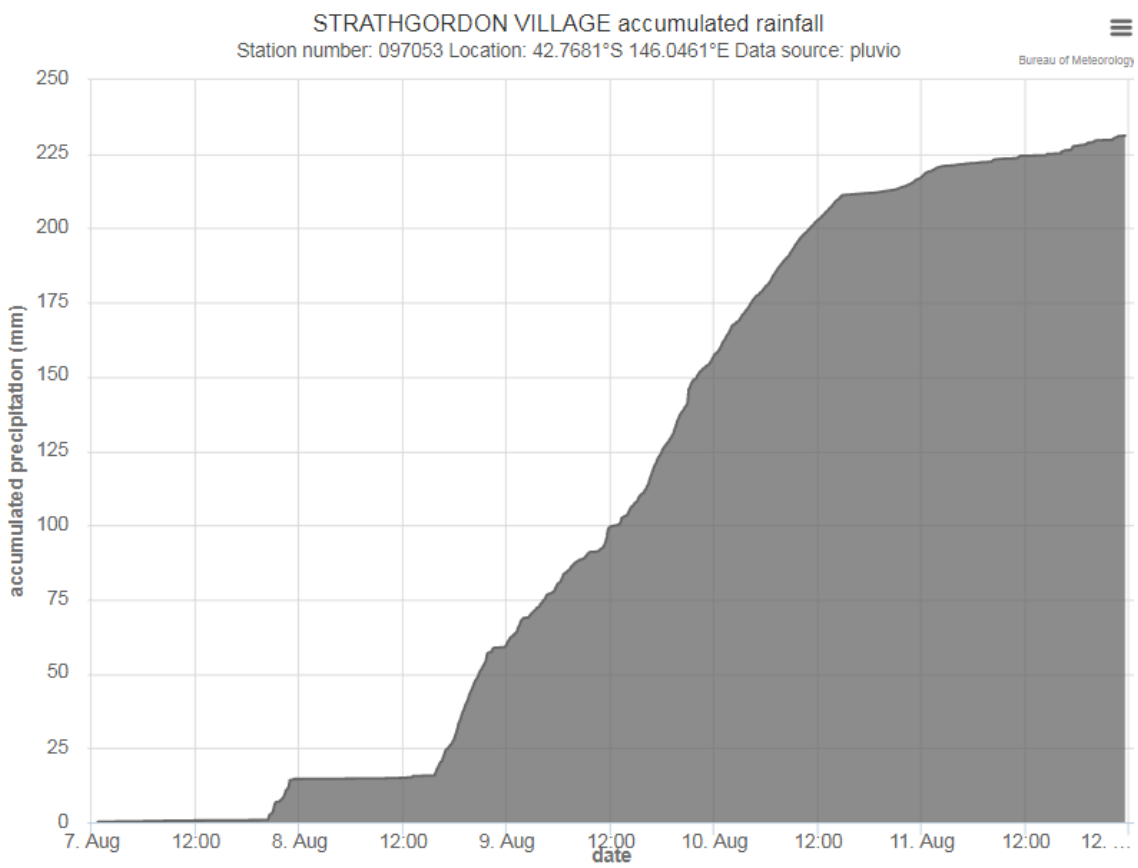


Figure 6.14: Rainfall accumulation at Strathgordon Village

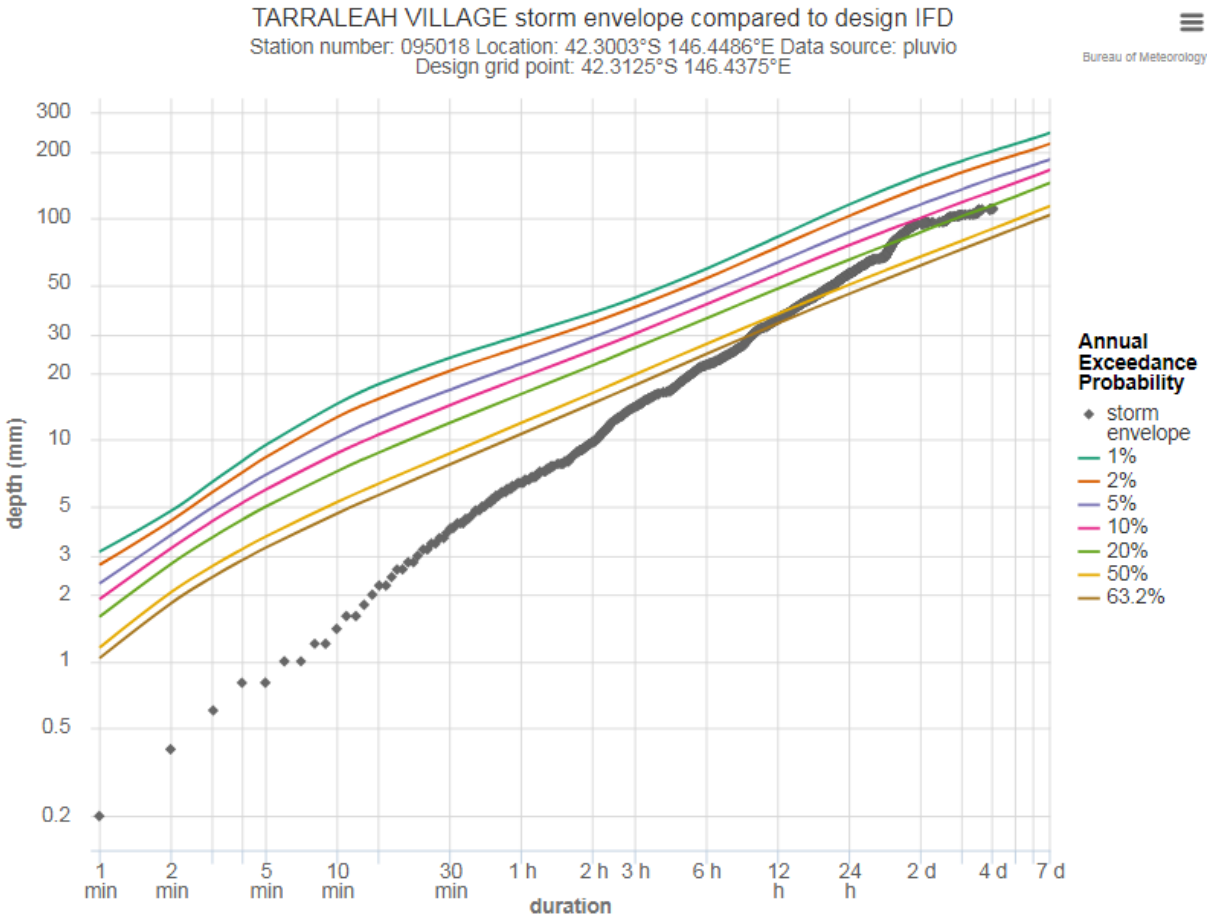


Figure 6.15: Storm envelope for Tarraleah Village

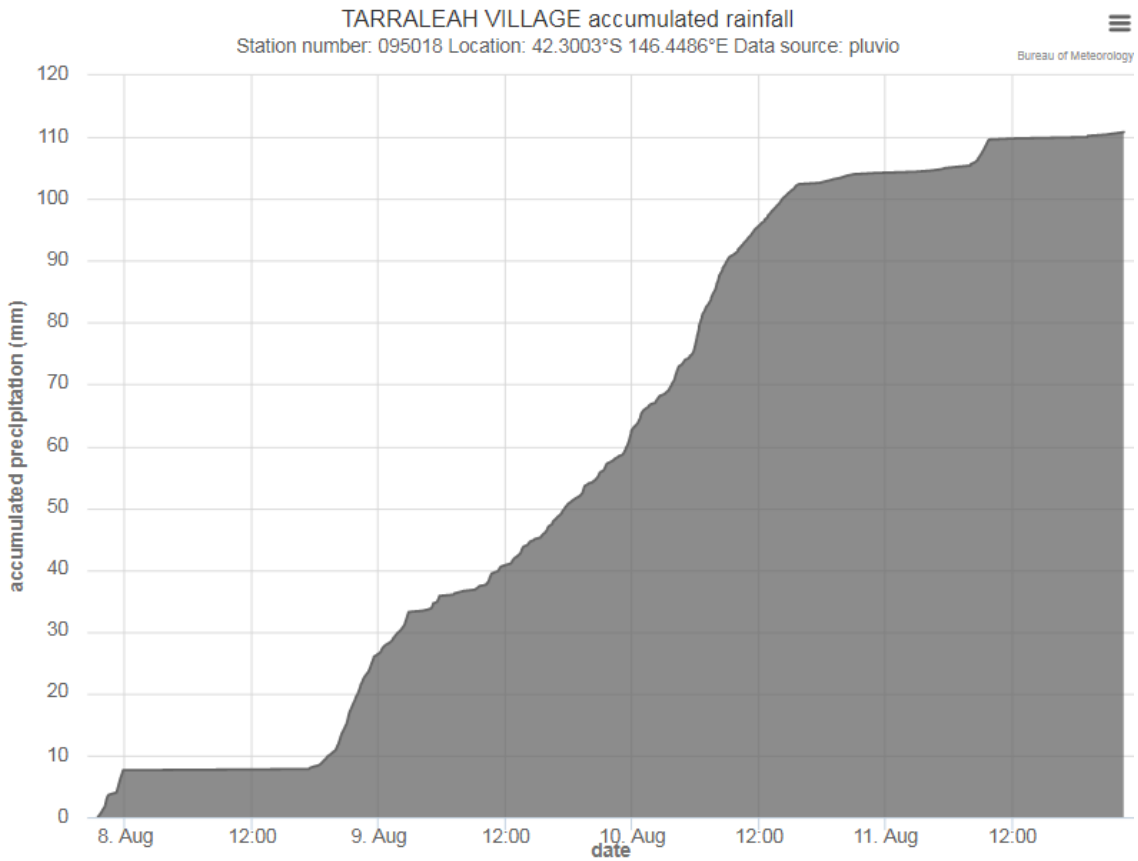
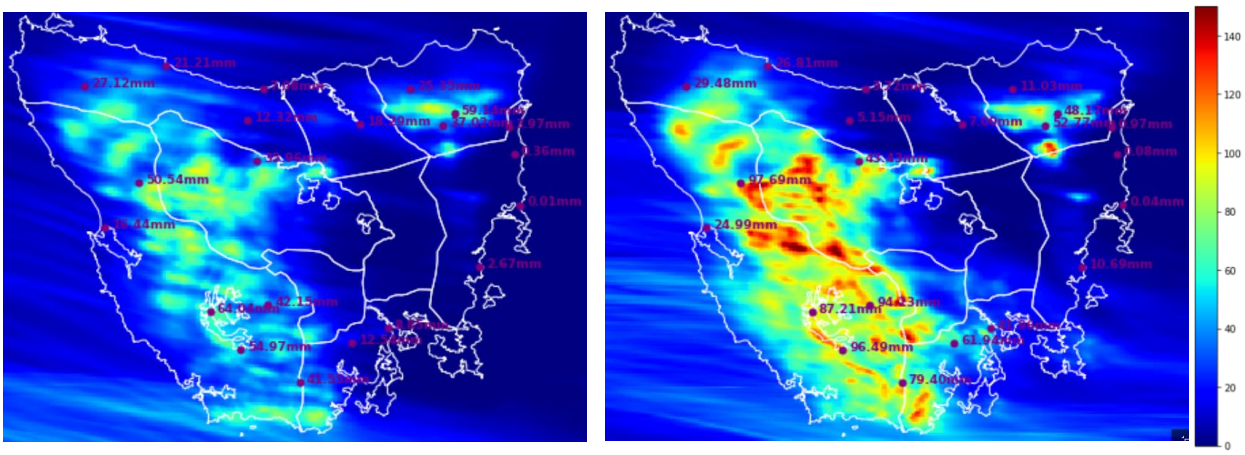


Figure 6.16: Rainfall accumulation at Tarraleah Village

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania during this event. A sample of the data is shown below (Figure 6.17).



24 hours to 10 am, 9th of August 24 hours to 10 am, 10th of August

Figure 6.17: BARRA-TA 24-hour rainfall accumulation (mm) to 10 am of the stated date

BARRA seems to have captured the event reasonably well and may be of some use for hydrological modelling.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- BARRA-TA, ten-minute accumulated rainfall
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

7. January 2011 – Northwest and Northeast

Summary

A strong and humid north to northeasterly airstream produced exceptionally heavy rainfall across parts of northern Tasmania between the 12 and 14 January 2011. Much of the northwest and northeast received 100 to 300 mm of rainfall during this period, however a small part of the northern East Coast received over 300 mm, most of which fell in during the 24 hours to 9 am of the 13th.

The heavy rain brought flash flooding which caused significant damage in northern and northeastern Tasmania. Major flooding occurred in the Mersey and Meander Rivers, with moderate flooding in the Forth, South Esk and Macquarie Rivers, and minor flooding in the North Esk River.

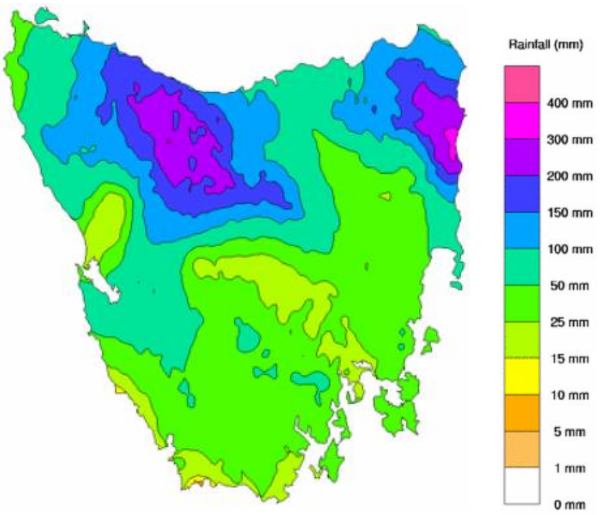


Figure 7.1: Rainfall totals for the 3 days from 9 am of the 12th to 9 am of the 15th January 2011.

Antecedent Conditions

During the seven months leading up to the end of December 2010, above average rainfall was recorded across much of northern Tasmania, with near average rainfall elsewhere (Figure 7.2).

However, December 2010 was very wet in the northwest, with monthly totals of around 200 to 300 mm across much of the west and northwest, with about 100 to 200 mm about the northeast (Figure 7.3). There was no significant rain across Tasmania during the first part of January 2011 until the 12th.

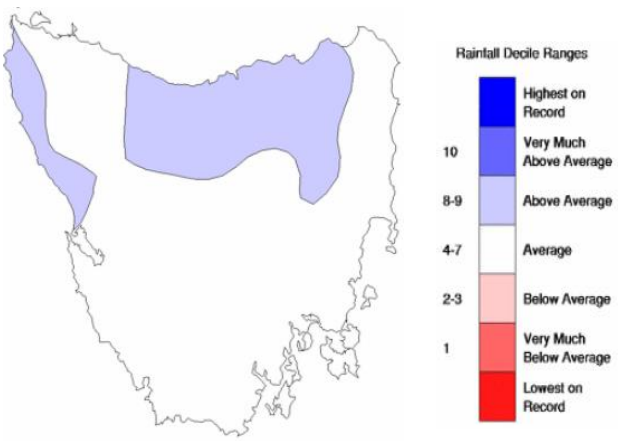


Figure 7.2: Rainfall deciles from 1 June 2010 to 31 December 2010.

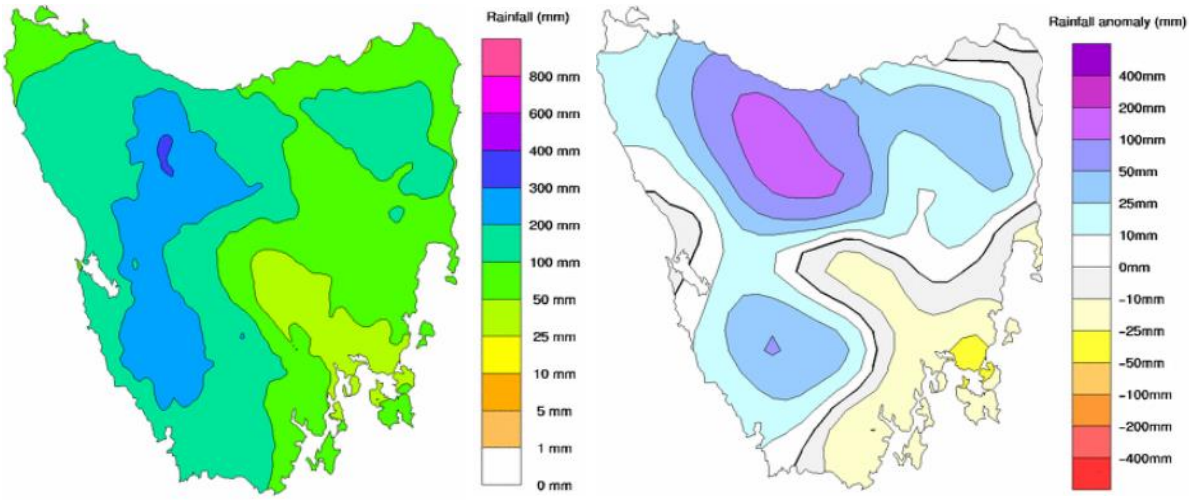


Figure 7.3: The left map shows recorded rainfall across Tasmania during December 2010 with the right map showing the deviation from the December mean (in mm).

The rainfall during December 2010 led to moderate levels of rootzone soil moisture across the west and northwest of Tasmania. Figure 7.4 shows the Bureau's AWRA-L rootzone soil moisture model. Much of the west and northwest has soil moisture values of around 140 to 160 mm, whereas much of the northeast has lower values of 80 to 120 mm. This is also evident in the observed Soil Dryness Index (SDI) map (Figure 7.5), with low values of around 20 mm across much of the northwest and elevated parts of the northeast, and higher values of around 50 mm across lower parts of the east and northeast.

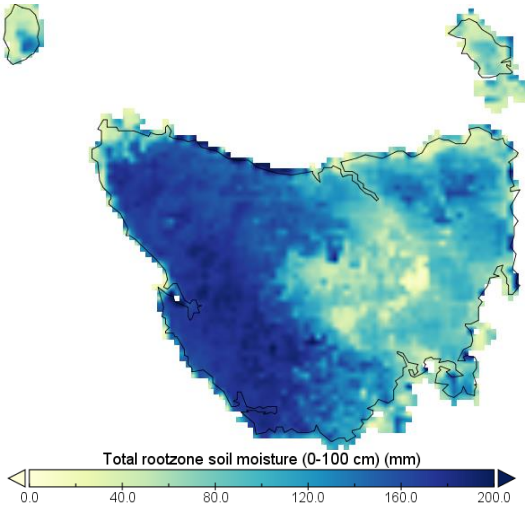


Figure 7.4: AWRA-L Rootzone soil moisture on 11th January, 2011.

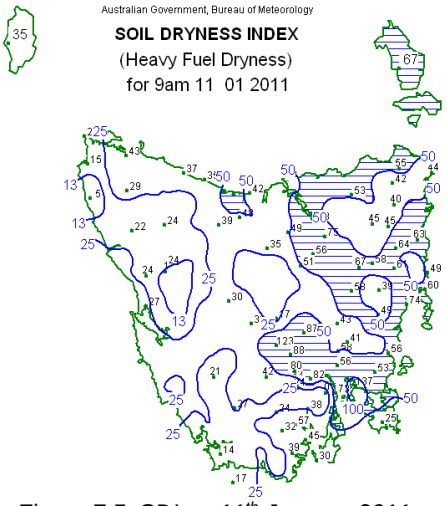


Figure 7.5: SDI on 11th January 2011.

Meteorological Discussion

During the four days leading up to the 12th of January 2011, a trough and area of low pressure persisted to the west of Tasmania, being held in place by a high-pressure region to the south and east of Tasmania. The combination of these systems resulted in a persistent east to northeasterly airstream across Tasmania during this period. The airstream had a tropical origin over the warm waters of the eastern Pacific Ocean and was highly humid.

During the 12th of January, the trough and associated low pressure centre to the northwest of Tasmania slowly moved towards the State, 'running into' the stationary high-pressure ridge to the east of Tasmania (Figure 7.6). This created a large pressure gradient and strong northeasterly winds across the State. During the afternoon and evening of the 12th of January, heavy rain began to fall across the northwest and northeast of Tasmania, with highly exceptional rainfall (200 to 300 mm) falling over a small pocket of the upper East coast during the evening of the 12th and morning of the 13th of January.

As the area of low pressure continued to slowly approach during the morning of the 13th of January, it began to move a southwards so that it was to the west of Tasmania by 11 am of the 13th of January (Figure 7.7). The strong and humid northeasterly airstream prevailed across Tasmania, maintaining heavy rain into the northwest and northeast.

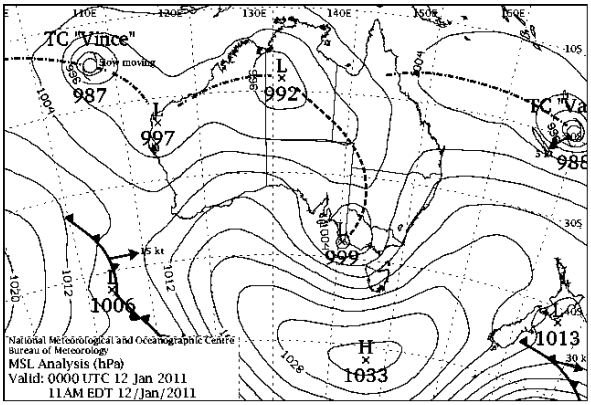


Figure 7.6: Mean sea level pressure chart at 11am 12th January 2011

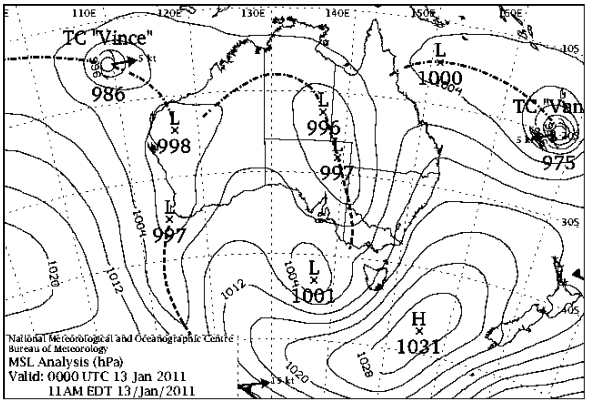


Figure 7.7: Mean sea level pressure chart at 11am 13th January 2011

During the morning of the 14th of January, the low-pressure centre had moved close to the southwest of Tasmania (Figure 7.8). This resulted in a moist northerly airstream across Tasmania. During this time, windward, elevated terrain across northern Tasmania began to see heavier rainfall.

As the low moved away to the south during the afternoon of the 14th, rainfall quickly eased across the state as a narrow ridge of high pressure approached from the west, crossing during the 15th of January (Figure 7.9).

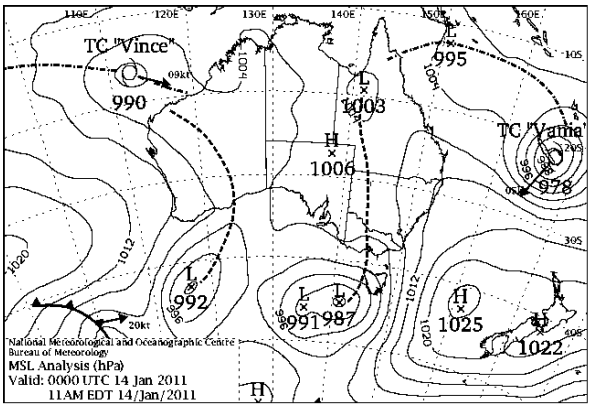


Figure 7.8: Mean sea level pressure chart at 11am 14th January 2011

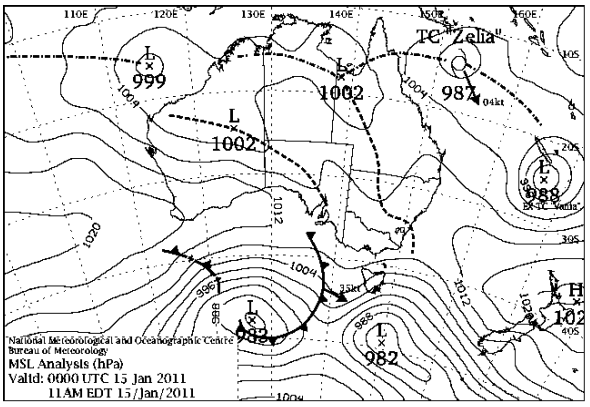
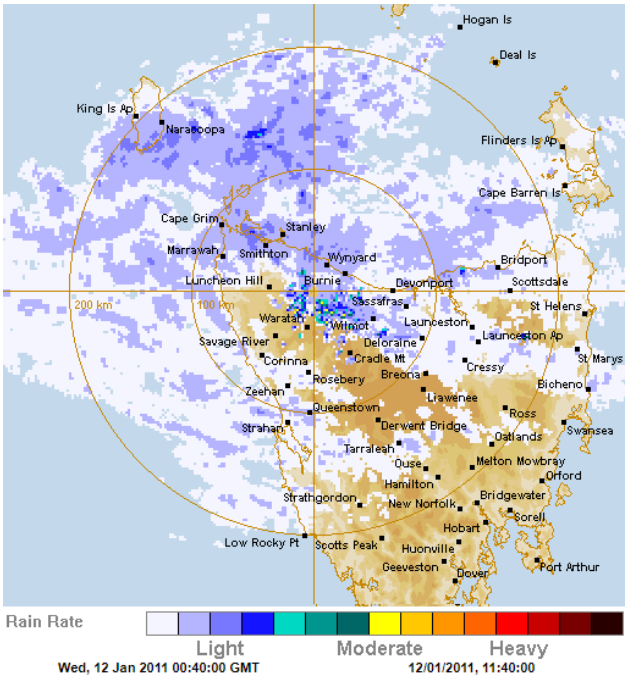


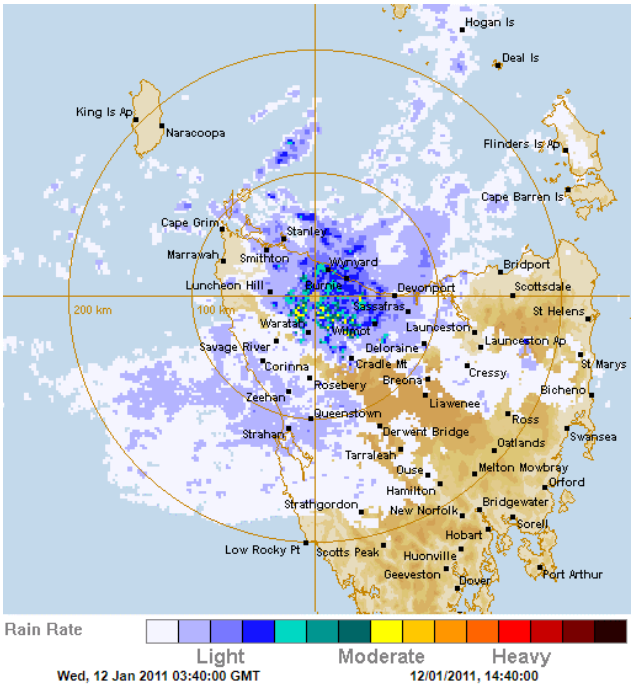
Figure 7.9: Mean sea level pressure chart at 11am 15th January 2011

Radar reflectivity imagery from the West Takone radar is shown below (Figure 7.10). The images at 11:40 and 14:40 on the 12th of January show areas of rain moving into northwestern Tasmania. Small areas of higher radar reflectivity are evident across the northwest. This signifies that the atmosphere was moderately convective with possible thunderstorm activity. As such, isolated heavier rainfall totals were experienced in some locations.

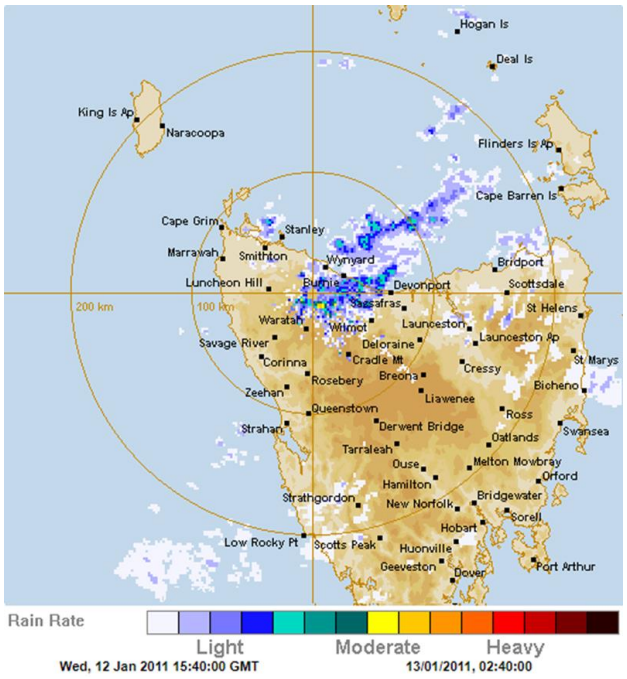
The image at 02:40 on the 13th of January shows a convective line of showers along the northwest coast. This pattern would have resulted in brief, heavy bursts of rainfall followed by lulls. Also note, during this time exceptional rainfall rates were occurring along the upper east coast. However, radar is not detecting any rain over that area. This is because that rainfall was generated by the strong, humid northeasterly airstream interacting with the topography and most rainfall fell from lower cloud beneath the radar beam. The image at 02:30 on the 14th of January shows heavy rain streaming into to the northwest as the northerly airstream interacts with the topography.



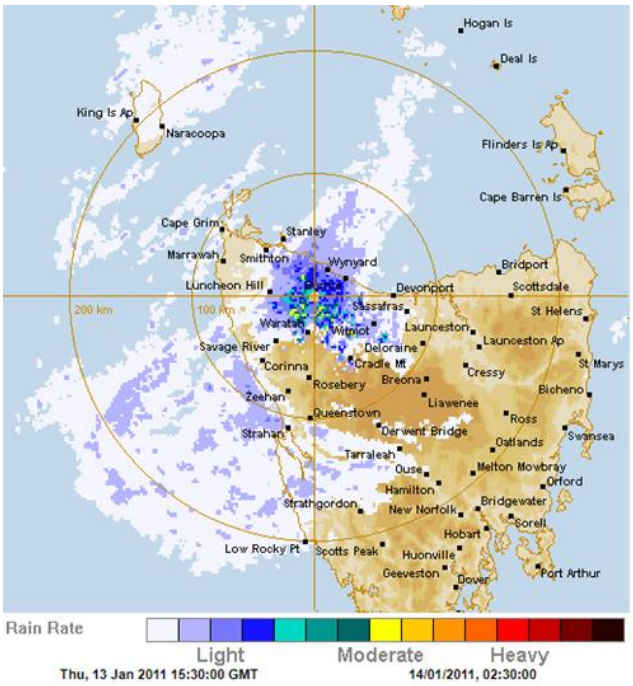
11:40, 12th of January



14:40, 12th of January



02:40,13th of January



02:30, 14th January

Figure 7.10: Radar reflectivity images during the event at the designated time and date.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 7.11). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. Heavy rain began to fall about the northwest and northeast during the 24 hours to 9 am on the 13th of January, with generally 50 to 150 mm of rain being recorded over those parts. However, exceptionally heavy rainfall (200 to 300 mm) was recorded within a small pocket along the upper east coast. This rainfall mostly occurred during the night time period. Heavy rainfall continued across parts of the northwest and northeast during the 24 hours to 9 am on the 14th of January with a further 50 to 150 mm of rainfall recorded about

higher topography in the northwest. A further 50 to 100 mm was recorded about the northwest and northeast during the 24 hours to 9 am on the 15th of January.

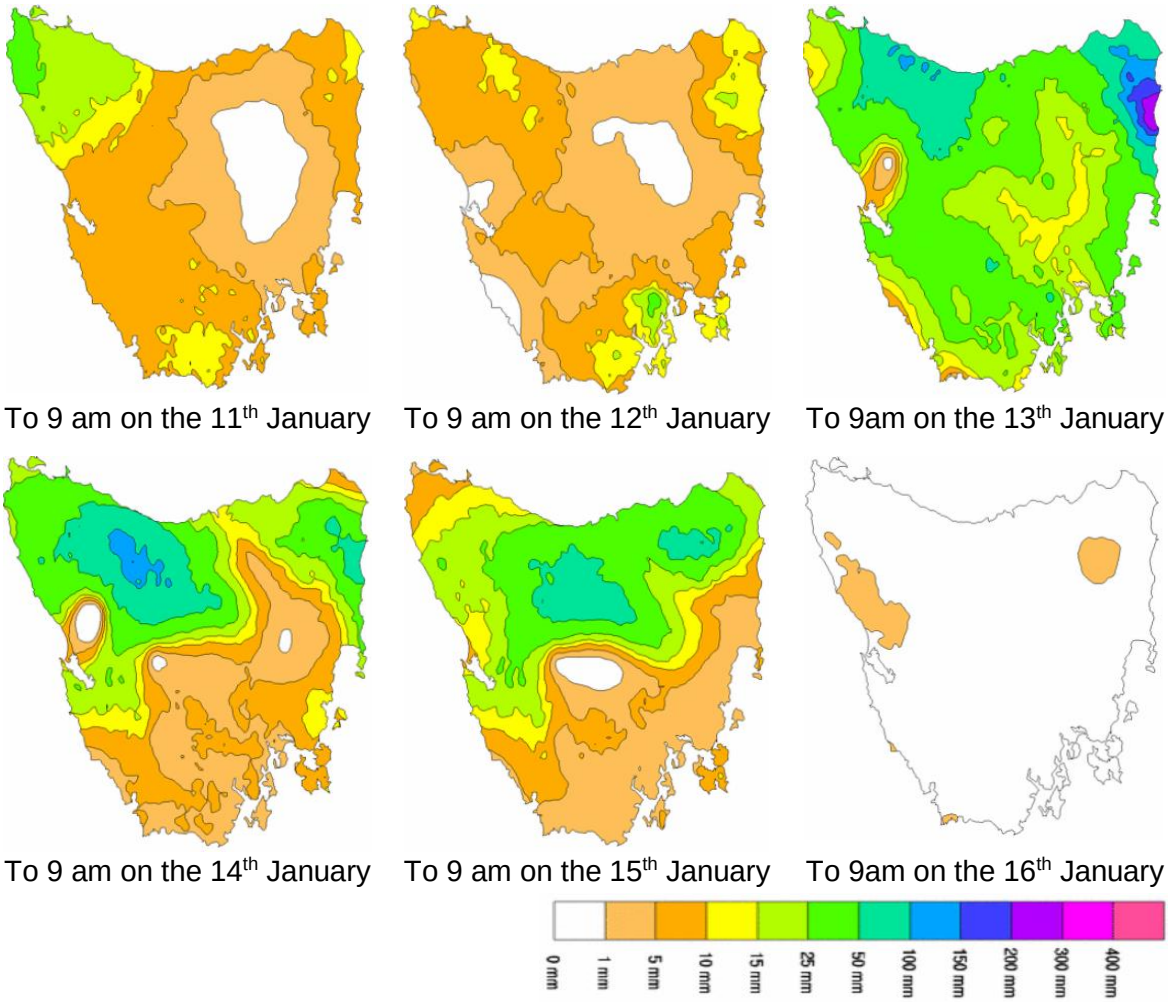


Figure 7.11: 24 hour rainfall to 9 am of the designated date for six days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Upper Scamander, Wynyard Airport and Lake Mackenzie. Also shown are the rainfall accumulation graphs for these sites.

The rainfall accumulation graph at Upper Scamander (Figure 7.13) shows exceptionally heavy and persistent rain beginning during the evening of the 12th of January, easing a little during the morning of the 13th and clearing late that afternoon. The storm envelope shows that rainfall rates at durations of around two hours to 24 hours have an AEP of around 1% (Figure 7.12).

At Wynyard Airport, heavy rainfall began near midday of the 12th of January and eased a little during the morning of the 13th, clearing on the morning of the 14th (Figure 7.15). The Wynyard storm envelope shows that rainfall rates with AEP of 2% are reached at durations of two days and beyond.

At Lake Mackenzie, heavy rain begins late morning on the 12th of January then increases significantly early on the 14th at a remarkably uniform rainfall rate until early that afternoon - about 12 hours later (Figure 7.17). The uniform rainfall rate looks almost unnatural and suspect, however at least three other stations nearby observed the same uniform rainfall, so it was likely a correct observation. The storm envelope peaks beyond 1% AEP at durations of 12 hours (Figure 7.16).

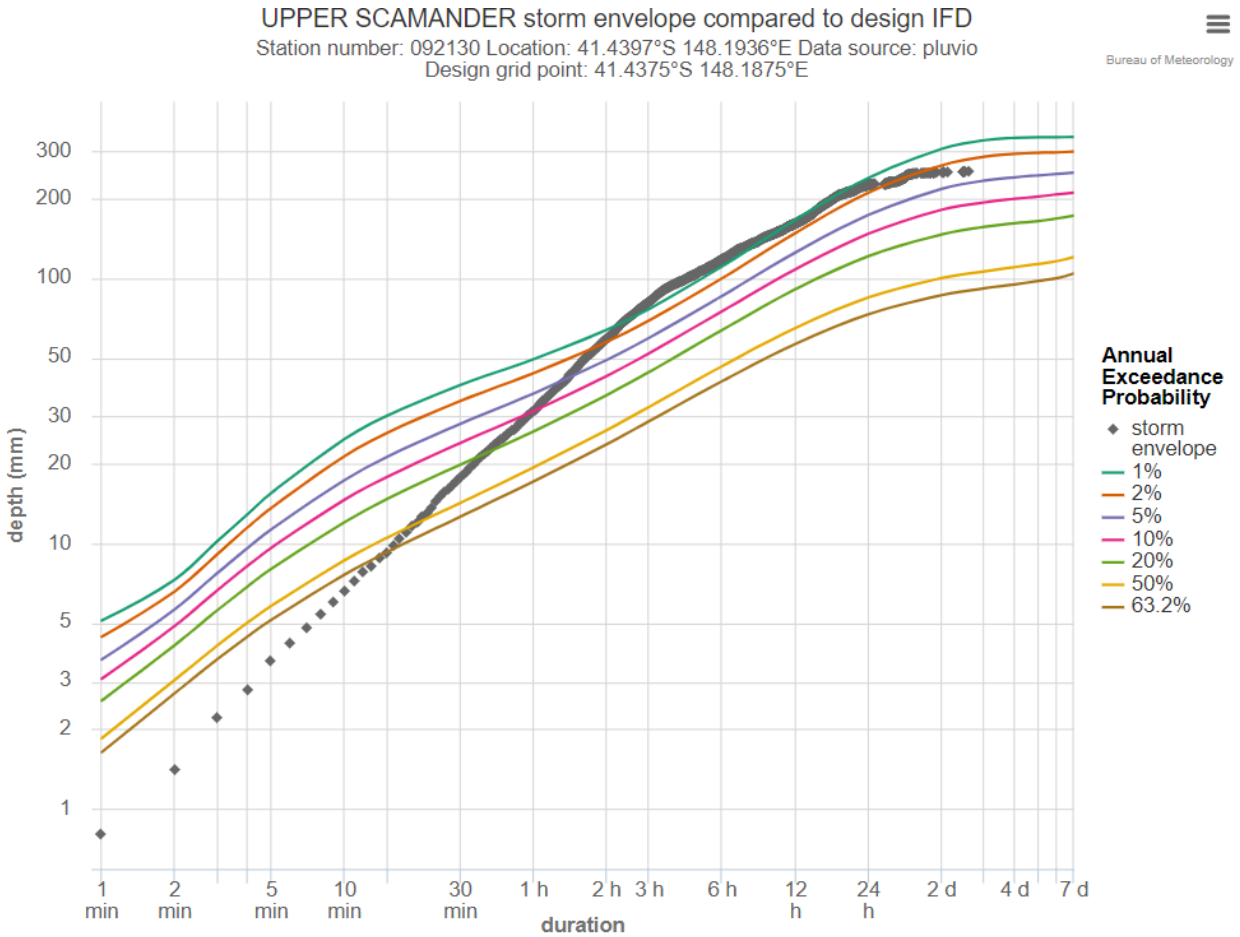


Figure 7.12: Storm envelope for Upper Scamander

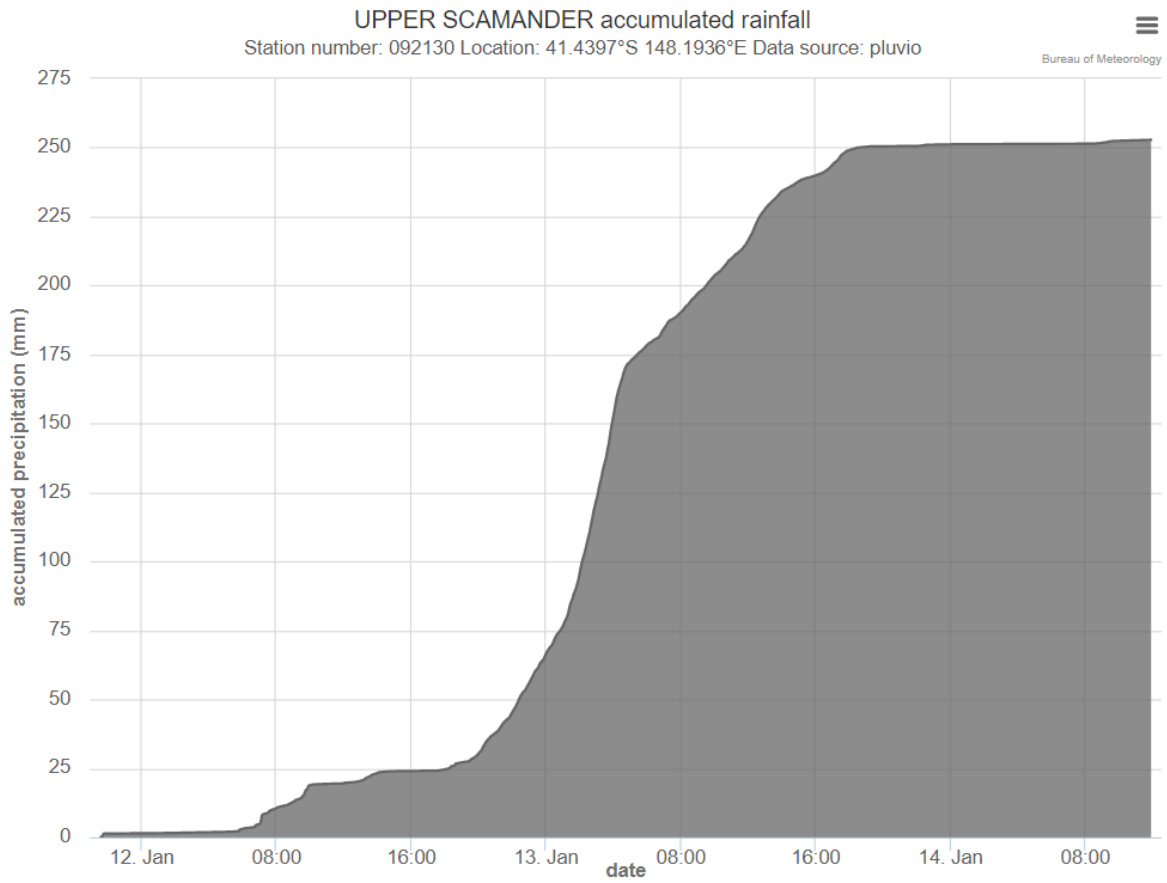


Figure 7.13: Rainfall accumulation at Upper Scamander

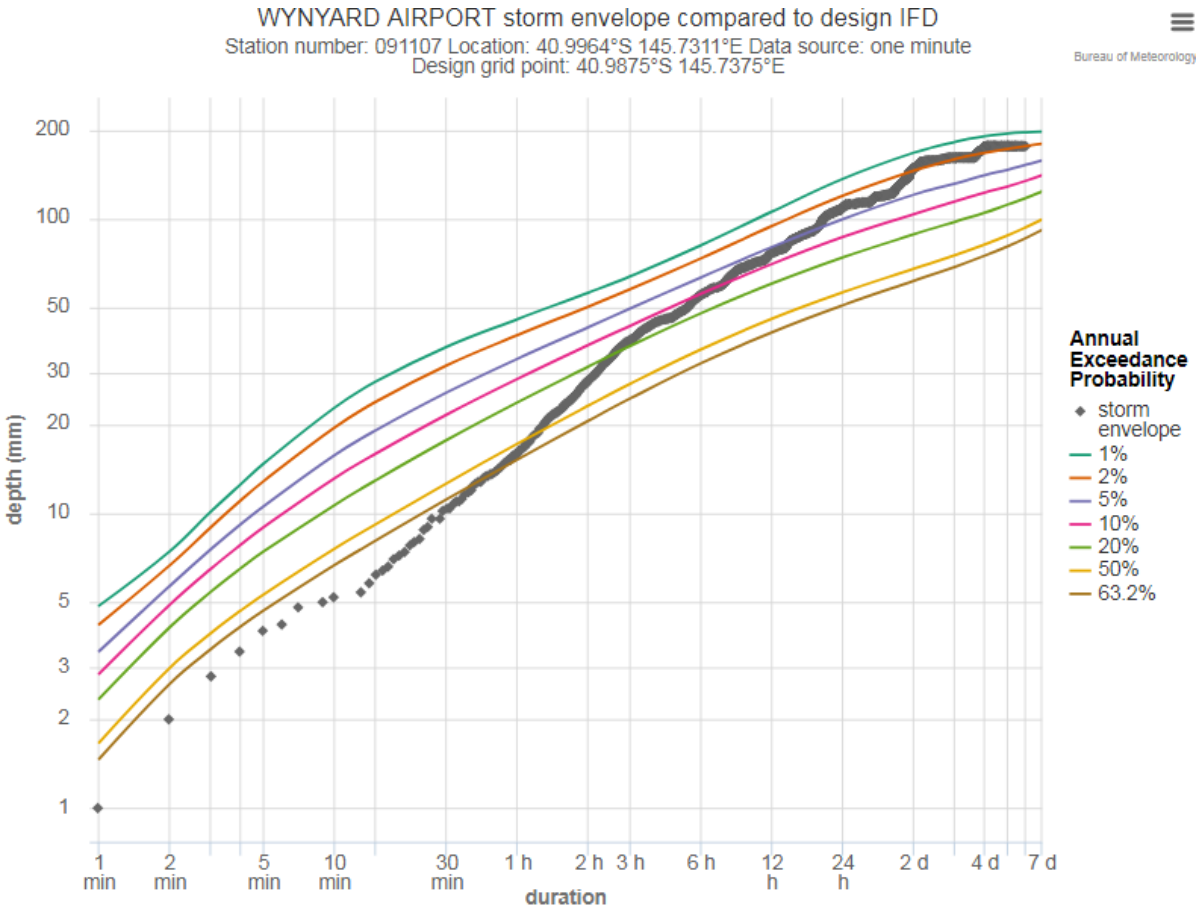


Figure 7.14: Storm envelope for Wynyard Airport

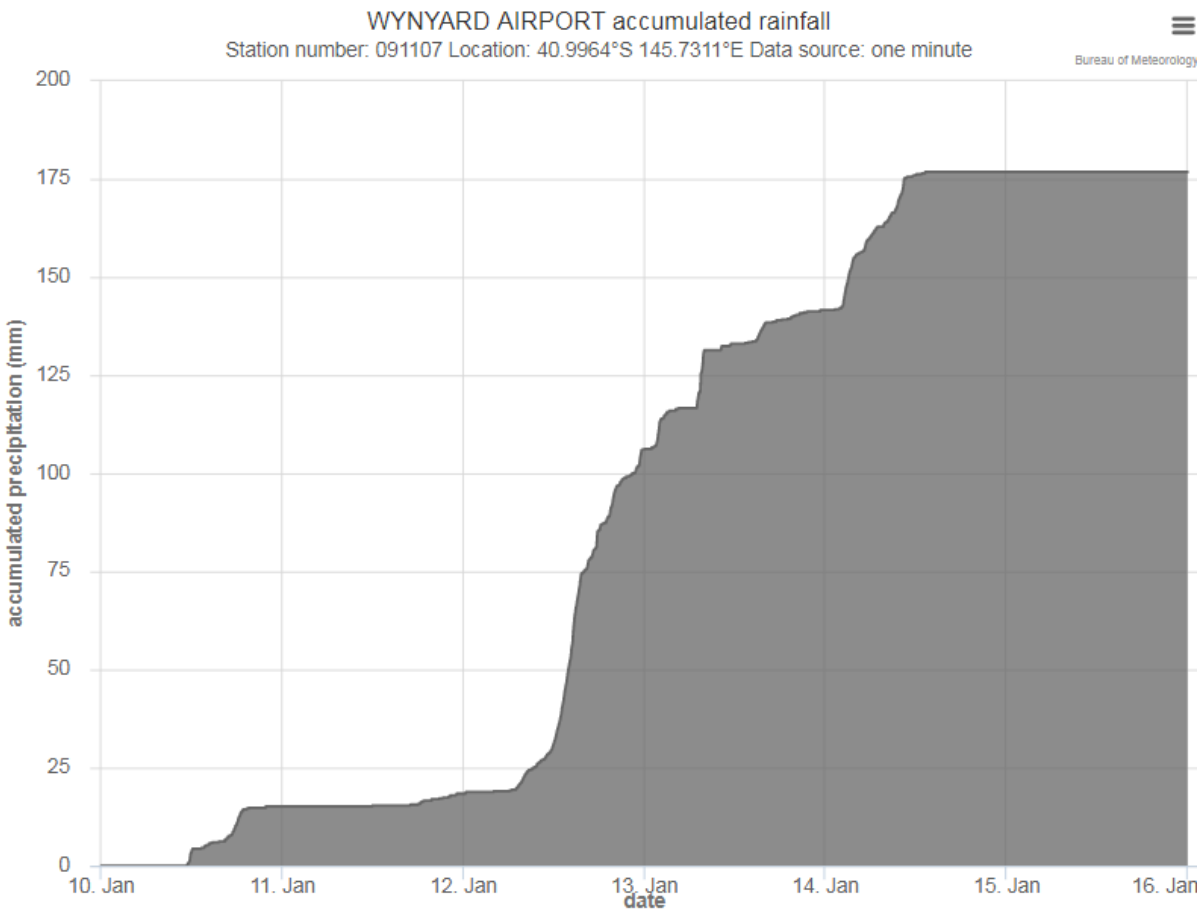


Figure 7.15: Rainfall accumulation at Wynyard Airport

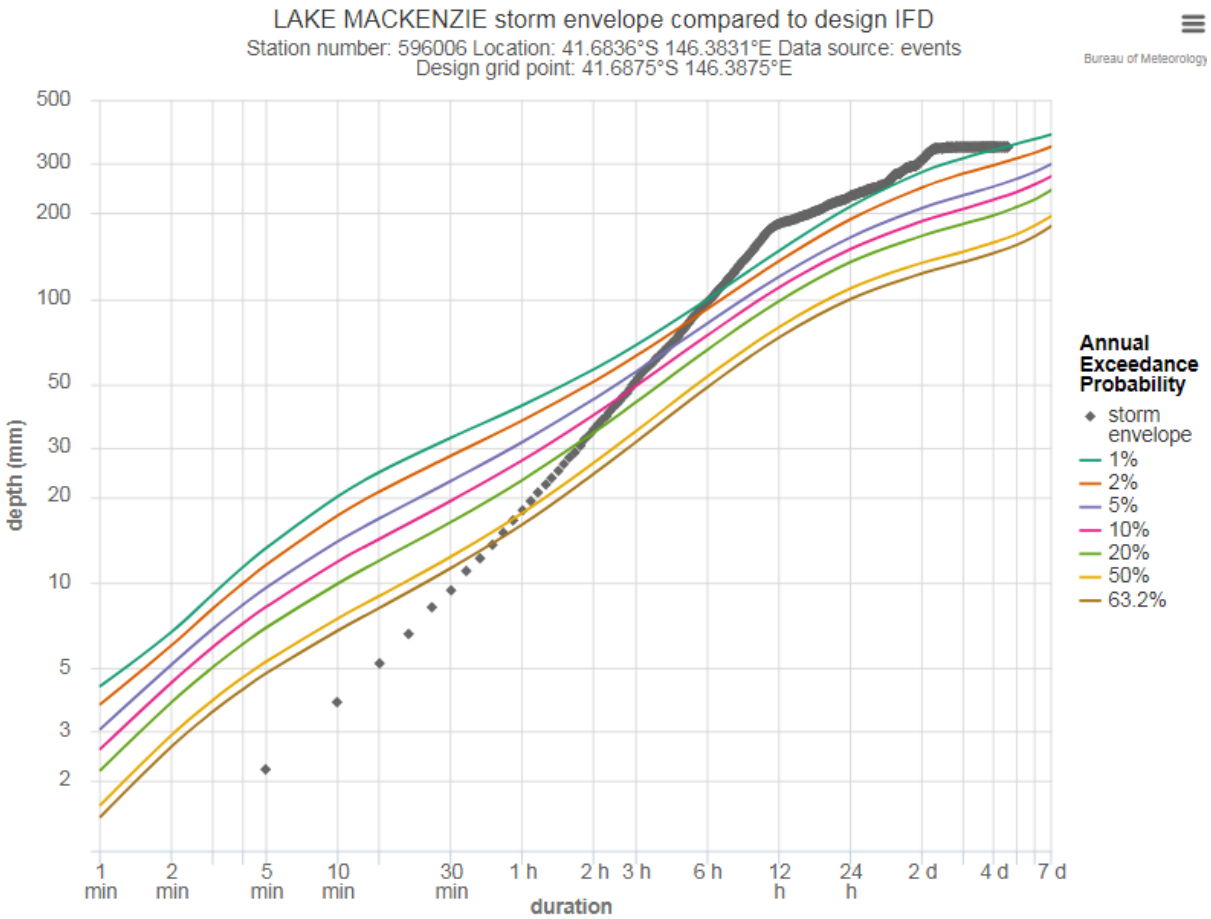


Figure 7.16: Storm envelope for Lake Mackenzie

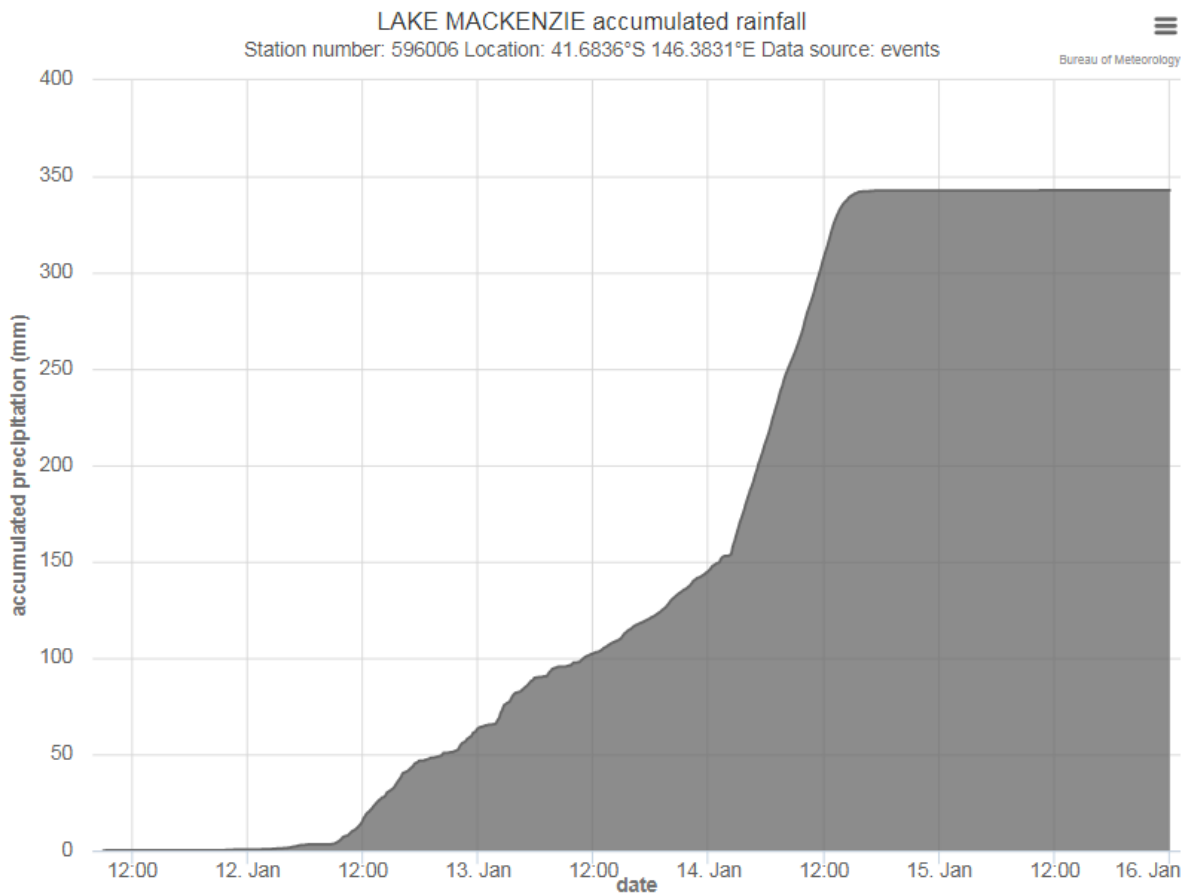
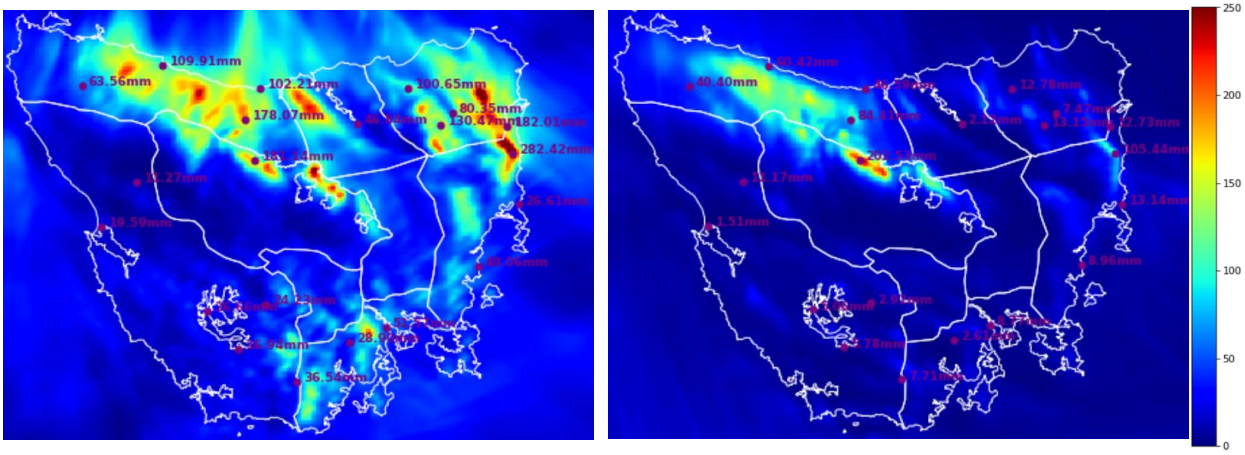


Figure 7.17: Rainfall accumulation at Lake Mackenzie

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania during this event. A sample of the data is shown below (Figure 7.18).



24 hours to 11 am, 13th of January 24 hours to 11 am, 14th of January

Figure 7.18: BARRA-TA 24-hour rainfall accumulation (mm) to 11 am of the stated date

BARRA data seems to have exaggerated the amount of convective rainfall about northwest Tasmania as well as misplacing some convective elements, so it is not recommended that the data is used for use for hydrological modelling across that area. However, the rainfall across the northeast seem reasonably well modelled, so the data may be of use across that area.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- Rain_event, usually ten-minute accumulation
- BARRA-TA, ten-minute accumulated rainfall
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

8. March 2011 – Northeast

Summary

Exceptionally heavy rainfall occurred across northeast Tasmania on the 23rd and 24th of March 2011 as a series of low-pressure centres across Bass Strait directed a strong, humid northeasterly airstream across the state. 200 to 300 mm of rainfall was observed across northeastern Tasmania during the 3 days to 9 am of the 24th of March (Figure 8.1). However Gray recorded 327.2 mm in 24 hours to 9 am of the 24th.

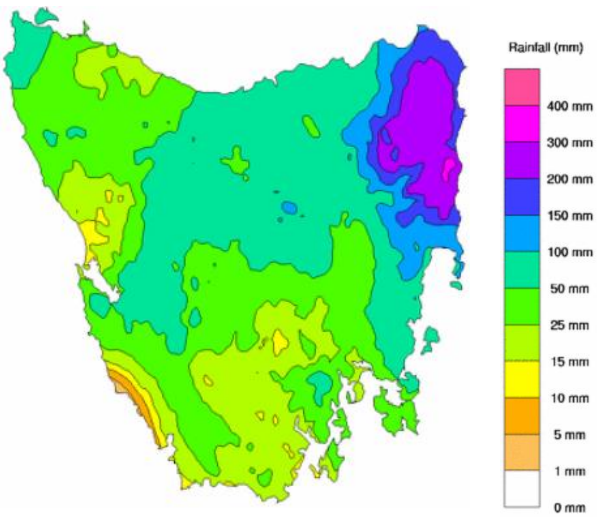


Figure 8.1: Rainfall totals for the 3 days from 9 am of the 22nd to 9 am of the 24th of March 2011.

The rain caused major flooding in the South Esk river basin, with peak heights in some places comparable to the floods of May 1969 and just slightly lower than the levels observed during the floods of April 1929. There was also flash flooding and minor to moderate flooding in several other rivers in the northeast and central north.

Antecedent Conditions

Exceptionally heavy rainfall had fallen across much of the north during January 2011, so the seven months leading up to the end of February 2011 were very much wetter than average about much of the north, and mostly wetter than average elsewhere (Figure 8.2).

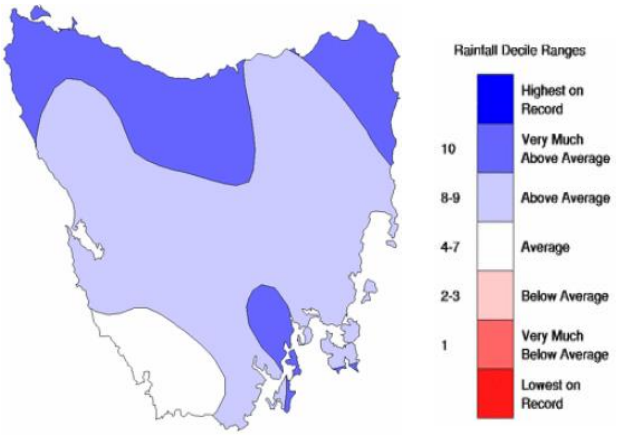


Figure 8.2: Rainfall deciles from 1 August 2010 to 28 February 2011.

During January and February 2011, much of the north and east of Tasmania received around 100 to 200 mm of rainfall, with some parts receiving over 400 mm (Figure 8.3). This rainfall was generally 50 to 300 mm above the January/February average. Most of this rain fell during January.

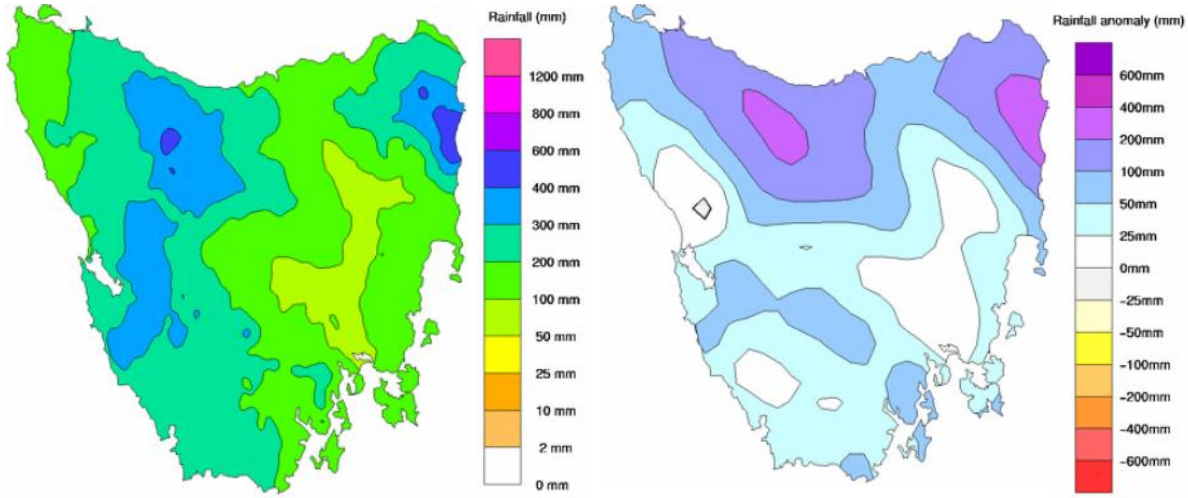


Figure 8.3: The left map shows recorded rainfall across Tasmania during January and February 2011 with the right map showing the deviation from the January and February mean (in mm).

Rainfall during the first 19 days of March was not significant about eastern Tasmania, with 25 to 50 mm north of the northeast highlands, and less than 25 mm elsewhere (Figure 8.4).

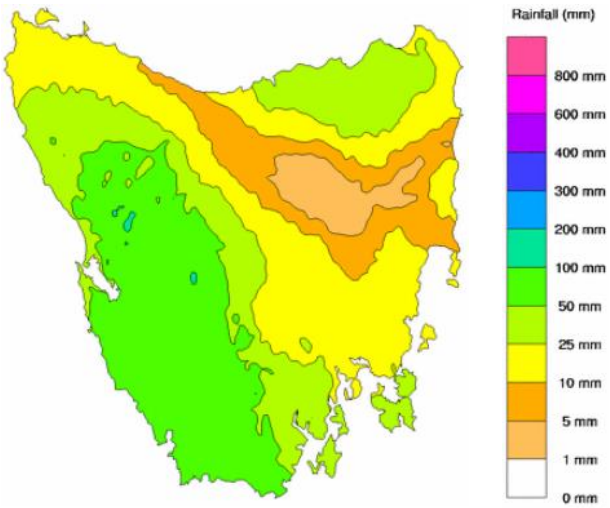


Figure 8.4: Rainfall totals from 9 am of the 28th of February to 9 am of the 19th of March 2011

Despite the wet conditions during January 2011, the lack of significant rain during the 7 to 8 weeks preceding this rain event, combined with warm temperatures and longer days, resulted in soils partially drying across eastern Tasmania. Figure 8.5 shows the Bureau's AWRA-L rootzone soil moisture model. Much of eastern Tasmania has between 60 to 100 mm of rootzone soil moisture, with elevated areas having 150 mm or more. Similarly, the Soil Dryness Index (Figure 8.6) shows high values in excess of 100 mm across low areas such as the Fingal and Tamar Valleys, with values of 50 to 100 mm generally elsewhere across the east.

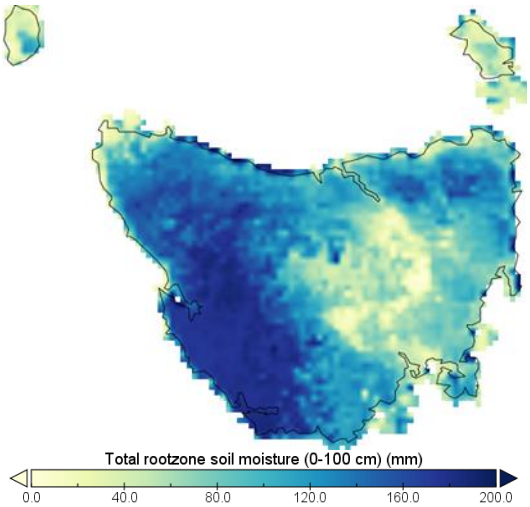


Figure 8.5: AWRA-L Rootzone soil moisture on 20th March, 2011.

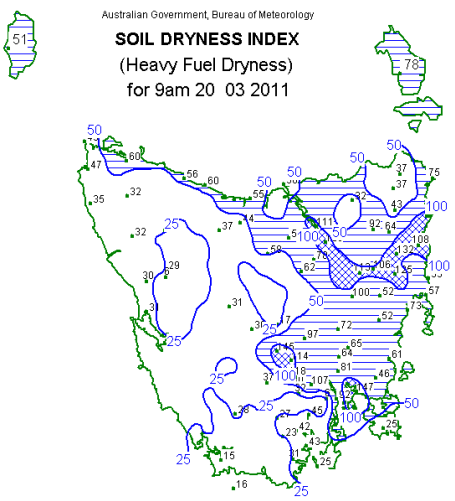


Figure 8.6: SDI on 20th March, 2011.

Meteorological Discussion

The synoptic setup of this rain event was not too dissimilar to that of the event of January earlier that year. A complex and slow-moving area of low pressure over southeastern Australia extended a trough to the northwest of Tasmania while a ridge to the distant south held it in place for a prolonged period. The trough and ridge acted to direct strong and humid east to northeasterly winds across Tasmania from the 21st to 25th March 2011. Several low-pressure centers triggered locally very heavy rain falls in the northeast of the State during the period.

The first of these low centres moved slowly eastwards from South Australia to the New South Wales coast during March 21st, 2011 (Figure 8.7). A trough extended from that low, across Victoria and to the west of Tasmania. Along this trough, a second low developed over western Bass Strait on the morning of March 22nd, bringing a strong northeasterly airstream and locally heavy rainfall to northwest and northeast Tasmania (Figure 8.8).

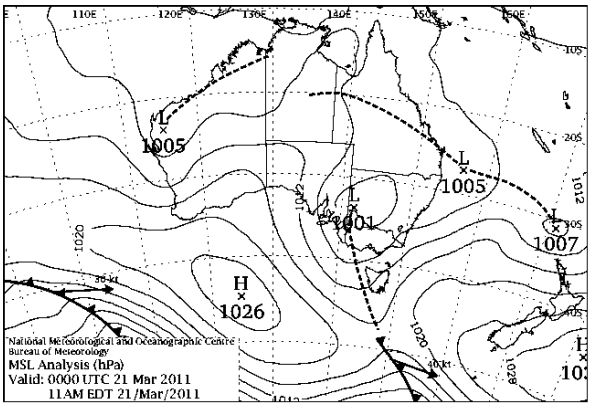


Figure 8.7: Mean sea level pressure chart at 11am 21st March 2011

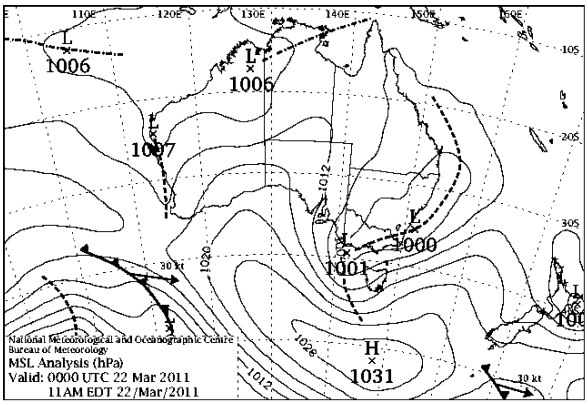


Figure 8.8: Mean sea level pressure chart at 11am 22nd March 2011

The trough remained over Bass Strait with further low centres developing along it during March 23rd (Figure 8.9). A low centre near northwest Tasmania maintained strong, humid northeasterly winds and very heavy, continuous rain into northeast Tasmania for a prolonged time. The low near the NSW coast slowly approached Tasmania late on the 23rd and crossed the State during the 24th, with winds and rainfall easing as it crossed (Figure 8.10). The area of low pressure then moved southeast of Tasmania with a southerly airstream and ridge to quickly follow on the 25th.

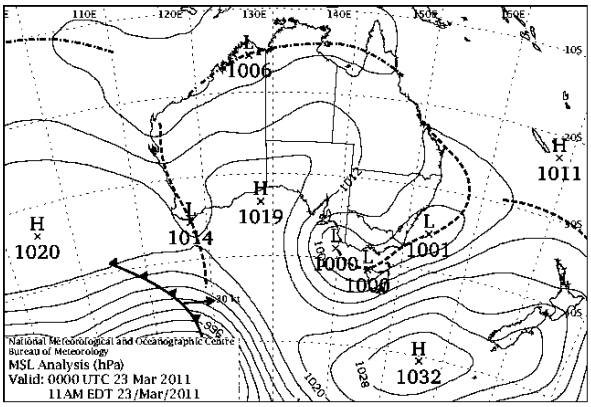


Figure 8.9: Mean sea level pressure chart at 11am 23rd March 2011

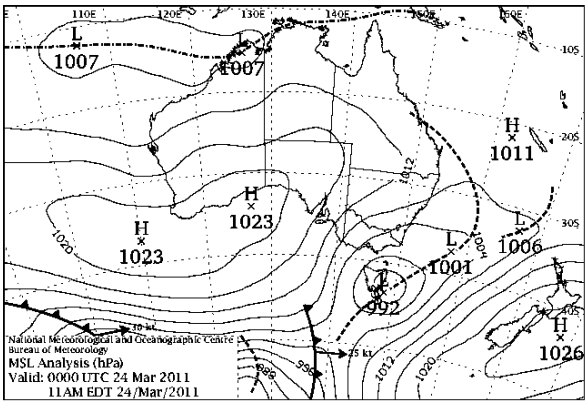
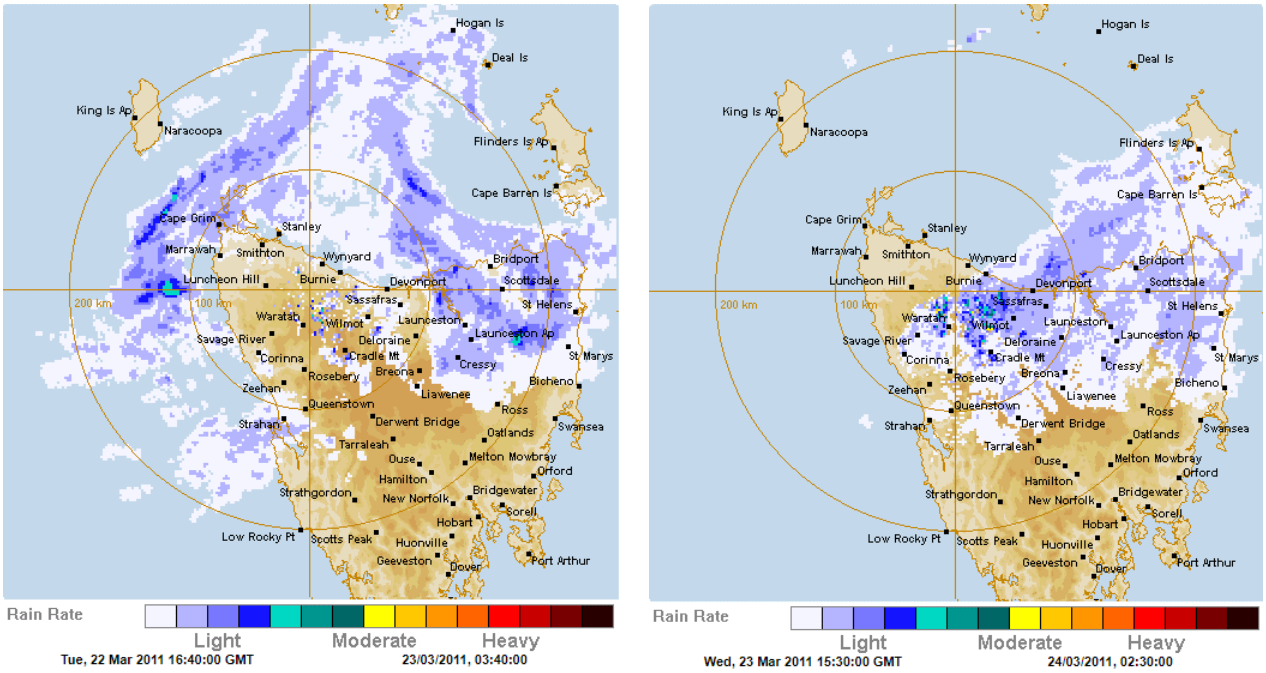


Figure 8.10: Mean sea level pressure chart at 11am 24th March 2011

Radar reflectivity imagery from the West Takone radar is shown below (Figure 8.11). The image at 03:40 on the 23rd of March shows broad areas of rain moving over northeastern Tasmania. Very heavy rain had begun falling across the northeast during this time, however radar coverage over this area is very poor and not much insight about the rainfall can be gleaned from the imagery. Similarly, the image at 02:30 on the 24th of March shows broad

rainfall across the northeast but doesn't capture the very heavy rainfall that was occurring at that time.



03:40, 23rd of March 02:30, 24th of March

Figure 8.11: Radar reflectivity images during the event at the designated time and date.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 8.12). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. Moderate rains of 25 to 50 mm fell across eastern Tasmania during the 24 hours to 9 am on the 21st of March as an east to northeasterly airstream developed over the State. The northeasterly airstream then brought around 25 to 75 mm of rain to northeastern and northwestern elevated areas during the 24 hours to 9 am of the 22nd of March. Then as the northeasterly airstream strengthened and interacted with topography later during the 22nd, rain become very heavy in the northeast with over 100 mm recorded about elevated terrain during the 24 hours to 9 am of the 23rd. Very heavy rain continued for the remainder of the day with a further 150 to 300 mm falling about the northeast of Tasmania during the 24 hours to 9 am of the 24th and generally 50 to 100 mm about the remainder of the north and east. Rainfall quickly eased during the 24th, and no significant rain was observed in the days after the 24th of March.

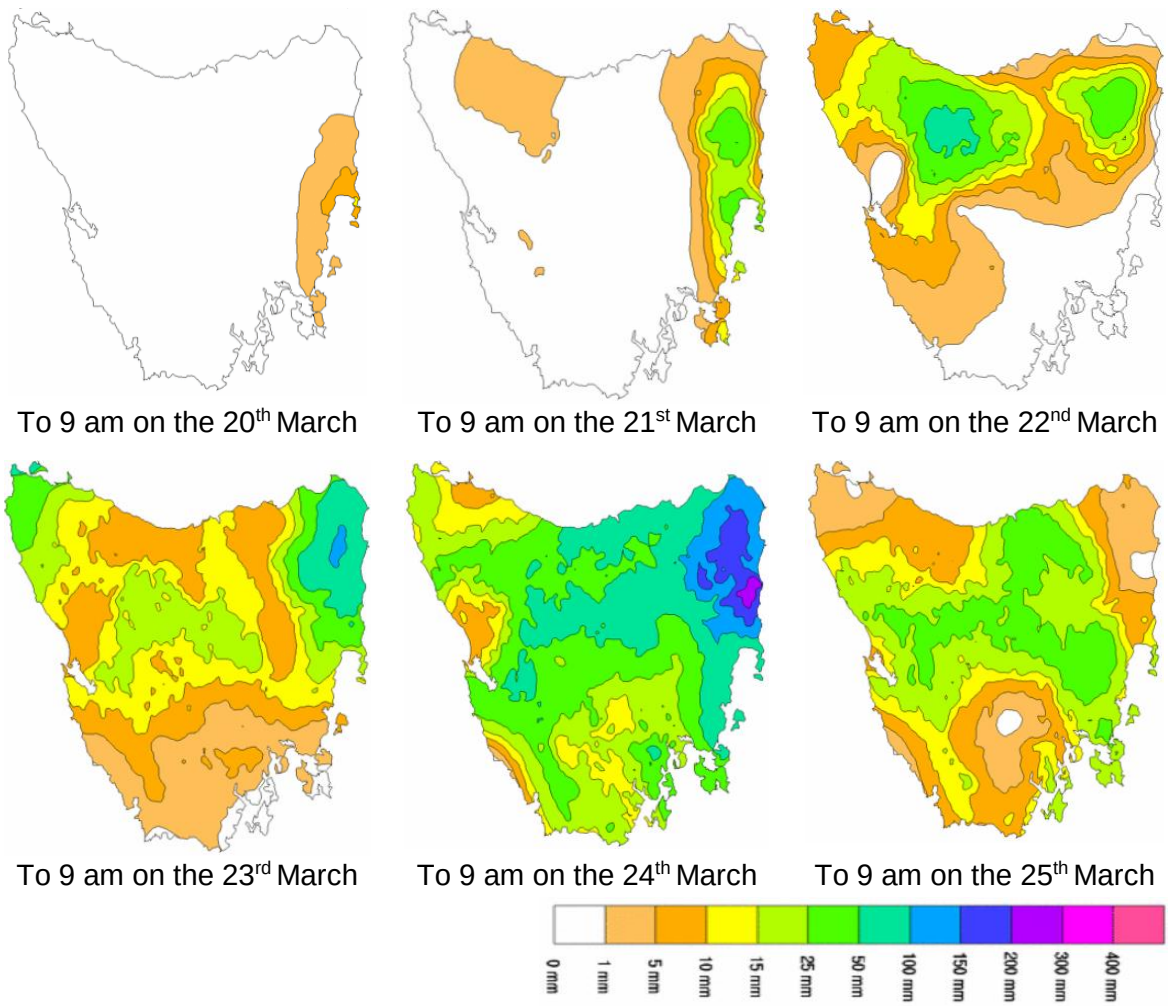


Figure 8.12: 24 hour rainfall to 9 am of the designated date for six days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Gray, Mount Victoria and Upper Esk. Also shown are the rainfall accumulation graphs for these sites.

The rainfall accumulation graph at Gray (Figure 8.14) shows exceptionally heavy and persistent rain beginning during the morning of the 23rd of March and mostly persisting until the morning of the 24th. The storm envelope shows that rainfall rates at durations of around two hours to two days have an AEP of around 1% (Figure 8.13). Gray is highly susceptible to very heavy rainfall in strong northeasterly airstreams and usually has significantly more rainfall than most other northeastern locations under this regime.

Mount Victoria was a little more sheltered from the northeasterlies and didn't experience the intense rainfall that was seen at Gray. However, heavy and persistent rain did develop at Mount Victoria during the morning of the 23rd until the morning of the 24th (Figure 8.16). The storm envelope shows rainfall rates were near 2% AEP at durations of two days and beyond (Figure 8.15).

Similarly, at Upper Esk, heavy and persistent rain developed at during the morning of the 23rd until the morning of the 24th (Figure 8.18). The storm envelope shows rainfall rates were beyond the 1% AEP threshold at durations of 24 hours and beyond (Figure 8.17).

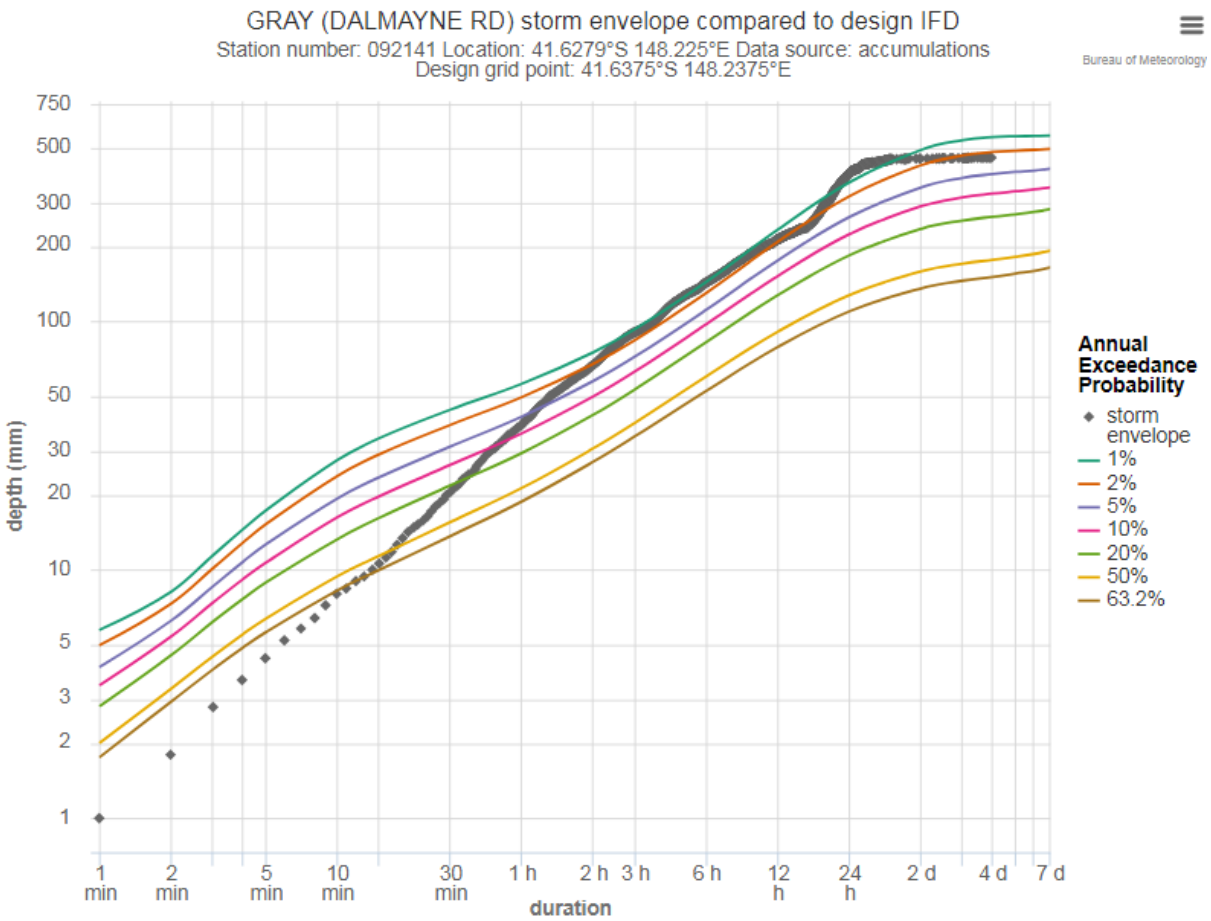


Figure 8.13: Storm envelope for Gray (Dalmayne Rd)

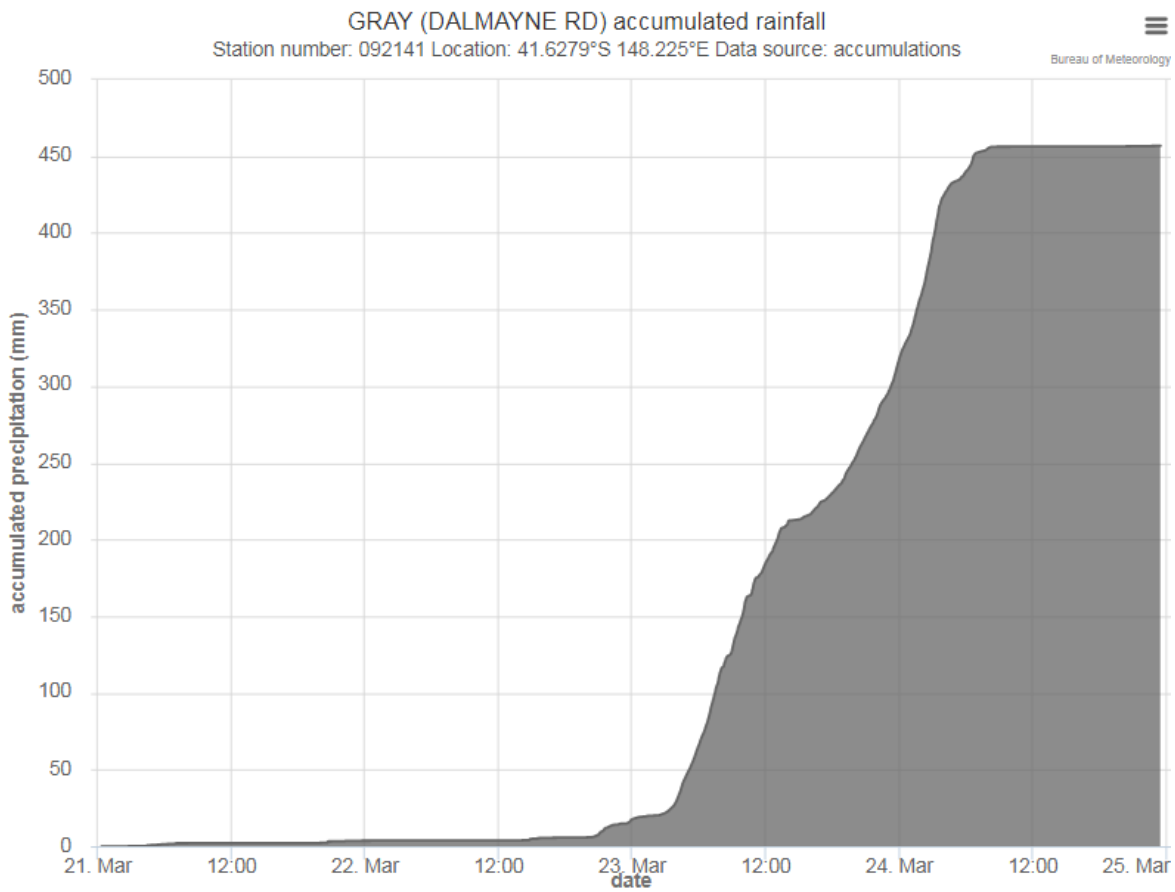


Figure 8.14: Rainfall accumulation at Gray (Dalmayne Rd)

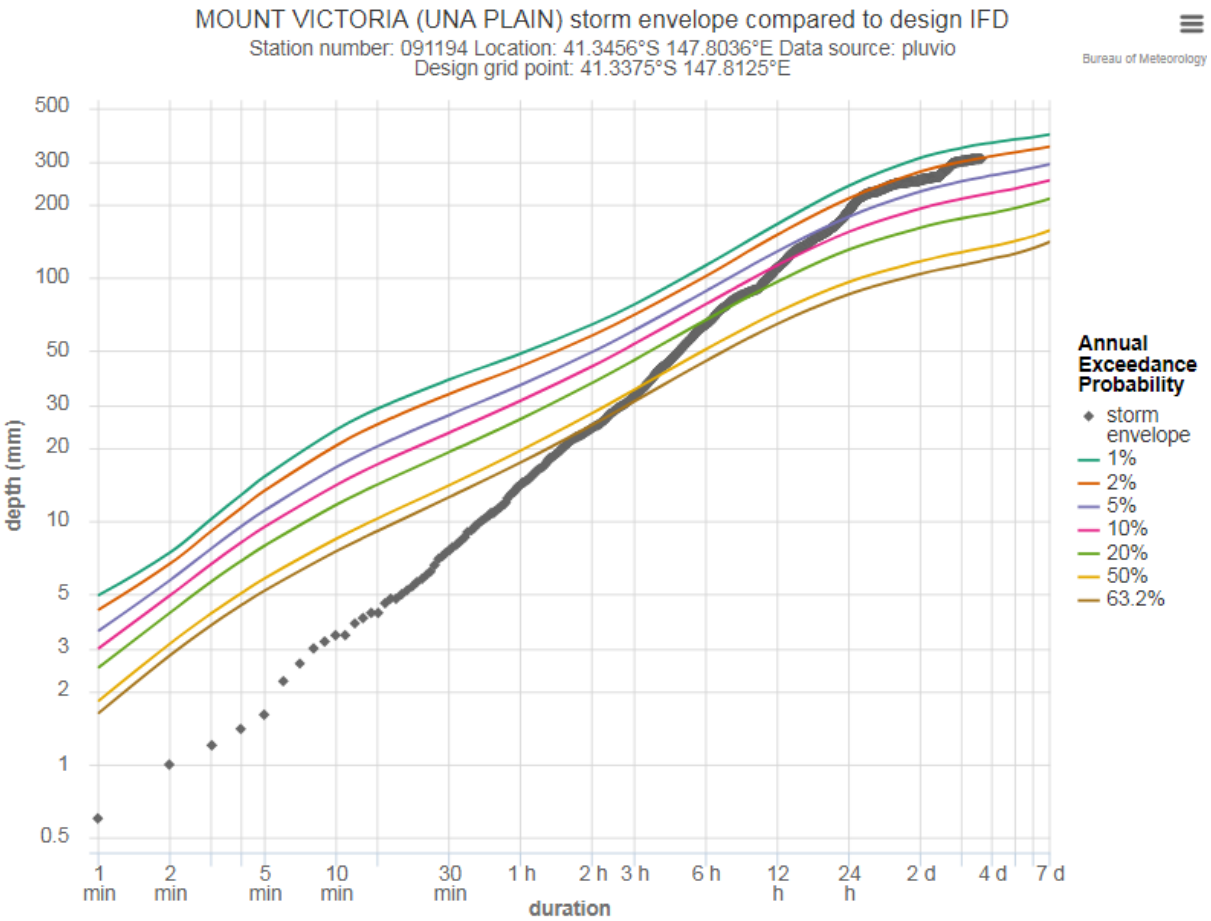


Figure 8.15: Storm envelope for Mount Victoria (Una Plain)

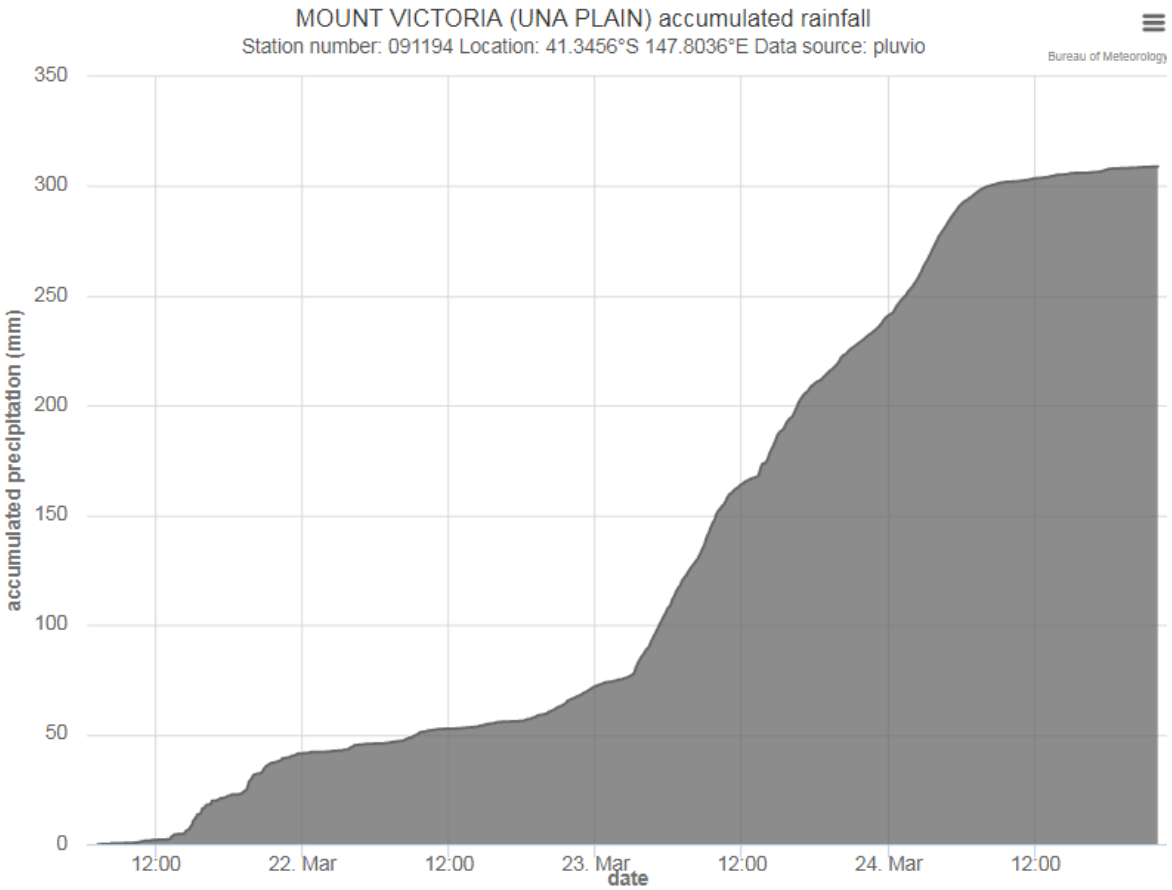


Figure 8.16: Rainfall accumulation at Mount Victoria (Una Plain)

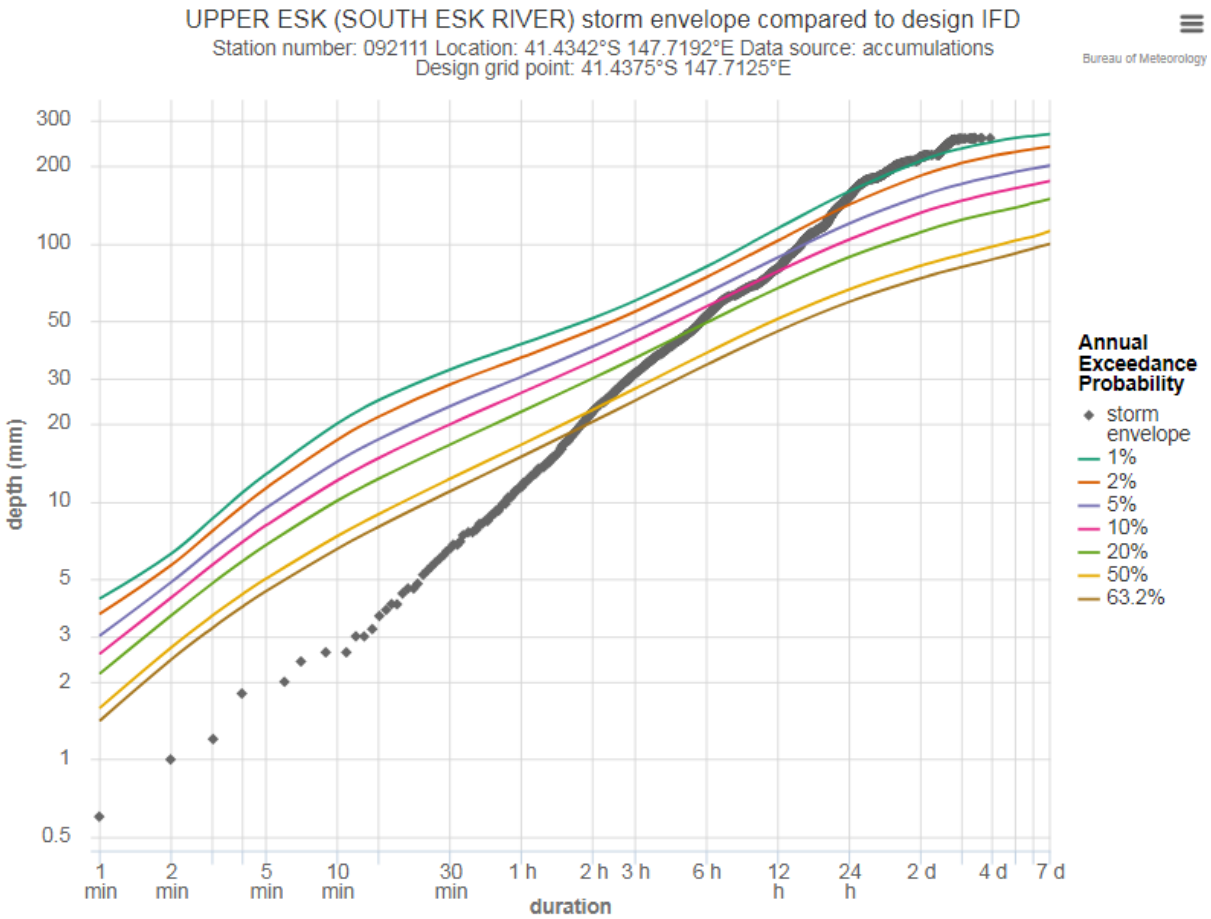


Figure 8.17: Storm envelope for Upper Esk (South Esk River)

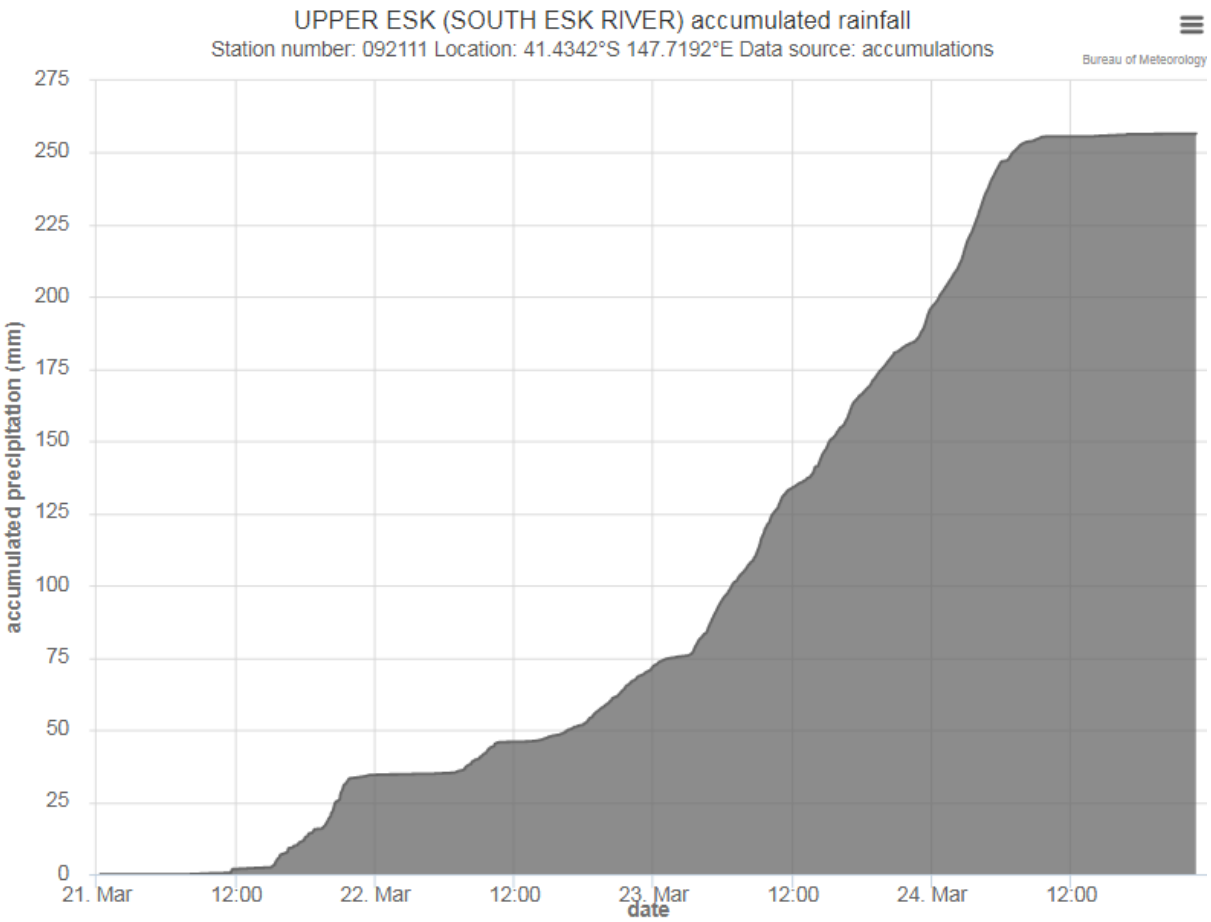
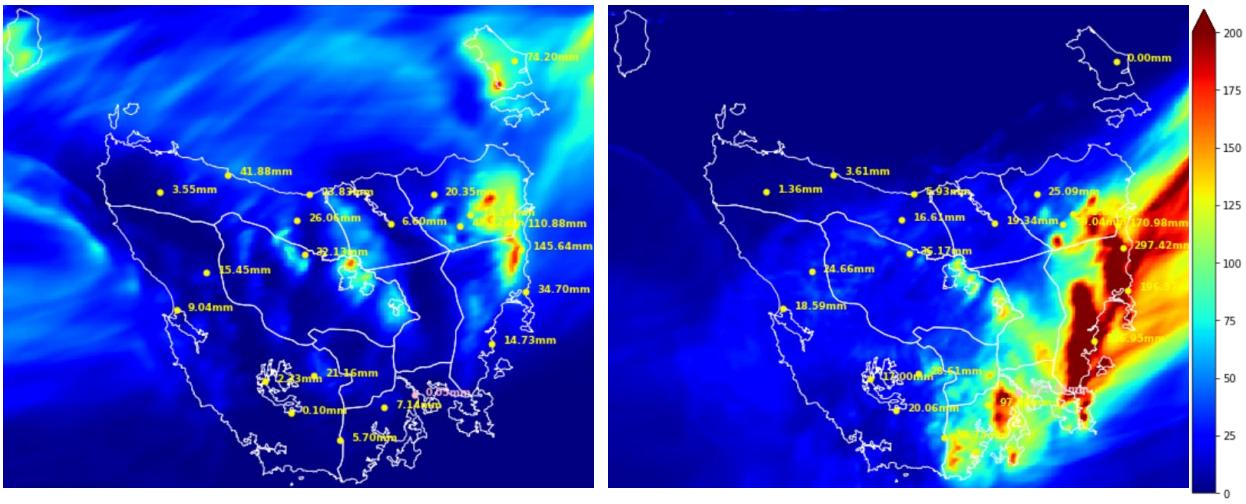


Figure 8.18: Rainfall accumulation at Upper Esk (South Esk River)

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania during this event. A sample of the data is shown below (Figure 8.19).



24 hours to 11 am, 23rd of March 24 hours to 11 am, 24th of March

Figure 8.19: BARRA-TA 24-hour rainfall accumulation (mm) to 11 am of the stated date

BARRA appears to have overestimated the amount of rainfall across much of the east as well as displacing the rain band a little too far south, however rainfall accumulations around the 'Gray' area seem reasonable, so the data may be of limited use for hydrological modelling across that area only.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- Rain_event, usually ten-minute accumulation
- BARRA-TA, ten-minute accumulated rainfall
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

9. February 2012 – Flinders Island

Summary

During the 10th and 11th of February 2012, a trough remained very close to the northern tip of Flinders Island and brought heavy rain to much of the north and east of the Island. During the 48-hour period to 9 am of the 11th February 50 to 100 mm of rainfall was observed on northern and eastern parts of the Island (Figure 9.1).

The rainfall was mostly generated by fresh and humid east to southeasterly winds interacting with topography over the Island, and as such had a generally uniform rate. However, thunderstorms along the trough brought isolated, intense short duration rainfall to parts of the far north of the Island.

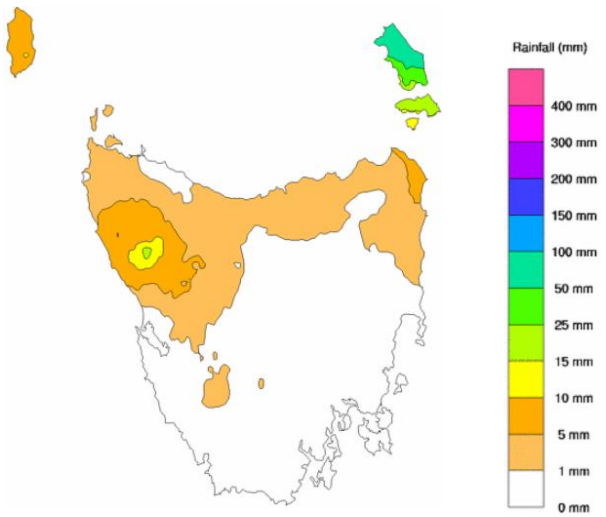


Figure 9.1: Rainfall totals for the 2 days from 9 am of the 9th to 9 am of the 11th February 2012.

Antecedent Conditions

Antecedent rainfall across Flinders Island (and Tasmania) was not particularly unusual. During the seven months leading up to the 31st of January, above average rainfall was recorded across Flinders Island, however no significant rain had fallen during the recent months (Figure 9.3).

During the three-week period from the 20th of January to the 9th of February 2012, Flinders Island had recorded light to moderate rainfall of around 10 to 40 mm (Figure 9.2)

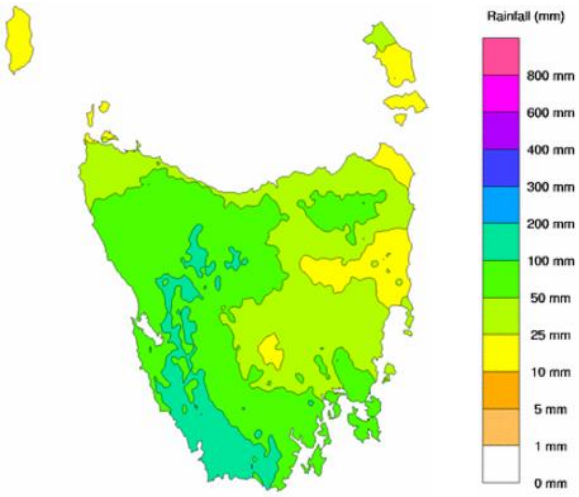


Figure 9.2: three-week rainfall from 20th January to 9th February

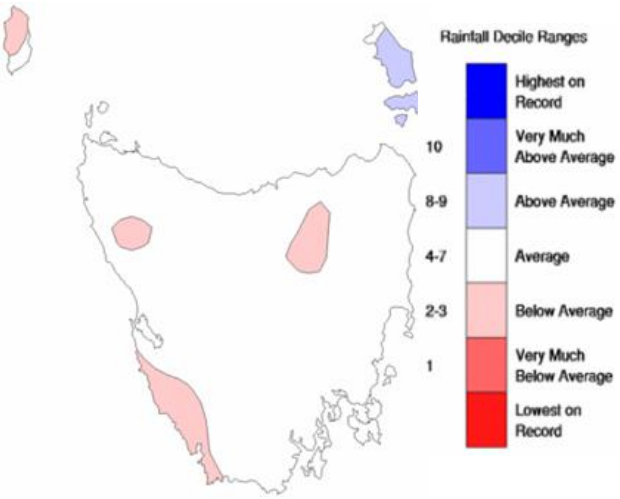


Figure 9.3: Rainfall deciles from 1st July 2011 to 31st January 2012

Despite above average rainfall during the seven months leading to the end January 2012, the lack of recent significant rain, combined with warm temperatures, resulted in dry soils across Flinders Island. Figure 9.4 shows the Bureau's AWRA-L rootzone soil moisture model. Low rootzone soil moisture values of around 20 to 40 mm are prevalent across Flinders Island. Similarly, the Soil Dryness Index (Figure 9.5) shows high values in excess of 100 mm across the Island.

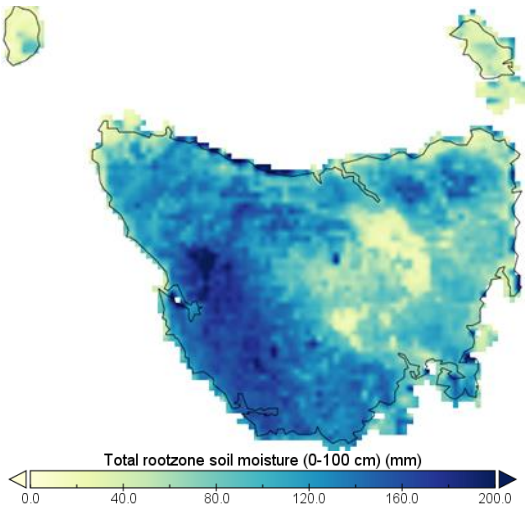


Figure 9.4: AWRA-L Rootzone soil moisture on 9th February 2012.

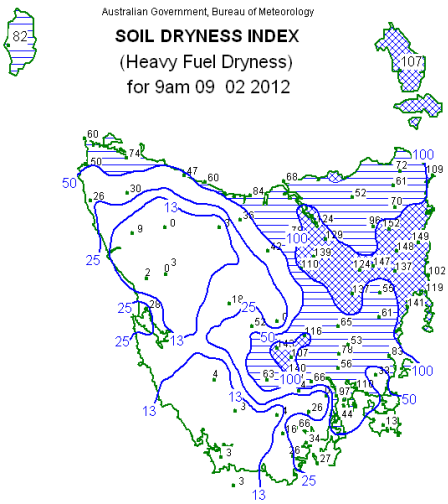


Figure 9.5: SDI on 9th February 2012.

Meteorological Discussion

During the 10th of February 2012, a trough of low pressure extended along eastern Australia towards northeastern Tasmania (Figure 9.6). The trough was very slow moving and held in place by a ridge of high pressure to the south of Tasmania. The trough remained very close to the northern tip of Flinders Island throughout the 11th of February (Figure 9.7) before moving eastward away from Flinders Island the following day.

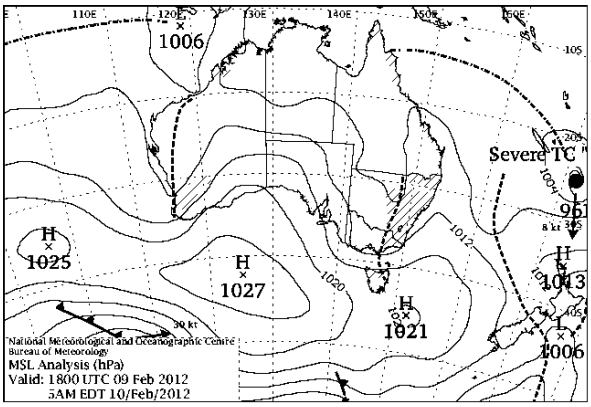


Figure 9.6: Mean sea level pressure chart at 5am 10th February 2012

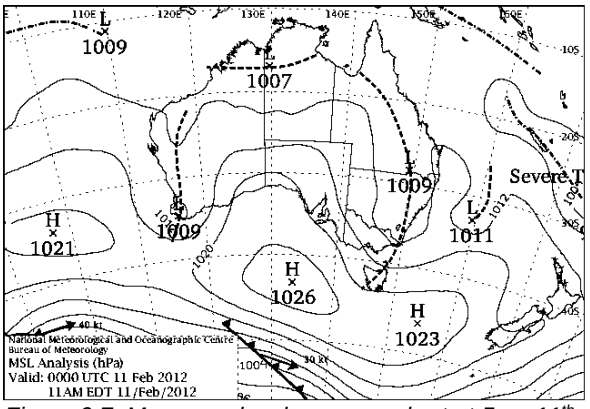
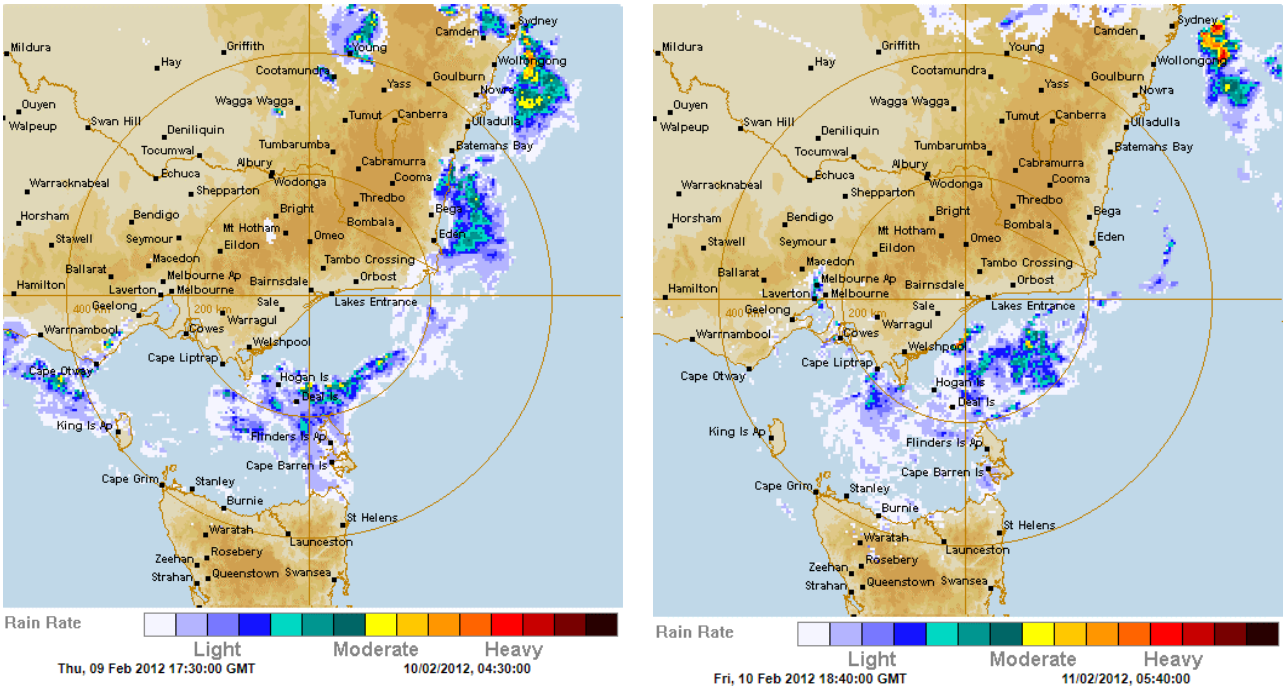


Figure 9.7: Mean sea level pressure chart at 5am 11th February 2012

The synoptic charts show a weak pressure gradient across Tasmania, indicating that light to moderate easterly winds would have prevailed across the State. However, due to the very close proximity of the trough, Flinders Island was exposed to locally stronger east to southeasterly winds that were present close to the southern flank of the trough. As such, strong, humid and persistent east to southeasterly winds brought heavy and continuous rain to much of Flinders Island (particularly the east) as the airstream interacted with topography.

The trough itself generated a line of slow-moving thunderstorms with heavy rainfall close to the north of the Island. This line of convection stayed mostly offshore, however there were periods where isolated convective showers moved over the northern parts of the Island, bringing waves of very heavy rainfall during the otherwise steady rainfall that was already occurring. Radar reflectivity imagery from the Bairnsdale radar, Victoria, is shown below (Figure 9.8). The image at 04:30 on the 10th of February shows thunderstorms and intense convective rain close to the northern tip of Flinders Island. The radar is too far away to capture the continuous rainfall that was occurring across eastern Flinders Island as the easterly airstream flowed onshore. The radar image at 05:40 of the 11th shows that the situation has not evolved much over 24 hours.



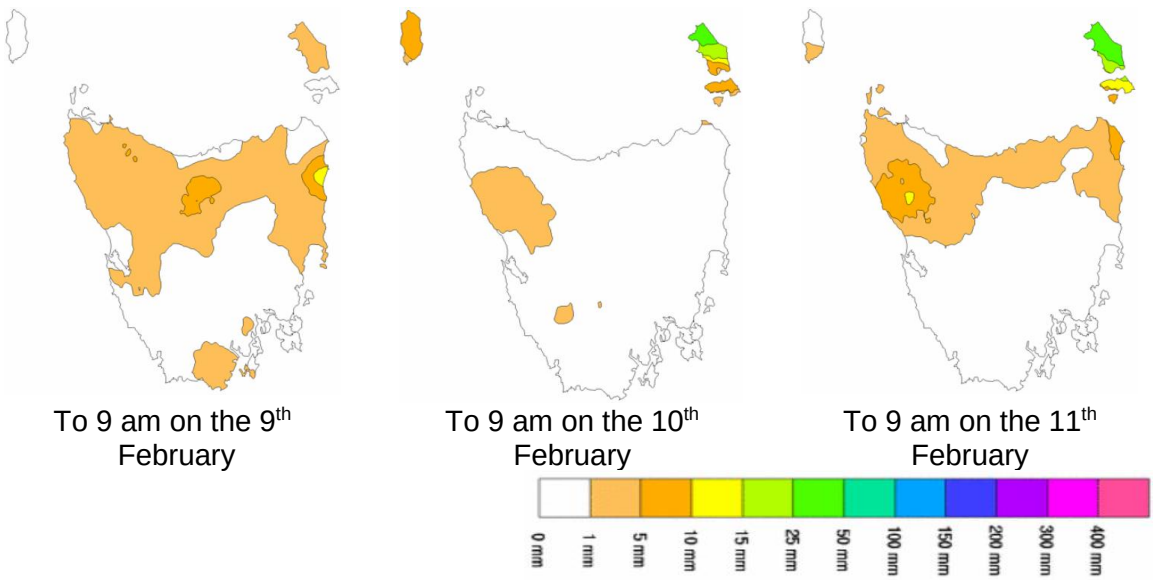
04:30, 10th of February

05:40, 11th of February

Figure 9.8: Radar reflectivity images during the event at the designated time and date.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 9.9). The three days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. There was little rain across Tasmania apart from northern and eastern Flinders Island, where 25 to 50 mm fell in the 24 hours to 9 am on both the 10th and 11th of February. No significant rain fell in the days after this time.



To 9 am on the 9th February

To 9 am on the 10th February

To 9 am on the 11th February

Figure 9.9: 24 hour rainfall to 9 am of the designated date for three days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelope (relative to AEP thresholds) and rainfall accumulation at Memana, central-eastern Flinders Island. The rainfall accumulation graph shows persistent rain beginning late on the 9th of February and clearing early on the 11th (Figure 10.12). This rainfall rate corresponds to near 5% AEP at a duration of 24 hours (Figure 10.10).

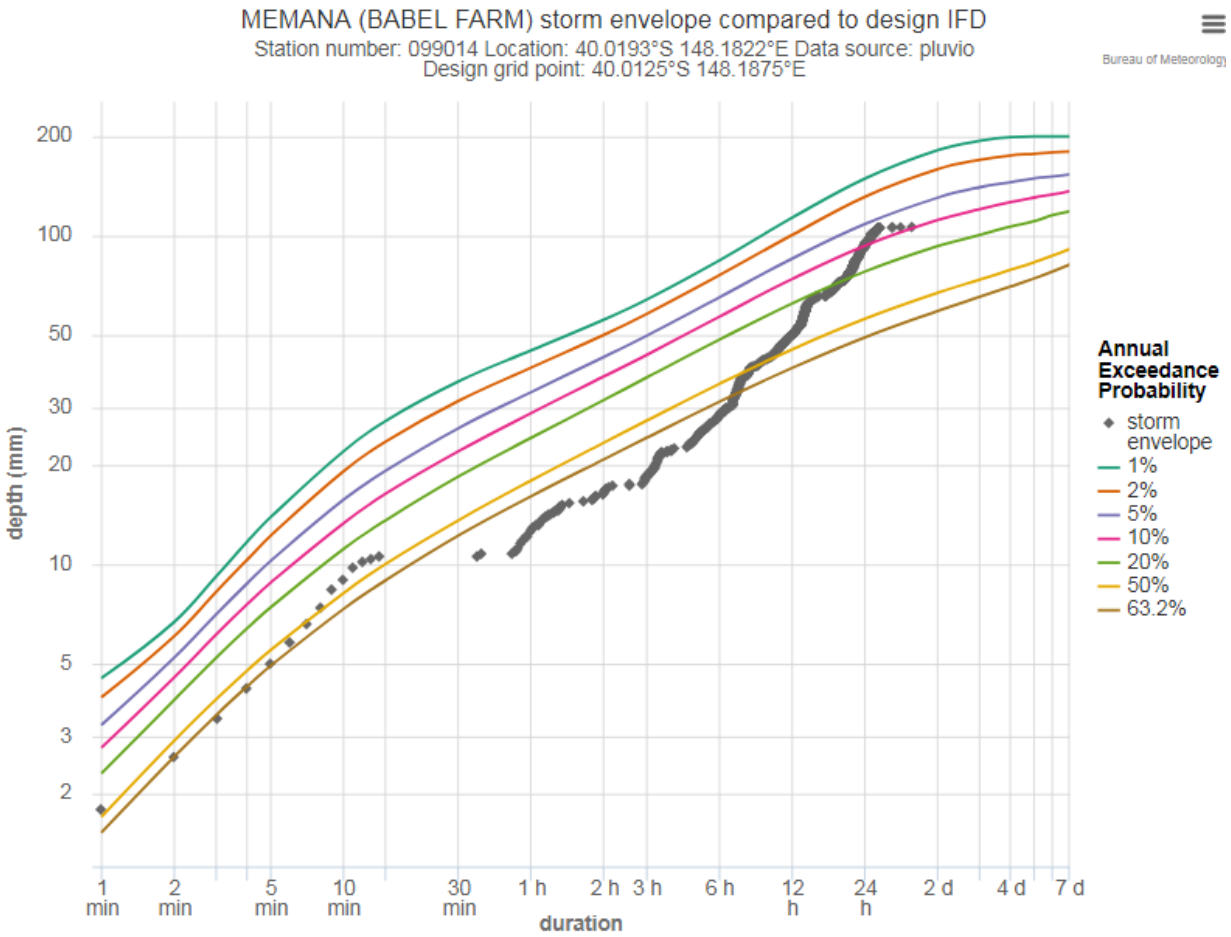


Figure 9.10: Storm envelope for Memana (Babel Farm)

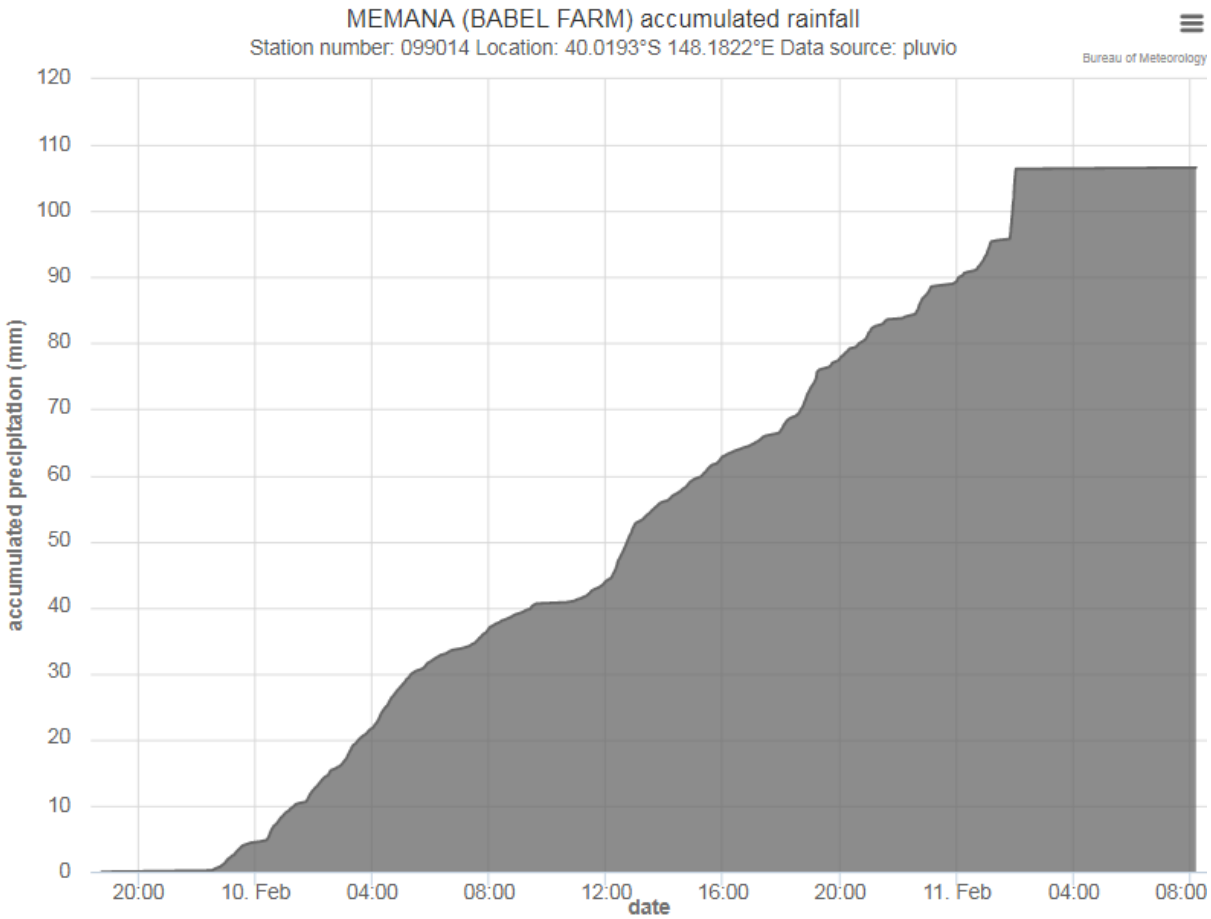
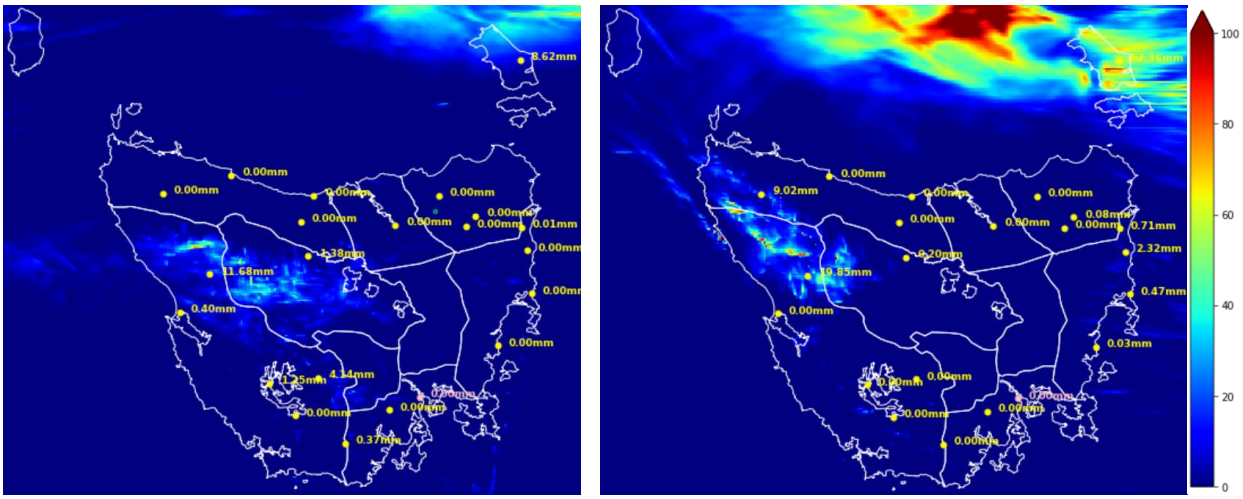


Figure 9.11: Rainfall accumulation at Memana (Babel Farm)

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania during this event. A sample of the data is shown below (Figure 9.12).



24 hours to 11am, 10th of February

24 hours to 11am, 11th of February

Figure 9.12: BARRA-TA 24-hour rainfall accumulation (mm) to 11 am of the stated date

BARRA seems to have captured the event reasonably well and may be of some use for hydrological modelling. However, there are some isolated rainfall maxima (related to modelled thunderstorm activity) that may not be realistic.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- Rain_event, usually ten-minute accumulation
- BARRA-TA, ten-minute accumulated rainfall
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

10. January 2016 – North and East

Summary

A very unstable north to northeasterly airstream with embedded thunderstorms brought exceptionally heavy, short-duration rainfall and flash flooding to isolated parts of north and east Tasmania during the 28th and 29th of January 2016.

During the 28th of January, storms about the north of the state produced flash flooding and large hail. Many rain gauges recorded 20 to 40mm in an hour or less. On the 29th of January, very heavy rainfall was observed about the east and the north of the state, with remarkable rain rates observed at Grindstone (near Orford). Widespread flash flooding, road closures and damage about the east coast and northeast was reported. Flash flooding was also reported about the northwest in the afternoon.

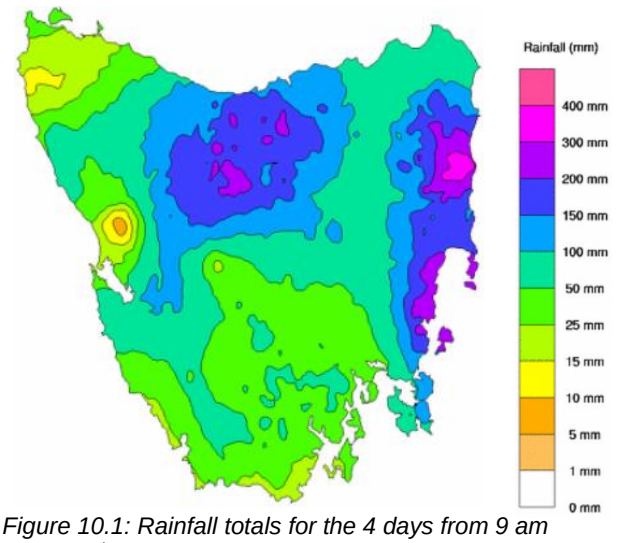


Figure 10.1: Rainfall totals for the 4 days from 9 am of the 27th to 9 am of the 31st of January 2016.

Antecedent Conditions

The seven months leading up to the end of December 2015 were very dry across Tasmania, with rainfall deciles very much below average across the state (first decile) (Figure 10.2).

December 2015 remained relatively dry and although much of the west received 100 to 200 mm during this month, the state generally received 25 to 100 mm below the December average (Figure 10.3).

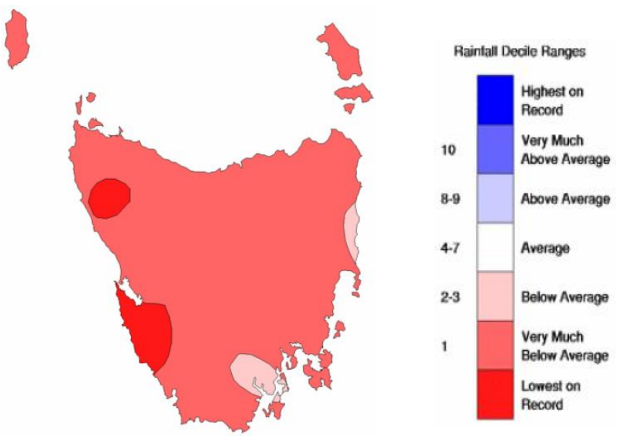


Figure 10.2: Rainfall deciles from 1 June to 31 December 2015.

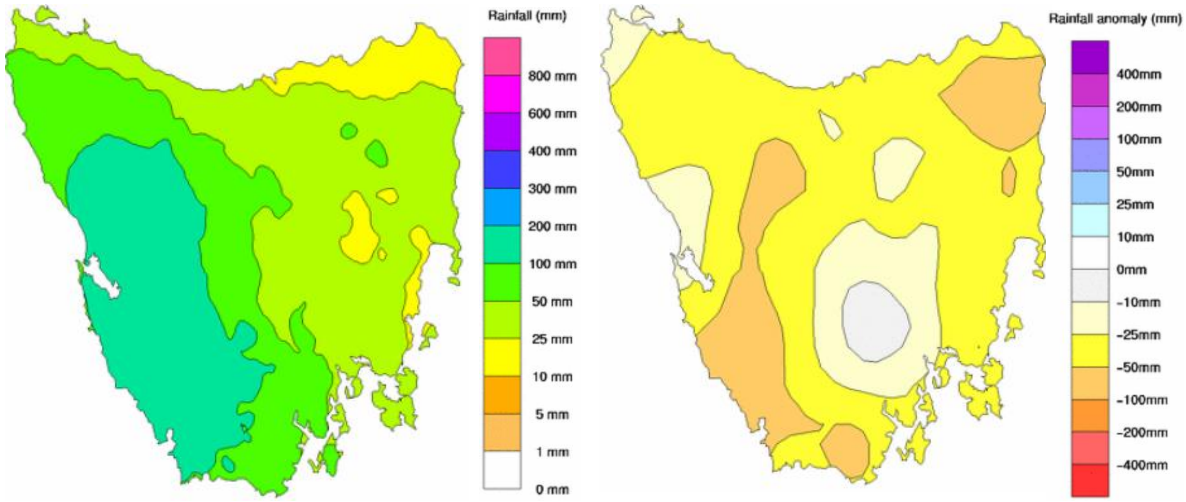


Figure 10.3: The left map shows recorded rainfall across Tasmania during December 2015 with the right map showing the deviation from the December mean (in mm).

Leading up to the event, relatively dry conditions continued with only 10 to 25 mm of rainfall being recorded across Tasmania during the first 27 days of January (Figure 10.4).

Due to the preceding dry conditions, Tasmania was experiencing very low levels of rootzone soil moisture ahead of the significant rainfall event. Figure 10.5 shows the Bureau's AWRA-L rootzone soil moisture model. Elevated parts of western and northeastern Tasmania have rootzone soil moisture levels of near 100 mm, with the remainder of Tasmania having low values below 40 mm. Similarly, the Soil Dryness Index (Figure 10.6) shows values in excess of 50 mm across the west, and well in excess of 100 mm elsewhere.

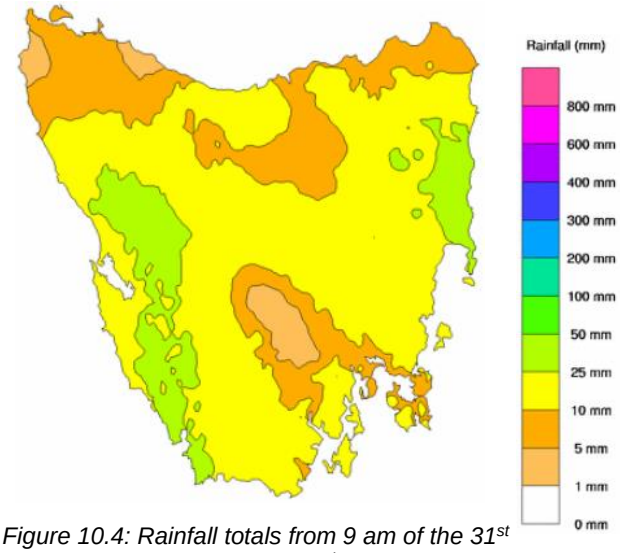


Figure 10.4: Rainfall totals from 9 am of the 31st of December to 9 am of the 27th of January 2016.

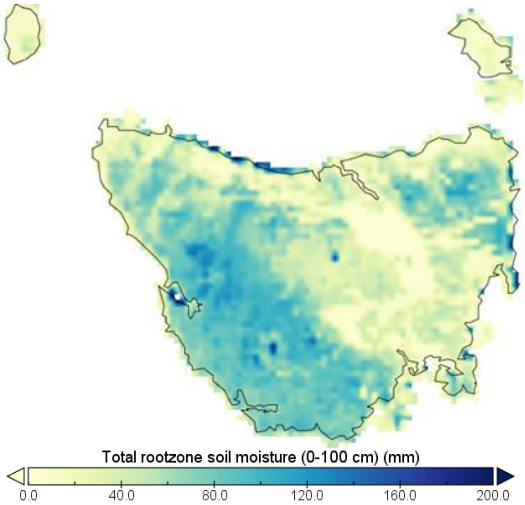


Figure 10.5: AWRA-L Rootzone soil moisture on 27th January 2016.

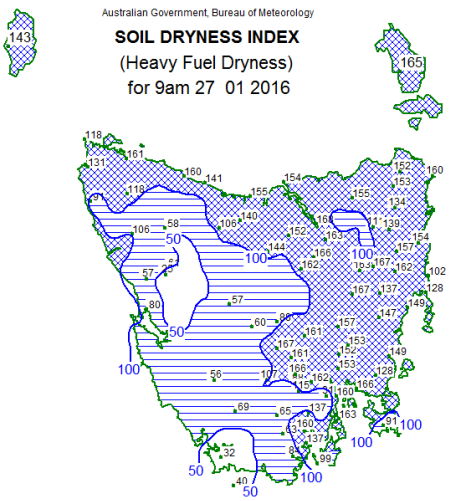


Figure 10.6: SDI on 27th January 2016.

Meteorological Discussion

During the 27th of January 2016, a high-pressure centre to the south of New Zealand extended a ridge to the southeast of Tasmania and northwards along the East Australian Coast (Figure 10.7). This ridge blocked the passage of a trough, keeping it in place over eastern Australia and to the northwest of Tasmania. The positioning of the trough and ridge resulted in a humid northeasterly airstream flowing over Tasmania. During the 28th of January, the trough to the northwest slowly approached Tasmania and several small low-pressure centres developed near it throughout Bass Strait (Figure 10.8). The northeasterly airstream prevailed over the state and brought moderate to locally heavy rainfall to areas of the east coast and elevated, windwards parts of the northeast.

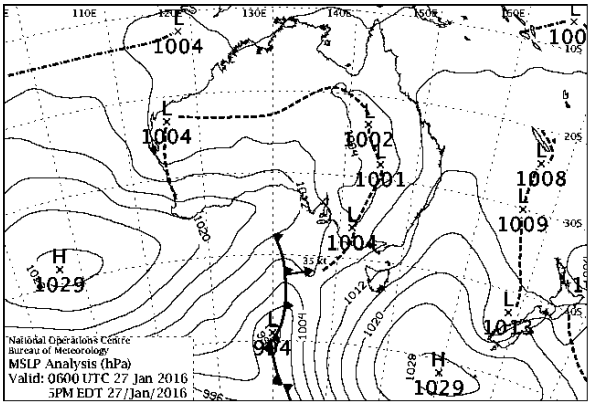


Figure 10.7: Mean sea level pressure chart at 5pm 27th January 2016

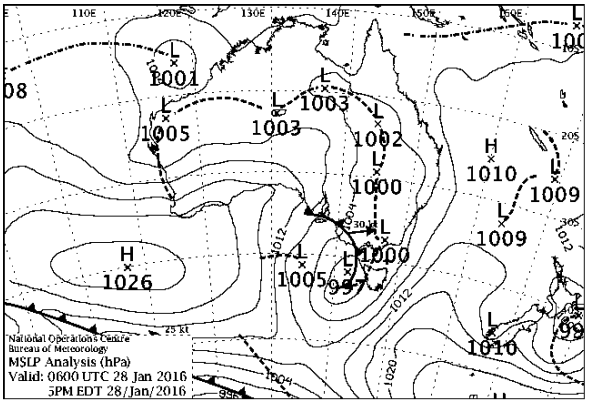


Figure 10.8: Mean sea level pressure chart at 5pm 28th January 2016

However, a narrow band of convective rainfall crossed the state during the evening of the 28th, bringing many thunderstorms and exceptionally heavy rain to the central northern areas of Tasmania, including Launceston. As this thundery rainband continued to cross northeastern Tasmania early on the 29th, rainfall dramatically intensified about elevated areas of the northeast. As of midday of the 29th, a broad trough and area of low pressure remained over Bass Strait and Eastern Australia, and a blocking high was still established to the southeast of Tasmania (Figure 10.9). The prevailing northeasterly airstream continued to bring moderate to locally heavy rain to the east coast, especially to the south of Freycinet. However, a narrow zone of thunderstorms developed near Maria Island and brought incredibly intense rainfall to a small pocket just north of the Island. Grindstone recorded near 200 mm in the 5 hours between 9 am and 2 pm of the 29th.

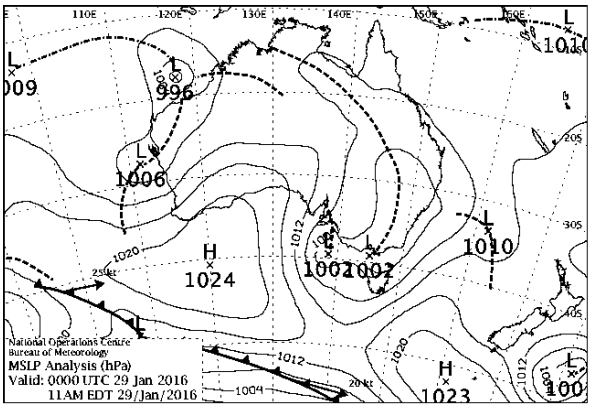


Figure 10.9: Mean sea level pressure chart at 11am 29th January 2016

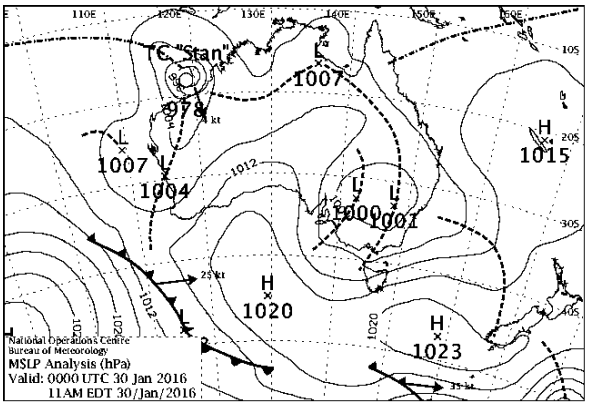
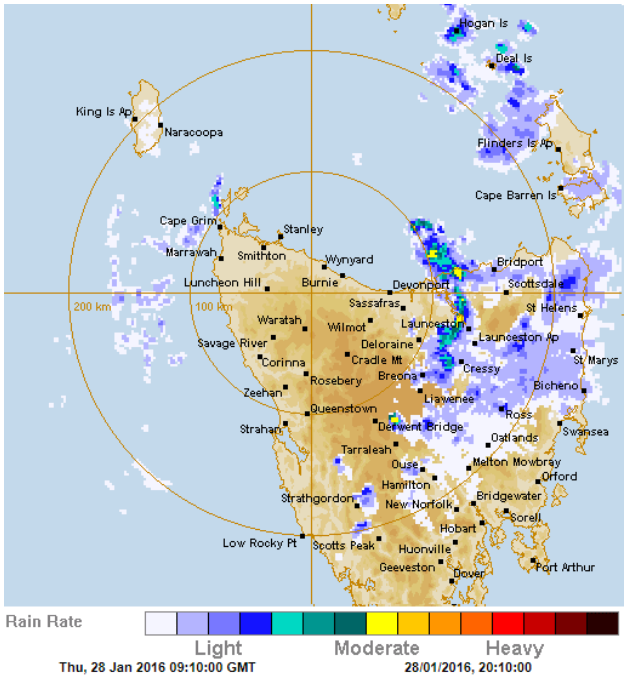


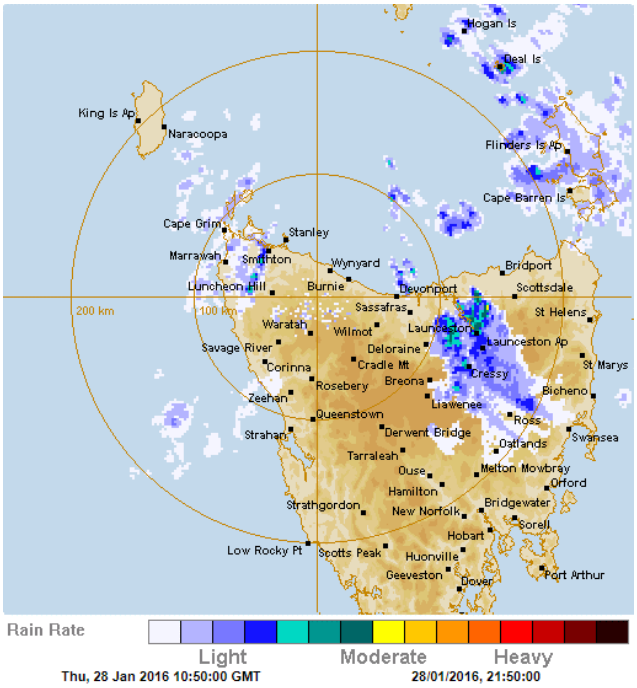
Figure 10.10: Mean sea level pressure chart at 11am 30th January 2016

Later on the 29th, rain quickly eased about the east of Tasmania as the ridge to the south slowly migrated northwards, moving the area of low pressure away from Tasmania and directing a drier easterly airstream over the state (Figure 10.10). However, further heavy rain developed about inland areas of the north and northwest on the evening of the 29th until early on the 30th as another trough crossed the area.

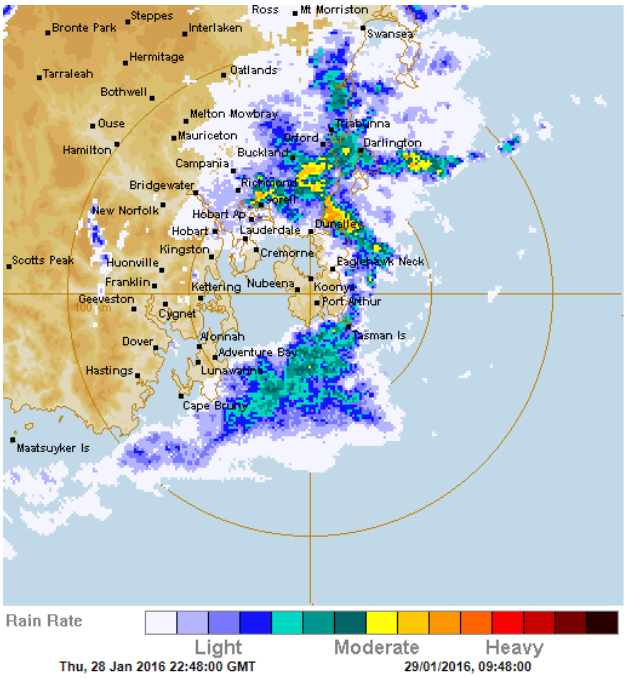
Radar reflectivity imagery from the West Takone and Mt Koonya radars are shown below (Figure 10.11). The images from 20:10 and 21:50 on the 28th of January show scattered thunderstorms moving over northern Tasmania, including areas inland of Devonport and around Launceston. Thunderstorm activity generally lasted 3 to 6 hours throughout the area, and very intense rainfall occurred in storms. The images from 9:48 and 12:48 on the 29th of January show broad areas of rain across the lower east and southeast Tasmania, bringing moderate to locally heavy rainfall to the area. However, during this time exceptional rainfall was occurring in a small area to the north of Orford. The radar images show slow moving, convective cells associated with this rain. It is surprising how innocuous these cells look considering the incredible rainfall they were generating.



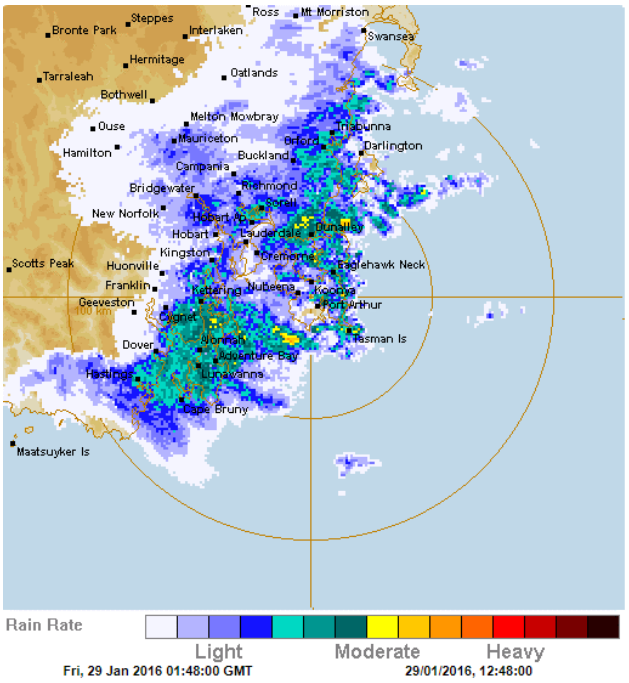
20:10, 28th of January



21:50, 28th of January



09:48, 29th of January



12:48, 29th of January

Figure 10.11: Radar reflectivity images during the event at the designated time and date.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 10.12). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. Very heavy rain in thunderstorms began on the evening of the 28th, with generally 50 to 150 mm about inland areas of the north, and over 200 mm in a small area in the northeast. Then on the morning of the 29th, 50 to 150 mm was observed along the east coast, with a small part of the lower east coast receiving near 250 mm in storms. On the evening of the 29th and early on the 30th, another narrow rain band brought a further 50 to 150 mm to parts of the central north and northwest, particularly inland. Rain mostly cleared during the 30th.

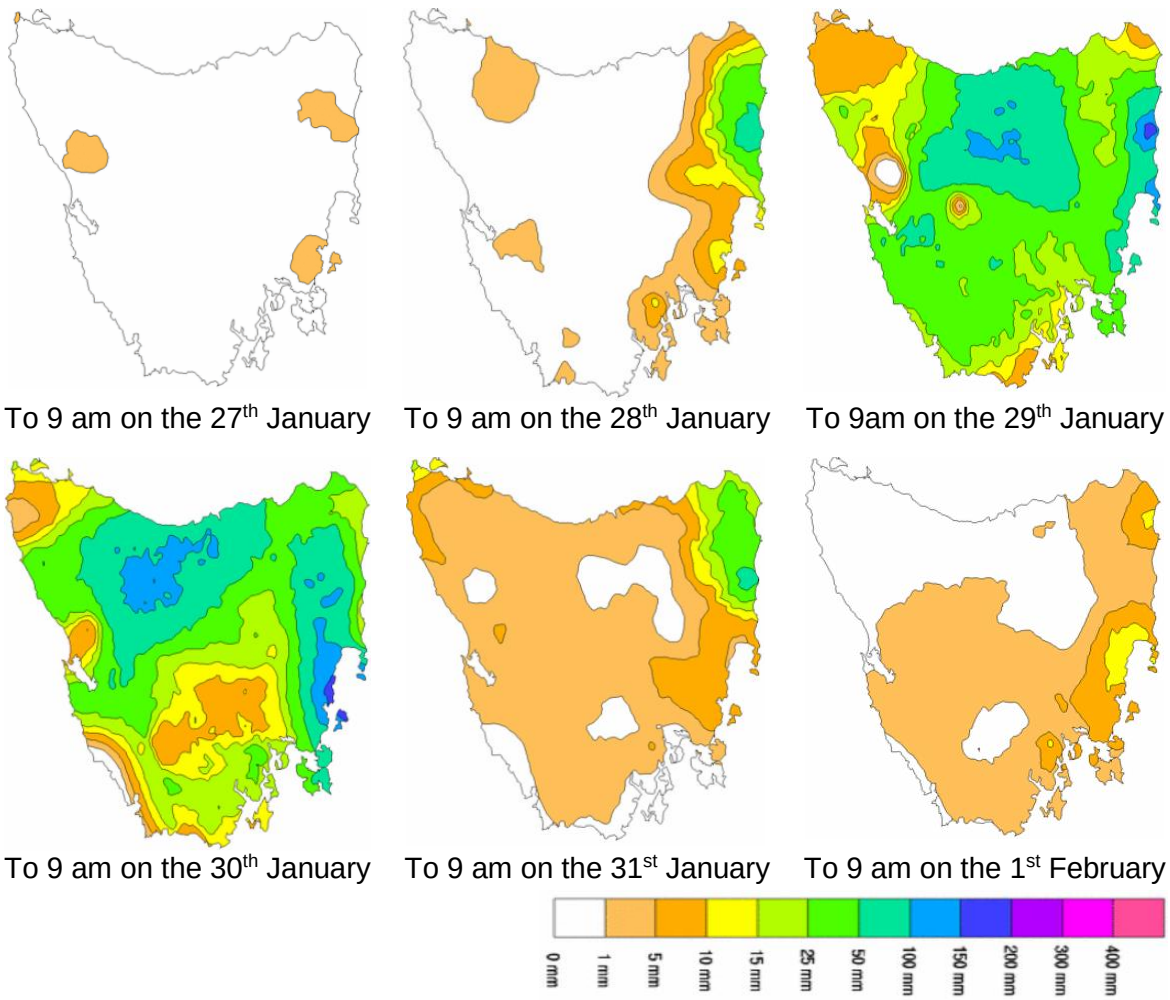


Figure 10.12: 24 hour rainfall to 9 am of the designated date for six days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Gray, Launceston and Grindstone Point (north of Orford). Also shown are the rainfall accumulation graphs for these sites.

The rainfall accumulation graph at Launceston (Figure 10.16) shows exceptionally heavy, short duration rain associated with thunderstorms on the evening of the 28th of January, with about 50 mm falling within two hours. Rainfall then quickly eases before intermittent heavy showers redevelop during the afternoon and evening of the 29th. The storm envelope shows that rainfall rates at durations beyond 30 minutes have extreme AEP values of 1% or lower (Figure 10.15).

The rainfall accumulation graph at Gray (Figure 10.16) shows exceptionally heavy, short duration rain beginning on the 29th, with over 200 mm falling in around 6 hours. The rainfall rate then eases and remains reasonably persistent over the next few days as the northeasterly airstream continues. The storm envelope shows that rainfall rates at durations between 10 minutes and 15 hours were dramatically more significant than 1% (Figure 10.15). Gray is highly susceptible to heavy rainfall in northeasterly airstreams and usually has significantly more rainfall the most other northeastern locations under this regime.

The rainfall accumulation graph at Grindstone (Figure 10.18) shows highly exceptional, short duration rain beginning near 9 am on the 29th, with 73.2 mm falling in the hour from 9 am to 10 am and near 200 mm falling in the 5 hours between 9 am and 2 pm. Exceptional rainfall rates persisted until abruptly ending around 4 pm. The storm envelope shows that rainfall rates at durations beyond 10 minutes were significantly below 1% (Figure 10.17).

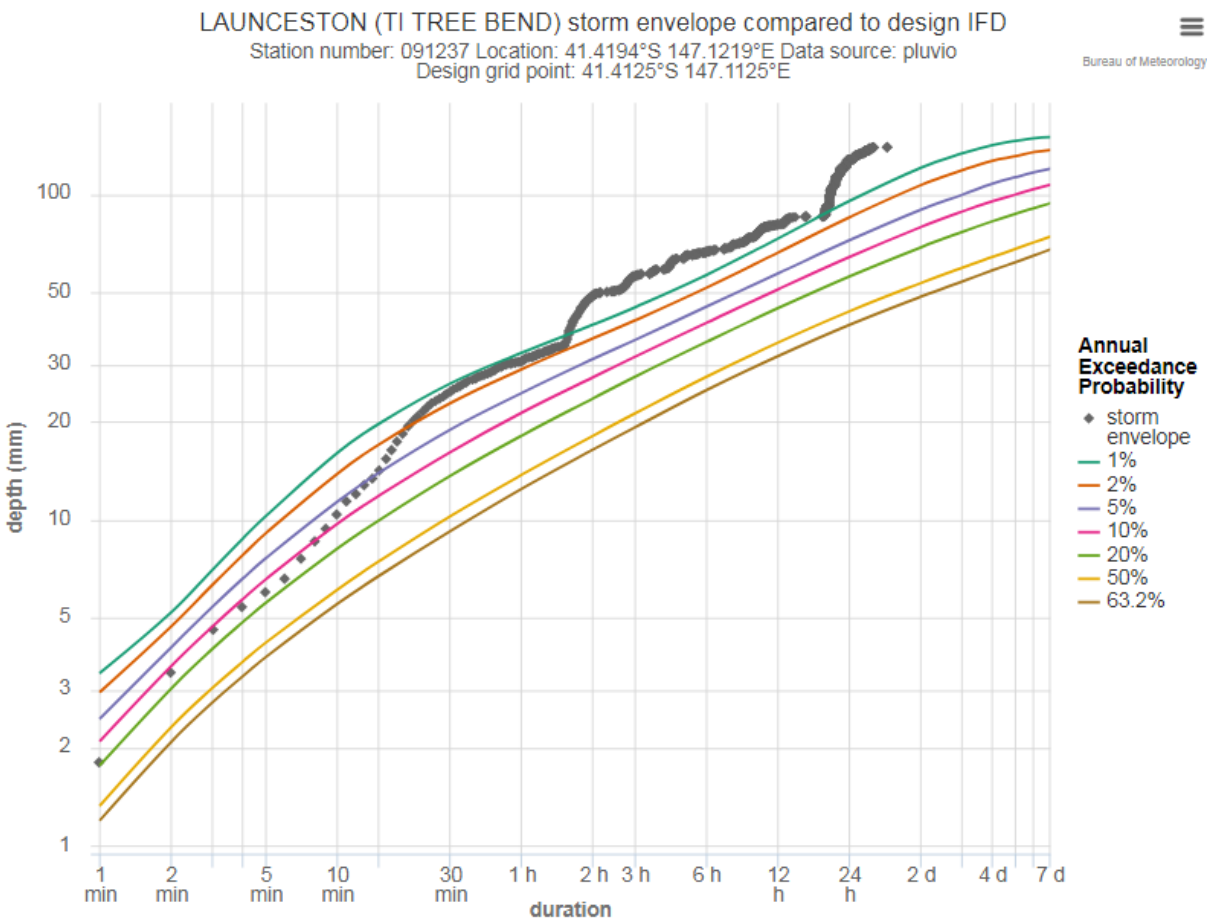


Figure 10.13: Storm envelope for Launceston (Ti Tree Bend)

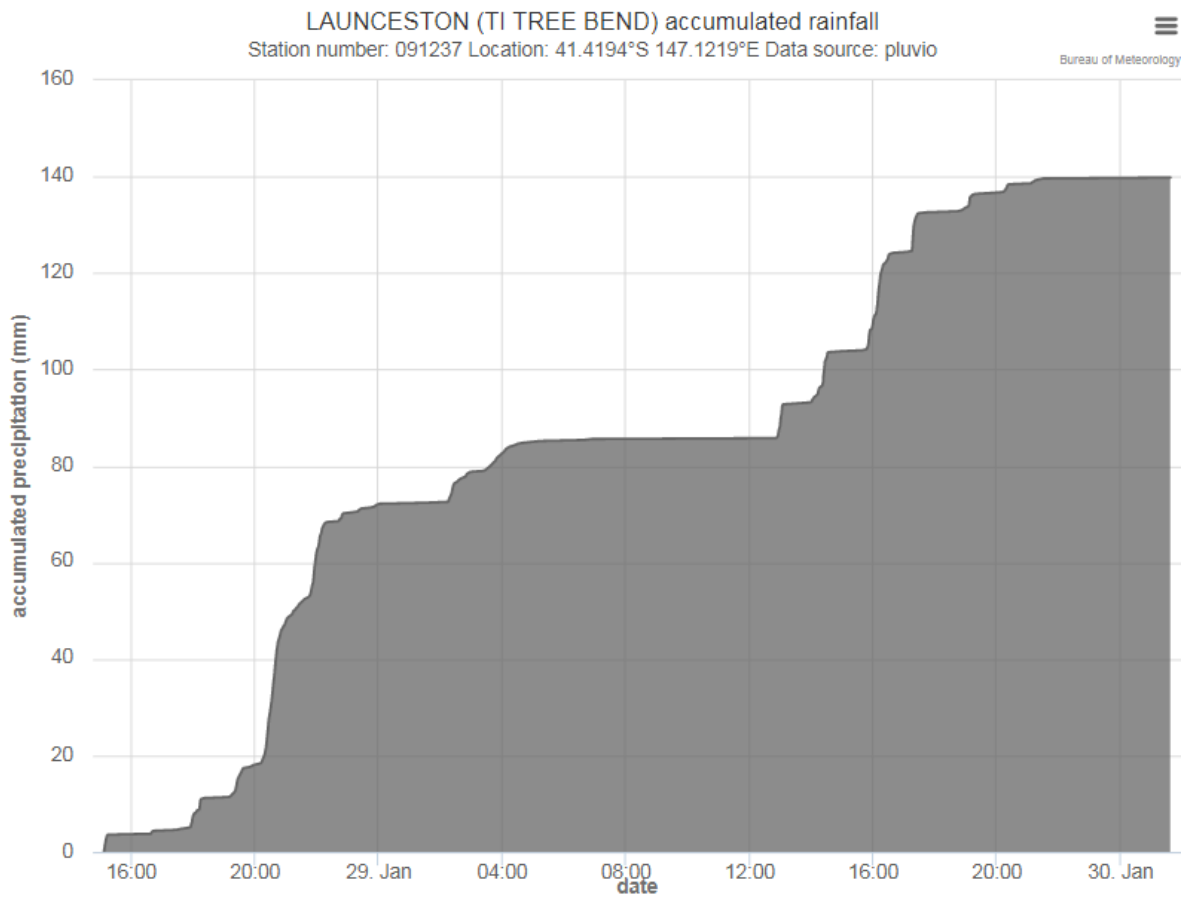


Figure 10.14: Rainfall accumulation at Launceston (Ti Tree Bend)

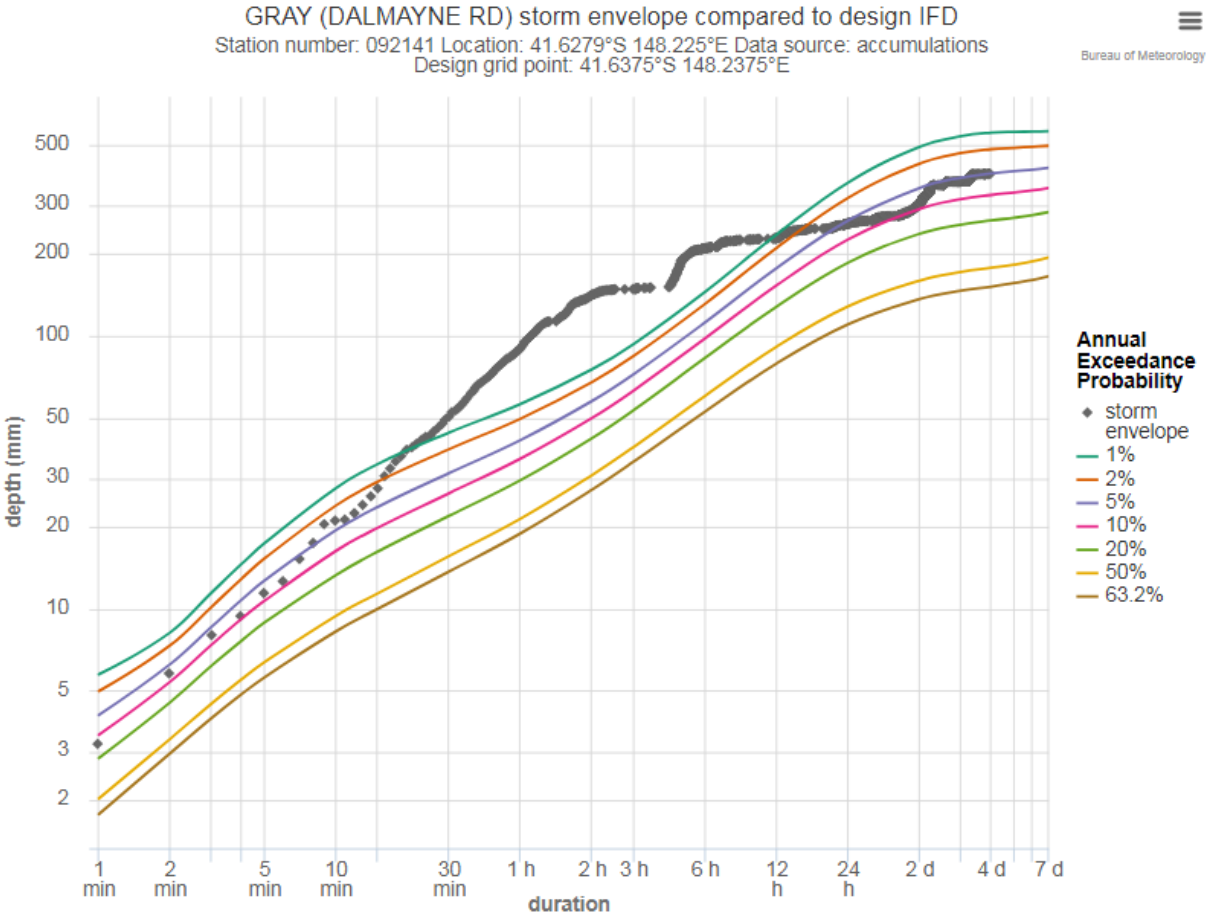


Figure 10.15: Storm envelope for Gray (Dalmayne Rd)

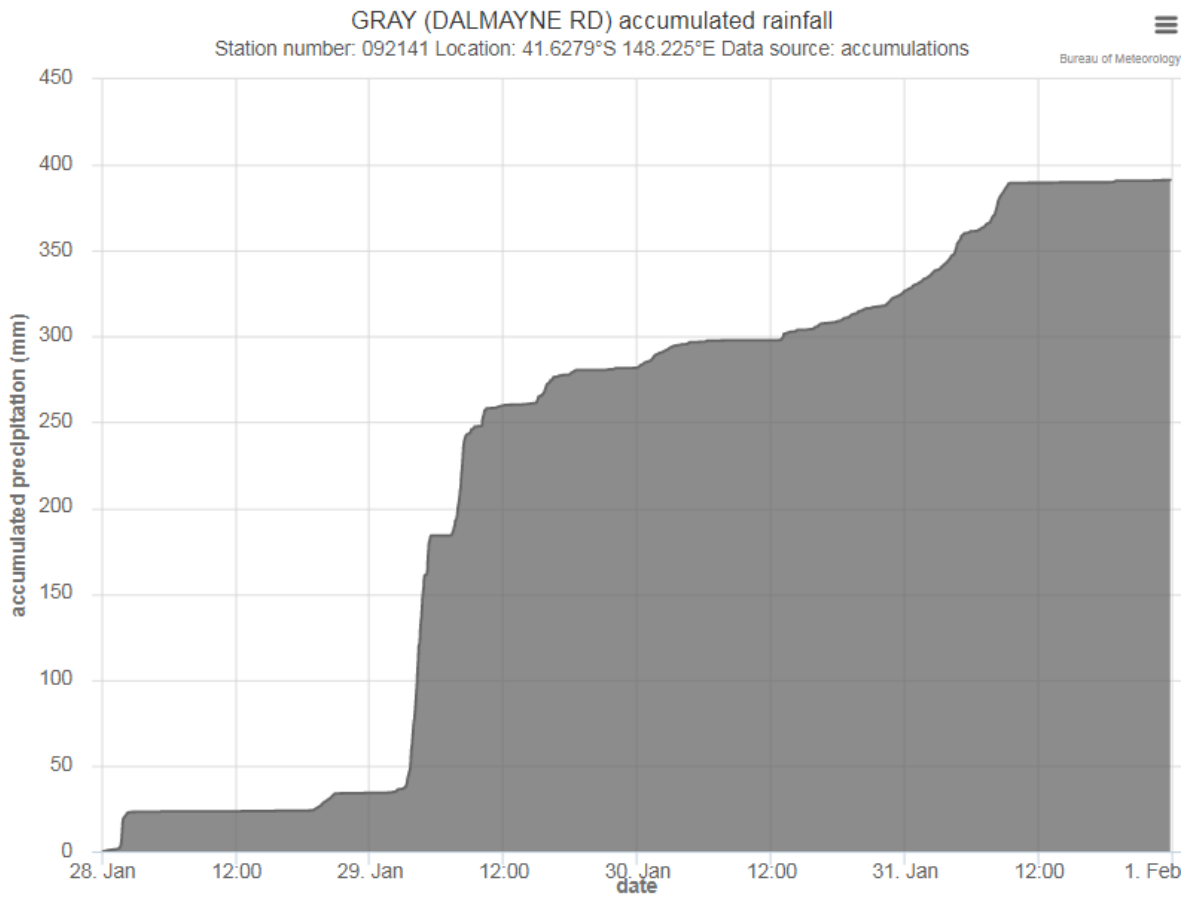


Figure 10.16: Rainfall accumulation at Gray (Dalmayne Rd)

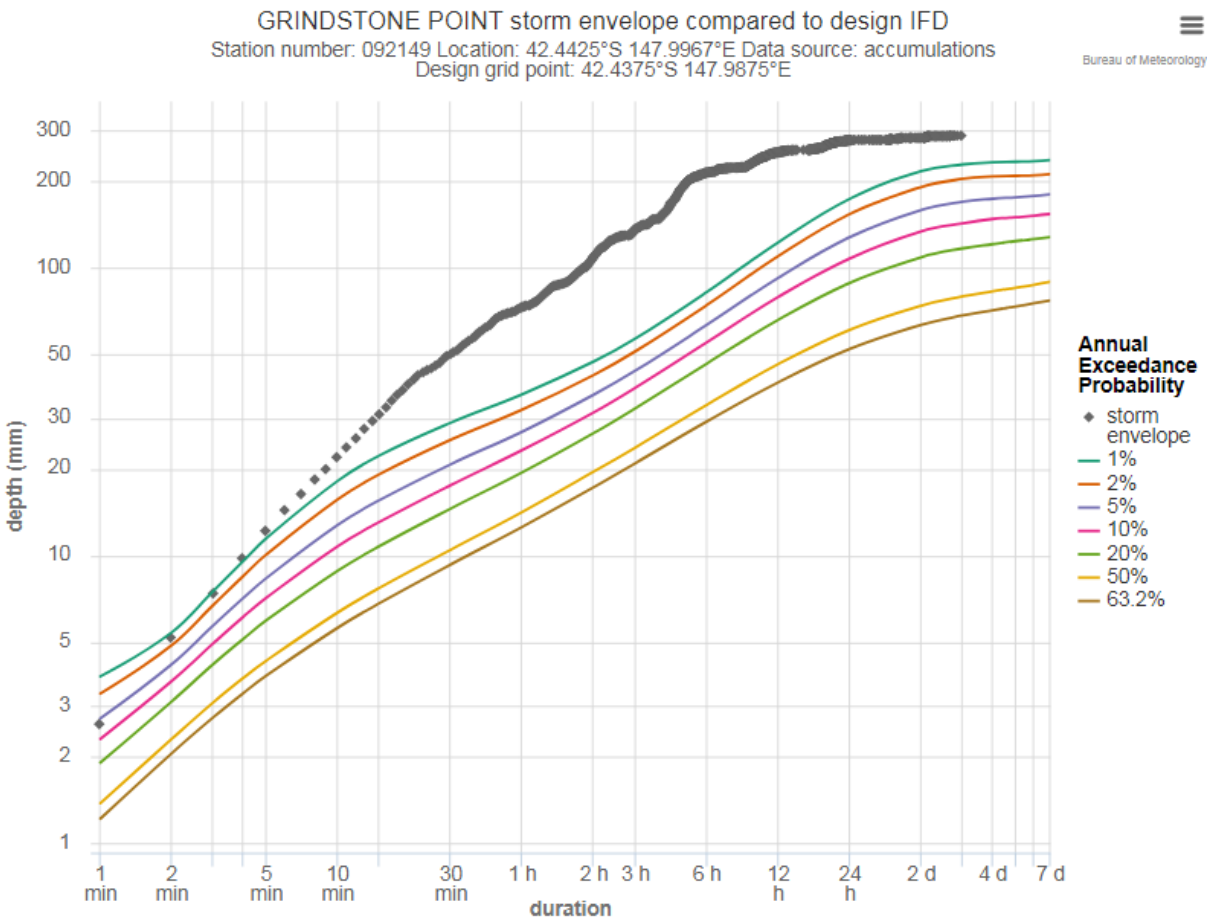


Figure 10.17: Storm envelope for Grindstone Point

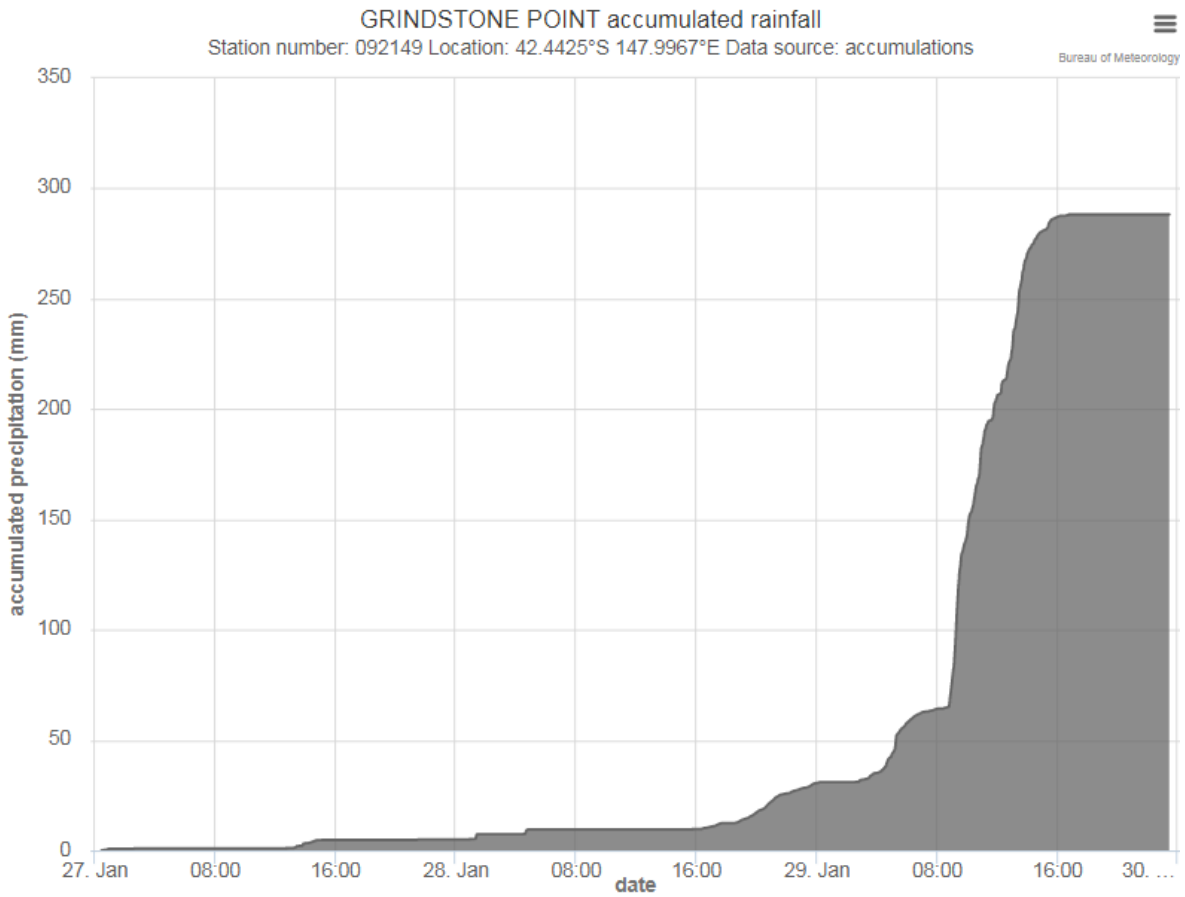
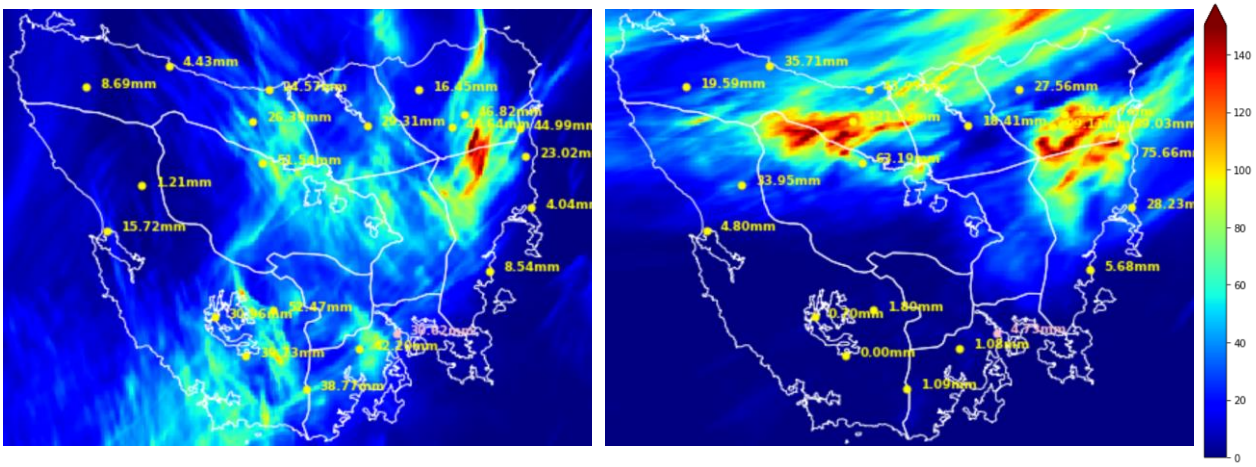


Figure 10.18: Rainfall accumulation at Grindstone Point

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania during this event. A sample of the data is shown below (Figure 10.19).



To 11am, 29th of January To 11am, 30th of January

Figure 10.19: BARRA-TA 24-hour rainfall accumulation (mm) to 11 am of the stated date

BARRA did not accurately model the exact location and intensity of the very heavy rainfall. This is due to the highly convective and localised nature of the rainfall. In this case, it is not recommended that BARRA data be used for hydrological modeling.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- Rain_event, usually ten-minute accumulation
- BARRA-TA, ten-minute accumulated rainfall
- Rainfields, radar and observation derived six-minute rainfall accumulation across southeast Tasmania
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

11. June 2016 – Northern Tasmania

Summary

Major riverine flooding and flash flooding occurred across all river basins in northern Tasmania, and some rivers in the south, as a persistent and very moist northeasterly airstream delivered exceptionally heavy rain over several days across northern districts, with daily totals in excess of 200 mm in the 24 hours to 9 am on the 6th. Some sites broke long-standing flood records from 1929 and 1970 and there was extensive damage to infrastructure. Two people were confirmed dead and one missing.

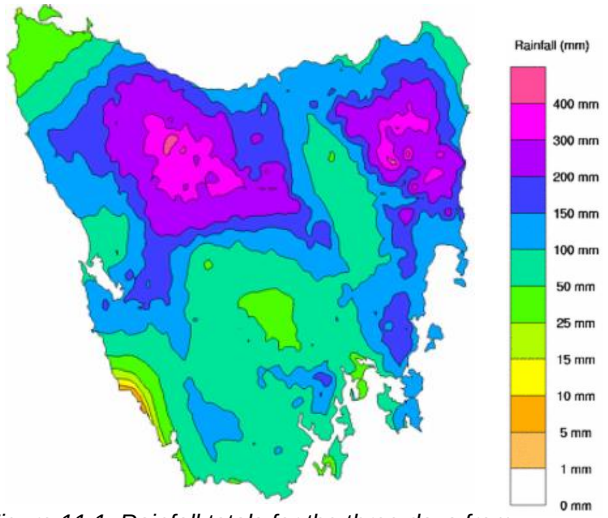


Figure 11.1: Rainfall totals for the three days from 9 am of the 4th to 9 am of the 7th.

Antecedent Conditions

During the 12 months leading up to the end of May 2016, below average rainfall was recorded about much of the state, particularly in the west.

However, Tasmania experienced a very wet May 2016, particularly across much of the west and north. 100 to 300 mm of rainfall was recorded about parts of the north, with in-excess of 600 mm recorded about parts of the west. This corresponds to 200 to 400 mm above the May average for the west, and between 50 to 200 mm above the May average in the north (Figure 11.3).

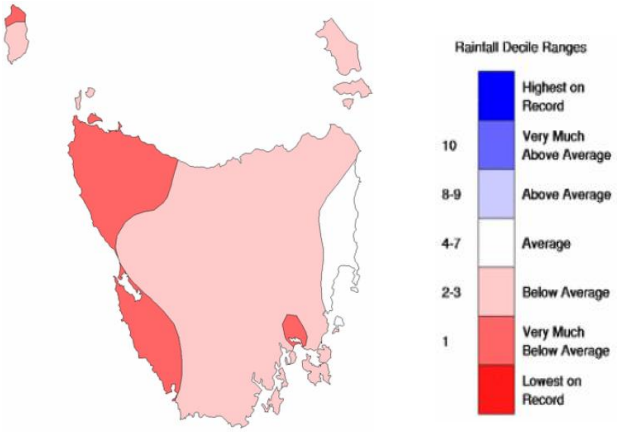


Figure 11.2: Rainfall deciles from 1 June 2015 to 31 May 2016.

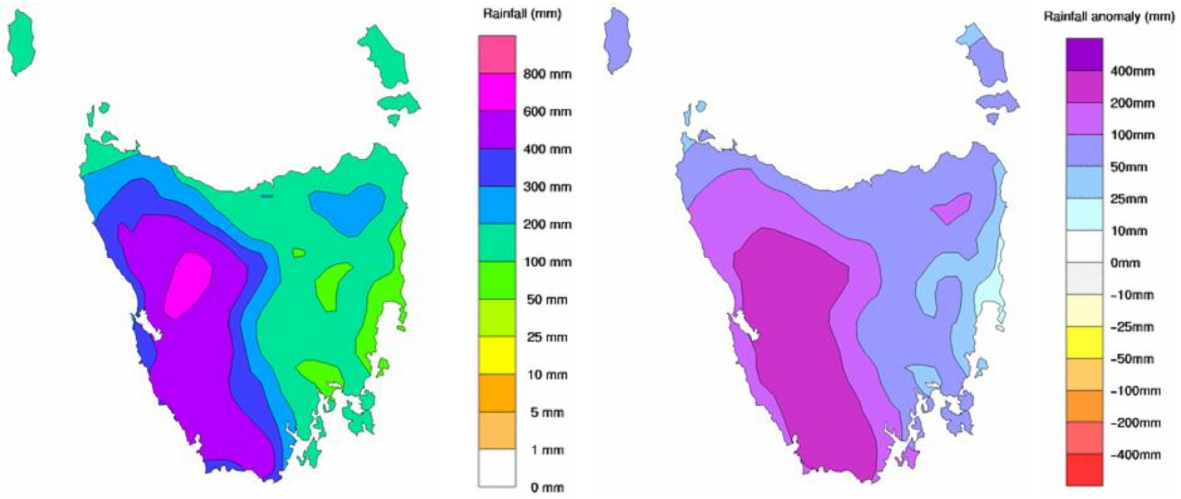


Figure 11.3: The left map shows recorded rainfall across Tasmania over the month of May 2016. The right map shows the deviation of the observed rainfall from the May mean (in mm).

After the wet May of 2016, soils were generally quite wet ahead of the event. Figure 11.4 shows the Bureau's AWRA-L rootzone soil moisture model. Much of the west and north have rootzone soil moisture values of around 150 mm or higher, especially above higher ground. Similarly, the Soil Dryness Index map shows near saturated soils about much of the west and elevated areas (Figure 11.5).

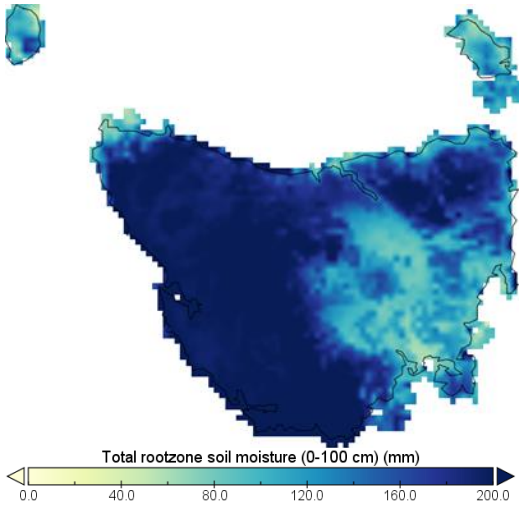


Figure 11.4: AWRA-L Rootzone soil moisture on 4th of June 2016.

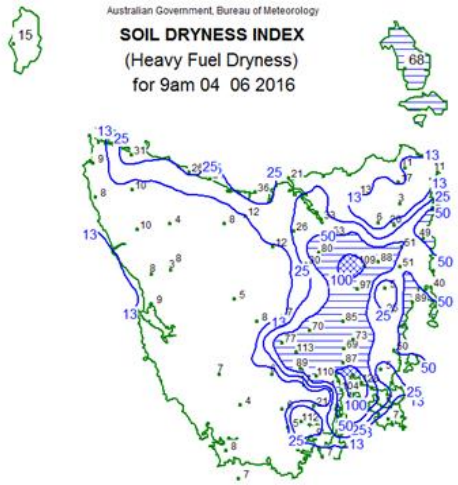


Figure 11.5: SDI on 4th of June 2016.

Meteorological Discussion

The heavy rain began during the 4th of June 2016 when a slow-moving trough established along the east Australian coast, extending to the northwest of Tasmania (Figure 11.6). Several small 'East Coast Low' pressure centres developed along the trough while a high centre over New Zealand extended a ridge to the south of Tasmania, resulting in a very moist northeasterly airstream with deep Tropical origin. The northeasterly airstream coincided with record-high sea surface temperatures across the Tasman Sea and as the air moved onshore and interacted with topography across northern Tasmania, exceptionally large amounts of rain began to fall (especially about windward elevated terrain). The trough was slow moving and maintained the moist northeasterly airstream and heavy rainfall across northern Tasmania for several days. During the 5th of June, the trough slowly moved southeast-wards towards the blocking high centre over New Zealand (Figure 11.7). This increased the pressure gradient and wind strength over Tasmania, delivering even more moisture and rainfall to the north.

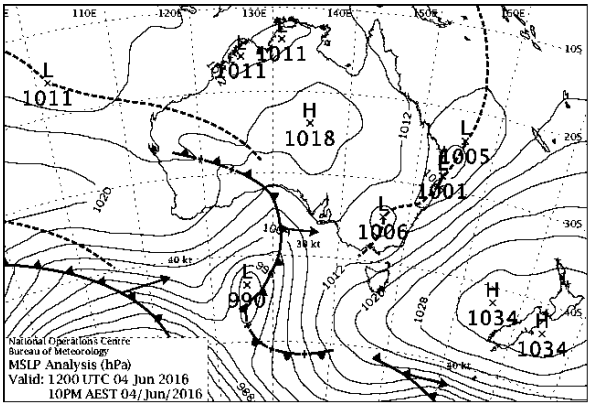


Figure 11.6: Mean sea level pressure chart at 10pm 4th June 2016

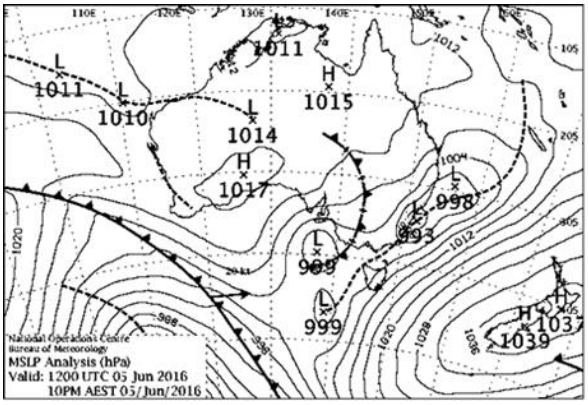


Figure 11.7: Mean sea level pressure chart at 10pm 5th June 2016

The very heavy and continuous rainfall maintained across northern Tasmania until the trough crossed the state, bringing an end to the relentless northeasterly steam. The trough

began to cross northwest Tasmania early on the June 6th (Figure 11.8) and slowly moved over the southeast of Tasmania during June 7th, bringing a period of heavy rain to east and south Tasmania during that time (Figure 11.9). Rain quickly cleared as the trough crossed.

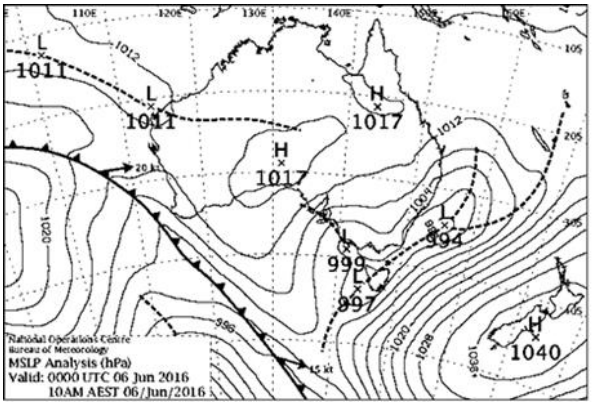


Figure 11.8: Mean sea level pressure chart at 10am 6th June 2016

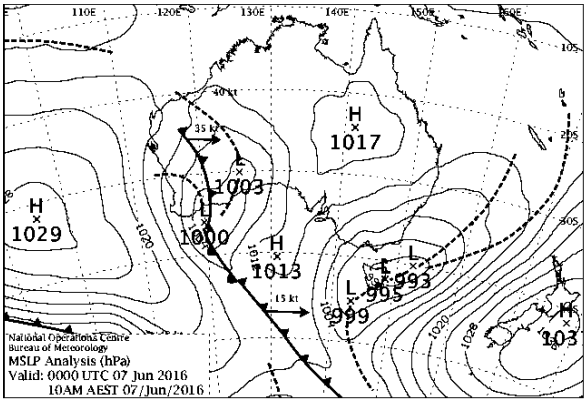
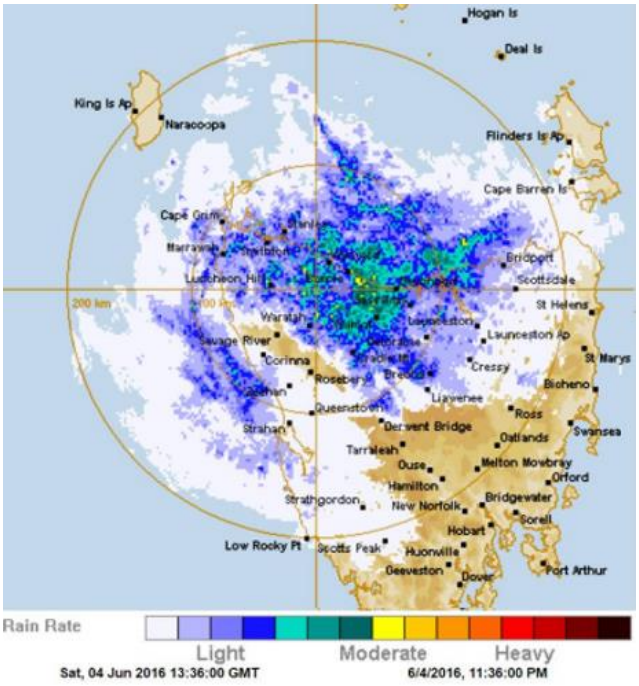
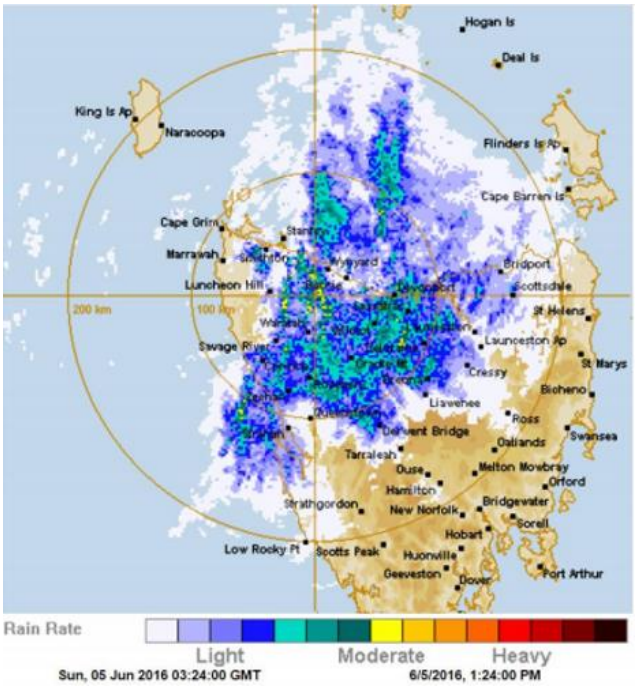


Figure 11.9: Mean sea level pressure chart at 10am 7th June 2016

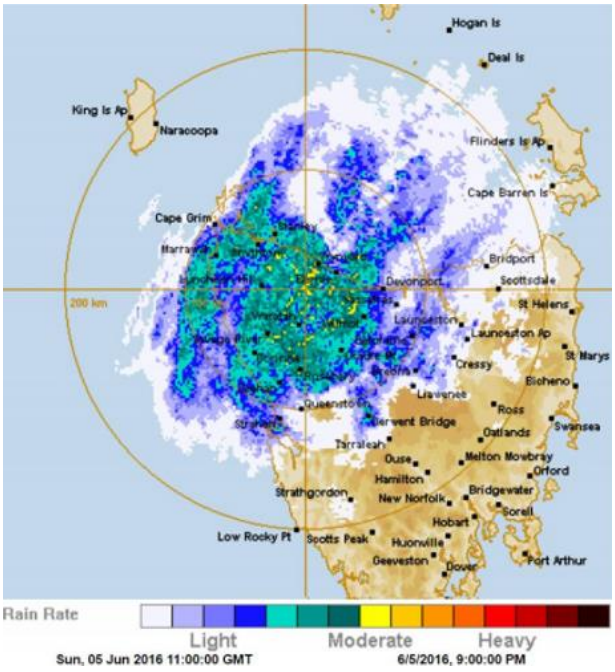
Radar reflectivity imagery from the West Takone radar (northwest Tasmania) is shown below (Figure 11.10). The radar shows generally uniform, widespread heavy rainfall across northern Tasmania between the 4th and 6th of June. The trough and the back edge of the rain band can clearly be seen crossing the northwest 06:24 local time during 6th June, with rain quickly easing after it.



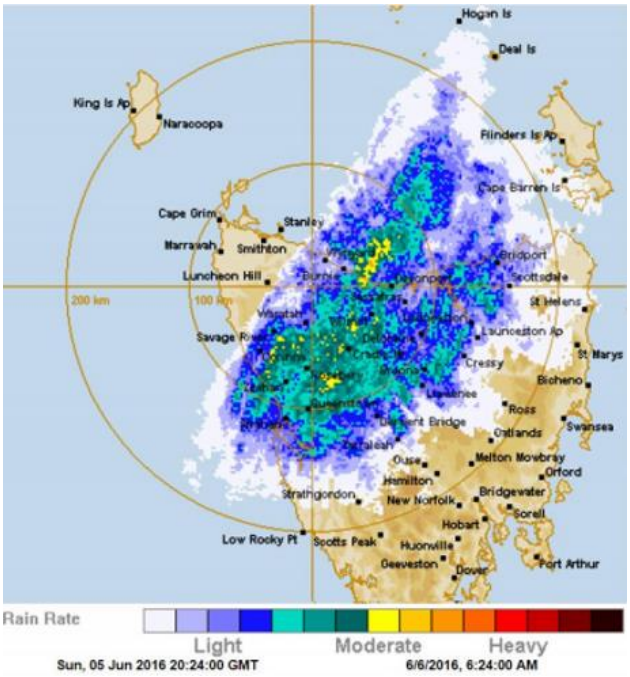
23:36, 4th of June



13:24, 5th of June



21:00, 5th of June



06:24, 6th of June

Figure 11.10: Radar reflectivity images during the event at the designated time and date

Rainfall maps

Below are the AWAP daily rainfall maps (based on observed rainfall), showing the 24-hour rainfall accumulation to 9am of the stated date (Figure 11.11). The heavy rain began late on June 4th and maintained in the north until the morning of the 6th. Although the heavy rain was widespread and continuous during this time, the most significant rainfall fell across elevated, windward areas across the northwest as the airstream interacted with topography. 50 to 100 mm of rain fell over these areas during the 24 hours to 9am on the 5th of June, followed by a further 200 to 300 mm during the 24 hours to 9am on Sunday the 6th of June.

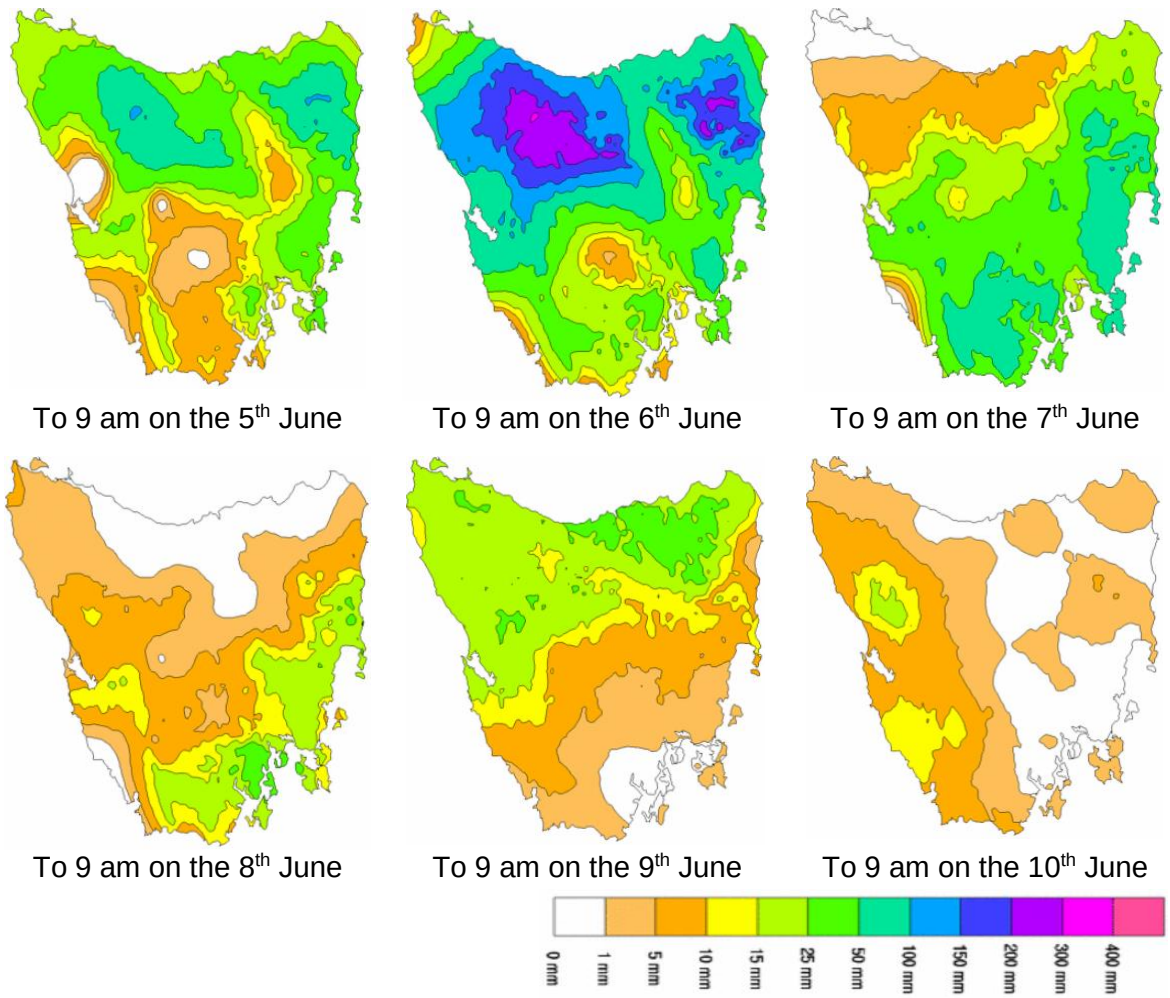


Figure 11.11: 24 hour rainfall to 9 am of the designated date for six days around the event.

Rainfall Intensity, Frequency and Duration Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Sheffield, Fisher River (above lake Mackenzie) and Iris River. Also shown are the rainfall accumulation graphs for these sites. The pluviometer at Sheffield reports rainfall accumulations at one-minute increments, whereas the other two report at five-minute increments.

Looking at the rainfall accumulation graph at the three locations shows mostly steady rainfall rates, with the persistent rain beginning late on June 4th and ceasing early on June 6th. The higher gauges accumulated significantly more rain (Figure 11.13, Figure 11.15, and Figure 11.17).

The storm envelopes at these gauges are very similar, with 3 hour rainfall rates near 10% AEP, 12 hour rates near 1% and remarkable 24 hour rain rates significantly exceeding 1% AEP.

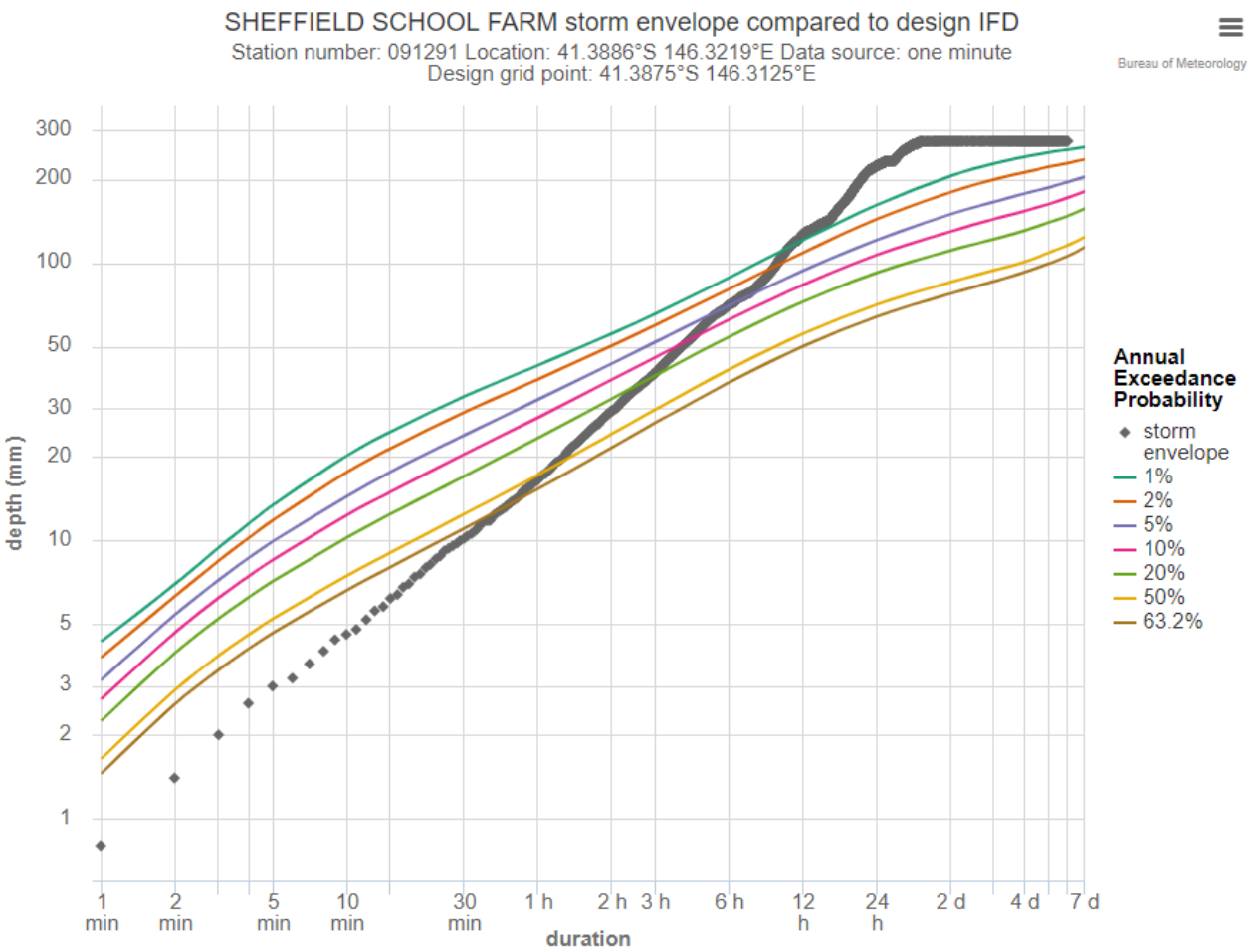


Figure 11.12: Storm envelope for Sheffield

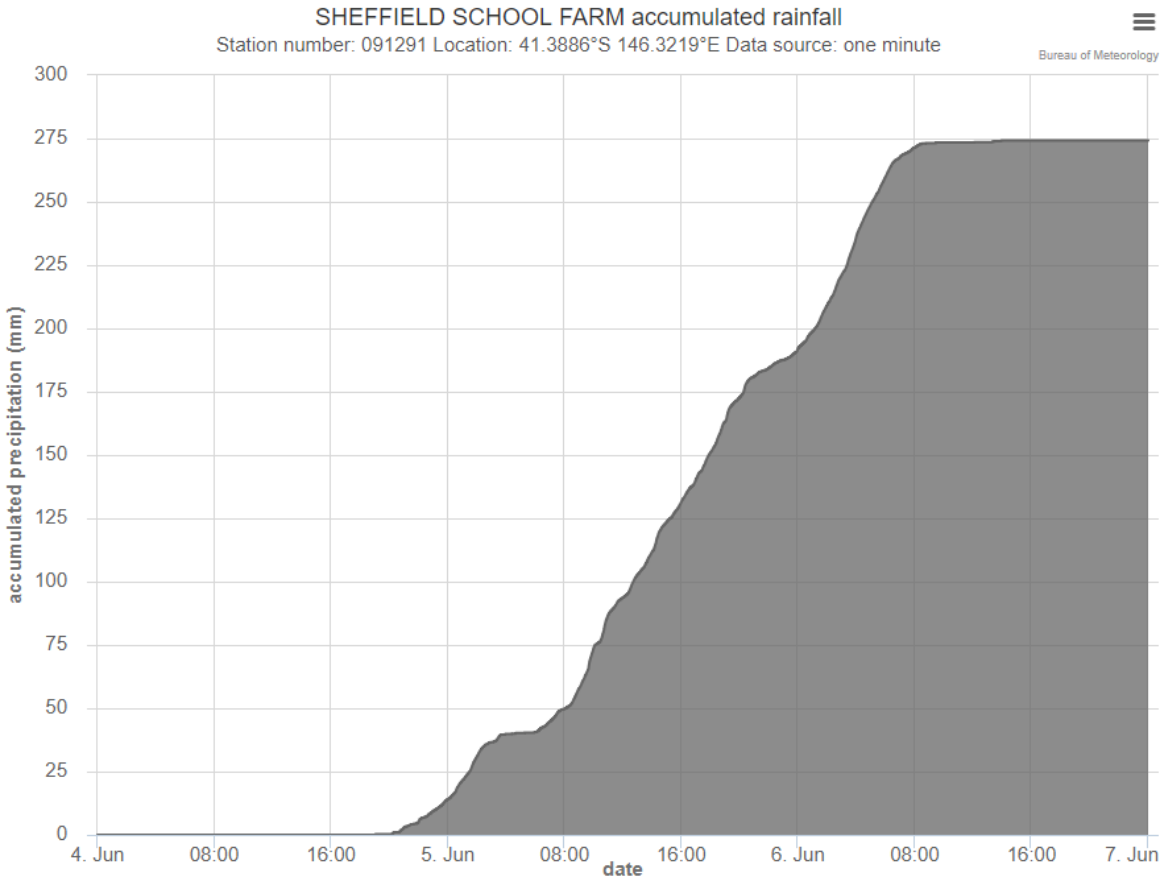


Figure 11.13: Rainfall accumulation at Sheffield

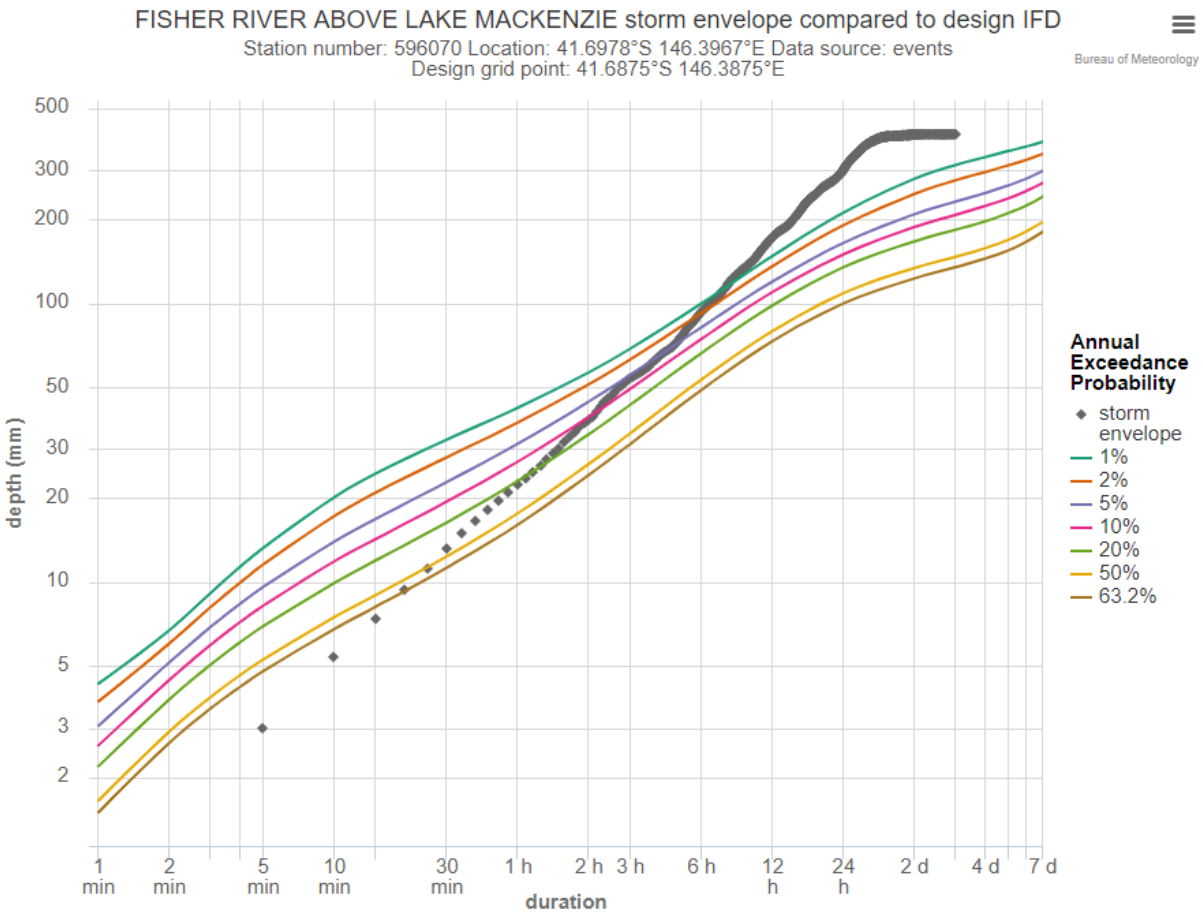


Figure 11.14: Storm envelope for Fisher River

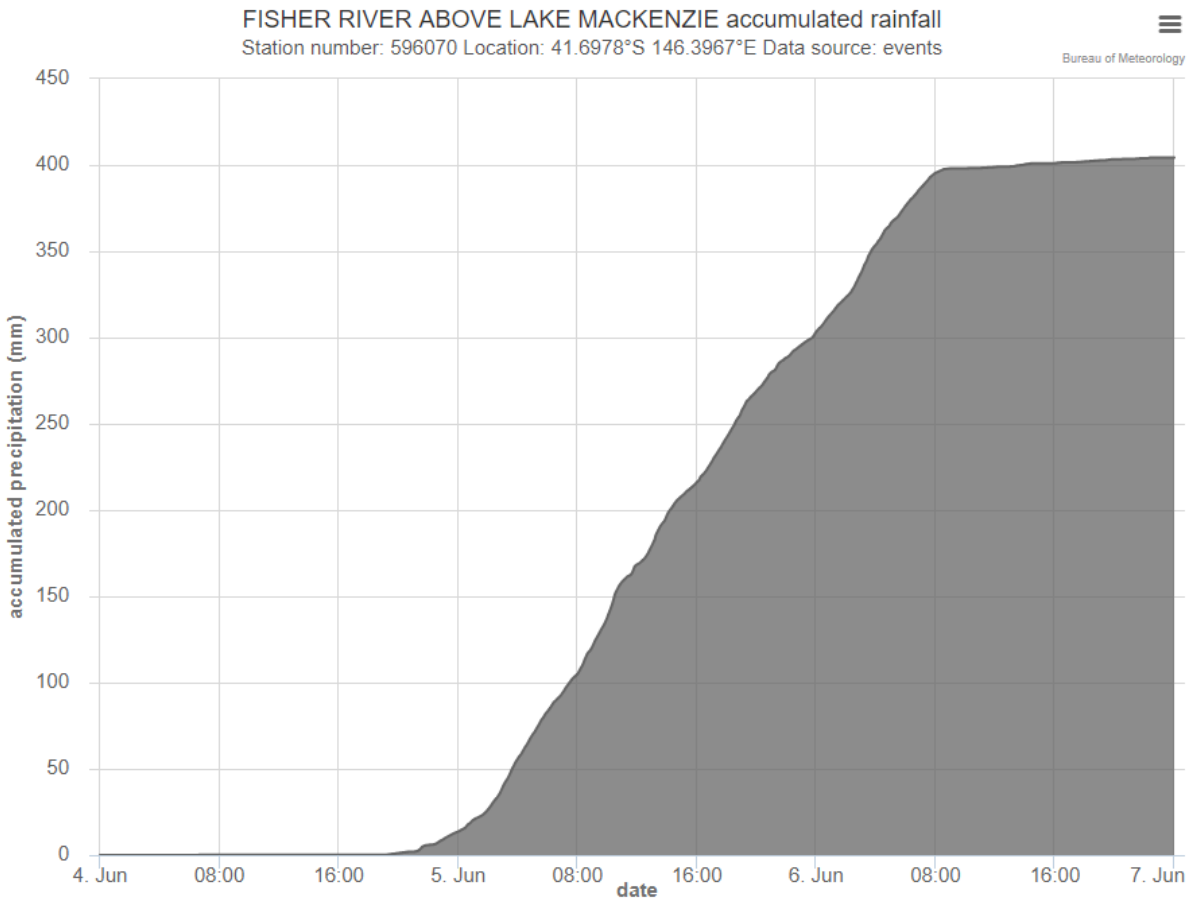


Figure 11.15: Rainfall accumulation at Fisher River

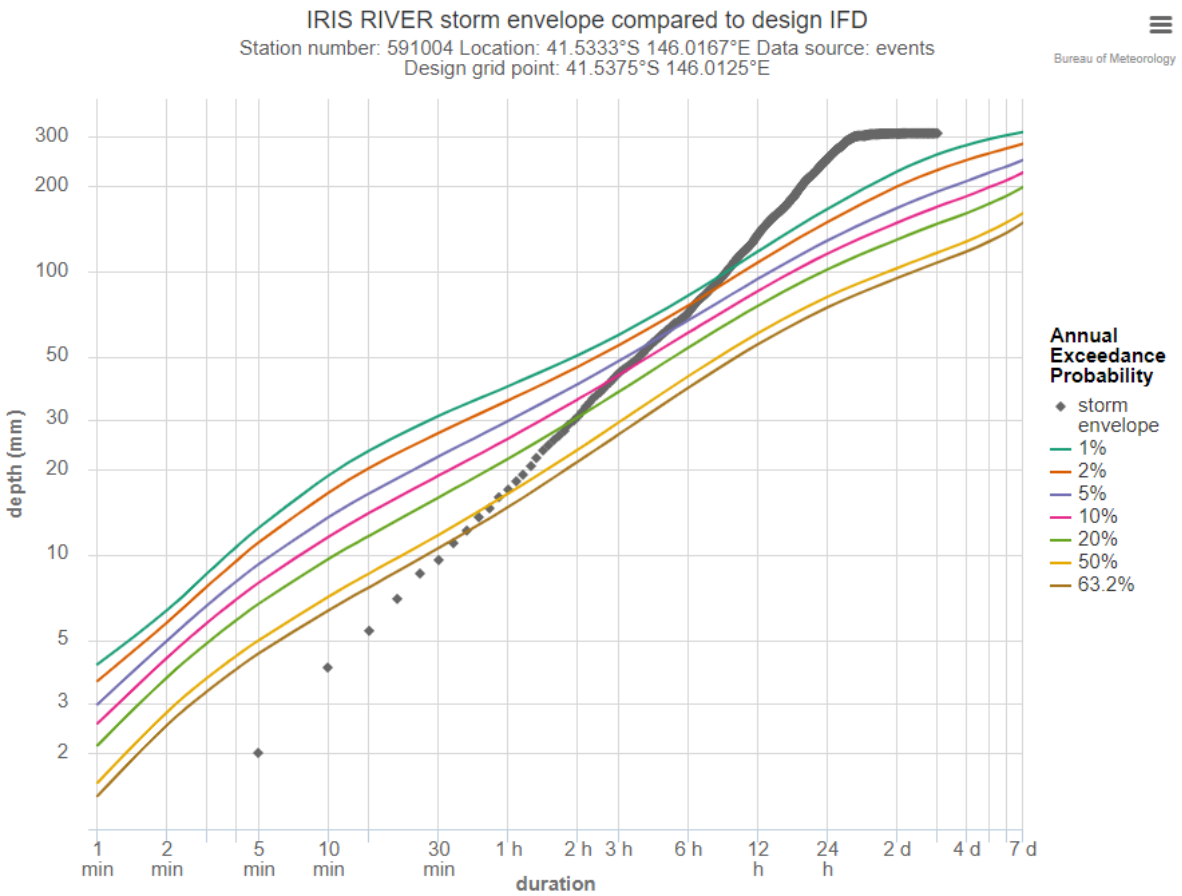


Figure 11.16: Storm envelope for Iris River

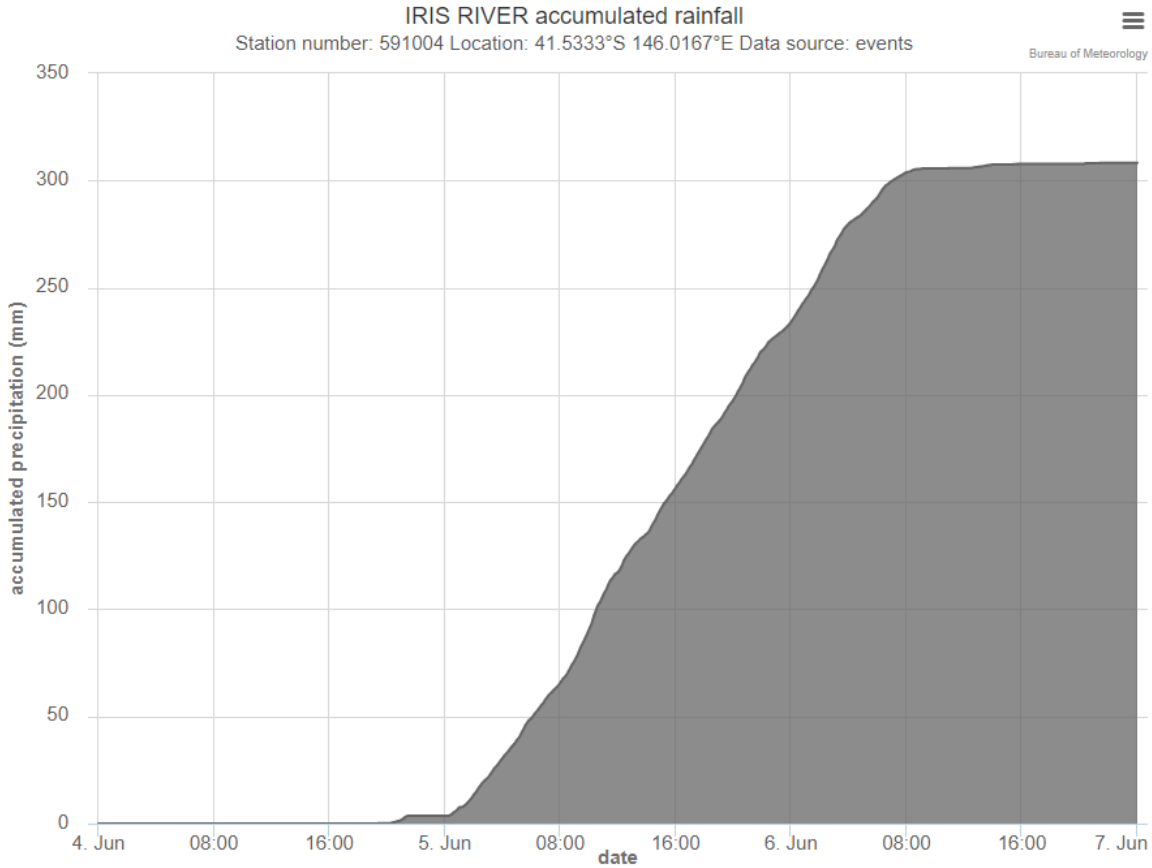
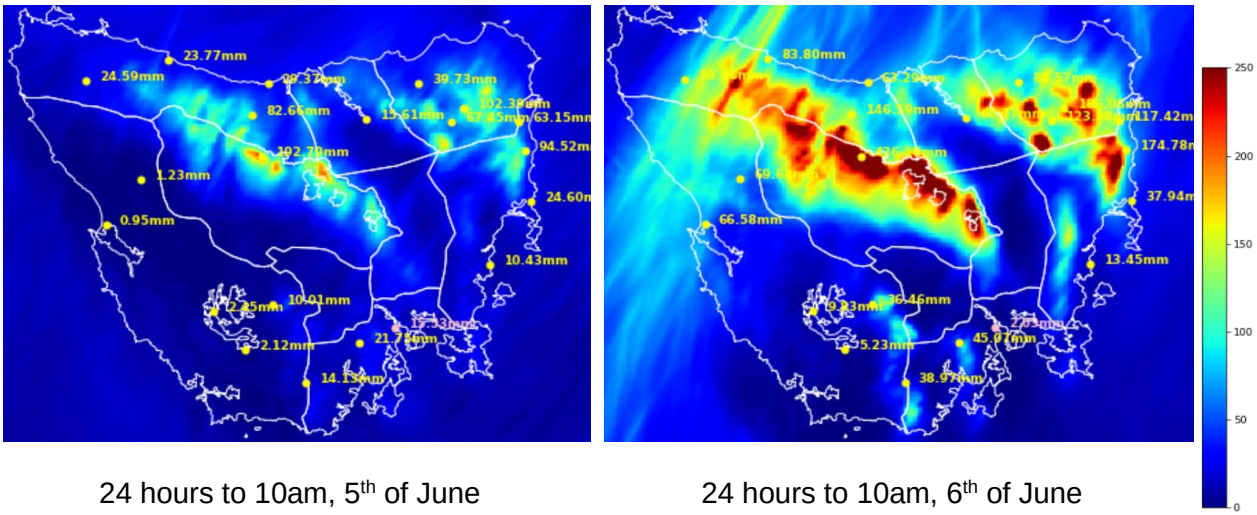


Figure 11.17: Rainfall accumulation at Iris River

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania during this event. A sample of the data is shown below (Figure 11.18).



24 hours to 10am, 5th of June

24 hours to 10am, 6th of June

Figure 11.18: BARRA-TA 24-hour rainfall accumulation (mm) to 10 am of the stated date

BARRA seems to have captured the event reasonably well and may be of some use for hydrological modelling.

Data Provided:

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- Rain_event, usually ten-minute accumulation
- BARRA-TA, ten-minute accumulated rainfall
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

12. July 2016 – West

Summary

After a prolonged period of rainfall into western Tasmania during June and early July 2016, a significant cold front crossed the state, bringing heavy snow to parts of the west and south on the 13th of July. This was followed by a warmer, moist westerly airstream, brining further heavy rain into the west and south during the 14th of July, and rapidly melting the recent snow. During the three days to 9 am of the 15th, over 100 mm of rainfall fell across elevated parts of the west (Figure 12.1).

River levels throughout the Huon catchment rose rapidly in response to the rainfall and snow melt, peaking during the morning of Friday 15 July 2016, with major flooding at Huonville.

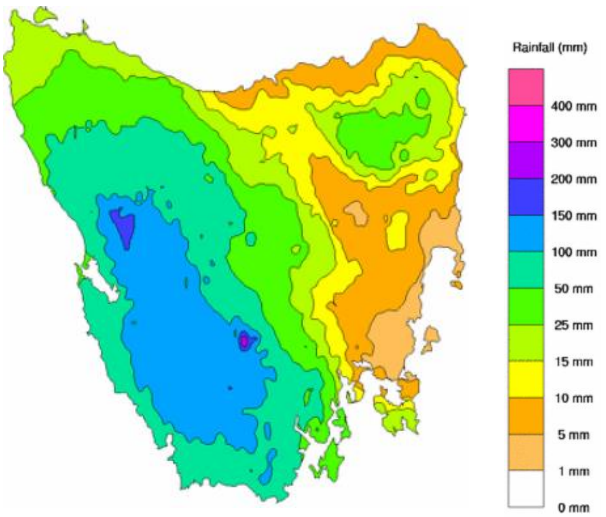


Figure 12.1: Rainfall totals for the three days from 9 am of the 12th to 9 am of the 15th July 2016.

Antecedent Conditions

During the six months leading up to the end of June 2016, above average rainfall was recorded across Tasmania , with very much above average rainfall recorded across much of the north and east (Figure 12.2).

June 2016 was a particularly wet month with about 200 to 400 mm of rainfall into the west, about 50 to 200 mm above the June average (Figure 12.3).

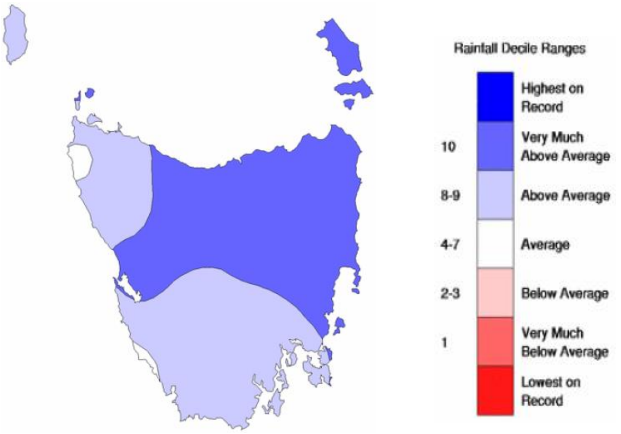


Figure 12.2: Rainfall deciles from 1 January to 30 June 2016.

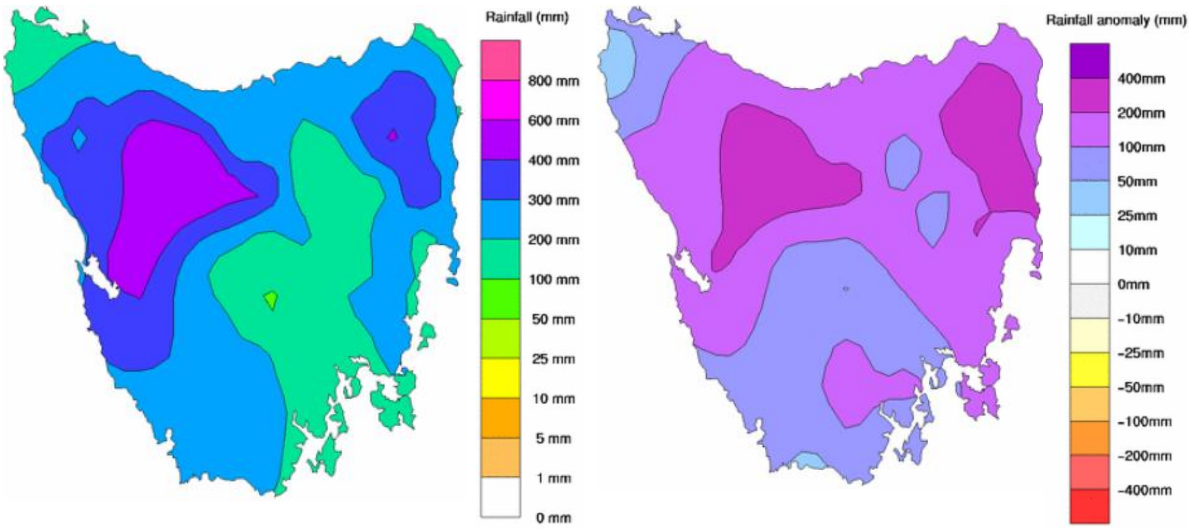


Figure 12.3: The left map shows recorded rainfall across Tasmania during June 2016 with the right map showing the deviation from the June mean (in mm).

Wet conditions continued into the beginning of July 2016, with a further 50 to 100 mm of rainfall falling into the west during the first ten days of the month (Figure 12.4).

Due to the very wet condition during the preceding six months, rootzone soil moisture was high throughout the west just ahead of the significant rainfall event. Figure 12.5 shows the Bureau's AWRA-L rootzone soil moisture model. Apart from parts of the South East and Upper Derwent Valley, much of Tasmania has values near or above 200 mm. Similarly, the Soil Dryness Index (Figure 12.6) shows that saturated soils are prevalent across the west with values of 0.

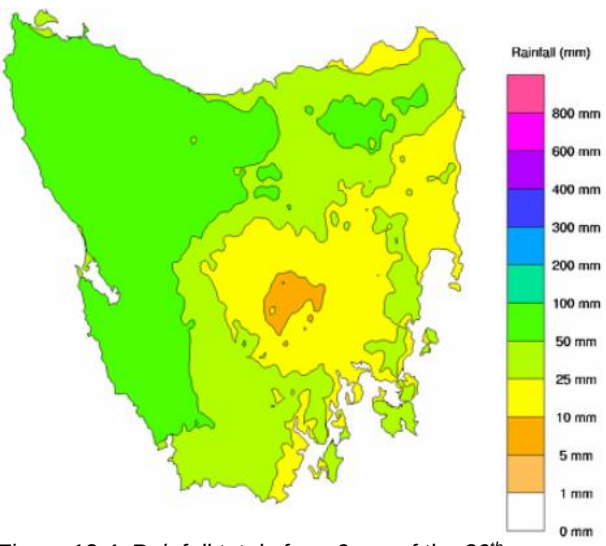


Figure 12.4: Rainfall totals from 9 am of the 30th of June to 9 am of the 10th of July.

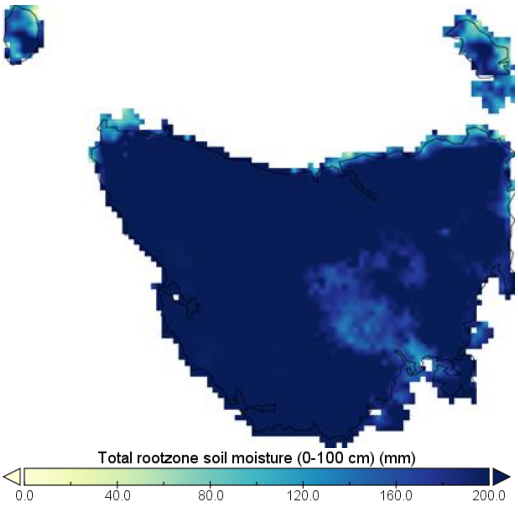


Figure 12.5: AWRA-L Rootzone soil moisture on 11th July 2016.

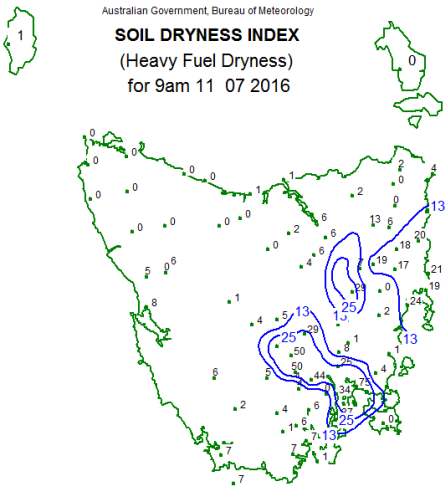


Figure 12.6: SDI on 11th July 2016.

Meteorological Discussion

This rain event occurred after a prolonged wet period across western Tasmania. The rain began to intensify as a low pressure centre and associated cold front crossed Tasmania during the afternoon of 12th July 2016 (Figure 12.7). A strong and very cold southwesterly airstream then followed, with rainfall falling as snow above elevations of 100 metres for the remainder of the 12th. The coldest air moved over Tasmania during the morning of the 13th of July with the snow level lowering to near sea level (Figure 12.8). During the 12th and 13th of July, heavy snowfalls would have occurred about parts of the west and southwest. It is estimated that around 30 to 70 cm of snow fell across the area during that time, with higher snow accumulations possible about the high peaks (note that 30 to 70 cm of snow roughly equates to 30 to 70 mm of water depth when melted).

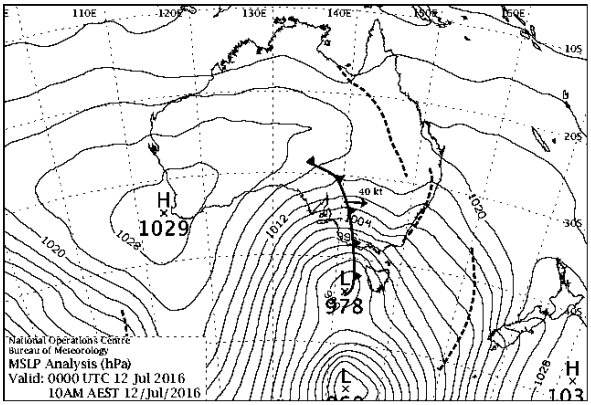


Figure 12.7: Mean sea level pressure chart at 10am 12th July 2016

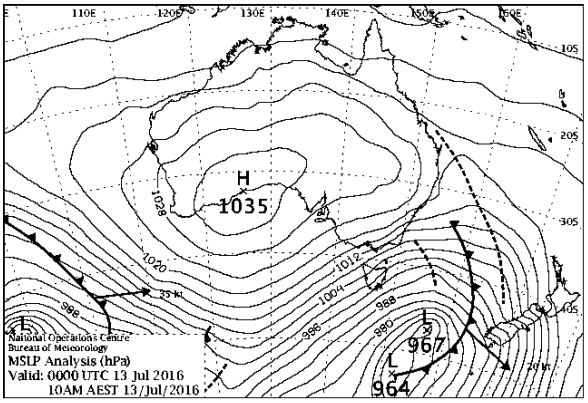


Figure 12.8: Mean sea level pressure chart at 10am 13th July 2016

By early 14th of July, the airstream had tended more westerly with the origin of the air now from over the warmer waters west of Perth, Western Australia (Figure 12.9). The airstream warmed and moistened considerably during this time, bringing generally 50 to 150 mm of rainfall to windward elevated areas across much of the west and southwest during this time. However, as the warmer rain fell on the previously deposited snow, the snow rapidly melted, resulting in increased runoff. The rainfall quickly eased early on the 15th of July as a ridge of high pressure crossed the state and the airstream tended northwesterly (Figure 12.10).

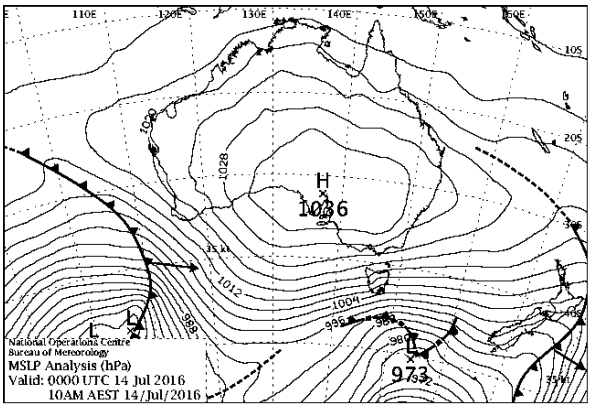


Figure 12.9: Mean sea level pressure chart at 10am 14th July 2016

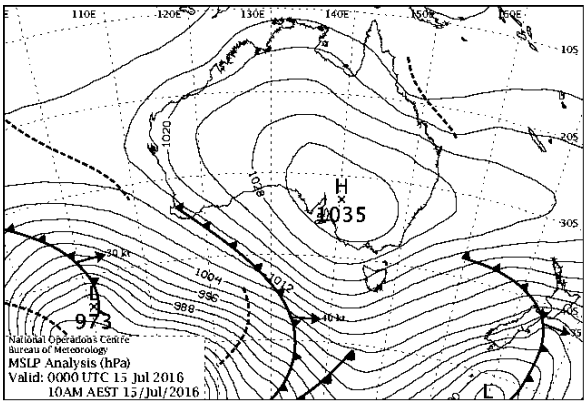
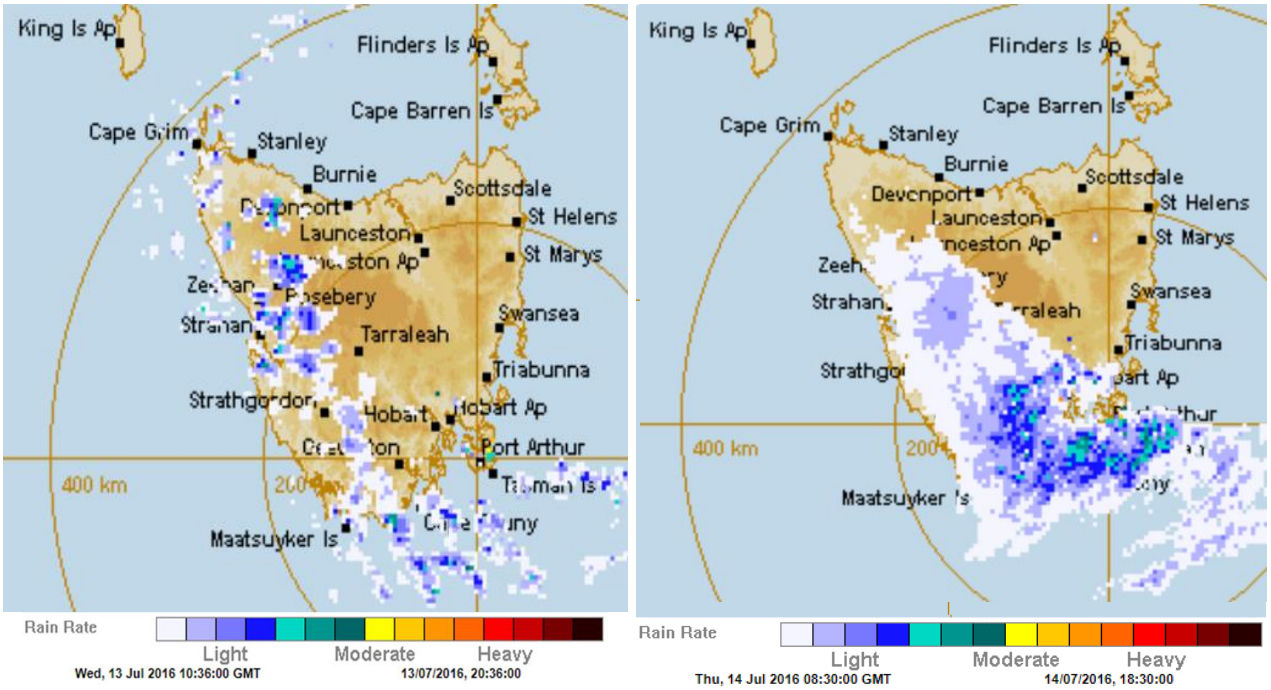


Figure 12.10: Mean sea level pressure chart at 10am 15th July 2016

Radar reflectivity imagery from the Koonya radar (southeast Tasmania) is shown below (Figure 12.11). The image at 20:36 on the 13th of July shows heavy, convective showers moving over west and southwest Tasmania. These showers were being generated by the cold air following the front, with rain falling as snow above 100 metres of elevation. The image at 18:30 on the 14th of July shows a very different rain regime. The rainfall is being generated by a strong, moist and warmer westerly airstream. As such, the rain was mostly uniform and consistent across the west and southwest, with the heaviest rainfall about elevated windward terrain.



20:36, 13th of July

18:30, 14th of July

Figure 12.11: Radar reflectivity images during the event at the designated time and date.

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 6.12). The six days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. It can be seen that rainfall persistently fell across western Tasmania during the four days leading up to the 15th of July 2016. The rainfall that fell during the 24-hours to 9 am on the 14th of July had fallen as snow above 100 meters and so is not recorded in the daily rainfall totals. The heaviest rainfall occurred during the 24 -hours to 9 am on the 15th of July, with snow melt making up some of the daily total. Rain quickly eased during the 15th. Note that throughout the period, the significant rain fell to the west of the Huon Valley, with the valley itself not receiving significant rainfall.

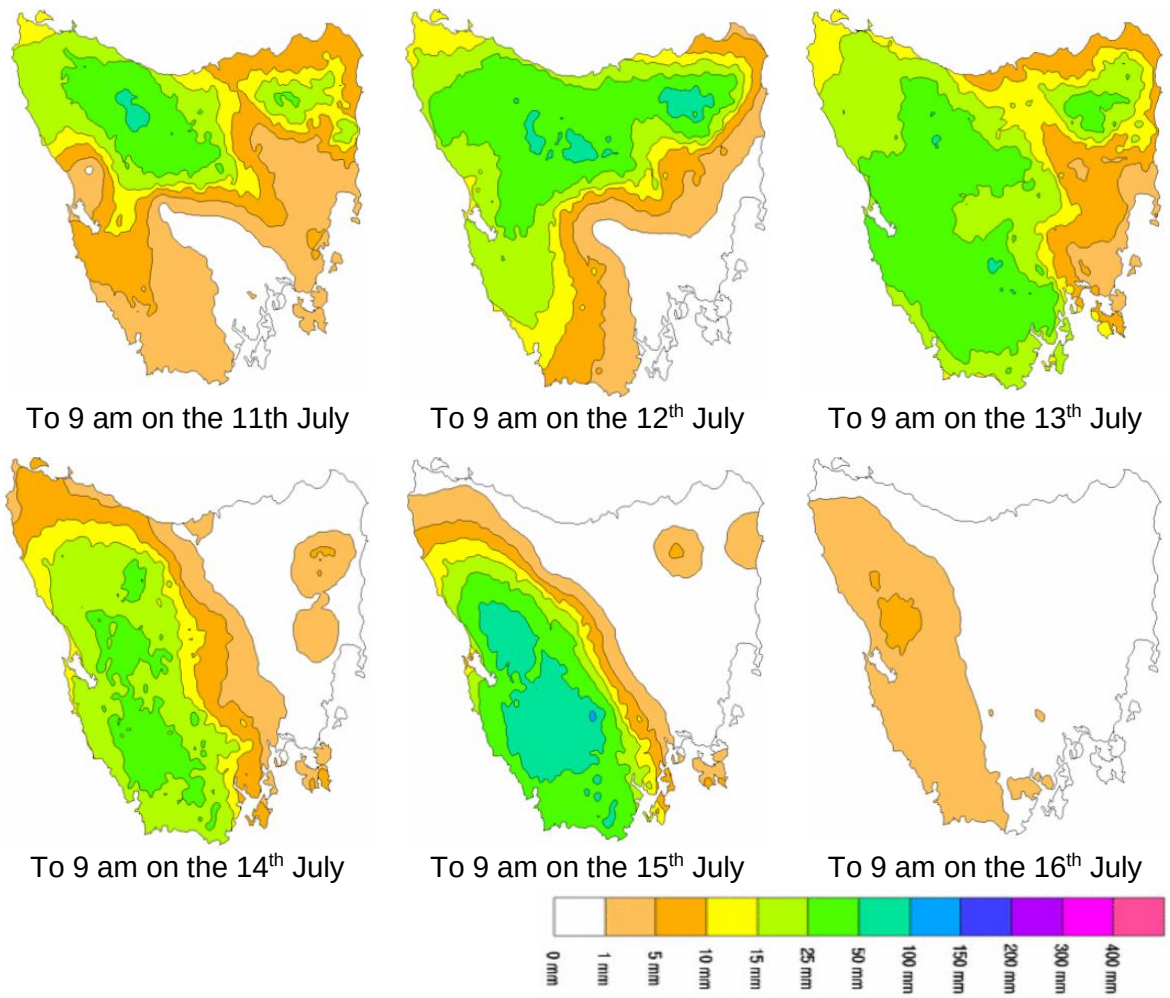


Figure 12.12: 24 hour rainfall to 9 am of the designated date for six days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Strathgordon (319 m elevation), Tim Shea Summit (925 m) and North Boomerang (Mt Bobs) (525 m). Also shown are the rainfall accumulation graphs for these sites. The pluviometers at these locations report rainfall accumulations at one-minute increments.

Looking at the rainfall accumulation graph at Strathgordon shows persistent periods of rain from late on the 11th of July until the 15th of July 2016 (Figure 12.14). The rain rate eases a little on the 13th, however some of the rainfall was falling as snow and as such was not captured by the rain gauge. The rain rate rapidly increases during the 14th of July and the warmer moist westerly set in. Some of this rainfall was snow melt. The rainfall accumulation graphs at Tim Shea and Mt Bobs tell a similar story, however as they are more elevated rainfall was falling as snow from late 12th and throughout the 13th of July, evident in the graph as an abrupt pause in the rainfall (Figure 12.16 and Figure 12.18). Both gauges show an impressive rain rate during the 14th, some of which is snow melt. It is very hard to determine how much is snow melt, probably between 30 to 70 mm.

The storm envelopes at these gauges show that this was a longer duration event with significant rainfall rates at durations of around 12 to 18 hours, peaking around 24 hours and maintaining significant values for several days. Rainfall rates at Strathgordon are at their most significant around 20 hours with an AEP near 2% (Figure 12.13). Rainfall rates were less significant at Tim Shea, peaking at 10% AEP at 24-hours (Figure 12.15). The rain rate at Mt Bobs was most significant at durations of around 18 hours and beyond, correlating to an AEP of around 5% (Figure 12.17).

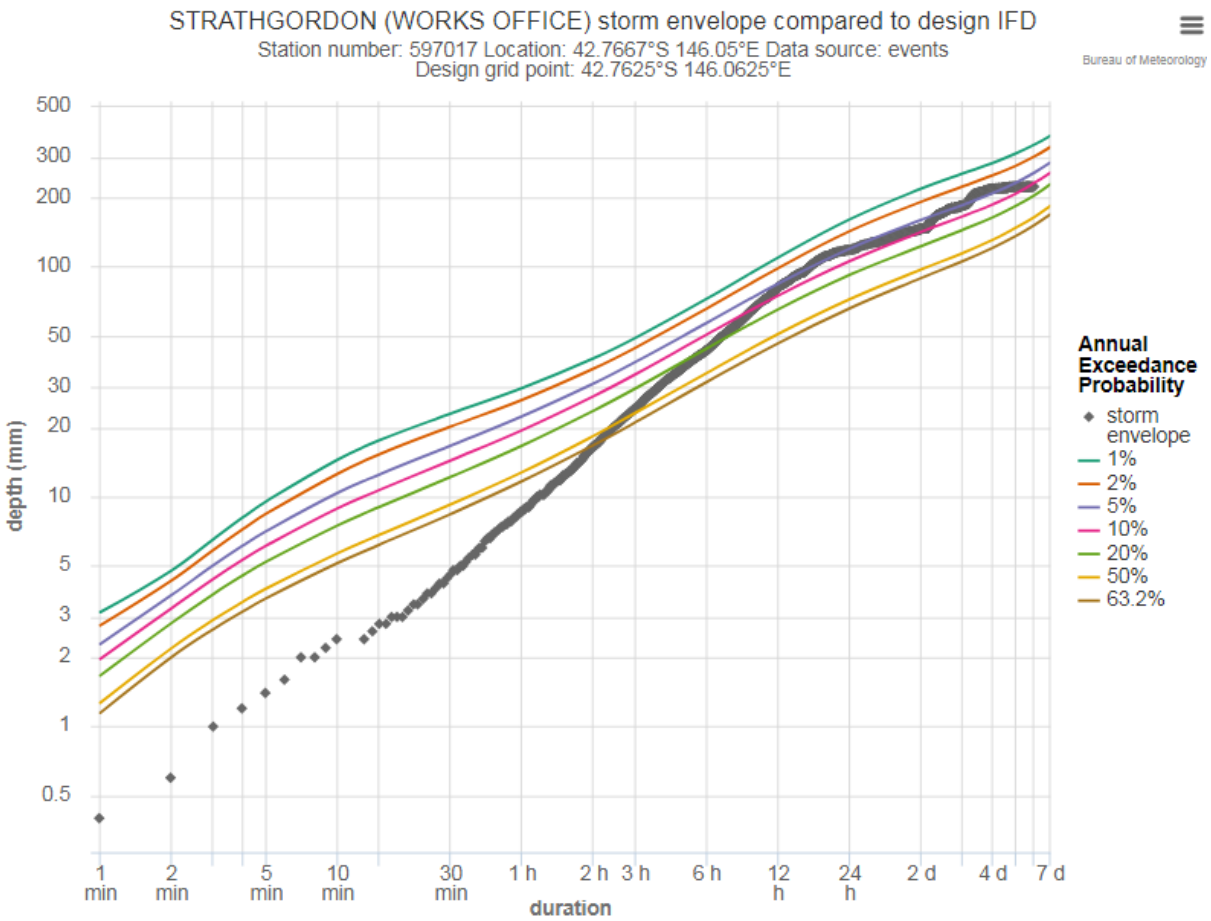


Figure 12.13: Storm envelope for Strathgordon

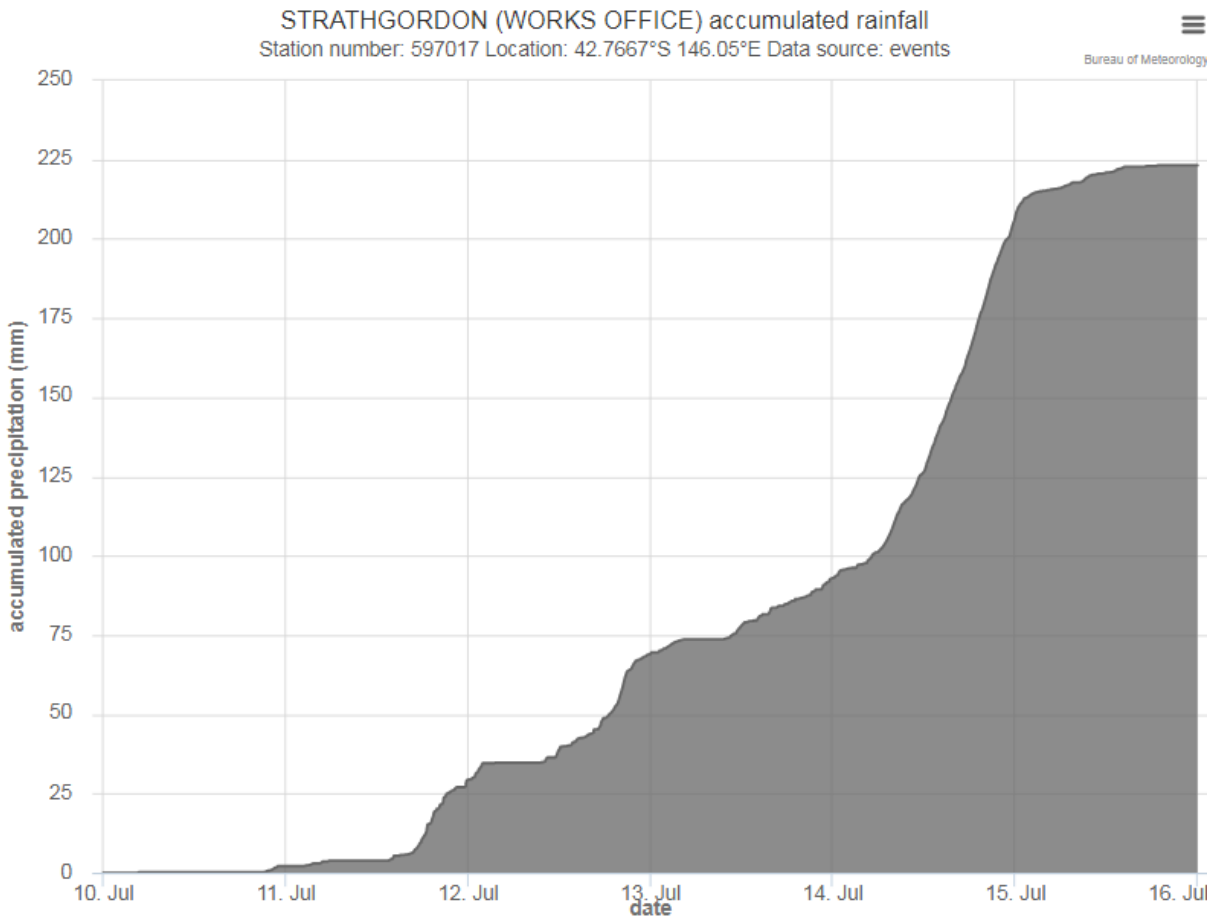


Figure 12.14: Rainfall accumulation at Strathgordon

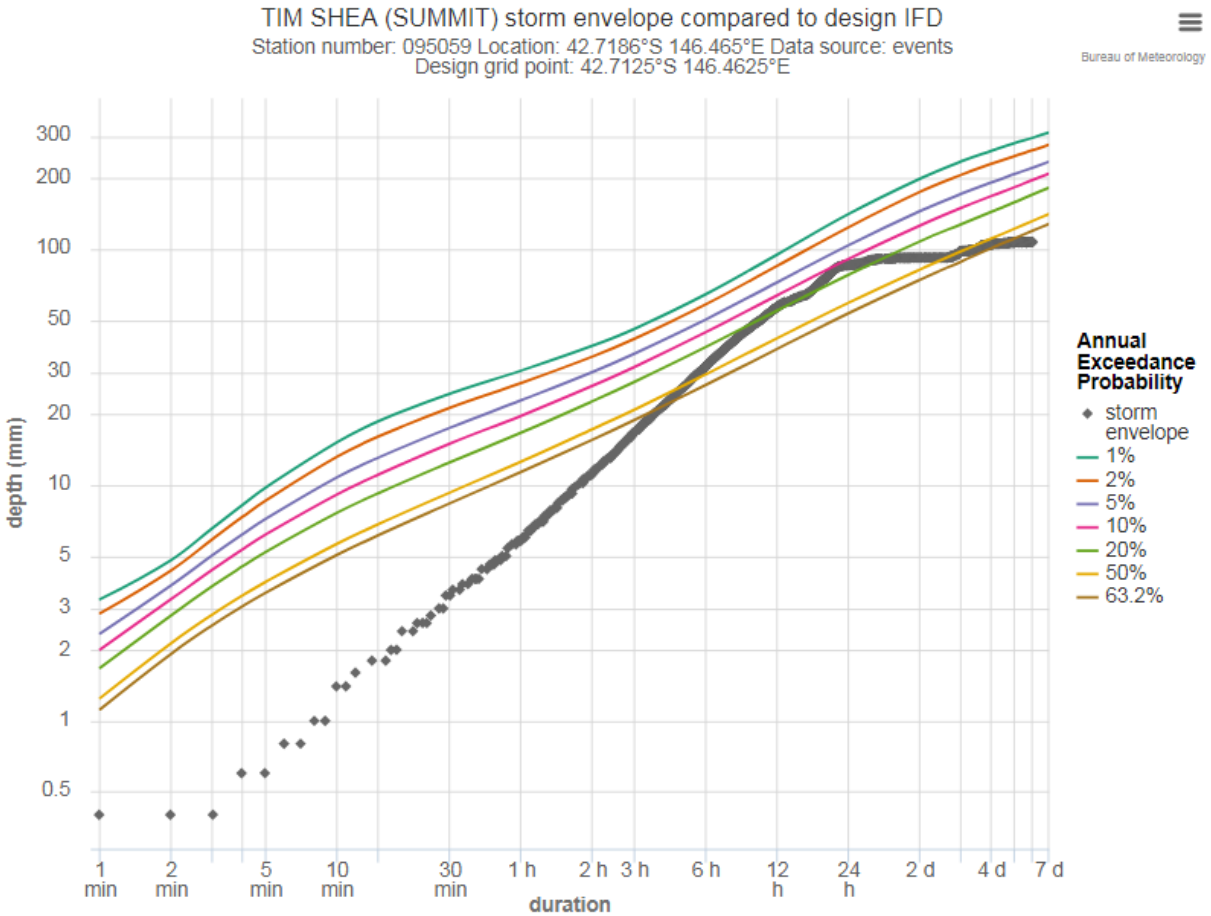


Figure 12.15: Storm envelope for Tim Shea (Summit)

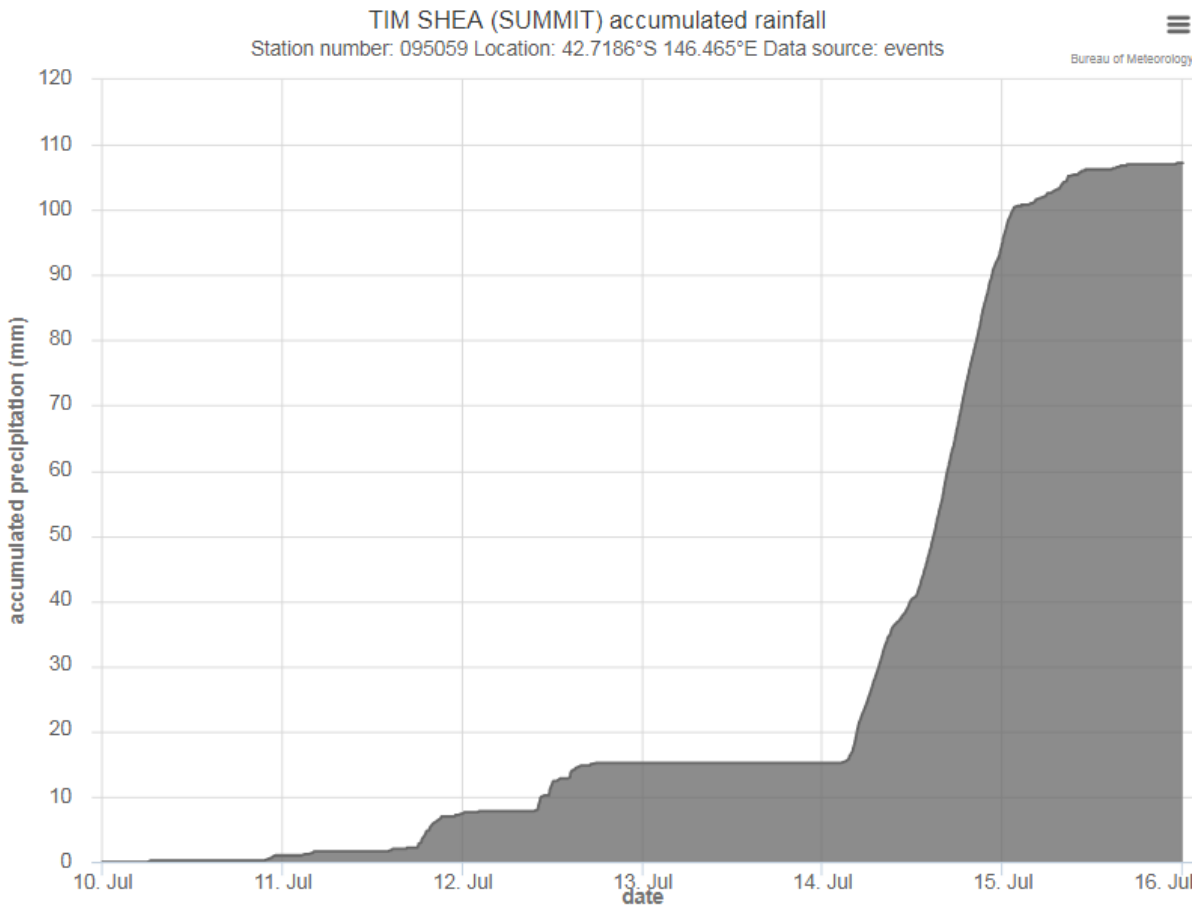


Figure 12.16: Rainfall accumulation at Tim Shea (Summit)

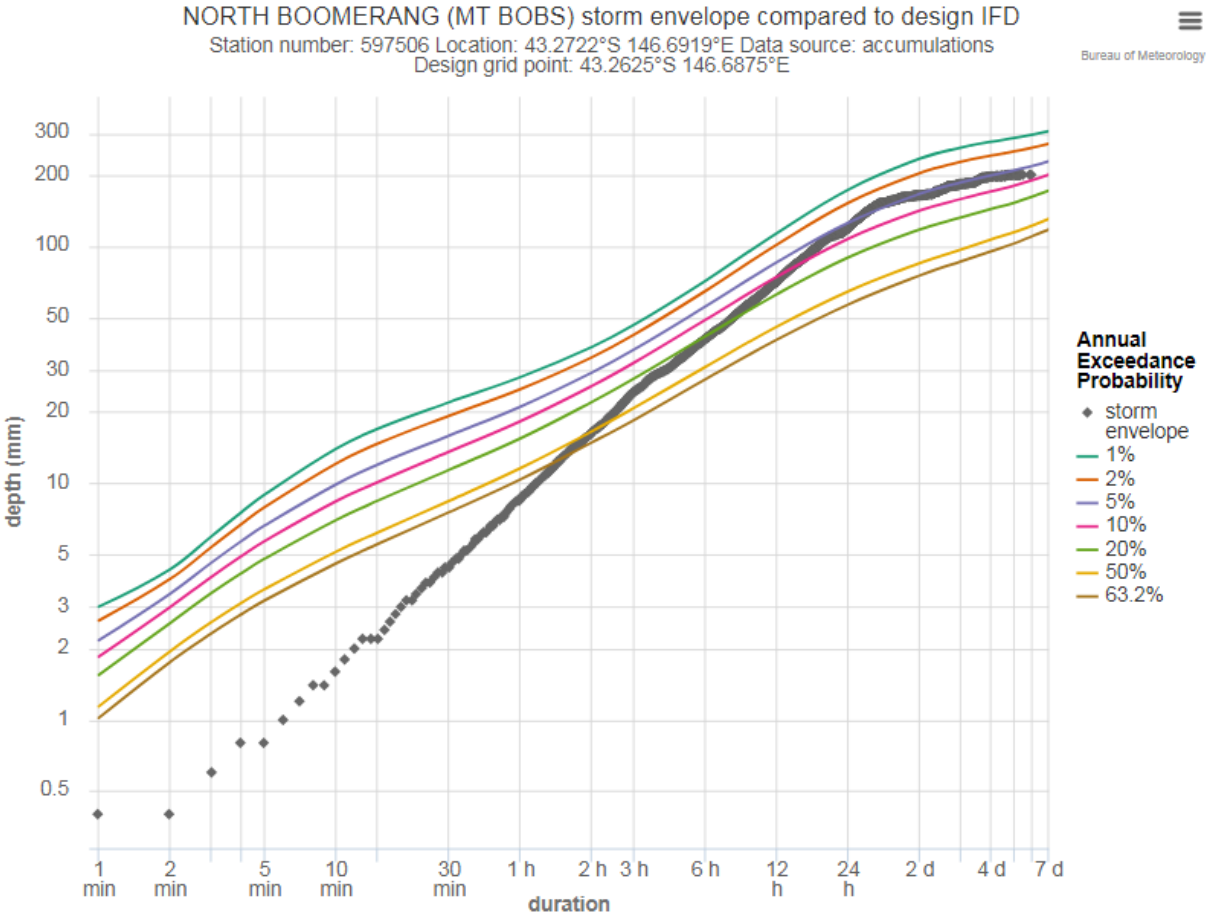


Figure 12.17: Storm envelope for North Boomerang (Mt Bobs)

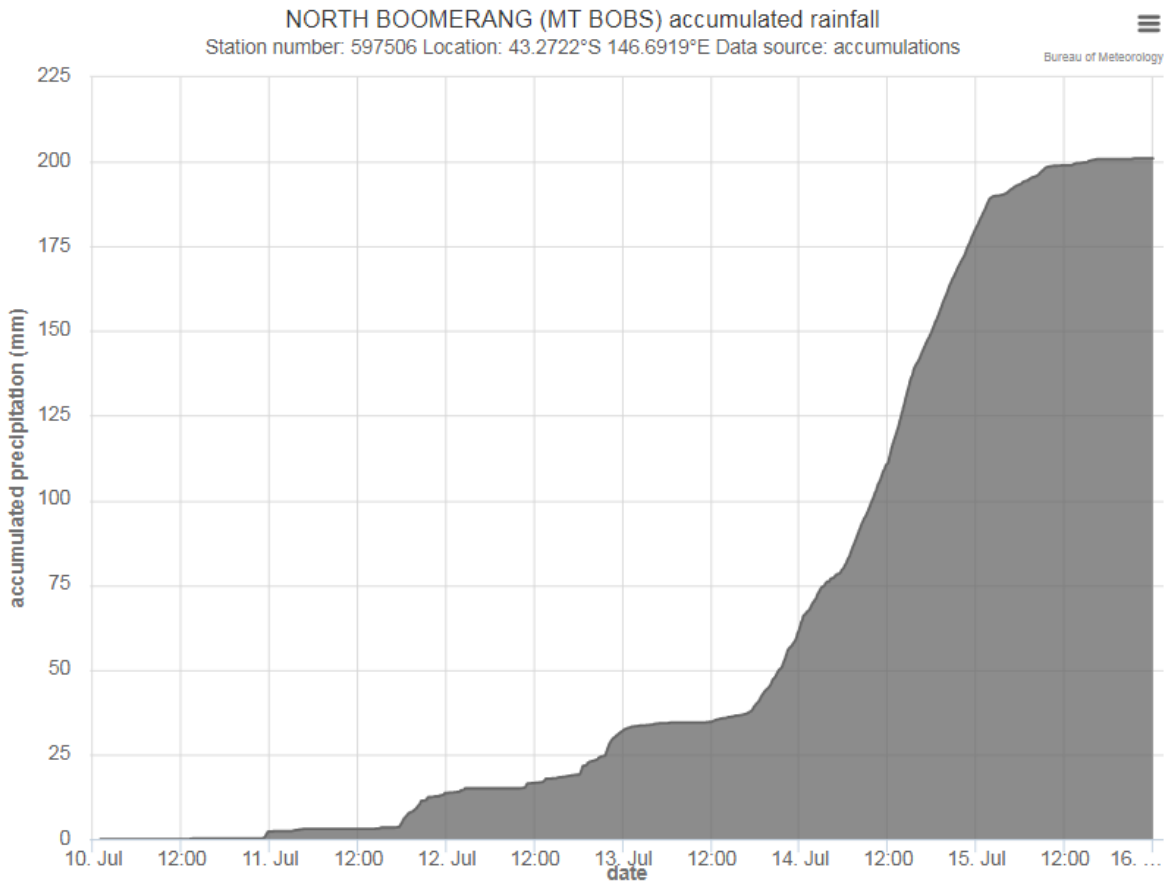
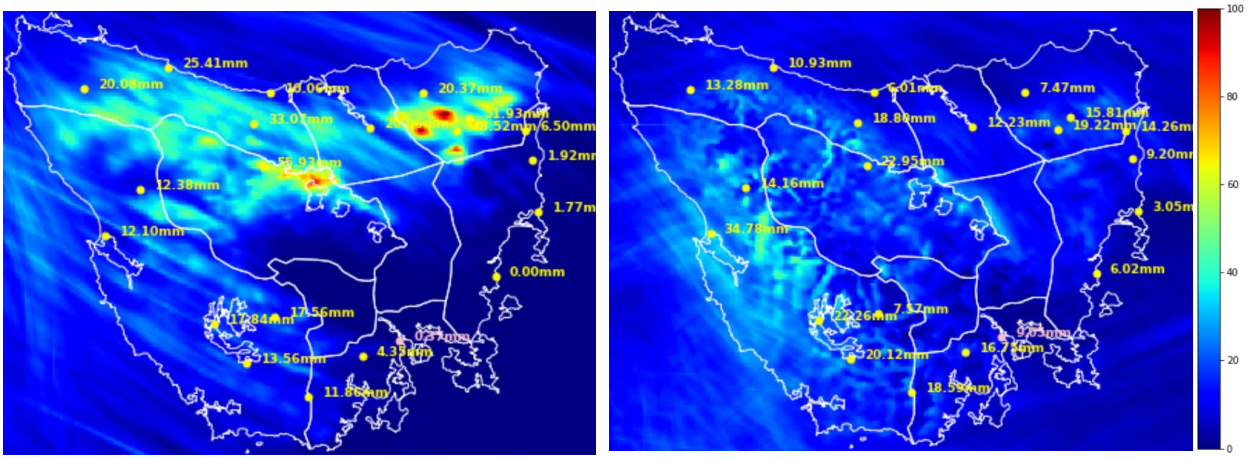


Figure 12.18: Rainfall accumulation at North Boomerang (Mt Bobs)

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania during this event. A sample of the data is shown below (Figure 12.19).



24 hours to 10am, 12th of July 24 hours to 10am, 13th of July

Figure 12.19: BARRA-TA 24-hour rainfall accumulation (mm) to 10 am of the stated date

BARRA seems to have captured the event reasonably well and may be of some use for hydrological modelling. Please note that the provided rainfall data does not discern between liquid or frozen precipitation.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- Rain_event, usually ten-minute accumulation
- BARRA-TA, ten-minute accumulated rainfall
- AWRA-L rootzone (0-100 cm) soil moisture (mm)

13. May 2018 – Hobart

Summary

During the evening of 10th May 2018, a line of thunderstorms brought highly exceptional and intense rainfall to the Hobart area, with the most significant rainfall occurring across the southern suburbs of Hobart and the areas directly inland. During the evening, widespread flash flooding and destruction was reported with Hobart recording 44.4 mm in an hour, far exceeding the previous record of 28.9 mm. Rainfall amounts in the affected areas were generally 100 to 230 mm during the 6 to 12-hour period (Figure 13.1).

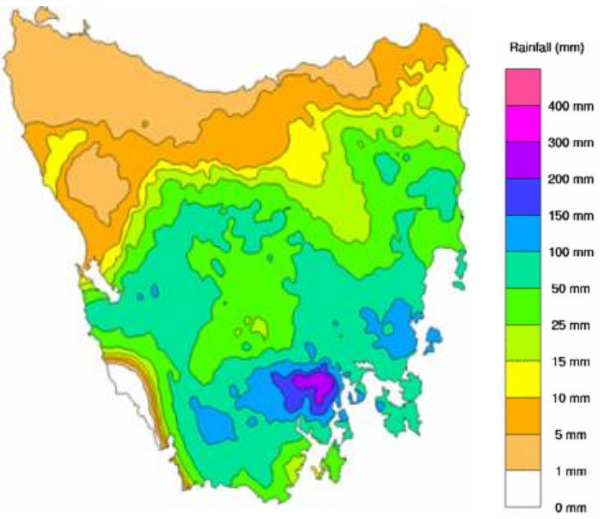


Figure 13.1: 24-hour rainfall totals to 9 am of May 11th 2018.

Antecedent Conditions

Rainfall during the six months leading up to the end of April 2018 was generally around average across eastern and southeastern Tasmania (Figure 13.2).

April 2018 was slightly drier than average around Hobart and southeast Tasmania, Around 25 to 50 mm fell around Hobart during the month which is around 10 to 25 mm below average (Figure 13.3).

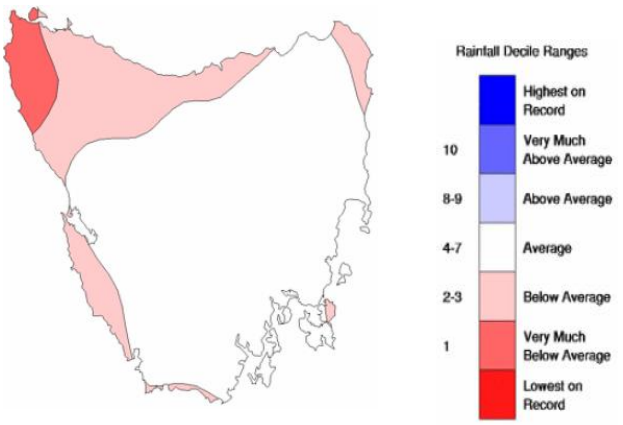


Figure 13.2: Rainfall deciles from 1 November 2017 to 30 April 2018.

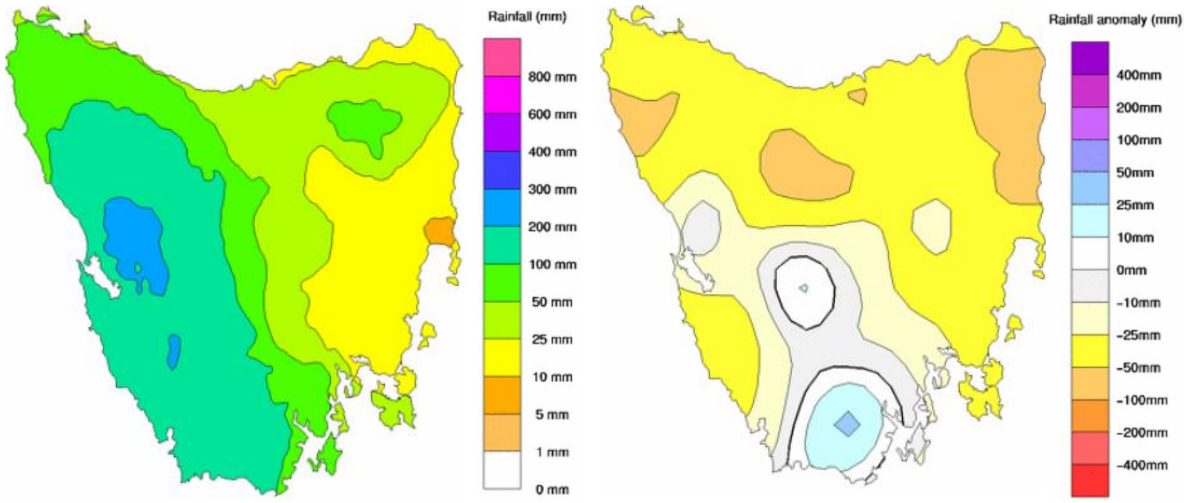


Figure 13.3: The left map shows recorded rainfall across Tasmania during April 2018 with the right map showing the deviation from the April mean (in mm).

During the first ten days of May 2018, less than 10 mm of rain fell around Hobart (Figure 13.4).

Since no significant rain had occurred across eastern and southeastern Tasmania since the preceding summer, soil moisture was low around those areas. Figure 13.5 shows the Bureau's AWRA-L rootzone soil moisture model. Elevated areas to the west of Hobart have rootzone soil moisture levels of around 40 to 80 mm, whereas lower areas across southeast Tasmania have low values below 40 mm. Similarly, the Soil Dryness Index (Figure 13.6) shows values in excess of 50 mm to the west of Hobart and in excess of 100 mm around Hobart and to the east.

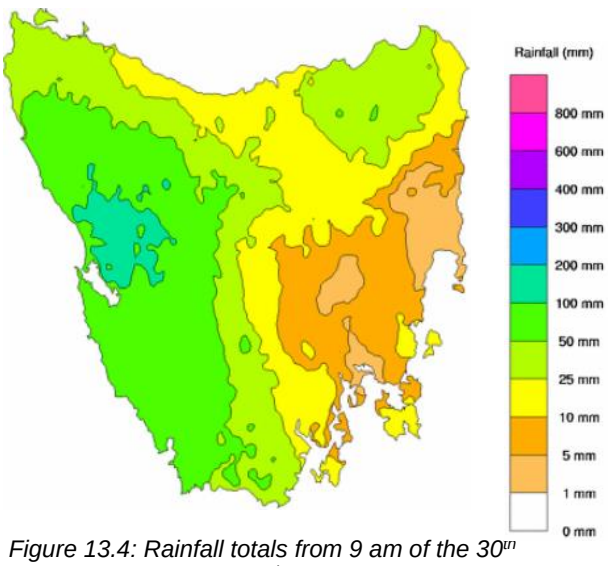


Figure 13.4: Rainfall totals from 9 am of the 30th of April to 9 am of the 10th of May.

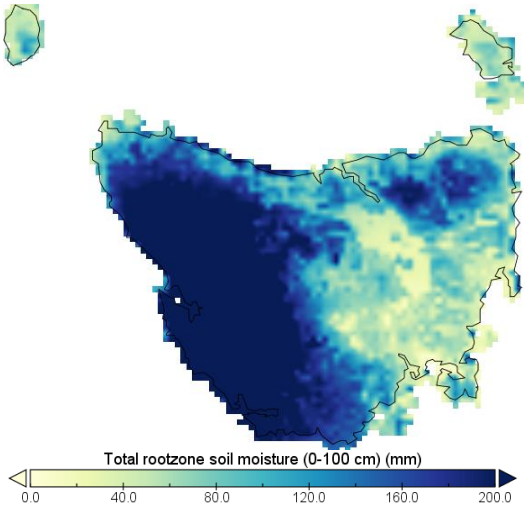


Figure 13.5: AWRA-L Rootzone soil moisture on 10th May, 2018.

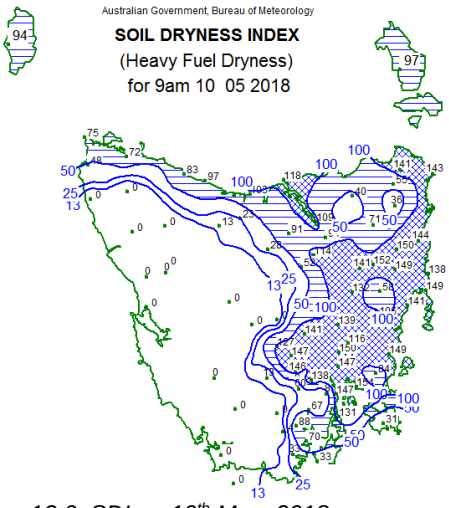


Figure 13.6: SDI on 10th May, 2018.

Meteorological Discussion

A cold front crossed Tasmania during the 9th of May 2018 (Figure 13.7). Cold air in the wake of the front helped to generate a complex area of low pressure to the east of Tasmania during the 10th of May (Figure 13.8). Although the pressure gradient across the Tasman Sea was fairly 'open' with no deep northeasterly airstream over Tasmania, a narrow channel of relatively moist air in the upper atmosphere was directed towards southeast Tasmania.

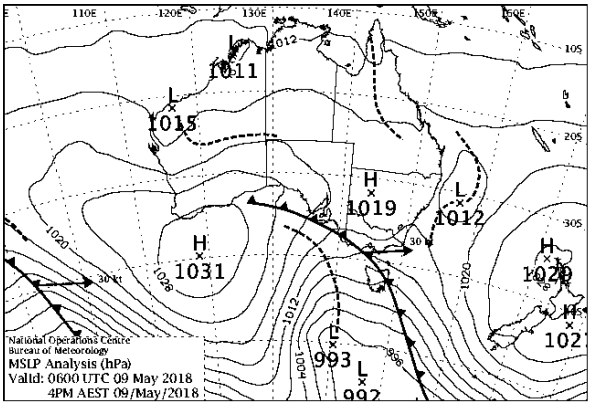


Figure 13.7: Mean sea level pressure chart at 4 pm 9th May 2018

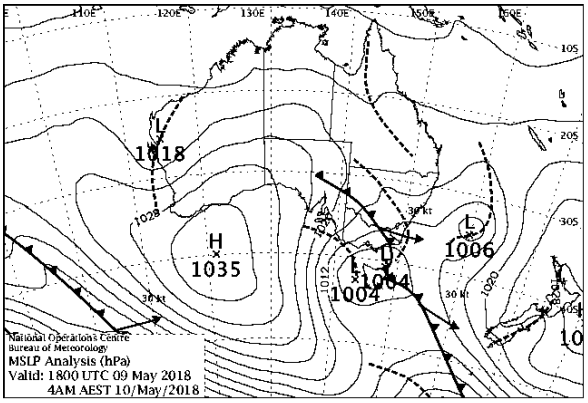


Figure 13.8: Mean sea level pressure chart at 4 am 10th May 2018

During the afternoon and evening of May 10th, the low deepened and moved close to southeast Tasmania, directing a southeasterly airstream and moderate rain over southeast Tasmania (Figure 13.9). As the narrow channel of moist upper air moved toward southeast Tasmania, a very distinct and localised trough of low pressure developed near Maria Island. The combination of the trough and upper moisture helped to generate a line of thunderstorms that was oriented east to west. During the evening, the trough and thunderstorms moved over the Hobart area with the trough remaining in the vicinity until early on the 11th of May. The nearly stationary line of thunderstorms brought incredibly intense and localised rainfall across Hobart and the areas directly inland. During the early morning of the 11th of May, the trough and line of thunderstorms began to decay and the low centre began to move to the northeast with the heavy rain dramatically easing before sunrise that day (Figure 13.10).

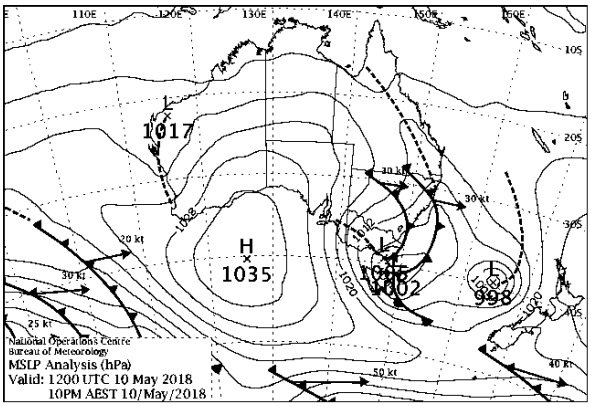


Figure 13.9: Mean sea level pressure chart at 10 pm 10th May 2018

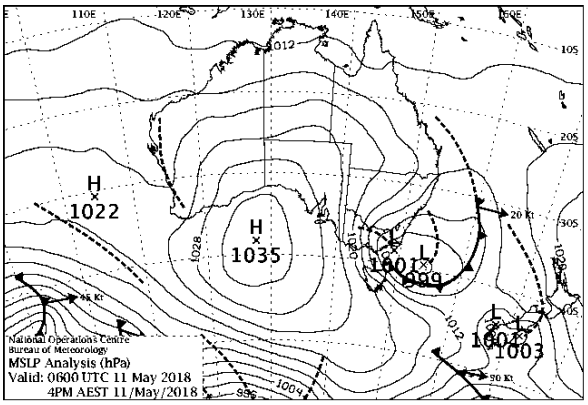
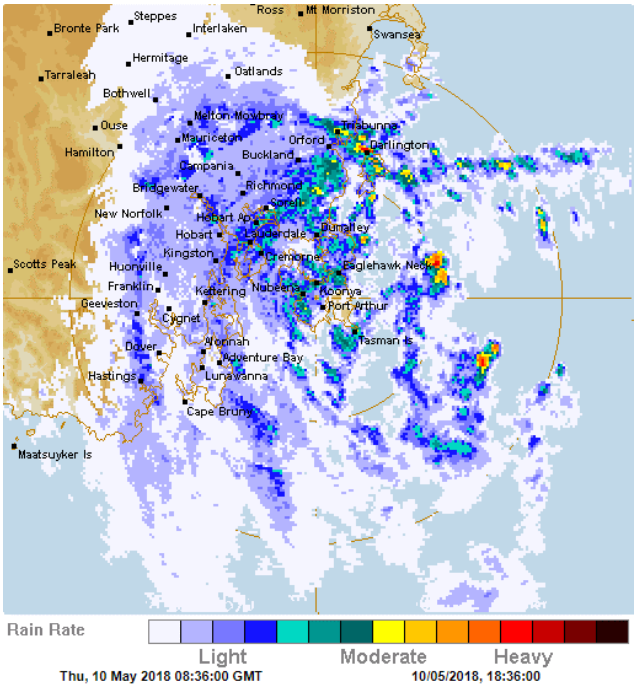
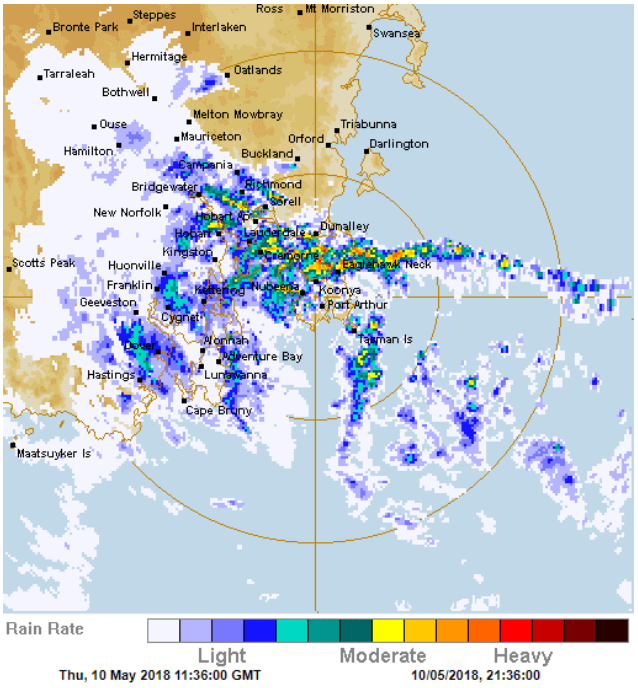


Figure 13.10: Mean sea level pressure chart at 4 pm 11th May 2018

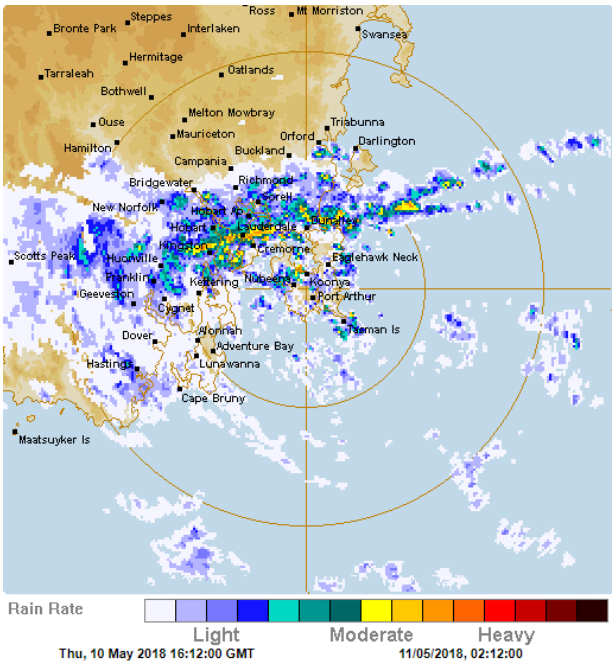
Radar reflectivity imagery from the Koonya radar (southeast Tasmania) is shown below (Figure 13.11). The image at 18:36 on the 10th of May shows the trough and line of thunderstorms developing near Maria Island and to the east. During this time, very heavy rainfall was falling around Orford and surrounds. A couple of intense storm cells can be seen to the east and southeast of the Tasman Peninsula. These storms moved over the Peninsula and into the Hobart area bringing brief heavy rain to those areas. Large hail was reported around Port Arthur. The radar image at 21:36 on the 10th of May shows a more coherent line of thunderstorms to the south of Dunalley and extending into the Hobart area. Exceptionally heavy rain had now developed around the Hobart area. As of 02:12 on the 11th of May, the line of thunderstorms had remained near stationary in the same area, with the southern suburbs of Hobart and elevated areas immediately inland experiencing the heaviest rain. The radar image at 03:48 shows the line of thunderstorms has moved to the north and decayed, with more moderate showers now moving into southeast Tasmania.



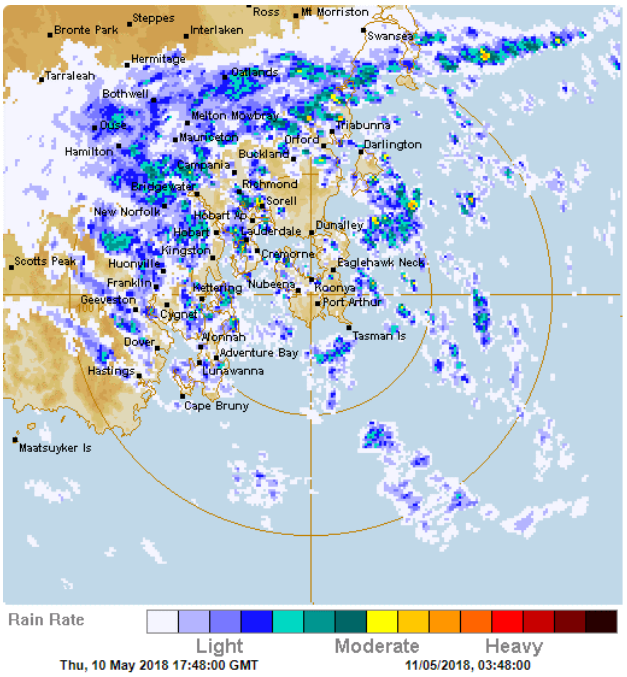
18:36, 10th of May



21:36, 10th of May



02:12, 11th of May



03:48, 11th of May

Figure 13.11: Radar reflectivity images during the event at the designated time and date

Rainfall Maps

Below are daily rainfall maps showing the 24-hour rainfall accumulation to 9am of the date stated below (Figure 13.12). The three days around the time of the event are shown. The data comes from the AWAP dataset and is based on observed rainfall with a topographic interpolation applied. The rain event occurred within the 24-hour period to 9 am of the 11th of May, with little rain falling across southeast Tasmania immediately before or after that. The highly localised nature of the intense rainfall is evident, with Hobart (Ellerslie Rd) recording 129.2 mm during the 24 hours to 9 am of the 11th, whereas Hobart Airport only recorded 41 mm during this time. Leslie Vale, Longley and Mt Wellington recorded in excess of 200 mm.

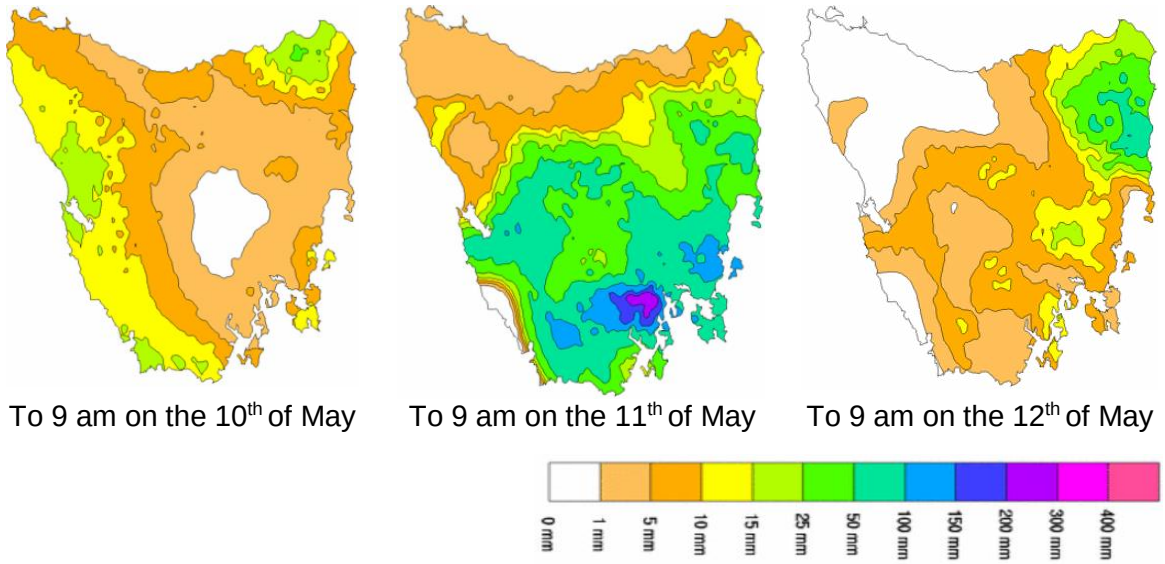


Figure 13.12: 24 hour rainfall to 9 am of the designated date for six days around the event.

Point Rainfall Probability Analysis

The below images show the observed storm envelopes relative to AEP thresholds for Hobart (Ellerslie Road), kunanyi (Mount Wellington Pinnacle) and Leslie Vale. Also shown are the rainfall accumulation graphs for these sites. The pluviometers at these locations report rainfall accumulations at one-minute increments.

The rainfall accumulation graphs at all three locations tell a similar story; during the morning and afternoon of the 10th of May, moderate rainfall was recorded as a southeasterly airstream developed over the area. This rainfall was mostly uniform and persistent, with higher elevations recording more rainfall. Then during that evening, thunderstorms moved over the area and abrupt and intense rainfall was observed. The rainfall then rapidly eased by around 4 am of the 11th (Figure 13.14, Figure 13.16 and Figure 13.18). Although kunanyi recorded the highest daily rainfall during this event, a component of this was due to the topographic, persistent rainfall that was being produced by the southeasterly airstream. Roughly trying to discern the thunderstorm generated rainfall from the background rainfall reveals that Hobart and kunanyi received comparable rainfall amounts from the thunderstorms, whereas Leslie Vale recorded more intense rainfall rates as this area had more storm activity. For example, the highest 2-hour rainfall rates at kunanyi and Hobart were 63.4 mm and 80.8 mm respectively, however at Leslie Vale it was 93 mm.

The storm envelopes at these gauges also tell a similar story, with all short rainfall durations from about 1 minute to 24 hours around 1% AEP or more extreme (Figure 13.13, Figure 13.15 and Figure 13.17). However, rainfall rates from around 30 minutes to 6 hours are remarkably rare.

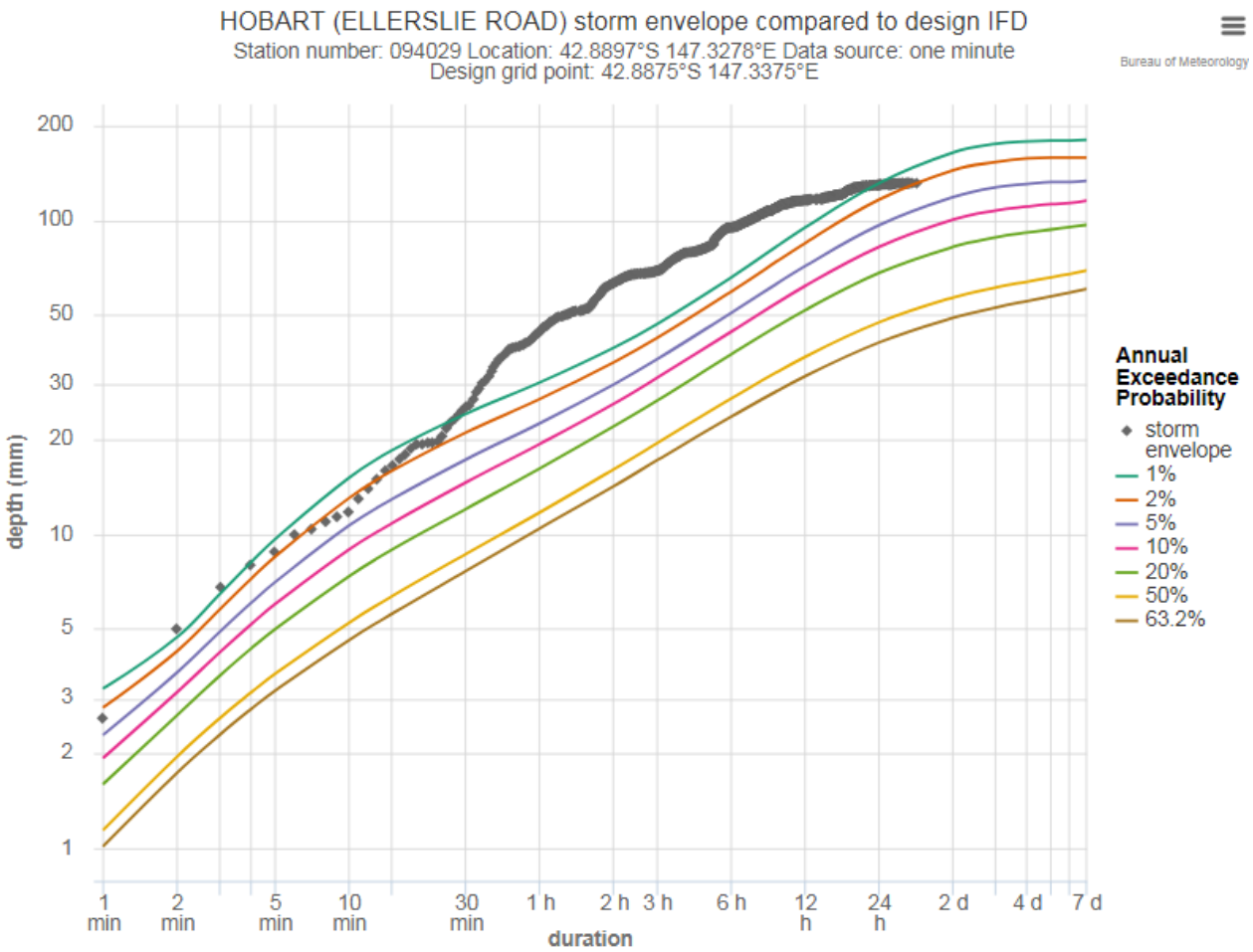


Figure 13.13: Storm envelope for Hobart (Ellerslie Road)

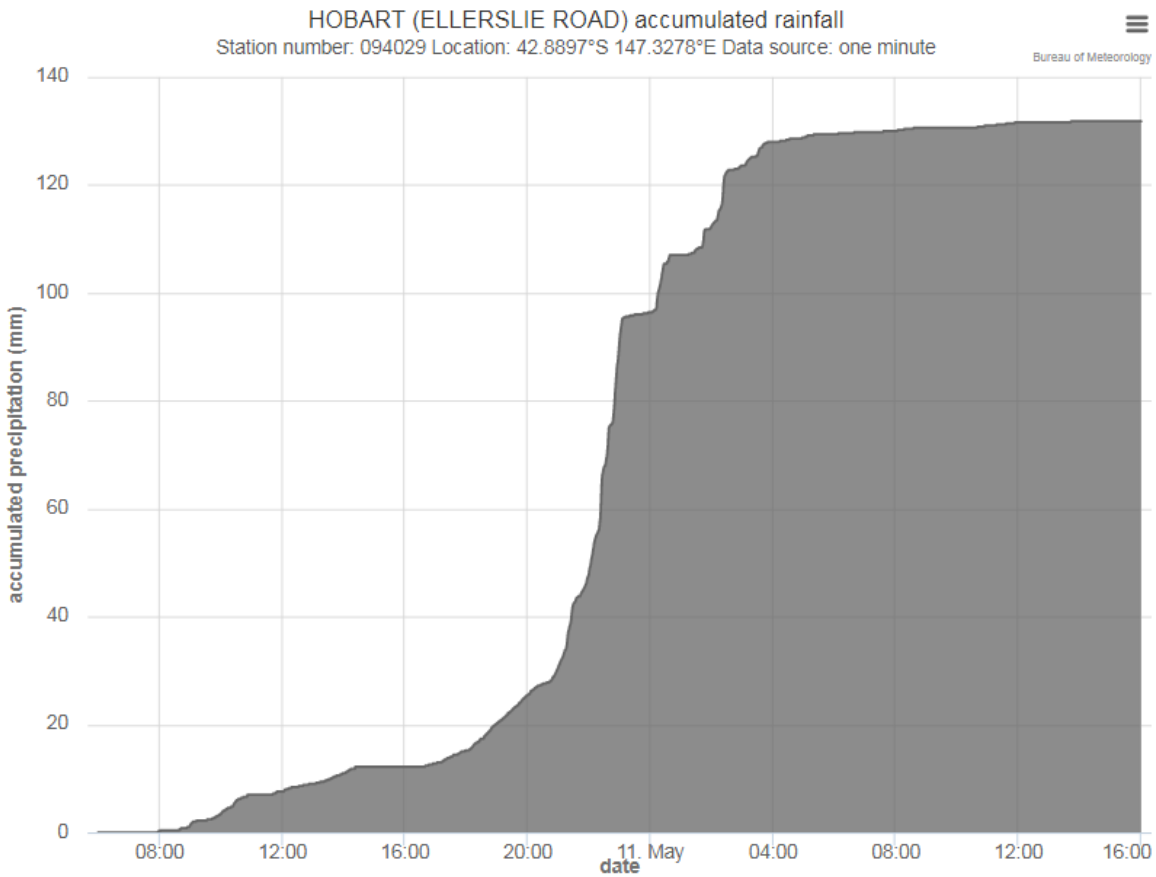


Figure 13.14: Rainfall accumulation at Hobart (Ellerslie Road)

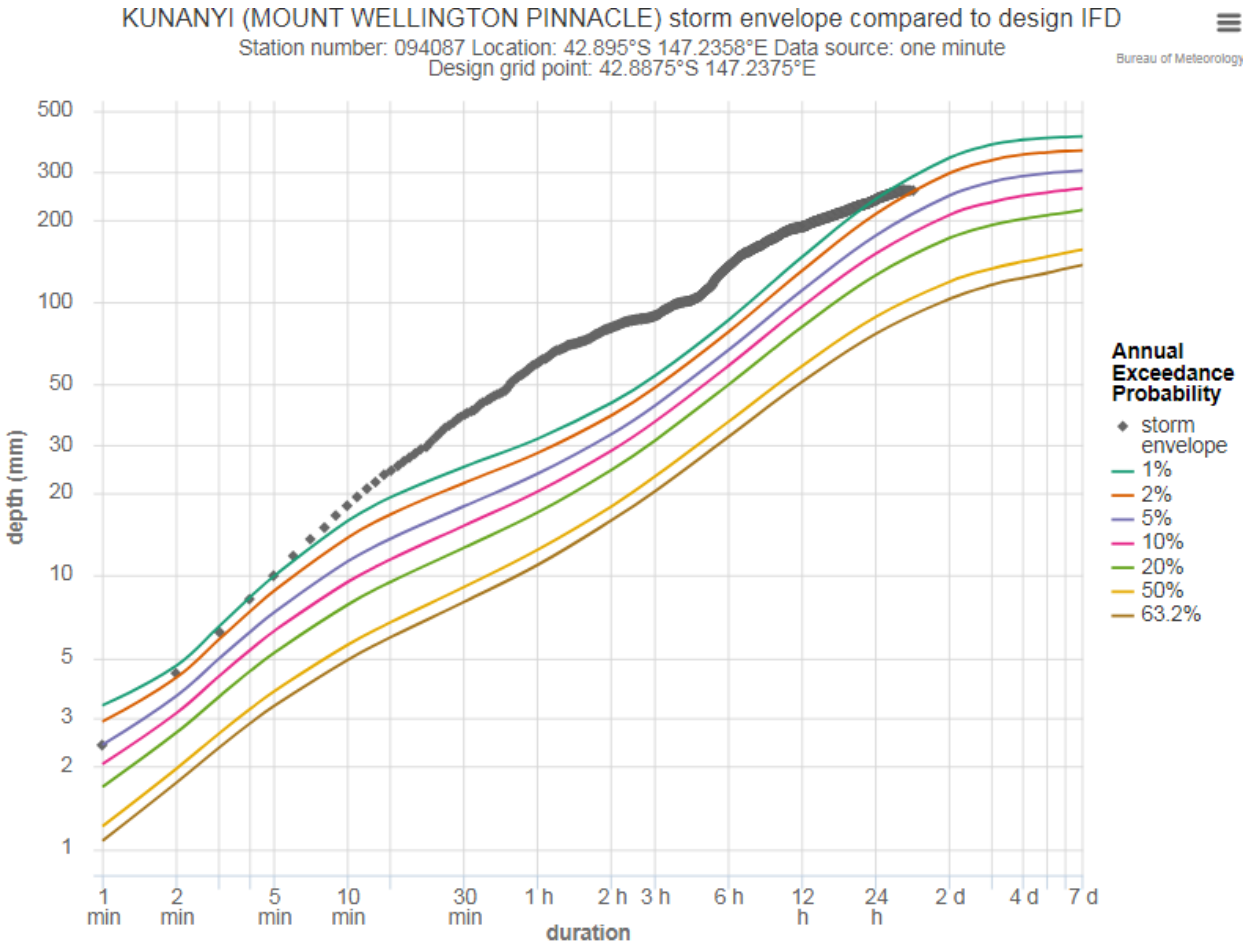


Figure 13.15: Storm envelope for kunanyi (Mount Wellington)

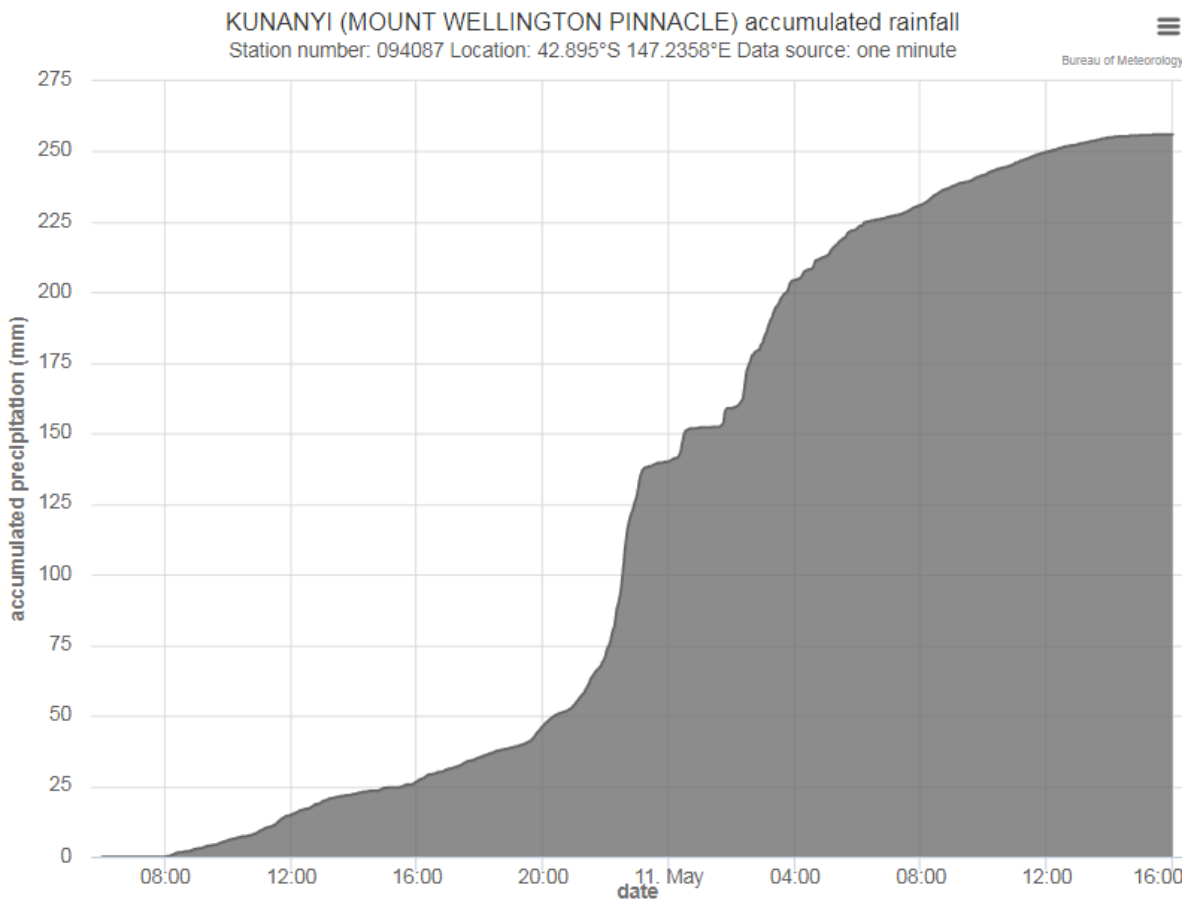


Figure 13.16: Rainfall accumulation at kunanyi (Mount Wellington)

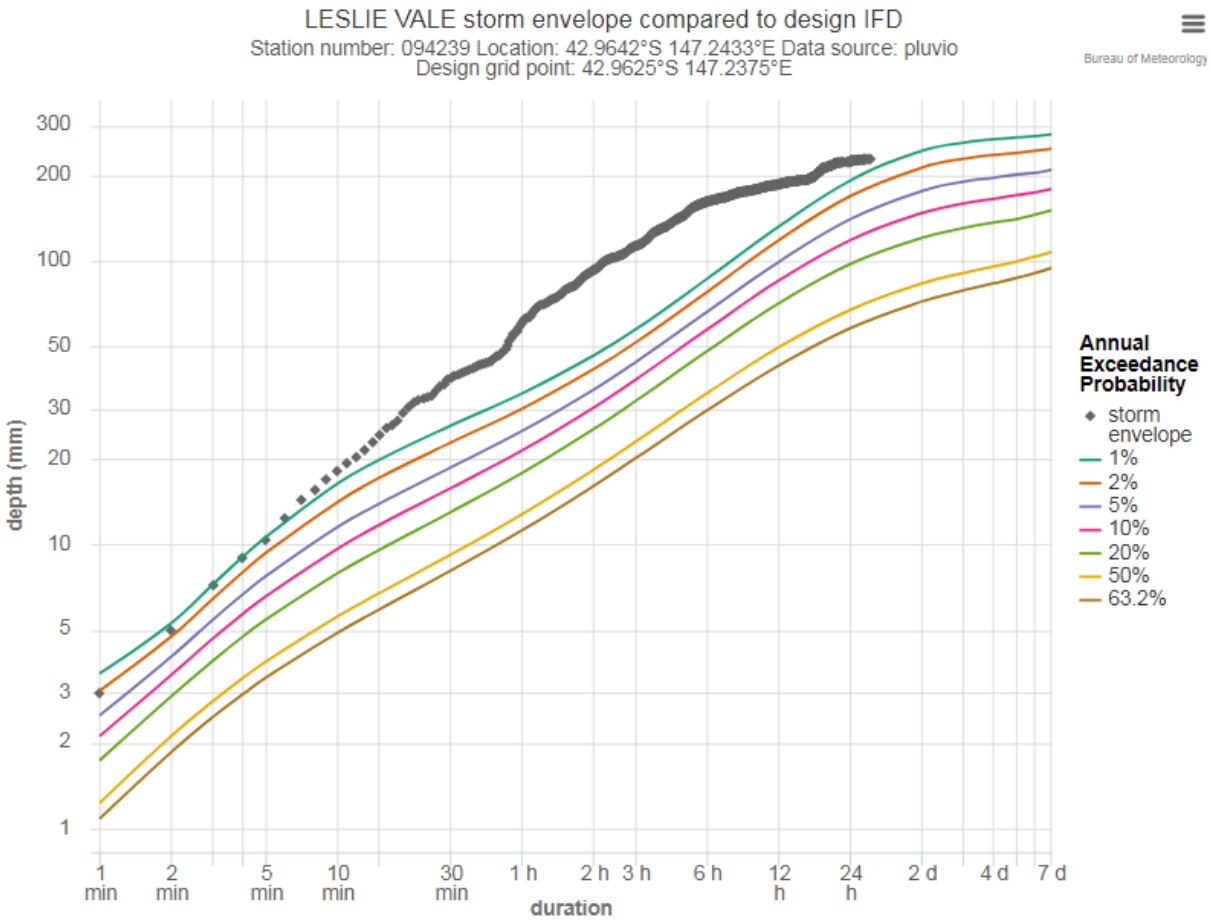


Figure 13.17: Storm envelope for Leslie Vale

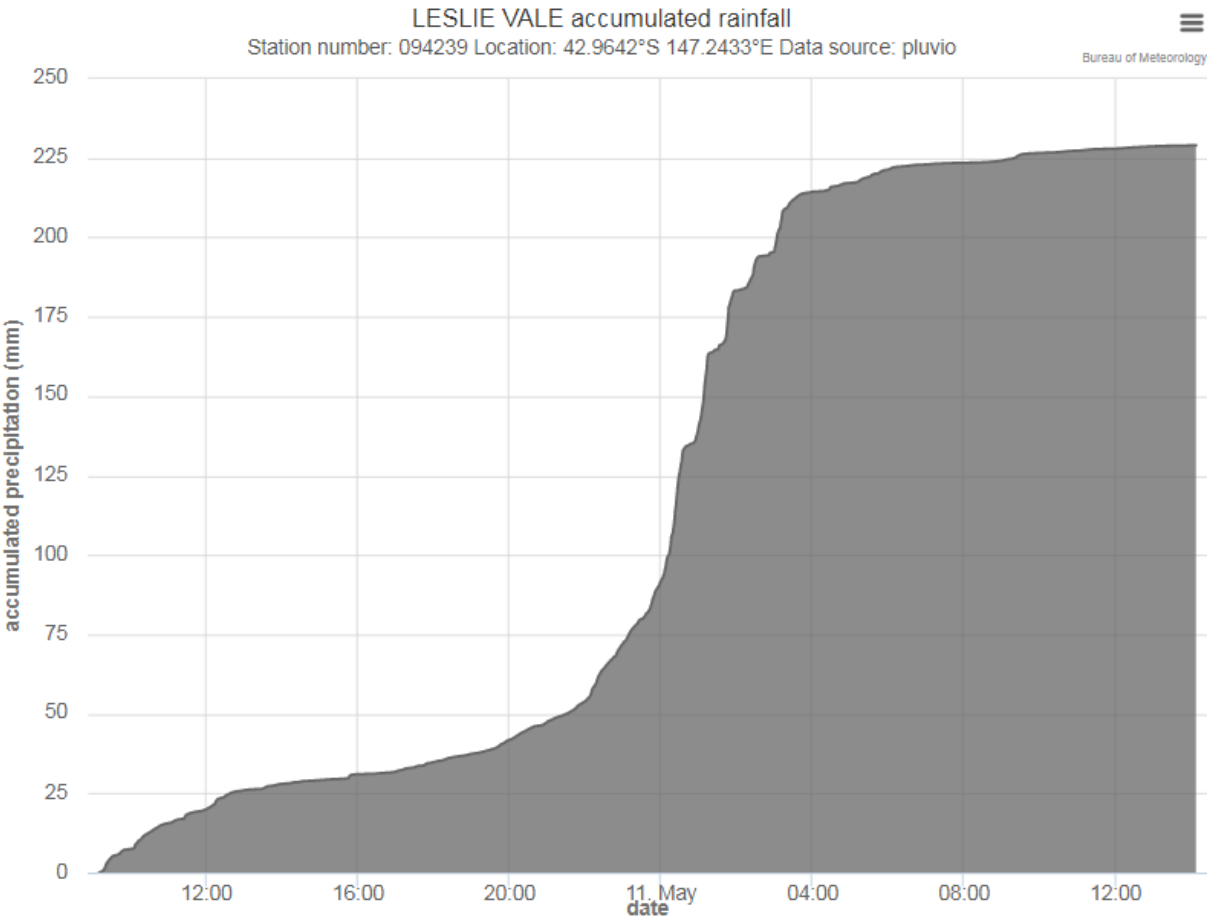
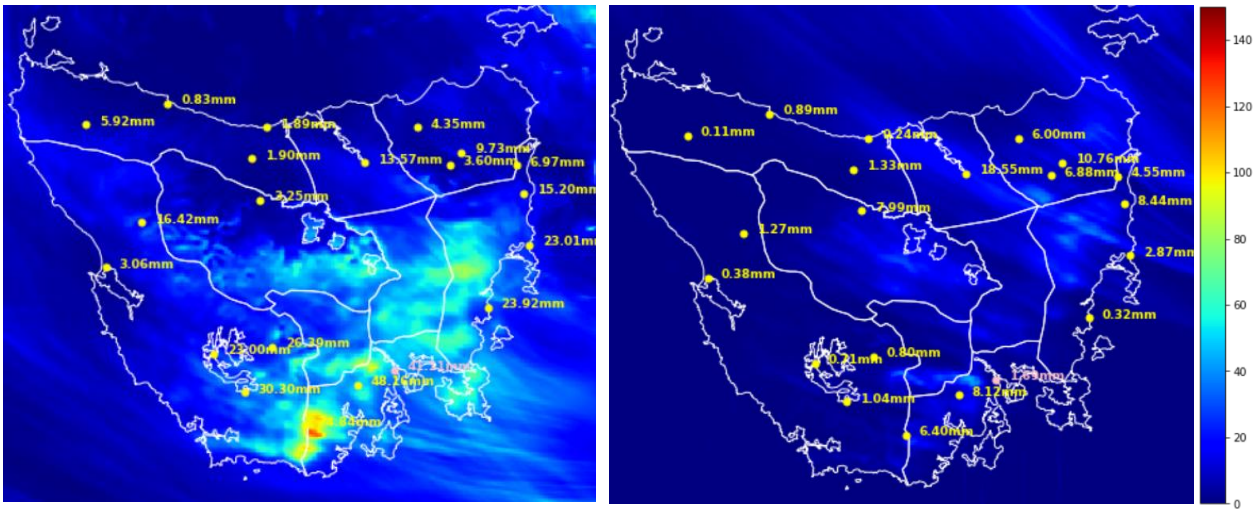


Figure 13.18: Rainfall accumulation at Leslie Vale

BARRA-TA Analysis

Data from the *Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, Tasmania Domain* (BARRA-TA) is provided for this event. This provides an *approximation* of the 10-minute rainfall accumulation across Tasmania throughout the period. A sample of the data is shown below (Figure 13.19).



24 hours to 10am, 11th of May 24 hours to 10am, 12th of May

Figure 13.19: BARRA-TA 24-hour rainfall accumulation (mm) to 10 am of the stated date

BARRA did not accurately model the exact location and intensity of the very heavy rainfall. This is due to the highly convective and localised nature of the rainfall. In this case, it is not recommended that BARRA data be used for hydrological modeling.

Data Provided

- AWAP rainfall, 24 hours to 9 am
- Daily rainfall observations, 24 hours to 9 am
- AWS (Automatic Weather Station), one-minute rainfall accumulation
- Pluvio, five-minute rainfall accumulation
- Rain_accum, rolling accumulation, exact time of bucket tip is reported
- Rain_event, usually ten-minute accumulation
- BARRA-TA, ten-minute accumulated rainfall
- Rainfields, radar and observation derived six-minute rainfall accumulation across southeast Tasmania
- AWRA-L rootzone (0-100 cm) soil moisture (mm)