WATER CONSERVATION AND IRRIGATION COMMISSION REPORT ON THE HYDROLOGICAL FEATURES OF THE FLOODS OF FEBRUARY 1954 NORTH COAST NEW SOUTH WALES

Preface

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Introduction

General

During February, 1954, severe flooding occurred on the northern coastal rivers of New South Wales. These floods were produced by an intense tropical cyclone or "hurricane", which, by its passage down the east coast of Australia, brought heavy rains to the entire coastal strip from Rockhampton, Queensland in the north to the New South Wales-Victorian border in the south.

In the coastal region from the Queensland border to Coffs Harbour, many streams reached their heighest levels in the history of white settlement.

Fifteen lives were lost during the floods and the resulting damage was estimated in excess of three million pounds.

Purpose of the Report

This report is intended to organise, correlate and summarise the available hydrologic data concerning this storm and the resulting floods, in a form suitable for reference by those engineers who may be concerned with the investigation and design of conservation, hydro-power, or flood mitigation works in the area. :p.It has been prepared to include considerable detail, with the knowledge that often the data so necessary for investigation and planning is scattered and lost so that many years later is is almost impossible to sift from the archives the essential facts and observations which were available at the time.

Scope of the Report

The report covers both the meteorlogical and hydrological features of the floods on the systems of the Tweed, Richmond and Clarence Rivers.

The area considered is thus bounded roughly by the Queensland border in the north, the Great Dividing Range in the west, the sea board in the east and a line joining Coff's Harbour and Guyra in the south. The location of this area showing streams, principal towns, guaging stations etc. can be seen from the plan, reference 2.3.6.

Although substantial rises occurred on all the coastal streams of New South Wales, severe flooding was confined to this area. :p.No attempt has been made in this report to comment of the effect of the flood on various flood mitigation proposals on streams in the area. It has been primarily concerned with reporting on the hydrometric data analysis.

Available Data

Data which is more or less readily available from Hydrographic Branch records has not been included in the report. That is to say, while hydrographs have been supplied for each gauging station the actual gauge readings and discharge curves have not been included. This information has been filed in calculation folders which are referred to in the schedule of run-off.

Adequacy of Data

Rainfall Stations and Pluviometers

The density of daily rain gauges and pluviometers is considered to be insufficient for accurate determination of the areal and temporal distribution of precipitation, particularly in the following areas:

- the upper section of the Richmond catchment;

- the Orara River catchment;
- west of the Nymboida, Mann and upper Clarence Rivers.

Gauging Stations and their Calibrations

Whilst a sufficient number of gauging stations have been established in the area and 35% of these stations had been equipped with automatic recorders at the time of the flood, however float recorders had been installed at only 14% of the stations, most of which are in the upper catchments.

Few stations had been calibrated beyond 20% of the peak discharge estimated at the site.

Recurrence Interval

This flood which ranks among the highest recorded in the area is estimated to have a recurrence interval of the order of 50 years. :p.A brief analysis of the dew point data would seem to indicate that for the same duration of rain, depths 30% greater than those recorded during this storm could be possible.

Meteorolgy

General: Meteorology of Cyclones

The North Coast of New South Wales lies in the central east climatological zone, an unstable broad belt between the steady trade wind area to the north and the anticyclonic region to the south. :p.In the early months of the year, tropical cyclones may move southwards into this zone where they are usually directed south-eastwards away from the continent.

Extra tropical cyclones originate in the higher latitudes and may swing eastwards across the southern portion of Australia. They are most numerous between February and September and sometimes cause major flooding on the south-east coast.

Tropical cyclones are by far the worst danger to the north coast in the flood producing aspect. Heaviest rains are usually experienced with cyclonic conditions when onshore gales, usually from the east or south-east, persist for a day or two. Over a long period of records, Brisbane's heaviest 24 hour rainfall is 18.3" (464.8mm). In the extremely wet February of 1893, Crohamhurst received 35.71" (907.0mm) in the course of 24 hours. This daily fall has not been exceeded at any rainfall station in Australia.

The number of cyclones which pass along the coast of New South Wales varies greatly from year to year. There are a few years in which only one was recorded as against 10 or more in other years. (The maximum number of cyclones recorded for any one year was sixteen in 1910). The last quarter of the year is relatively free from either of these disturbances.

Antecedent Meteorological Conditions

During the nine months prior to February, 1954, drought conditions prevailed over the north-east quarter of New South Wales and these conditions produced a general depletion of field moisture in the affected area.

On the 7th of February, a well developed rainfall depression which originated east of New Guinea, crossed the east coast near Townsville and moving in a south-westerly direction brought general rain to Queensland.

Light to moderate rain produced by this circulation commenced falling on the north coast of New South Wales on the 8th of February. As the depression continued southward movement, the wind strengthened and heavy rain was falling in this area by noon of the 9th. :p.This heavy rain continued until 5pm on the 11th, with some coastal border stations recording falls in excess of 12" (305mm).

Isolated showers fell on the 12th and mainly fine conditions prevailed from the 13th to the 17th.

The rainfall produced by this disturbance was sufficient to break the existing drought and to cause fairly saturated conditions in the area. :p.An isohyetal map of this storm has been prepared and the storm tracks plotted (diagram 2.1.3 and figures 2.1.4 and 2.1.5).

History of the Cyclone, February, 1954

On Saturday, 13th of February, the Sydney Weather Bureau's synoptic chart showed a well developed tropical cyclone centred approximately 11&degree.S, 180&degree.E, with a central pressure below 990 mbs. and a direction of travel south-west towards the New Hebrides (now Vanuatu). :p.The charts of the 14th, 15th and

16th confirmed this movement, and indicated that unless it recurved within the next day the east coast of Australia would be affective.

On the 17th at 11 a.m., the Brisbane Weather Bureau issued the following storm warning to shipping:

"Tropical cyclone central pressure below 985 mbs. centred 21.3&degree.S, 159.8&degree.E (position fair) moving south-east 10/15 knots, expect hurricane force winds within 50 miles of centre and gale force winds within 200 miles of centre."

This warning was renewed at 10 p.m.

During the 18th, gale force winds from the south-east lashed the Queensland coast and many townships south of Rockhampton suffered structural damage and severe flooding. Storm warnings were again issued on the 18th and further reports indicated that, if anything, the intensity of the cyclone had increased. Winds of hurricane force 50 miles from the centre and gale force winds within 300 miles of the centre were reported. The cyclone was now moving southward, parallel to the Queensland coast at a speed of about 10 knots.

Rain began to fall on the north coast of New South Wales (between Lismore and the Queensland border) at about mid-day on the 19th. This rain was accompanied by winds of gale force which backed easterly and strengthened to hurricane force as the cyclone centre moved south.

By midnight on the 19th, torrential rain was falling over the whole of the north coast and rainfall depths of up to 5 inches (125mm) had fallen at some stations on the windward side of the coastal barriers.

Continuous heavy rain fell over the entire northern coastal strip on the 20th as the cyclone continued to move south and to maintain its intensity.

Late on the 20th, the cyclone veered south west and at about midnight crossed the coast near Tweed Heads. The centre travelled inland for about 40 miles and swung to the south parallel to the coast. Coastal synoptic stations showed that the rain ceased and wind direction changed almost immediately the centre crossed the particular station's latitude.

By noon on the 21st, flood producing rainfall had ceased and weather conditions on the north coast had improved.

The cyclone continued to travel south along the plotted path of fig. 2.1.5, bringing heavy rains to the central and southern coasts of New South Wales.

The 9 a.m. weather maps issued by the Sydney Weather Bureau have been included for the period 18th to the 23rd (see figs. 2.2.1 - 2.2.6).

This cyclone is rated by the Weather Bureau as the most intense cyclone experienced on the east coast of Australia over the last half century. Damage on the north coast alone was estimated at 3 million pounds, while fifteen persons lost their lives as a direct result of the floods.

Rainfall Records

Recording Pluviometers and Synoptic Stations

Pluviometers

Records considered applicable to the area covered in this report were available from a total of six pluviometers. These were located at Brisbane and Springbrook in Queensland, Condong and Grafton on the coast and Glen Innes and Armidale on the tablelands. :p.The particulars of operation of the instruments are covered in more detail in section 2.3.5.

Synoptic Stations

:p.Synoptic reports at 9 a.m. and 3 p.m. daily were available for six official stations in the area. The stations were located at Byron Bay, Smoky Cape, Coff's Harbour, Yamba, Lismore and Tenterfield. :p.For detailed mass curves of rainfall for individual plumiometers and synoptic station, see figures 2.3.7 to 2.3.7.3.

Daily Read Rain Gauges

Official

Records were obtained from 72 official rainfall gauges throughout the area. These gauges are read daily at 9 a.m.

Official stations (usually Post Offices) are seldom situated in rugged country and are not considered adequate for the areal definition of rainfall from cyclonic storms of the type considered in this report.

Unofficial

To define more adequately the areal distribution of rainfall, records from 75 private stations in the area were obtained directly by officers of this Commisssion.

Isohyetal Map

Utilising the data from all sources, an isohyetal may for the storm period has been prepared (fig. 2.3.6). During Saturday, 20th and Sunday, 21st, falls of magnitude greater than the capicity of the standard rain gauge occurred and while some readers reported that their gauge had overflowed, it is suspected that other readers may have omitted to do so. With this in mind, some rainfall values were disregarded when drawing isohyets.

Where observations from official and unofficial gauges conflicted, the official reading was usually adopted unless evidence was available to indicate otherwise.

Temporal and Areal Distribution of Rainfall

From an analysis of the pluviometer traces, synographs (mass curves of rainfall constructed from synoptic stations rainfall readings), and the isohyetal map, the folling deductions may be made:

- The time of commencement and cessation of rainfall at coastal stations was dependant on the passage of the cyclone centre down the coast. The rain ceased almost abruptly as the centre passed each coastal station's latitude.
- The rainfall at the coastal pluviometer stations was limited to one burst of continuous rainfall, and their temporal pattern was remarkably similar, except for a modification in the early stages at Grafton and probably the more southerly stations.
- The tableland pluviometers at Glen Innes and Armidale showed dissimilar traces to those recorded at coastal pluviometers and this fact is attributed to the modifying effect of the mountain barriers on the impinging air mass.
- The rainfall period of the storm ranged from 36 hours at Grafton to 46 hours at Glen Innes.
- The three main factors affecting the rainfall intensity and depth at any place were:
    - elevation;
    - orientation;
    - distance from the sea.
- Greater intensity and depth of rainfall than that recorded at Springbrook probably occurred in elevated areas above 2200 ft (670m) in the Macpherson Ranges.

Results from and Operation of Individual Pluviometer Stations

Springbrook - elevation 2200 ft (670m)

This station is situated in Queensland about 14 miles inland on the eastern side of the Macpherson Range.

The pluviometer, a siphoning type Casella, is operated by the Queensland Department of Local Government for the purposes of hydrologic investigation of the Nerang River Valley. This instrument functioned satisfactorily during the cyclone.

Springbrook recorded a rainfall depth of 4,207 points (1068.6mm), which was the largest registration on the north coast. The average intensity at this station for the total storm duration was greater than 100 points (25mm) per hour. The maximum hourly fall was approxiamtely 250 points (65mm) and falls of 200 points (50mm) per hour occurred during several hourly periods.

Condong - elevation 30 ft (9m)

This station is located at the Condong Sugar Mill about 4 miles north-east of Murwillumbah. The pluviometer was installed by the Weather Bureau and is operated on their behalf by the Manager of the Mill.

The instrument, a 10" Dyne tilting siphoning type failed to register during the early stages of the storm, but it is likely that Condong followed approximately the same storm pattern as Brisbane and Springbrook during the missing period.

The total recorded depth was 1,914 points (486.2mm) and intensities during the latter part of the storm ranged from 80 to 200 points (20mm to 50mm) per hour, except for one hour when the intensity dropped to 10 points (2.5mm) per hour.

Grafton - elevation 27 ft (8m)

This station is situated in the Clarence River Valley about 25 miles from the coast. The 6" Casella siphoning type pluviometer installed at this station is operated by the Department of Main Roads and was reported to have functioned satisfactorily during the cyclone. :p.As previously stated, the rainfall pattern appears to be modified in the early stages, but after the time of commencement of heavy rain the pattern was comparable with that experienced at other stations. The maximum intensity recorded was 100 points (25mm) per hour for two consecutive hours and the average intensity during the second burst was about 40 points (10mm) per hour. The total depth recorded for the storm period of 36 hours was 1055 point (268mm).

Dorrigo - elevation 2360 ft (720m)

The Weather Bureau controls the 8" Bendix Friez weighing bucket-type pluviometer which was installed at this station but unfortunately no record was obtained as no reader was available during the storm period.

Dorrigo registered a total rainfall depth of 3,902 points (991.1mm) in approximately 40 hours. As the total rainfall, duration of rainfall, and the physical features of this station are somewhat similar to those of Springbrook, the mass curves at both stations should be approximately the same.

Glen Innes - elevation 3,520 ft (1073m)

This station is situated on the New England Ranges, at approximately the same latitude as Grafton.

The 8" Esdaile siphoning type pluviometer was installed and is operated by the Soil Conservation Service and it is reported to have functioned satisfactorily during the cyclone.

The intensities recorded at this station during the total storm period of 45 hours were of smaller magnitude than those recorded at coastal stations. The maximum was 30 points (7.6mm) per hour while the average was only 6 points (1.5mm) per hour. The total depth registered was 281 points (71.4mm).

Armidale - elevation 3,250 ft (990m)

This station is located on the New England Ranges, about 60 miles south of Glen Innes and has similar topographical features. :p.The pluviometer was installed and is operated by the C.S.I.R.O.

Pastoral Laboratory and functioned satisfactorily during the storm period.

The maximum intensity was 20 points (5mm) per hour and the average about 4 points (1mm) per hour.

Brisbane

The Brisbane pluviometer, although not closely related to the area under study, does help to confirm the uniformity of the temporal distribution of rainfall as the cyclone moved south. This fact is best illustrated when the mass curve of rainfall is plotted on a percentage basis and compared with similar plots of the mass curves from Springbrook and Condong (see fig. 2.3.7.1).

Results from Synoptic Stations

The results from the official synoptic stations were plotted as mass curves of rainfall but due to lack of readings, these curves are not very well defined and do not permit an analysis to be made of them (see figs. 2.3.7.2, 2.3.7.3).

Intermediate readings from Tuntable Falls, an official rainfall station, were plotted and when compared with Condong and Springbrook mass curves, indicated that the corresponding intensities at this station were roughly proportional to those at the two latter stations.

Complete observer's reports from the synoptic stations have not been included in this report; full information may be obtained directly from the Sydney Weather Bureau.

Dew Point Data

Comprehensive dew point data could be obtained from only seven Weather Bureau stations, six of which are practically at sea level and situated on the coastal strip. These stations are Brisbane, Cape Byron, Lismore, Clarence Heads (Yamba), Coff's Harbour and Smoky Cape. The seventh station is Armidale on the New England Range, and for the purpose of comparison, the dew points at this station have been reduced to sea level.

This information is presented as a series of curves, all of which roughly indicate the same temporal pattern during the period of heavy rain (see fig. 2.4.1). By inspection of the figure, it is seen that the dew point increases to a maximum on the 20th and 21st, as the case may be, immediately prior to the arrival of the cyclone's centre at that particular station. The sudden decrease in dew point following this peak is associated with a sharp veering of the wind from a south-easterly to a north-westerly direction, resulting in a rapid decrease of the absolute humidity.

Although the actual dew points at most stations were high during the period of heavy rain, the dew points persisting for 24 hours were, on the average, 5&degree. to 6&degree. below Wapole's maximum. This fact indicates that greater depths of precipitation would be obtained if this storm is considered for maximisation. For example, the maximum persisting dew point for 24 hours at Clarence Heads on the 20th was 69&degree.F (20.5&degree.C) and is equivalent to 2.16" (54.86mm) of precipitable water in a column of air extending from sea level to 40,000 ft. (200 mb. level). The maximum dew point from Wapole's paper capable of persisting for 24 hours at this station is 75&degree.F (24&degree.C) and in terms of precipitable water is equal to 2.9" (73.66mm), an increase of 34%. Similar increases are approximately true for most stations in the area.

All dew point data, including additional information from Casino, Grafton, Nymboida Power Station and Brooklana, are tabulated in the appendix.

Maximum Depth-Area-Duration Curves, 19th-20th February, 1954

Depth-area-duration curves were prepared for the subject storm in order to examine the maximum average depths of precipitation occurring over areas of various magnitudes. The method used was similar to that outlined in Technical Paper No. 1, Co-operative Studies Manual for Depth Area Duration Analysis of Storm Precipitation prepared for the U.S. Bureau of Reclamation.

U.S. Procedure

The U.S. method has the following steps:

- selection of storm period and preparation of preliminary isohyetal map;
- grouping of rainfall stations according to geographical proximity, topography, similarity of storm precipitation and autographic records available;
- preparation of a mass curve for every station, according to its grouping and using interpolation between autographic records;
- more detailed analysis of data and preparation of a final total storm isohyetal map;
- division of isohyetal pattern into zones conforming as closely as practicable to the principal rainfall "centres"; these zones are more convenient for planimetering and enable intensity variations in different areas to be more easily investigated;
- tabulation of comtemporaneous rainfall amounts at each station as scaled from the mass curves for periods increasing by equal increments of time;
- calculation of areas enclosed by the isohyets in each zone and the average depth of rainfall over these areas.

  When a single isohyet is situated in more than one zone, the area adopted for each zone is that enclosed by the isohyet and the zone boundary. This area and the calulated mean depth of rainfall are often later combined with those for the same isohyet in other zones to give the total area and the total mean depth for that isohyet. :p.It is permissable to combine zones such that a mean rainfall depth is found for only a portion of the total enclosed by an isohyet. This value may be useful in establishing the shape of the maximum depth-area-duration curves over certain ranges of areas but it should be borne in mind that the maximum depths obtained for areas enclosed by incomplete isohyets will tend to be too low.

- Computation of an average mass curve for each of the areas found in (7) by calculating the arithmetic mean of all the station rainfalls within the area for the selected periods of time.

    If only a few stations are within the area and the distribution of these is uneven, it is necessary to assign a weight to each station by the Thiessen polygon method and find the weighted mean rainfall.

- Computation of maximum depth-area-duration data and the plotting of curves.

The objectives of this lengthy procedure are not only to produce depth-area-duration relationships but to also assemble the storm data in such a way that it may be conveniently analysed and compared with data from other storms for such purposes as the study of rainfall-runoff relationships on individual catchments, design storms and station rainfall intensity.

All tubulations and computations are therefore made on standard forms.

Adopted Procedure

The actual method used consisted of the following steps:

- Obtaining of a total storm isohyetal map.
- Division of isohyetal pattern into four zones, A, B, C and D as shown (diagram 2.3.6), conforming closely to the principal rainfall "centres".
- Calculation of areas enclosed by the isohyets in each zone and the average depth of rainfall over these areas (table 2.5.1). :li.Adoption of an estimated average % mass curve for the areas enclosed by each of the following groups of isohyets:
    - Zone A - 21" (533.4mm) and over.
    - Zone A - under 21" (533.4mm).
    - Zone B - 18", 21", 24" (457.2mm, 533.4mm, 609.6mm) isohyets around centre B1.
    - Zone B - 12", 15" (304.8mm, 381mm) isohyets of B1 and 18" (457.2mm) isohyets of B2.
    - Zone B - 18" (457.2mm) isohyet of B3 (Lismore mass curve).
    - Zone C - All isohyets.
    - Zone D - 18" (457.2mm) isohyet.
    - Zone D - (Springbrook Mass Curve) isohyets above 18" (457.2mm).

    Each of these % mass curves was estimated by direct comparison and interpolation between the mass curves of the nearest effective pluviograph and synoptic records (see fig. 2.5.3).

- Tabulation of contemporaneous rainfall amounts for each selected area using calculated average depths and temporal patterns of adopted % mass curves (table 2.5.2).
- Computation of maximum depth-area-duration data and the plotting of curves (diagram 2.5.4).

Utility of Results

Since the pattern of this particular storm was largely affected by orographic features, it would be incorrect to use the derived depth-area-duration curves for direct transpositions to individual basins or other areas except for preliminary estimates in which case due allowance should be made for topographic influences. :p.The curves should be useful in comparing this storm with other severe storms of the same type and thus assist in the preparation of estimates of maximum possible prepicitation.

Zones of Rainfall

The location of the Zones of rainfall used for the maximum depth-area-duration study have not been shown on the isohyetal map Reference 2.3.6. However, details of the Zones are available from records held in the Commission's Hydrographic Section.

Hydrographic features

Flood Behavior of Streams on North Coast Catchments, February, 1954

General

Between the 5th and 9th of February, 1954, a cyclone moved S-S-W across the Queensland coast at Maryborough and, weakening as it moved roughly south, it was finally dissipated in north-western New South Wales. It caused substantial rises in all north coast streams and saturated the catchments.

On the 13th of February, another cyclone had developed east of the New Hebrides and was moving towards the Queensland coast. At 3 p.m. on the 19th, the centre was located approximately 250 miles N.E. of Brisbane and heavy rain had commenced on the north coast. :p.Record flood producing rains occurred on the north coast between approx. 9 a.m. on the 19th and 9 a.m. on the 21st.

The hydrographs of the smaller streams showed two peaks at approx. 3 p.m. - 6 p.m. and midnight - 3 p.m. on the 20th and 21st.

In the Tweed and Richmond catchments, the first peak was the larger whilst in the central Clarence catchment both peaks were approx. equal intensity. In the south, or Dorrigo area, the second peak at midnight was the greater.

At the larger gauging stations the two peaks merged to give record discharges. A slight bump will be noticed on one or the other side of the peak in hydrographs at these stations.

Peak discharges at gauging stations have been analysed on a catchment area basis. The maximum observed value occurred in the Dorrigo area at Slingsbys Road on the Never Never Creek (Catchment Area 4.6 sq. miles) where the estimated peak discharge gives a value of approx. 1500 cusecs/sq. mile.

Maximum envelope curves of cusecs/sq. mile and acre ft./sq. mile for this flood on the north coast, together with similar curves for all streams in New South Wales are included in section 3.7 of this section.

As can be expected from the short duration and mignitude of the rainfall and the wet state of the catchments, the rates of rise and fall at the majority of stations were more rapid than had previously been experienced. An example of this behavior is illustrated in the case of Casino where the river rose from a gauge height of 6 feet to the peak of 53 feet in 20 hours, or an average rate of rise of 2.35 feet per hour.

In previous floods when the river reached between 30 and 40 feet, the time of rise between 6 ft. and the peak was 40 hours or greater, corresponding to a rate of rise of less than 0.90 ft./hour. :p.Similarly, the river fell at approx. 4 ft. per hour at 30 ft. gauge height as against a previous known maximum rate of fall of 1 ft. per hour at this gauge height.

All important towns on the North Coast were affected by the flood. More costly damage than ever before experienced occurred at Murwillumbah, Lismore, Wiangaree and Kyogle. Casino was seriously flooded for the first time in 60 years and a near record flood passed through Grafton, causing considerable inundation and loss of property. :p.A brief description of the catchments of the Tweed, Richmond and Clarence Rivers is given in sections 3.2, 3.3 and 3.4, together with details of flooding at important towns. A general topographical map is shown on diagram 3.1.1.

Tweed River Catchment

Description of Catchment

The Tweed River Basin, which is 420 square miles in area, is located in the extreme north-east corner of the State. It is bounded in the north by the Macpherson Range, which rises in places to 3,700 ft. (1128m), and in the west by an eastward tending spur of this range which continues to within a few miles from the sea coast near Norie's Head and forms the southern boundary of this region.

The rugged mountainous country forming the catchment boundary gives way to hilly to steep country as the land falls towards the stream beds of the numerous small valleys. At Murwillumbah, the basin becomes a broad open valley, comprised of alluvial flats. Flats extend upstream from this point for short distances along the three arms of the Tweed as narrow flood plains.

Natural vegetation, consisting of rugged mixed forest and scrub covers the major portion of the basin. Open country is confined mainly to the alluvial flats of the broad valley below Murwillumbah and to the useless swamp and heath of the narrow coastal fringe. :p.The uplands of the entire region, including the highest part of the Macpherson Range and its satellite spurs south of the Tweed, are capped by basaltic lavas. The basalt covered spur in the south extends as a band into the central portion of the catchment as far as Mt. Warning. Shales, calcareous sandstones and basal conglomerates constitute the rock formation of the upper reaches of the north, middle and south arms of the Tweed River. To the east of Eungella, phyllites, schistose slates, quartzites and sandstones predominate the area. The remaining narrow coastal strip, extending from Coolangatta to Norie's Head is comprised of alluvial, estuarine deposits, beach and dune sands, and rock waste.

The mean annual rainfall for the catchment is 68 ins. (1727mm) and it is more uniformly distributed throughout the year than it is on the neighbouring Clarence basin.

The basin is roughly U-shaped, being open to the sea in the east and moist maritime air can penetrate into the valley without undergoing much lift, loss of moisture, or change in properties. However, in the upper tributaries where the topography is of a mountainous nature, a rapid uplift would be imparted to an incident stream of air.

Description of Stream System

The Tweed River is made up of three arms, the North Arm, Middle Arm and South Arm.

The North Arm

Rises in the Macpherson Ranges, at the Queensland border and flows generally east-south-east to the north of Murwillumbah then turns east to join the Tweed River at North Tumbulgum. A network of creeks join the North Arm above Chillingham. The North Arm then passes through the districts of Chillingham, Crystal Creek, Boat Harbour, Kynnumboon, Dungay and Dulguigan.

The Middle Arm

Commences at Tyalgum, where several creeks which drain the southern and eastern slopes of Macpherson Range, unite. The Middle Arm then flows practically due east through the Eungella district to meet the South Arm at Byangum.

The South Arm

Commences at Loft's Pinnacle on the mountain range which forms the western boundary of the Tweed River Basin. It flows generally in a north-easterly direction and passes through the districts of Kunghur, Terragon, Uki, Dum Dum and Byangum. It is met by the Middle Arm at the village of Byangum, where it becomes the Tweed River. :p.The Tweed River, after leaving Byangum, is met by the Dundible Creek from the south and passes between Murwillumbah and South Murwillumbah. It then flows east through the districts of Condong, Tygalgah and Tumbulgum where it is joined by the North Arm. It continues in this direction to its mouth at Tweed Heads.

Flood Behavior

The highest flood ever recorded at Murwillumbah occurred in February, 1954, when the Tweed River rose rapidly to a peak of 19'-10" (6.045m) at 6 p.m. on the 20th (powerhouse gauge), inundating low lying areas of the township to considerable depths. This flood was 1'-1" (0.330m) higher than the previous record flood in 1931. Floodwaters and gales caused severe damage to the town buildings and residential areas. One person was drowned and loss of stock and property along the lower reaches of the river was considerable.

The South Arm of the river contributed the major portion of floodwaters at Murwillumbah, the flood at Braeside being the greatest of known record in that locality. At Eungella on the Middle Arm and Boat Harbour on the North Arm the flood was two to three feet lower than the previous record peaks of June, 1945.

The rainfall over the catchment was not evenly distributed. Ranges on the south east boundary recorded falls of over 30" (762mm) and west of this barrier a rainfall shadow (with rainfall depths of 15" (381mm) or less) extended from north to south of the catchment. Further west the depth of rainfall increased to approximately 20" (508mm). :p.A maximum registration of rainfall of 42" (1066.8mm) was recorded at Springbrook.

The peak heights and times of peaks at various gauges in the Tweed catchment are given in the appendix. All peaks occurred on the 20th of February, 1954.

A summary of rainfall-runoff figures has been prepared, together with a plot of estimated hydrographs at the three gauging stations in the area (see Schedule 3.2.3.1 and diagram 3.2.4).

Richmond River Catchment (2,660 sq. miles)

Description of Catchment

The coastal basin of the Richmond River is bounded in the north by part of the Macpherson Range and a satellite spur of this range, in the west by the main Richmond Range, and in the south by the south-eastern extremity of the Richmond Range. Although the catchment boundary of the region is clearly defined in the north and west by rugged mountain ranges where elevations exceed 4,000 feet, the southern boundary (the south-eastern extremity of the Richmond Range) is more of the nature of a line of long broken hills which extend from the main Richmond Range to the coast near Evans Head. For the most part, the catchment is an extensive valley of a comparitively flat nature with an average elevation estimated at about 200 feet. The hilly to steep plateau situated to the north of Lismore fringes the rugged spur extending from the main Macpherson Range.

Particularly in the eastern portion of the valley, much of the original vegetation has been removed and in the western section the cover has been reduced to open forest country. In the rugged infertile uplands of the ranges, the vegetation is basically poor forest. Dense forest and scrub covers the plateau north of Lismore. :p.The upland area, including the highest part of the Macpherson Range and its satellite spurs south of the Tweed, is covered by basalt. The hilly to steep plateau fringing this spur on the southern flank is also composed of basalt. The remaining area, except for deposits of beach and dune sands along the coastal strip, is comprised of shales, calcareous sandstones and basal conglomerates.

The mean annual rainfall for the basin varies from 45 ins. (1143mm) in the western section to about 70 ins. (1778mm) in the vacinity of Byron Bay. Maritime air traversing the catchment from east to west is not subjected to any rapid uplift except over the Richmond Range in the north-east. Hence, a more uniform distribution of rainfall is anticipated over the middle and lower sections of the catchment during cyclonic disturbances than would occur over the range and plateau areas.

Description of River Systems

The Richmond River, like the Tweed River, consists of three arms, the North Arm, the Main Arm and the South Arm. Due to the mountainous country in the nothern and western sections of the catchment, the North and Main arms are subject to rapid rises and the fast flowing waters are a great danger to towns and settlers in the lower areas.

The North Arm

:p.A large area of country to the north of Lismore is drained by a network of creeks which flow into either Leycester or Wilsons Creeks. These two creeks unite at Lismore to form the North Arm of the Richmond River which flows almost due south to Coraki where it joins the Main Arm.

The Main Arm

Drains mountainous country to the north and west of Kyogle. It flows south through Kyogle and Casino and then flows E.S.E. to be joined by the North Arm at Coraki. The river then flows roughly south-east, picking up the South Arm about three miles below Coraki, thence on to Woodburn where it turns roughly N.N.E. through Broadwater and Wardell. (The Main Arm is known to many locals as the South Arm, and the South Arm as Bungawalbyn Creek).

The South Arm

Or Bungawalbyn Creek, drains the country around Rappville and joins the main Richmond River about three miles below Coraki.

Flood Behavior

Floodwaters from the Richmond River entered all large towns in the catchment causing considerable damage and some loss of life. Heavy loss of stock and property was experienced by the majority of farmers living along the river flats downstream of Lismore and Wiangaree.

North Arm

The flood warning stations of Bangalow and Nimbin, situated on the headwaters of Byron and Goolmagar Creeks, reported a rise at approximately 9 a.m. on the 20th. At 2 p.m. these stations reported peak levels of 15'-0" (4.572m) and 29'-6" (8.992m) respectively. :P.The river at Lismore reached the critical height of 25'-0"

(7.62m) (police gauge) at 3 p.m. and continued to rise rapidly to a record level of 44'-0" (13.411m) at 4 a.m. on the 21st. The city remained in varying stages of inundation until the morning of the 23rd.

The main tribuaties on the North Arm consist of seven creeks which form a wide fan-shaped catchment above Lismore and gauging stations have been established on each of these streams. Details of run-off and rainfall for all stations are included in schedule 3.3.3.4. Hydrographs at individual stations are shown on Diagram 3.3.3.5. A hydrograph of the flow at Lismore has been estimated, the peak discharge being about 180,000 cusecs (vide diagram 3.3.3.6).

Maximum values of rainfall and run-off/sq. mile were observed on the Terania Creek catchment. Tuntable Falls, a rainfall station in the northern part of this catchment, registered 30.9" (784.9mm) of rainfall for the three day period ending 9 a.m. on the 21st. Records from the gauging station at Blakes (catchment area 17.0 miles) indicated a peak discharge of 1,180 cusecs/sq. mile with an estimated run-off of 1,170 acre ft./sq. mile.

The average precipitation on the Lismore catchment was 17.6" (447mm), a minimum depth of approximately 13" (330mm) occurring on the south-eastern section.

There are no pluviometers in the catchment but synoptic readings at Tuntable Falls and Lismore in conjunction with Springbrook and Condong pluviometer records reasonably define the temporal pattern of rainfall.

This information is included in Section 2.2

Main Arm

The three towns of Wiangaree, Kyogle and Casino suffered severely as a result of this flood. At all towns the river rose rapidly to a peak which surpassed previous known flood levels by many feet.

Because of the fast rate of rise to considerable heights above the river banks, large differences in head were developed between the river and the surrounding terrain. The flow of floodwaters from the river to low lying areas was therefore fast and destructive and constituted the main cause of the loss of life.

At Wiangaree the river reached a peak of 60'-0" (18.288m) at 6 p.m. on the 20th February. No lives were lost but damage to buildings and property was considerable.

At 7 p.m., the flood reached a peak of 62'-0" (18.898m) at Kyogle; many homes were swept away and ten persons lost their lives. :p.At Casino the river broke its banks and inundated low lying sections of the town. The peak gauge height of 53'-1" (16.18m) occurred at 4 p.m. on the 21st. Seven houses were destroyed and two lives were lost. :p.Serious river bank erosion occurred along the whole length of the Richmond River. As a result of this erosion, one span of the road bridge at Casino collapsed.

Large depths of rainfall were registered on the ranges west of Doubtful Creek and on the ranges in the north east portion of the catchment. At Babyl Gate on the Richmond Ranges, a depth of rainfall of 24" (609.6mm) was observed. This quantity represents the maximum registration on the Main Arm catchment. No information could be obtained regarding the rainfall in the large area of country north of Wiangaree. :p.High values of peak discharge were obtained for all gauging stations in the catchment. Schedule 3.3.3.4 gives a comprehensive table of rainfall run-off data in the Richmond River catchment. The coefficient of run-off at Alcorns and Wiangaree is high and it is thought that heavier falls of rain than are indicated on the isohyetal map may have occurred in the mountainous country north west of Wiangaree. Hydrographs at gauging stations on this arm are shown on diagram 3.3.3.7.

South Arm

No gauging station has been established on this arm of the Richmond River and information has not been obtained with respect to the flooding in this system.

Clarence River Catchment

Description of the Catchment (8,320 sq. miles)

For the purpose of illustrating the main physical features of the basin, the area has been divided into four sections, each of which will be described separately, viz:

- Northern
- Western
- Southern
- Central

Northern Catchment Area

Is bounded to the north by the southern slopes of the Great Dividing Range and to the east by the western slopes of the Richmond Range. The slopes consist of rugged mountainous country rising to over 4,000 feet (1219m) in the extreme north west. The central portion of the valley is of a hilly to steep nature with a relatively small flood plain at Tabulam. Approximately one-third of the area has been cleared, whilst the remaining country retains a natural cover of scrub and dense timber.

Elevated ranges and spurs in the catchment are capped by basaltic rocks, which overlay sedimentary rocks, principally shales, calcareous sandstones and basal conglomerates. To the west of Tabulam, the sedimentary rock type changes to claystones, mudstones, shales and sandstones, with numerous igneous instrusions of granite, pegmatite and aplite.

The average annual rainfall over the area is approximately 40 inches (1016mm), two-thirds of which falls during the summer months. On the eastern side of the catchment, the Richmond Range, at an average elevation of approx. 2,500 feet (762m), presents a natural barrier against maritime air masses. Considering that a larger proportion of moisture is precipitated on the coastal strip to the east and that further precipitation occurs due to mechanical uplift over the ranges, it is apparent that the amount of moisture entering the area will be considerably reduced.

Western Catchment Area

Embraces the catchments of the Rocky, Mitchell and Boyd Rivers which drain the area west of the Gorge. This area is bounded on the west by the Great Dividing Range and consists mainly of rugged mountainous country which rises in places to elevations of over 4,000 feet (1219m). The average river slope is estimated to be greater than 20 ft./mile and gives rise to rapid run-off.

Except for cleared areas in the upper reaches of the Mitchell River, the remainder of the catchment area is covered by dense timber. :p.The entire western catchment area is wholly comprised of igneous rock types, except for a relatively small deposit of sedimentary rock in the extreme eastern section.

The average annual rainfall in 35 ins. (889mm) and is predominantly summer rainfall. During cyclones, maritime air penetrating this section of the basin is forced to deposit a proportion of its moisture charge over the coastal plain and thus arrives at the catchment area relatively drier than it was at the seaboard.

Southern Catchment Area

Embraces the catchment of the Nymboida River above its junction with the Mitchell River and includes all the headwater tributaries, namely the Blicks, Little Murray, Little Nymboida and Bobo Rivers. The greater part of the area is heavily timbered with some cleared land in the upper reaches of the abovementioned tributaries. :p.Geologically, the southern catchment area is a heterogeneous area which consists mainly of phyllites, schistose slates, quartzites, sandstones ans some igneous intrusions of granite, pegmatite and aplite. The Dorrigo Plateau consists of volcanic rocks, principally basaltic lavas.

The average annual rainfall veries from 40 ins. (1016mm) in the lower country around Nymboida to 70 ins. (1778mm) in the uplands around Dorrigo.

The Dorrigo Plateau, located at the southern end of the catchment, is at a general elevation of 2,000 - 2,500 feet (610-762m), rising in the west to a maximum height in the headwaters of the Blicks River of neraly 5,000 feet (1524m). The southern boundary of the area forms an escarpment at a general elevation of 2,400 feet (732m) from which a very rapid drop of over 2,000 feet (610m) occurs in 2-3 miles to the Bellingen River. From a study of cyclones on the north coast, it has been established that the impinging air mass undergoes a rapid uplift over the Dorrigo Plateau and deposits the majority of its moisture charge in that area.

Central Catchment Area

Embraces the eastern portion of the catchment and extends from "The Gorge" located 30 miles upstream of Copmanhurst to the coast. The area is bounded to the north by the Richmond Range and to the south by a line drawn through "The Gorge" to follow the western boundary of the Orara River catchment.

This section of the basin consists almost entirely of undulating country, except in the upper reaches of the Orara River and those sections north of the Gorge where rugged mountainous country rises in places to over 1,500 feet (457m).

Because of the favourable topographic features, large portions of the catchment, (approx 50% of the area), mostly along the Clarence River, have been cleared of natural vegetation. The natural vegetal cover of the uncleared areas consists mainly of small stands of commercial timber and scrub.

Sedimentary rocks such as shales, calcareous sandstones and basal conglomerates constitute the major geological formation of the area. In the western portion, the formation is mostly matamorphic consisting of phyllites, schistose, slates and quartzites with some igneous intrusions of granite, pegmatite, aplite and serpentine. :p.The average annual rainfall over the area varies from 40 ins.

(1016mm) around Grafton to 65 ins. (1651mm) in the headwaters of the Orara River.

During cyclones, orographic uplift is limited to the upper reaches of the Orara River; the remaining area receives comparitively uniformly distributed rainfall.

Description of Stream System

The Clarence River system commences on the eastern side of the Great Dividing Range at the Queensland Border. The Tooloom, Koreelah Creeks and Maryland, Boonoo Boonoo and Cataract Rivers drain the area from Woodenbong to Tenterfield, and meet west of Paddy's Flat to form the Clarence River. The river is then joined by the Tooloom River or Duck Creek from the north and the Rocky or Timbarra River from the south. The town of Tabulam is on the main river near the Rocky River junction. The Clarence River follows a general S.S.E. direction from Tabulam to Grafton and between these points is joined by the Mitchell or Mann and the Orara Rivers from the south. The Mitchell River at its junction with the Clarence, carries the waters of the Henry, Sara, Boyd or Little, Guy Fawkes, Blicks, Bielsdown and Nymboida Rivers and drains a large area south-west of Grafton, extending from near Glen Innes, south to Guyra and east to Dorrigo. The towns of Dalmorton, Dorrigo and Nymboida are in this area. The Orara River commences to the west of Coff's Harbour and flows generally in a northerly direction to meet the Clarence River between Grafton and Copmanhurst. :p.The Clarence River flows between Grafton and South Grafton and immediately turns in a general north-easterly direction through Ulmarra and Lawrence, where it turns E.N.E. through Maclean and Harwood Island, to enter the sea between Iluka and Yamba.

The principal towns affected by flooding are Glenreagh, Grafton, South Grafton, Ulmarra, Lawrence and Maclean. These towns are situated on the lower reaches of the Clarence and Orara Rivers.

Flood Behavior

Heavy rainfall was recorded over the most of the Clarence River catchment during the three days ending 9 a.m. 21st February. This rainfall produced record stream levels in the Dorrigo area and major rises in other streams of the catchment.

The peak discharge approached record values at Newbold Crossing and Copmanhurst.

At Grafton the flood reached 24'-6.5" (7.48m) on the Prince Street gauge, compared with a record flood of March, 1890, which reached 25'-11" (7.9m).

The towns of Grafton, South Grafton, Ulmarra and Maclean were seriously affected by the flood. However, residents of these towns heeded flood warnings and very few lives were endangered. :p.The maximum registration of rainfall in the catchment was observed at Dorrigo, where 39.32" (998.7mm) depth of rainfall was reported for the three days ending 21st February. Six other stations in the area registered depths of greater than 20" (508mm) for this period. The maximum intensity of run-off was contributed by the upper portions of the Nymboida and Orara Catchments in the south and seemingly by the eastern section of the Tabulam catchment in the north. :p.Values of peak discharges greater than 1,000 cusecs/sq. mile were estimated at six of the smaller catchments in the Dorrigo area. The greatest value (1,480 cusecs/sq. mile) occurred at Slingsby's Road, a station adjacent to the Nymboida catchment.

A general definition of the temporal pattern of rainfall for the Clarence catchment is given by pluviometer records from Condong, Grafton and Glen Innes, together with synoptic readings taken at Clarence Heads, Coff's Harbour, Smoky Cape, Tabulam and Tenterfield. This information has been included in Section 2.2.

A schedule of rainfall and run-off has been prepared which gives the discharges for measured and unmeasured catchments on the system (Schedule 3.4.1.1).

Hydrographs of flow at gauging stations are shown on diagram 3.4.1.2 to 3.4.1.10. The appropriate diagram number for any particular station is given on Schedule 3.4.1.1.

Hydrograph Analysis

Accuracy of Gauge Height Records

At about 50% of gauging stations in the area, flood gauge height profiles were poorly defined. However, valuable records of continuous river stages were obtained from the seventeen recorder stations then in existence.

A brief summary of the results obtained from the various types of stations is given below in order of efficiency of operation:

Float Recorders

(Leupold & Stevens Equipment). (Seven installations). Excellent records were obtained from four of these stations. Unfortunately, the recorder at Bobo Nursery was washed away while at the other two stations the float wire became detached from the instrument and subsequent records were not obtained.

Pressure Type Recorders

(Bristol Equipment). (Ten installations). Good profile records appear to have been obtained from six recorder charts and useful information, particularly in regard to the rising leg and shape of profile, was obtained from the remainder. Satisfactory operation of this instrument depends, among other things, upon the stability of the lower length of the gauge to which the bulb is attached. It is often the case in even minor floods that this lower length is washed away and records lost.

Daily Read Staff Gauges

(31 installations). The records from the majority of these stations, particularly those on catchments less than 6,000 square miles, were unsatisfactory due to insufficient gauge readings.

The primary causes of this lack of readings may be attributed to:

- time of peak occurred late at night or in the early hours of the morning;
- gauge readers lost interest during falling stages;
- gauge lengths were destroyed after submergence and most gauge readers did not peg water levels when subsequent readings were due.

Flood Warning Stations

Gauge height profile information was obtained from many of these stations but, in general, readings were not made after the peak. This was no doubt due to the impression held by flood warning observers that further information after the peak height has been reached is of no value.

Gauge Height - Discharge Rating Curves

It was found necessary to examine and extend all discharge rating curves for gauging stations in the area. At the older stations, extensions had been carried out to within a few feet of the February, 1954 peak and unless reliable evidence was available that the rating curves were in error, no alterations were made. However, the majority of stations in existence on the north coast are relatively new and in most cases curve extensions far above the highest gaugings were required.

In general, the extensions adopted were the result of combination of various estimates. These estimates include slope-area methods where satisfactory slopes were available, estimates of mean velocity at the peak based on experience of officers with a personal knowledge of the station, or log-log extension.

Where river sections were regular and the flow was confined, the high water curves were constructed by extending the known part of the curve to the estimated peak discharge logarithmically, and if otherwise, area velocity extensions to the peak mean velocity were adopted.

Complication of Hydrographs

Hydrographs for those stations where inadequate data was available were estimated by utilisation of the following procedures:

- comparisons with recording gauging stations in the vicinity;

- peak flood heights determined by hydrographers subsequent to the flood;
- readings from flood warning stations and local newspaper reports;
- analyses of temporal distribution of rainfall.

Loss Rate (0)

Horton's Method was employed in an attempt to derive accurate rates of loss for the various North Coast catchments. Families of "total rainfall" against "excess rainfall" curves were computed (using records from the several pluviometers in the area) in conjunction with the "excess rainfall" against "loss rate" curves for the individual gauging stations. However in view of the facts that:

- only two pluviometers were located on the area under study and their areal coverage was not considered sufficient to apply to all catchments;
- the gauge height profiles at the majority of stations were not clearly defined;
- the majority of discharge curves required considerable extension, :eol. the method was abandoned as it was considered that the amount of detailed calculation which would be required for the accurate determination of loss rates was not warranted.

However, first approximations of the loss rates have been calculated for all catchments under study from the relationship:

```
0  =  (P - Q) / t
where:

P = the average depth of rainfall over the catchment in inches;
Q = the average depth of run-off over the catchment in inches;
t = the time during which rainfall was infiltrating at capacity
rate (adopted at 40 hours as an average estimate of time for the entire area);
0 = rate of loss in inches/hour.
```

Although several cases arise where an extremely high or low value of the loss rate is indicated, the results obtained for the first approximations of 0 are fairly consistent. The presence of inconsistent values was thought to be due to the incorrect definition of rainfall or run-off or both. The calculated values of the loss rate are for comparitive purposes only and are by no means final. :p.In comparing the loss rate concept with the older idea of the run-off coefficient, the former indices give not only a more definite value of the rate of loss but results can be applied to other storm studies. :p.For calculated values of loss rate refer to run-off schedules.

Comparison With Previous Floods

General

In February, 1954, record river levels occurred at most gauging stations on the New South Wales coast north of Dorrigo. However, comparison of this flood with previous floods at the older established gauging stations indicates that many of the recently established stations probably reached higher levels in previous years. The smaller streams in the Clarence River catchment (excluding the Dorrigo area) probably attained higher levels in one or other of the floods of 1890, 1921, 1946 or 1948.

An important feature of the flood was the rapid rate of rise at all stations. Little warning was given to Murwillumbah, Lismore, Kyogle or Casino before floodwaters entered these towns. It was inconceivable to older residents that the rivers with which they were familiar could rise from low stages to dangerous levels in less than half the time taken by previous floods.

Schedule 3.6.3 sets out a general gauge height comparison of the flood with previous floods.

Illustrative Examples

For the purpose of illustrating the main features of the flood, two stations have been selected. The tables below set out the details at Newbold Crossing and Casino of the larger floods for which full information is available.

Clarence River at Newbold Crossing

Date	Peak Height	Average rise rate (ft/hr)	Maximum rise rate (ft/hr)	Peak Discharge (cusecs)	Run-off (acre feet)	Remarks
June, 1945	59'-0"	1.7	3.0	418,000	1,610,000	Rates of rise
March,1946	67'-0"	2.7	2.9	544,000	1,720,000	considered
June, 1948	60'-10"	1.5	2.0	451,000	1,830,000	between 20'
June, 1950	65'-5"	1.7	2.2	516,000	2,800,000	and peak.
Feb. 1954	68'-1"	2.9	4.1	565,000	1,420,000	

Richmond River at Casino

Date	Peak Height	Average rise rate (ft/hr)	Maximum rise rate (ft/hr)	Peak Discharge (cusecs)	Run-off (acre feet)	Remarks
June, 1945	39'-9"	0.75	2.0	64,000	270,000	
March,1946	26'-6"	Minor	Flood	only		
June, 1948	37'-5"	0.75	1.0	58,000	280,000	
June, 1950	37'-2"	0.75	1.0	57,000	360,000	
Feb. 1954	53'-1"	2.35	4.0	150,000	325,000	

Envelope Curves of Maximum Discharge

Analysis of Flood Flows on a Catchment Area Basis

Peak discharges per sq. mile and total flood run-off per sq. mile of catchment area which occurred at stations on the north coast in February, 1954, have been plotted against catchment area for the purpose of drawing envelope curves for this flood. However, the envelope curves are not defined for catchments less than 50 square miles as few areas of this order are sampled.

A key to the stations numbers and actual values of the plotted points is given in 3.7.2 and a plot of susecs/sq. mile against catchment area (daigram 3.7.3) together with a plot of acre feet run-off/sq. mile against area (diagram 3.7.4).

The three most outstanding values obtained for this flood, each approx. 10% below values given by Myer's Maximum, occurred at Richmond River at Alcorns (catchment area 220 sq. miles), Richmond River at Wiangaree (catchment area 272 sq. miles) and Richmond River at Lismore (catchment 550 sq. miles).

Similar plots are given of maximum estimated discharge /sq. mile at gauging stations of New South Wales together with schedules of maximum observed values and dates of occurrence. Schedule 3.7.5, Diagram 3.7.6 applies to coastal stations and Schedule 3.7.7 and Diagram 3.7.8 apply to all New South Wales catchments.

Appendix

Dew Points Observed at Synoptic Stations, February, 1954

Armidale (3264')

Date		18th	19th	20th	21st	22nd	23rd	24th
Dew	9a.m.	58	58	57	64	62	59	62
Point (F)	3p.m.	55	58	62	65	63	49	52

Coffs Harbour (16')

Date		18th	19th	20th	21st	22nd	23rd	24th
Dew	9a.m.	73	63	71	72	71	71	70
Point (F)	3p.m.	75	65	69	72	68	70	74

Brooklana (1634')

Date		15th	16th	17th	18th	19th	20th	21st
Dew	9a.m.	68	72	70	70	60	66	-
Point	3p.m.							
(F)								

Casino (84')

Date		18th	19th	20th	21st	22nd	23rd
Dew	9a.m.	74	64	70	-	68	71
Point	3p.m.						
(F)							

Grafton (27')

Date		18th	19th	20th	21st	22nd	23rd
Dew	9a.m.	76	63	69	68	69	72
Point	3p.m.						
(F)							

Bellingen (100')

Date		18th	19th	20th	21st	22nd	23rd
Dew	9a.m.	60	64	71	72	71	73
Point	3p.m.						
(F)							

Brisbane (31')

Date		18th	19th	20th	21st	22nd	23rd
Dew	9a.m.	72	73	70	65	71	73
Point	3p.m.	70	71	72	67	74	72
&degree.F	9p.m.	70	70	66	73	73	75

Cape Byron (20')

Date		18th	19th	20th	21st	22nd	23rd
	3a.m.	73	73	72	72	69	74
Dew	6a.m.	73	73	71	68	71	75
	9a.m.	75	70	73	66	74	76
Point	12noon	75	69	73	67	77	77
	3p.m.	73	73	75	66	75	76
&degree.F	6p.m.	73	73	74	70	76	76
	9p.m.	72	73	75	70	75	75

Smoky Cape (470')

Date		18th	19th	20th	21st	22nd	23rd
	3a.m.	70	72	70	69	61	69
Dew	6a.m.	70	71	63	70	73	70
	9a.m.	71	73	64	73	73	70
Point	12noon	71	72	64	71	71	73
	3p.m.	73	74	65	68	70	74
&degre e.F	6p.m.	71	73	64	68	71	74
	9p.m.	71	72	64	61	72	74

Nymboida Power Station (378')

Date		16th	17th	18th	19th	20th	21st	22nd
Dew	9a.m.	74	75	74	66	68	69	72
Point (F)	3p.m.							

Lismore (37')

Date		18th	19th	20th	21st	22nd	23rd
	3a.m.	73	73	69	68		72
Dew	6a.m.	73	73				
	9a.m.	74	68	72			74
Point	12noon	76	68	72			
	3p.m.	74	68	73			67
&degre e.F	6p.m.	72	69	74		83	82
	9p.m.	73	73				

Clarence Heads (135')

Date		18th	19th	20th	21st	22nd	23rd
Dew	6a.m.	74	72	71	72	68	73
	9a.m.	75	68	71	65	70	74
Point	noon	76	71	72		70	75
	3p.m.	76	68	69	68	73	75
&degre e.F	6p.m.	76	67	72	66	74	77

Flood Gauge Readings from Flood Warning, and Department of Public Works Stations

Tweed River Catchment

Observed Maximum Heights and Times of Peaks

	STATION	TIME	PEAK HEIGHT
North Arm	Chillingham	1.30 p.m.	No gauge - observed
	Boat Harbour	5.00 p.m.	20'-6" - observed

	Kynumboon	Midnight	13'-10" - levelled
Middle Arm	Tyalgum *	3.00 p.m.	26'-0" - levelled
	Eungella	3.15 p.m.	31'-2.5" - levelled
South Arm	Kunghur	1.00 p.m.	No gauge - observed
	Byrill Ck. Junction	2.00 p.m.	No gauge - observed
	Doon Doon Ck. Junction	2.00 p.m.	No gauge - observed
	Uki *	3.00 p.m.	35'-0" - observed
	Braeside	6.00 p.m.	28'-11" - levelled
	Bakers Farm	6.30 p.m.	27'-10" - levelled
	Murwillumbah	6.00 p.m.	19'-10" - observed

* Flood Warning Stations

Flood Readings - North Arm at Kynumboon

Department of Public Works Gauge, one mile from Murwillumbah Post Office. Zero of Gauge 1.84 L.W.O.S.T. Tweed Heads.

DATE	TIME	HEIGHT
20th	5.30 a.m.	5'-9"
	6.30 a.m.	6'-3"
	7.30 a.m.	7'-4"
	9.30 a.m.	7'-10"
	10.30 a.m.	8'-6"
	11.30 a.m.	9'-3"
	12.30 p.m.	9'-11"
	1.30 p.m.	10'-6"
	2.30 p.m.	11'-3"
	3.30 p.m.	11'-6"
	4.30 p.m.	11'-11"
	5.30 p.m.	12'-5"
	6.30 p.m.	13'-0"
21st	6.00 a.m.	13'-7" (peak)
	7.00 a.m.	13'-6"
	8.00 a.m.	13'-3"
	9.00 a.m.	13'-1"
	10.00 a.m.	13'-1"
	11.00 a.m.	12'-11"
	Noon	12'-10"
	1.00 p.m.	12'-7"
	2.00 p.m.	12'-5"
	3.00 p.m.	12'-1"
	6.00 p.m.	11'-0"
22nd	6.00 a.m.	10'-0"
	9.00 a.m.	9'-10"
	Noon	9'-4"
	3.00 p.m.	8'-11"
	6.00 p.m.	7'-5"

23rd	6.00 a.m.	7'-0"
	10.00 a.m.	6'-4"
	2.00 p.m.	5'-10"
	6.00 p.m.	5'-4"
24th	Below gauge.	

Range of Gauge = 5' to 18'-6". F.L. = 13'10" by debris and step at reader's house at midnight on 19/20th February, 1954.

Flood Readings - South Arm at Uki Post Office

Zero of gauge 66.00 assumed datum

DATE	TIME	HEIGHT
20th	6.00 a.m.	18'-0"
	8.30 a.m.	18'-0"
	9.00 a.m.	19'-0"
	11.15 a.m.	25'-0"
	11.30 a.m.	26'-0"
	11.50 a.m.	27'-0"
	Noon	28'-0"
	12.15 p.m.	29'-0"
	12.45 p.m.	30'-0"
	1.15 p.m.	32'-0"
	1.30 p.m.	33'-0"
	1.45 p.m.	34'-0"
	2.35 p.m.	35'-0" (Peak)
	3.30 p.m.	falling

Richmond River Catchment

Byron Creek at Bangalow

Zero of gauge 78.60 assumed datum

DATE	TIME	HEIGHT
20th	8.20 a.m.	4'-0"
	11.15 a.m.	7'-0"
	12.50 p.m.	12'-0" (25'-0" at Nashua)
	1.30 p.m.	15'-0" (1st peak started to fall at 2 p.m.)
	2.15 p.m.	14'-6"
	3.45 p.m.	13'-0"
	5.18 p.m.	7'-0"
	9.00 p.m.	8'-0"
	11.30 p.m.	8'-0"
21st	1.00 a.m.	11'-0" (2nd peak)
	2.00 a.m.	11'-0"

Goolmagar Creek at Nimbin

Zero of gauge 77.24 assumed datum

DATE	TIME	HEIGHT

20th	7.00 a.m.	16'-0"
	9.10 a.m.	16'-10"
	11.20 a.m.	Still rising
	11.55 a.m.	19'-6"
	12.45 p.m.	22'-9"
	2.20 p.m.	29'-6" (Peak)
	2.45 p.m.	25'-0"
	4.30 p.m.	23'-6"

Richmond River at Lismore

Zero of gauge 0.16 L.W. Ballina

DATE	TIME	HEIGHT
20th	2.00 p.m.	22'-4"
	3.00 p.m.	24'-6"
	4.00 p.m.	27'-0"
	5.00 p.m.	29'-0"
	6.00 p.m.	30'-6"
	7.00 p.m.	32'-9"
	8.00 p.m.	35'-6"
	9.00 p.m.	38'-0"
	10.00 p.m.	39'-6"
	11.00 p.m.	41'-0"
	Midnight	43'-0"
21st	1.00 a.m.	43'-8"
	2.00 a.m.	43'-10.5"
	3.00 a.m.	43'-11.5"
	4.00 a.m.	44'-0" (Peak)
	6.00 a.m.	43'-9.5"
	7.00 a.m.	43'-9"
	8.00 a.m.	43'-7"
	9.00 a.m.	43'-5"
	10.00 a.m.	43'-2"
	11.00 a.m.	43'-0"
	Noon	42'-8"
	1.00 p.m.	41'-6"
	2.00 p.m.	41'-3"
	4.00 p.m.	40'-9"
	6.00 p.m.	40'-2"
	7.00 p.m.	39'-9"
	8.30 p.m.	39'-6"
	Midnight	38'-0"
22nd	6.40 a.m.	36'-6"
	8.30 a.m.	34'-11"
	6.00 p.m.	30'-6"
23rd	Noon	24'-0"

Richmond River at Kyogle

Zero of gauge 44.40 assumed datum

DATE	TIME	HEIGHT
20th	4.30 a.m.	20'-0"
	8.15 a.m.	29'-0"
	8.45 a.m.	31'-0"
	9.20 a.m.	32'-6"

10.45 a.m.	35'-0"
11.30 a.m.	38'-0"
12.30 p.m.	41'-0"
1.15 p.m.	43'-0"
1.30 p.m.	44'-0"
2.00 p.m.	45'-0"
2.30 p.m.	46'-6"
3.15 p.m.	48'-6"
4.45 p.m.	53'-8.5"
5.30 p.m.	55'-6"
6.30 p.m.	60'-0"
7.00 a.m.	62'-0" (Peak by level)

Richmond River at Rileys Hill

Zero of gauge 0.00 L.W. Ballina

DATE	TIME	HEIGHT
20th	2.00 p.m.	7'-4"
	4.30 p.m.	7'-3" (Tidal)
	6.00 p.m.	7'-6"
21st	5.00 a.m.	10'-2"
	6.00 a.m.	10'-3"
	8.30 a.m.	10'-4"
	12.30 p.m.	10'-8"
	3.00 a.m.	11'-2"
	5.00 a.m.	12'-0"
	8.00 a.m.	13'-1"
22nd	6.00 a.m.	16'-0"
	7.15 a.m.	16'-5.5"
	10.00 a.m.	16'-10"
	11.00 a.m.	16'-11"
	1.00 p.m.	17'-1"
	3.00 p.m.	17'-2" -
	5.30 p.m.	17'-2" - (Peak)
	6.30 p.m.	17'-2" -
23rd	7.00 a.m.	16'-9"
	10.00 a.m.	16'-7"
	3.00 p.m.	16'-3"
	7.00 p.m.	16'-0"
24th	7.00 a.m.	14'-7"
	10.00 a.m.	14'-6"
	11.00 a.m.	14'-4.5"
	3.00 p.m.	13'-11.5"
	6.30 p.m.	13'-7.5"
25th	7.00 a.m.	12'-4"
	11.00 a.m.	12'-0"
	1.00 p.m.	11'-9"
	4.00 p.m.	11'-6"
	6.30 p.m.	11'-3"
26th	5.00 a.m.	10'-2"
	4.00 p.m.	9'-3"
	7.00 p.m.	8'-10"
27th	6.00 a.m.	8'-1"

Richmond River at Wyrallah Township

Zero of gauge 6.00 L.W. Ballina

DATE	TIME	HEIGHT
20th	6.00 a.m.	5'-11"
	9.00 a.m.	8'-0"
	Noon	10'-1"
	3.00 p.m.	15'-4"
	5.00 p.m.	20'-2"
	5.30 p.m.	21'-1"
	6.30 p.m.	22'-0"
21st	5.30 a.m.	28'-6"
	6.30 a.m.	28'-7"
	9.00 a.m.	28'-8"
	11.00 a.m.	28'-10" -
	Noon	28'-10" - (Peak)
	3.00 p.m.	28'-6"
	6.00 p.m.	28'-0"
22nd	6.00 a.m.	26'-11"
	9.00 a.m.	26'-7"
	Noon	26'-4"
	6.00 p.m.	25'-10"
23rd	6.00 a.m.	23'-2"
	Noon	22'-6"
	4.00 p.m.	21'-1"
24th	6.00 a.m.	17'-6"
	Noon	16'-2"
	6.00 p.m.	15'-4"
25th	6.00 a.m.	14'-2"
	9.00 a.m.	13'-11"
	Noon	13'-6"
	6.00 p.m.	13'-1"
26th	6.00 a.m.	11'-10"
	Noon	11'-6"
	6.00 p.m.	11'-1"
27th	6.00 a.m.	9'-10"
	Noon	9'-5"
	6.00 p.m.	8'-11"
28th	6.00 a.m.	8'-6"
	Noon	8'-3"
	6.00 p.m.	8'-0"

Richmond River at Coraki

Zero of gauge 0.18 L.W. Ballina Datum

DATE	TIME	HEIGHT
20th	11.30 a.m.	7'-9"
	12.30 p.m.	8'-0"
	2.00 p.m.	9'-0"
	3.00 p.m.	9'-10"
	4.00 p.m.	10'-7"
	5.00 p.m.	11'-3"
	6.00 p.m.	12'-0"
	7.00 p.m.	13'-0"
	8.00 p.m.	14'-0"
	9.00 p.m.	14'-8"
	10.00 p.m.	15'-6"
	11.00 p.m.	16'-4"
	Midnight	17'-0"

21st	1.00 a.m.	17'-6"
	3.00 a.m.	18'-6"
	4.45 a.m.	21'-8"
	5.45 a.m.	21'-10"
	6.30 a.m.	22'-0"
	7.30 a.m.	22'-6"
	8.30 a.m.	22'-7"
	9.30 a.m.	22'-9"
	10.30 a.m.	22'-9"
	11.30 a.m.	22'-10"
	2.30 p.m.	22'-10"
	3.30 p.m.	22'-10"
	4.30 p.m.	22'-11" -
	5.30 p.m.	22'-11" - (Peak)
	6.30 p.m.	22'-11" -
	7.30 p.m.	22'-10"
	8.30 p.m.	22'-10"
	9.30 p.m.	22'-10"
	10.30 p.m.	22'-10"
	11.30 p.m.	22'-9"
22nd	6.30 a.m.	22'-5"
	7.30 a.m.	22'-4"
	9.00 a.m.	22'-3"
	10.00 a.m.	22'-2"
	11.00 a.m.	22'-2"
	Noon	22'-1"
	1.00 p.m.	22'-1"
	2.00 p.m.	22'-1"
	3.00 p.m.	22'-0"
	4.30 p.m.	21'-11"
	5.30 p.m.	21'-10"
	8.30 p.m.	21'-9"
	10.30 p.m.	21'-6"
	11.30 p.m.	21'-5"
23rd	6.00 a.m.	20'-10"
	10.00 a.m.	20'-6"
	Noon	19'-6"
	6.00 p.m.	18'-6.5"
	7.00 p.m.	18'-5.5"
	9.00 p.m.	18'-0"
24th	5.30 a.m.	16'-7"
	4.00 p.m.	14'-8"
	6.00 p.m.	13'-3"
25th	8.00 a.m.	12'-0"
	Noon	10'-8"
	4.00 p.m.	9'-0"

Clarence River Catchment

Clarence River at Baryulgil

Zero gauge 53.31 assumed datum

DATE	TIME	HEIGHT
20th	Noon	4'-0"
	5.00 p.m.	15'-0"
	6.00 p.m.	17'-6"
	7.30 p.m.	21'-0"

21st	7.00 a.m.	36'-0"
	10.00 a.m.	38'-4"
	Noon	38'-6" -
	1.00 p.m.	38'-6" - (Peak)
	2.00 p.m.	37'-6"
	3.00 p.m.	36'-6"
	7.00 p.m.	34'-0"

Clarence River at Copmanhurst

Zero gauge 2.24 L.W. Iluka Datum

DATE	TIME	HEIGHT
20th	6.00 p.m.	6'-0"
	9.00 p.m.	11'-0"
21st	5.45 a.m.	48'-0"
	6.00 a.m.	48'-0"
	6.25 a.m.	49'-6"
	8.00 a.m.	52'-0"
	9.00 a.m.	55'-0"
	10.30 a.m.	58'-0"
	Noon	63'-0"
	1.15 p.m.	65'-0"
	2.00 p.m.	67'-6"
	3.30 p.m.	69'-0"
	4.00 p.m.	70'-0"
	5.30 p.m.	71'-2"
	6.15 p.m.	71'-5" (Peak)
	6.30 p.m.	71'-1"
	7.30 p.m.	69'-7"
	8.30 p.m.	69'-2"
22nd	6.30 a.m.	54'-0"
	4.00 p.m.	44'-0"

Clarence River at Grafton

Prince St. gauge. Zero of gauge 1.86 standard datum 4.69 L.W Iluka Datum

DATE	TIME	HEIGHT
20th	6.00 p.m.	1'-4"
	8.00 p.m.	1'-9"
	9.00 p.m.	3'-3"
	10.00 p.m.	3'-9"
	11.00 p.m.	5'-0"
21st	2.00 a.m.	8'-9"
	3.00 a.m.	10'-0"
	4.00 a.m.	11'-0"
	4.50 a.m.	12'-0"
	5.15 a.m.	12'-6"
	5.40 a.m.	13'-0"
	6.00 a.m.	13'-4"
	6.25 a.m.	13'-10"
	7.00 a.m.	14'-4"
	7.30 a.m.	14'-10"
	8.00 a.m.	15'-3"
	9.00 a.m.	16'-0"
	9.30 a.m.	16'-5"
	10.30 a.m.	17'-4"

	11.00 a.m.	17'-9"
	11.30 a.m.	18'-2"
	Noon	18'-7"
	12.30 p.m.	19'-0"
	1.15 p.m.	19'-7.5"
	2.00 p.m.	20'-0"
	2.40 p.m.	20'-5"
	3.00 p.m.	20'-7"
	3.30 p.m.	20'-10"
	4.00 p.m.	20'-0.5"
	4.30 p.m.	21'-3"
	5.00 p.m.	21'-6"
	5.50 p.m.	21'-9"
	6.45 p.m.	22'-0"
	7.30 p.m.	22'-3"
	7.50 p.m.	22'-4"
	8.25 p.m.	22'-6.5"
	8.55 p.m.	22'-8"
	9.25 p.m.	22'-10"
	9.55 p.m.	23'-0"
	10.25 p.m.	23'-2"
	11.00 p.m.	23'-3.5"
	11.30 p.m.	23'-4.5"
	Midnight	23'-5"
22nd	12.30 a.m.	23'-5.5" -
	1.05 a.m.	23'-5.5" - (Peak)
	2.00 a.m.	23'-4.5"
	2.30 a.m.	23'-4"
	3.00 a.m.	23'-3.5"
	3.30 a.m.	23'-2.5"
	4.00 a.m.	23'-1"
	4.30 a.m.	23'-0"
	5.00 a.m.	22'-11"
	5.30 a.m.	22'-9"
	6.00 a.m.	22'-8"
	6.30 a.m.	22'-6"
	7.00 a.m.	22'-4.5"
	7.30 a.m.	22'-3"
	8.00 a.m.	22'-2.5"
	8.30 a.m.	21'-11"
	9.00 a.m.	21'-9"
	9.30 a.m.	21'-8"
	10.00 a.m.	21'-5.5"
	11.00 a.m.	21'-2"
	Noon	20'-11"
	2.00 p.m.	20'-0"
	3.00 p.m.	19'-9"
	4.00 p.m.	19'-5"
	5.00 p.m.	19'-1"
23rd	6.00 a.m.	14'-6"
	9.00 a.m.	14'-0"
	11.00 a.m.	13'-0"
	Noon	12'-9"
	1.00 p.m.	12'-6"
	2.45 p.m.	12'-0"
	4.00 p.m.	11'-9"
	5.00 p.m.	11'-6"
24th	9.30 a.m.	8'-0"
	11.00 a.m.	7'-7"
	2.00 p.m.	7'-1"

	4.00 p.m.	6'-6"
	5.15 p.m.	6'-5"
25th	9.00 a.m.	4'-0"
26th	9.00 a.m.	1'-9"

Clarence River at South Grafton

Zero of gauge 4.61 L.W Iluka Datum

DATE	TIME	HEIGHT
18th	3.00 p.m.	0'-3"
22nd	1.30 a.m.	22'-11.5" (Peak)
23rd	3.00 p.m.	11'-6"
	6.00 p.m.	11'-0"
24th	8.00 a.m.	8'-2"
	11.00 a.m.	7'-6"
	1.00 p.m.	7'-3"
	2.00 p.m.	7'-0"
	4.00 p.m.	6'-9"
25th	7.30 a.m.	4'-6"
	9.00 a.m.	4'-0"

Clarence River at Maclean

Zero of gauge 0.00 L.W Iluka Datum

DATE	TIME	HEIGHT
20th	9.30 p.m.	7.50
	10.00 p.m.	7.75
	11.00 p.m.	8.17
21st	4.30 a.m.	8.92
	7.30 a.m.	9.50
	8.30 a.m.	9.67
	9.30 a.m.	9.75
	10.00 a.m.	9.92
	10.30 a.m.	10.21
	11.30 a.m.	10.33
	Noon	10.42
	12.30 p.m.	10.50
	1.00 p.m.	10.54
	1.30 p.m.	10.58
	2.00 p.m.	10.67
	2.30 p.m.	10.75
	3.00 p.m.	10.83
	3.30 p.m.	10.88
	4.00 p.m.	10.92
	4.30 p.m.	10.96
	5.50 p.m.	11.08
	6.00 p.m.	11.12
	6.30 p.m.	11.21
	7.00 p.m.	11.25
	7.30 p.m.	11.33
	8.00 p.m.	11.33
	8.30 p.m.	11.42
	9.00 p.m.	11.54
	9.30 p.m.	11.58
	10.30 p.m.	11.67

	11.00 p.m.	11.75
22nd	4.00 a.m.	12.25
	5.30 a.m.	12.38
	6.00 a.m.	12.42
	6.30 a.m.	12.46
	7.00 a.m.	12.50
	7.30 a.m.	12.50
	8.00 a.m.	12.50
	8.30 a.m.	12.58
	9.00 a.m.	12.58
	9.30 a.m.	12.58
	10.00 a.m.	12.63
	10.30 a.m.	12.67
	11.00 a.m.	12.71
	11.30 a.m.	12.71
	Noon	12.75
	12.30 p.m.	12.75
	1.00 p.m.	12.79 -
	1.30 p.m.	12.79 -
	2.00 p.m.	12.79 -
	3.00 p.m.	12.79 - (Peak)
	3.30 p.m.	12.79 -
	4.00 p.m.	12.79 -
	4.30 p.m.	12.79 -
	5.00 p.m.	12.75
	6.00 p.m.	12.75
	7.00 p.m.	12.71
	7.30 p.m.	12.67
	8.00 p.m.	12.67
	8.30 p.m.	12.67
	9.00 p.m.	12.63
	10.00 p.m.	12.58
	11.00 p.m.	12.50
	Midnight	12.42
23rd	2.00 a.m.	12.33
	5.30 a.m.	12.17
	6.30 a.m.	12.12
	7.00 a.m.	12.12
	7.30 a.m.	12.00
	8.00 a.m.	12.00
	8.30 a.m.	11.96
	9.00 a.m.	11.96
	9.30 a.m.	11.92
	10.00 a.m.	11.92
	10.30 a.m.	11.88
	11.30 a.m.	11.83
	Noon	11.83
	12.30 p.m.	11.79
	1.00 p.m.	11.75
	1.30 p.m.	11.67
	2.00 p.m.	11.67
	2.30 p.m.	11.62
	3.00 p.m.	11.58
	3.30 p.m.	11.54
	4.00 p.m.	11.50
	4.30 p.m.	11.42
	5.00 p.m.	11.37
	7.00 p.m.	11.12
	8.00 p.m.	11.08
	9.00 p.m.	11.00
	10.00 p.m.	10.92

	11.00 p.m.	10.83
24th	5.30 a.m.	10.04
	6.30 a.m.	9.92
	7.30 a.m.	9.75
	8.30 a.m.	9.67
	10.30 a.m.	9.54
	Noon	9.25
	12.30 p.m.	9.21
	3.30 p.m.	8.92
	4.30 p.m.	8.75
	6.00 p.m.	8.50
	8.30 p.m.	8.17
25th	7.00 a.m.	7.00

Clarence River at Coldstream Gauge

Zero of gauge 0.00 L.W Iluka Datum

DATE	TIME	HEIGHT
20th	Noon	1'-0"
	6.00 p.m.	3'-9"
21st	6.00 a.m.	6'-9"
	9.00 a.m.	7'-0"
	10.00 a.m.	7'-4"
	12.30 p.m.	7'-7"
	3.00 p.m.	7'-10"
	6.00 p.m.	8'-0"
22nd	6.00 a.m.	10'-0"
	9.00 a.m.	11'-1"
	Noon	11'-5"
	3.00 p.m.	11'-8"
	6.00 p.m.	12'-0"
	10.00 p.m.	12'-2"
23rd	4.00 a.m.	12'-4" (Peak)
	6.00 a.m.	12'-3"
	9.00 a.m.	12'-1"
	Noon	12'-0"
	3.00 p.m.	11'-10"
	6.00 p.m.	11'-8"
24th	6.00 a.m.	11'-0"
	9.00 a.m.	10'-9"
	Noon	10'-7"
	3.00 p.m.	10'-5"
	6.00 p.m.	10'-2"
25th	6.00 a.m.	9'-6"
	1.00 p.m.	9'-0"
	4.00 p.m.	8'-10"
	6.30 p.m.	8'-8"
26th	6.00 a.m.	8'-1"
	9.00 a.m.	7'-10"
	2.00 p.m.	7'-8"
	3.00 p.m.	7'-7"
	6.00 p.m.	7'-6"
27th	6.00 a.m.	6'-11"
	9.00 a.m.	6'-8"
	1.00 p.m.	6'-4"
	6.00 p.m.	5'-9"
28th	9.00 a.m.	4'-6"
	Noon	4'-5"
	6.00 p.m.	3'-11"

Clarence River at Ulmarra

Zero of gauge 0.97 Standard Datum; 3.80 L.W. Iluka Datum

DATE	TIME	HEIGHT
21st	7.00 a.m.	11'-0"
	9.30 a.m.	12'-2"
	1.30 p.m.	15'-0"
	3.00 p.m.	15'-10"
	5.00 p.m.	16'-6"
	7.30 p.m.	17'-2"
	9.15 p.m.	17'-7"
22nd	12.30 a.m.	18'-2"
	2.30 a.m.	18'-3" (Peak)
	3.30 a.m.	18'-2"
	9.00 a.m.	17'-8"
	11.00 a.m.	17'-4"
	3.15 p.m.	16'-5"
23rd	9.00 a.m.	13'-0"