The March, 1978 flood on the Hawkesbury and Nepean River between Penrith and Pitt Town

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Introduction

As a result of three days of heavy rainfall over the Hawkesbury catchment in March, 1978 floods occurred on all the streams in the Hawkesbury system. These floods caused considerable property damage and resulted in morphological changes to the channels and floodplains of the Hawkesbury system. This paper describes the flood in the Hawkesbury-Nepean system in the reach extending from Penrith to Pitt Town.

Storm Pattern

An intense low pressure cell developed over the Coral Sea on the 16th March, 1978. This low pressure system travelled southeast towards the Queensland coast and gained in intensity (Fig.1). On the 18th March it appeared that the cell would move eastwards away from Australia. However, the system reversed its direction of travel and moved inland. Resultant wind systems brought warm moist air from the east onto the coast of New South Wales. Consequently, heavy rainfalls occurred from the 18th to 24th March over the whole of eastern New South Wales.

The low pressure system was intense in its initial stages (Fig.2). The system began to dissipate as soon as it crossed the coast although it persisted until it moved out to sea in a southeasterly direction. An intense pressure gradient to the east of the cell during its early stages resulted in a high rate of landward movement of maritime air.

Rainfall Pattern

Rainfall less than 25 mm occurred over most of the Hawkesbury catchment during the 24 hr period to 9am, 18th March (Table 1). On the three following days the volume of daily rainfall increased considerably (Figs.3A-B). Several recording stations reported daily rainfall totals in excess of 250 mm. From the 21st March onwards daily rainfall declined rapidly as the low pressure system moved out to sea. Only light showers were recorded on the 24th March.

For the 6 day period to 9am, 24th March more than 500 mm of rain fell over 742 km^2 of the catchment, that is 3.4% of the Hawkesbury catchment (Fig.3E, Table 2). The 24 hr period to 9am, 20th March was the one in which the highest 24 hr rainfalls for the catchment were recorded (Fig.3B, Table 1).

The orographic nature of the rainfall is evident from the distribution of rainfall over the catchment (Fig.3E). High rainfall volumes were recorded along the Illawarra escarpment, Lapstone Monocline and the high area around Mount Victoria. The distinct westwards declining rainfall gradient is also a result of the orographic nature of the rainfall (Figs.3D & 3E). The absence of serious flooding in the western rivers was a result of the rapid decline in rainfall westwards of the coast.

The highest 6 day rainfall registration was at Robertson, on the boundary of the Hawkesbury and Shoalhaven catchments. The station recorded 940 mm of rain in the 6 day period to 9am on 24th March. While this may be a large volume of rain it is nowhere near the world record for a 6 day rain of 3,111 mm, recorded at Silver Hill Plantation, Jamaica (Jennings, 1950). However, the rainfall had a recurrence interval of greater than 100 yrs on the basis of data available for Sydney (Pierrehumbert, 1974). Even the 3 day rainfall to the 20th March of 640 mm has a recurrence interval greater than 100 yrs relative to Sydney. A 24 hr summer rainfall of 250 mm or greater for Sydney has a recurrence interval of approximately 50 years (Table 3).

Floods

Although rain fell in the Hawkesbury catchment prior to the storm of the 18th the catchment was relatively dry. A long dry period over summer had depleted soil moisture stores. Dams on the catchment had low levels. Consequently, the initial period of rain did not produce much runoff and it was not until Sunday the 19th that significant rises in stage occurred in the Hawkesbury system (Figures 4, 5 & 6).

Flood peaks occurred on the 20th for the headwater reaches of the main streams and on the 21st for the lower reaches (Table 4). The delay in the flood peak at Windsor, which occurred 13 hours after that at North Richmond, was probably a result of backwater effects from flooding in the Colo and MacDonald Rivers. The only alternative explanation to backwater effects for the lag between the two peaks is that the flood wave moved at the low velocity of 0.28 m/sec.

Analysis of the flood frequency records for the Nepean at Penrith and for the Hawkesbury at Windsor suggest that flooding in the lower reaches of the Hawkesbury was considerably influenced by flooding in the Colo and MacDonald Rivers.

The volume of rain which passed through the Penrith gauge (Fig. 4) was equivalent to a depth of 136 mm over the catchment. That is, approximately 40% of the catchment rainfall was converted into runoff.

Flood Frequency

A recurrence interval of between 6 and 13 years (Fig. 7, Table 5) is obtained from various flood frequency curves for the Nepean River at Penrith. However, the estimate of the recurrence interval of the flood at Windsor ranges between 21 and 44 years (Fig.8, Tables 5 & 6).

The various estimates for the frequency of the March flood at Windsor arise from the poor fit between the data and the assumed frequency distribution. Although flood records are available for Windsor from 1790 they are incomplete with gaps of at least 20 years in them. The period of record from 1900 to 1978 is well documented and the selected cut off level of 8 m has reduced the possibility that small floods have been omitted. The series was split at 1940 because it is after this time that dams became important in the catchment hydrologic cycle. Also, Pickup (1974) suggests a distinct change in the hydrologic regime for sections of the Hawkesbury catchment sometime in the period 1940 to 1950.

The inability to accurately define the flood frequency for Windsor has some implications for land use planning in the area.

Morphological effect of the flood

Large sections of river bank along the Hawkesbury slumped immediately after the flood peak (Fig.9). Bank collapse along Terrace Rd at Windsor was restricted to fluvial deposits overlying shale bedrock which outcrops at 1 metre (approximately) above low flow level.

Initial reports suggest that considerable volumes of sand were deposited in the Argyle, Windsor and Wilberforce Reaches of the Hawkesbury River. Some of this sand came from sand mining areas near North Richmond, some from bank collapse, and some may have come from erosion of the floodplain.

The floodplain between Bakers Lagoon and Pitt Town Bottoms was scoured in several areas. Scour holes up to 1 metre deep formed, particularly along depressions that drained the floodplain back into the river. Sinuous large scale ripples (Allen,1968) with avalanche faces up to 30 cm deep developed on the floodplain on the convex side of meander bends. Note: River overtopped bank above Agnes Banks

Along South Creek and the Hawkesbury River upstream of North Richmond there appeared to be only minor alteration of the floodplain surface. Deposits in these two areas are of silt-clay texture, which probably settled out during the long period of still water that occurred during the 22nd. Thickness of silt-clay deposits on grass, fence posts, cans, bottles, and other artifacts were less than 1 mm and generally less than 0.5 mm.

Sand and silt texture deposits up to 0.5 m thick were noted by the author at several localities along the Hawkesbury. However, as the deposits appeared to be thickest where the floodplain had been eroded floodplain deposits of sand and silt derived from the River were probably negligible. The area inundated between Agnes Banks and York reach is estimated to have had an average depth of river derived deposits less than 0.5 mm, and more likely less than 0.1 mm.

Unfortunately, because of rain in the week following the flood, initial observations of flood deposits could not be extended to obtain an accurate figure of average depth of deposits. The problem of sorting out locally derived and river derived deposits was also too complex to be solved in the time available.

Area of inundation

The area inundated between Agnes Banks and York Reach (Fig.10) was km^2. The actual area of flooding is slightly more extensive than that indicated as several creeks to the south of Windsor and Richmond also flooded. However, these local floods were short, generally less than 12 hours duration.

Economic effects of flooding

In Windsor a large number of houses were inundated (Fig.11) although not all of the houses indicated as being under water were actually underwater. In some cases floor levels are above flood level. Still, these houses did have water frontages for several days. Windsor Council building regulations now prohibit floor levels below 15 m.

Many houses on the levee along Freemans Reach and Argyle Reach were inundated. Again, in the case of double storey houses, the second floor was above flood level.

Shane Park on South Creek and Riverstone on Eastern Creek were affected by flooding. Approximately 40 houses were flood damaged.

Orchard and market gardens were destroyed or severely damaged. Orange orchards just on the point of being harvested were flood damaged. In one instance, a farmer on South Creek who had planted the week before the flood lost $2,500 (approximately) worth of seed.

CROP WAS LOST

Sand deposition on paddocks along the Hawkesbury and scour of soil from the paddocks will cause loss of productivity for some time.

Many roads were damaged, tarmac being ripped off in many cases and culverts undermined and approaches washed away. The approach to Yarrumundi Bridge was washed away (Fig. 12).

Bank collapse imperilled several riverside homes at Penrith and severely damaged a main sewer line at Windsor. The estimated cost of repair of the latter is in excess of $150,000. New bank stabilization works upstream of Windsor Pump station held. However, older works on the upstream area of Argyle Reach suffered minor slump failure.

HIGH? INCLUDE REPAIR OF BANK SLIP.

The flood blocked roads and rail links over the area. The sewage treatment works at McGraths Hill was inundated.

Conclusion

The flooding was far more extensive than this report has indicated. The Colo and MacDonald Valleys and Hawkesbury Valley downstream of York Reach were all seriously affected by the flooding. However, the situation for the Hawkesbury as described herein is fairly typical for the remainder of the catchment.

Economic losses have not been assessed in monetary terms. Although, when one considers the losses that accrued from diversion of man power to flood relief, loss of productivity, transport delay, etc. as well as actual physical losses, the March flood in the area of discussion probably cost the local people and tax payers well over $2 million.

References

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Pickup, G. 1976. Geomorphic effects of changes in river runoff, Cumberland Basin, N.S.W. Australian Geographer, 13(3), 188-193.

Pierrehumbert, C.L. 1974. Point rainfall intensity - frequency - duration data. Capital cities. Dept. Science Bureau of Meteorology Bull. 49.

* Not enclosed.

Figure Captions

Figure 1 — Path of the low pressure cell of March 1978 that was responsible for floods in Eastern Australia. Crosses indicate the position of the cell centre at the time and date indicated.

Figure 2 — Temporal isobaric trend map of the low pressure system of March, 1978. Isobars define the width of the cell normal to its direction of movement.

* Figure 3A — 24 hr rainfall to 9am, 19th March.

* Figure 3B — 24 hr rainfall to 9am, 20th March.

* Figure 3C — 24 hr rainfall to 9am, 21st March.

* Figure 3D — 72 hr rainfall to 9am, 20th March.

* Figure 3E — Total rainfall for the 7 day period 18th to 9am, 24th March.

Figure 4 — Hydrograph for Nepean River at Penrith.

Figure 5 — Stage hydrographs for Hawkesbury River at North Richmond and Windsor.

Figure 6 — Stage hydrographs for Grose River at Burralow and Nepean River at Penrith

Figure 7 — Flood frequency curve for the Nepean River at Penrith. Frequency curve is of the annual series for the period 1900 to 1968.

Figure 8A — Flood frequency curve for Hawkesbury River at Windsor, 1900 to 1977.

Figure 8B — Flood frequency curve for Hawkesbury River at Windsor, 1900 to 1940.

Figure 8C — Flood frequency curve for Hawkesbury River at Windsor, 1941 to 1977.

Figure 8D — Flood frequency curve for Hawkesbury River at Windsor, 1900 to 1977. Base level of series 10m.

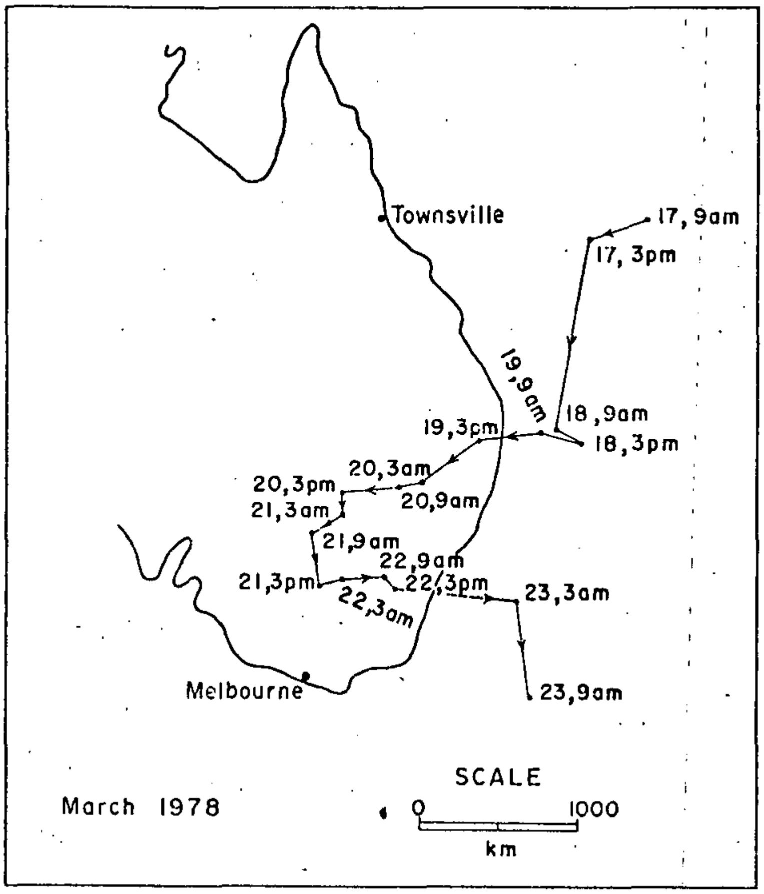
* Figure 9A — Bank collapse along River Road, Penrith. March, 1978.

* Figure 9B — Bank collapse along Nepean River at Penrith. March, 1978.

Figure 10 — Area of inundation by the March, 1978 flood. Map composed from flood heights field mapped onto 1:4,000 orthophotomaps.

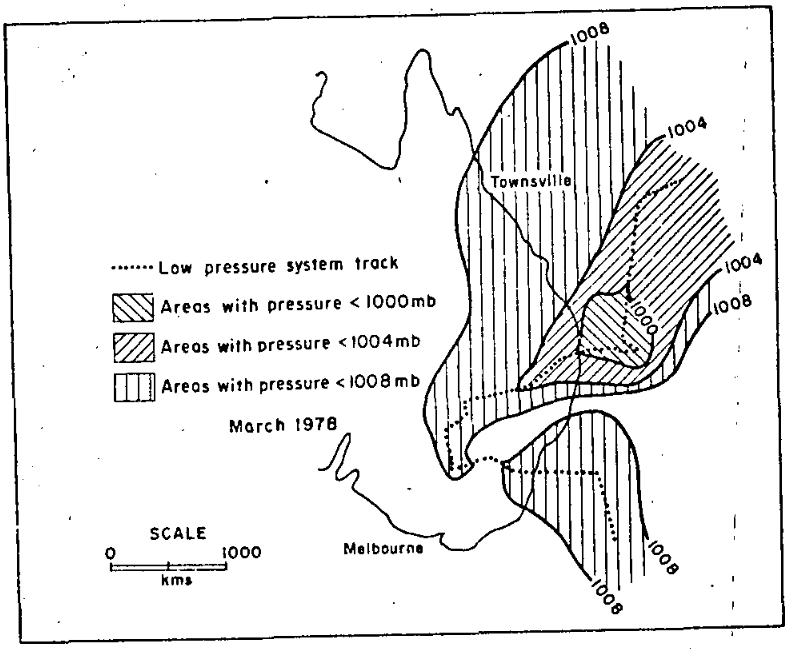
Figure 11 — Extent of flooding at Windsor by the March, 1978 flood.

* Figure 12 — Washed out approach to Yarramundi Bridge, March, 1978.



Townsville
17, 9am
17, 3pm
19, 9am
18, 9am
19, 3pm
18, 3pm
20, 3am
20, 3pm
21, 3am
20, 9am
21, 9am
22, 9am
21, 3pm
22, 3pm
23, 3am
22, 3am
Melbourne
23, 9am
March 1978
SCALE
0
1000
km

Fig. 1.



1008
1004
Townsville
Low pressure system track
Areas with pressure < 1000mb
Areas with pressure < 1004mb
Areas with pressure < 1008 mb
1004
1008
1000
March 1978
SCALE
0
1000
kms
Melbourne
1008
1008

Fig. 2.

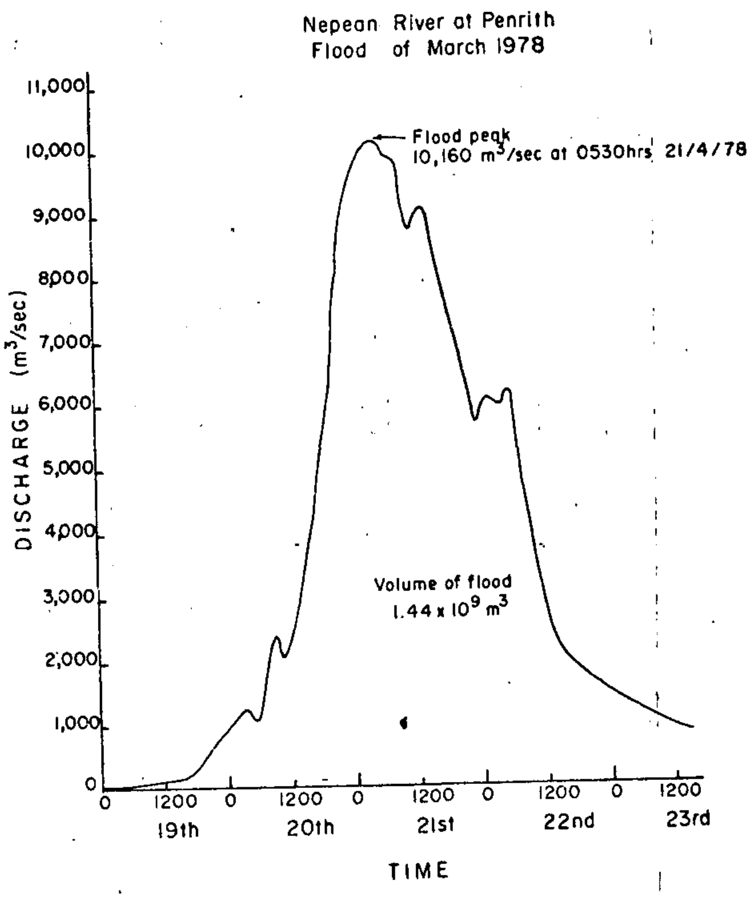
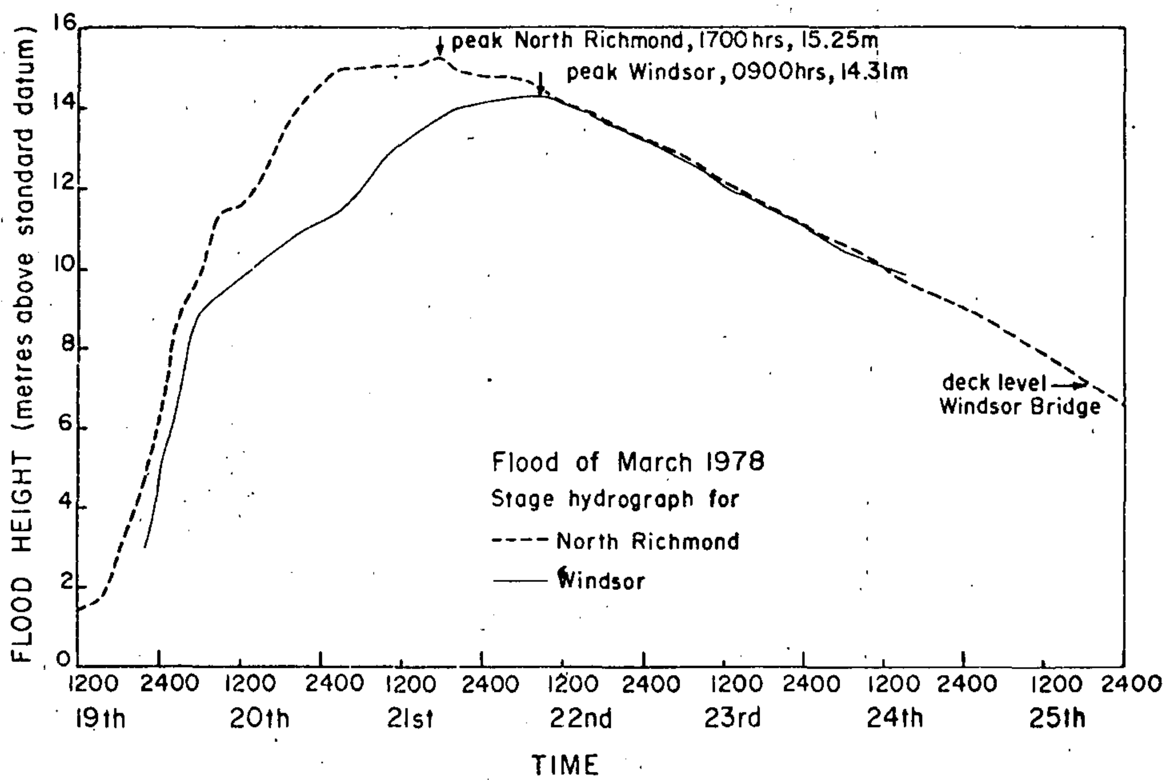

Nepean River at Penrith
Flood of March 1978
Flood peak
10,160 m³/sec at 0530hrs 21/4/78
Volume of flood
1.44 x 10⁹ m³
DISCHARGE (m³/sec)
11,000
10,000
9,000
8000
7,000
6,000
5,000
4000
3,000
2,000
1,000
0
0 1200 0 1200 0 1200 0 1200 0 1200
19th 20th 21st 22nd 23rd
TIME

Fig. 4.



peak North Richmond, 1700 hrs, 15.25m
peak Windsor, 0900hrs, 14.31m
FLOOD HEIGHT (metres above standard datum)
16
14
12
10
8
6
4
2
0
deck level
Windsor Bridge
Flood of March 1978
Stage hydrograph for
North Richmond
Windsor
1200 2400 1200 2400 1200 2400 1200 2400 1200 2400 1200 2400 1200 2400
19th
20th
21st
22nd
23rd
24th
25th
TIME

Fig. 5.

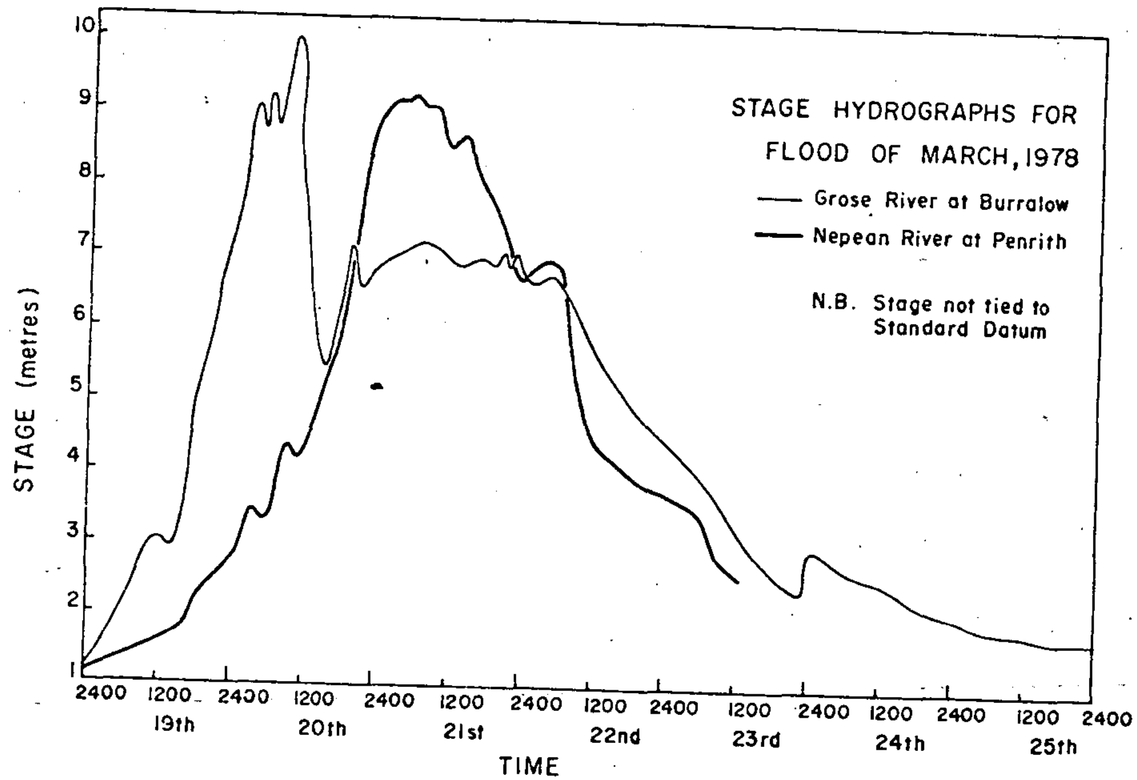
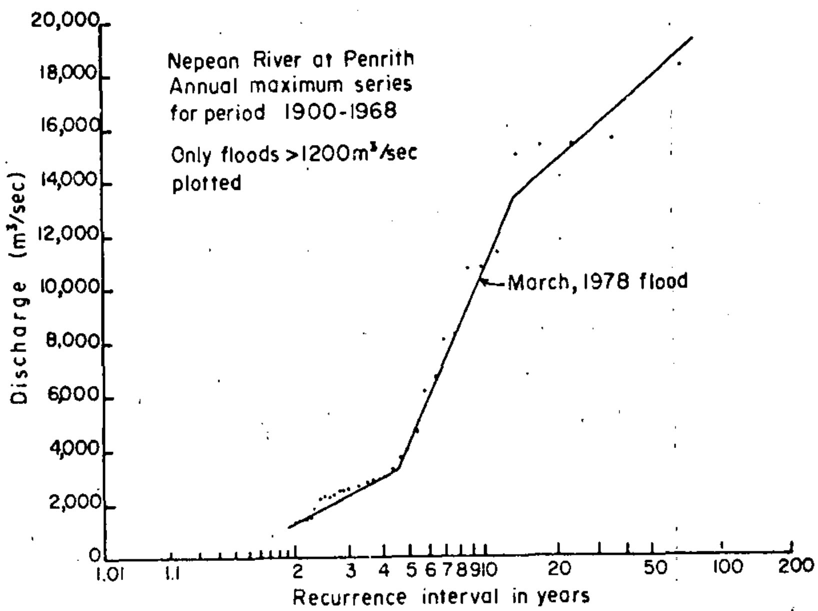
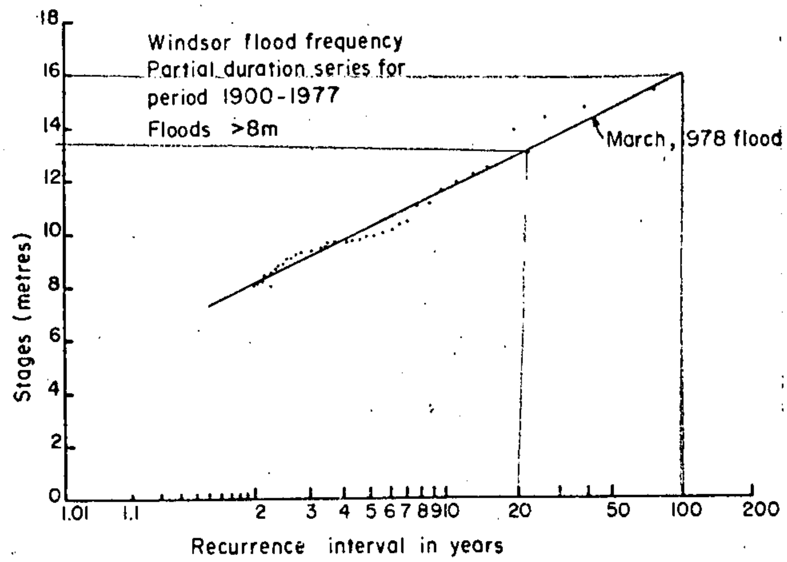

STAGE HYDROGRAPHS FOR
FLOOD OF MARCH, 1978
Grose River at Burralow
Nepean River at Penrith
N.B. Stage not tied to
Standard Datum
STAGE (metres)
10
9
8
7
6
5
4
3
2
1
2400
1200
2400
1200
2400
1200
2400
1200
2400
1200
2400
1200
2400
1200
2400
19th
20th
21st
22nd
23rd
24th
25th
TIME

Fig. 6.



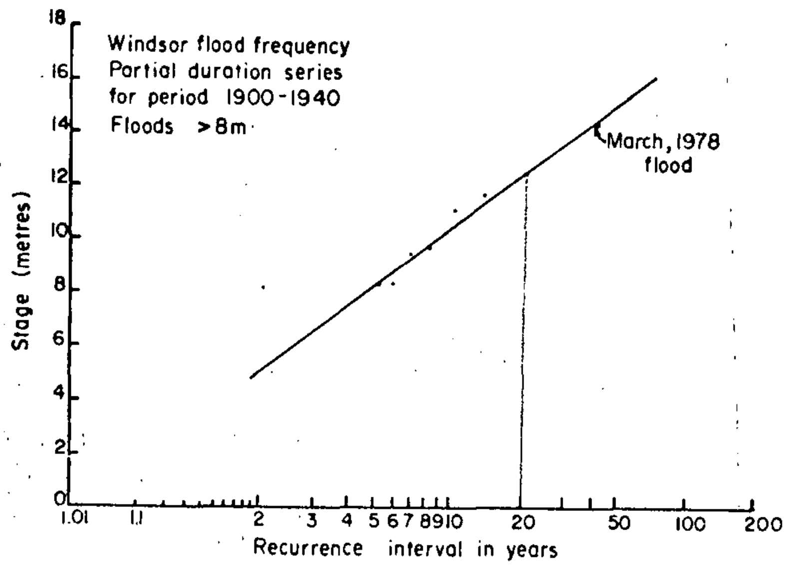
Nepean River at Penrith
Annual maximum series
for period 1900-1968
Only floods >1200m³/sec plotted
Discharge (m³/sec)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
March, 1978 flood
1.01
1.1
2
3
4
5 6 7 8 9 10
20
50
100
200
Recurrence interval in years

Fig. 7.



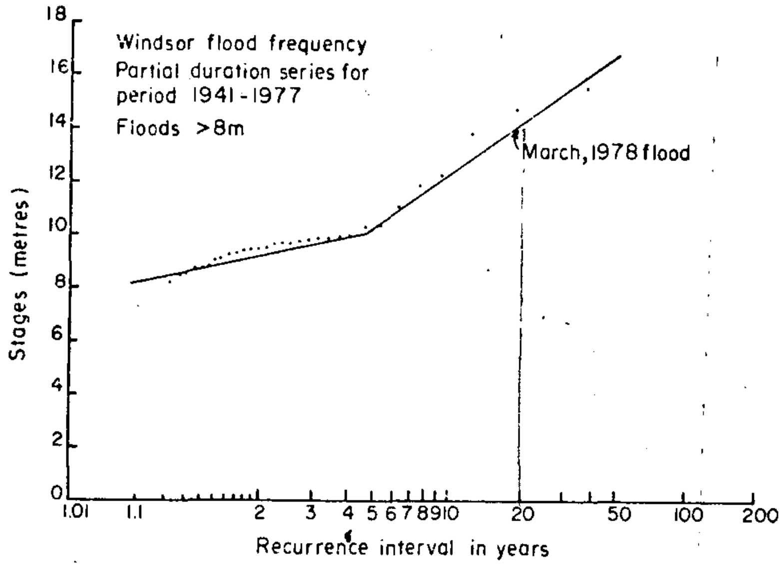
Windsor flood frequency
Partial duration series for
period 1900-1977
Floods >8m
March, 1978 flood
Stages (metres)
Recurrence interval in years
0
2
4
6
8
10
12
14
16
18
1.01
1.1
2
3
4
5 6 7 8 9 10
20
50
100
200

Fig. 8A.



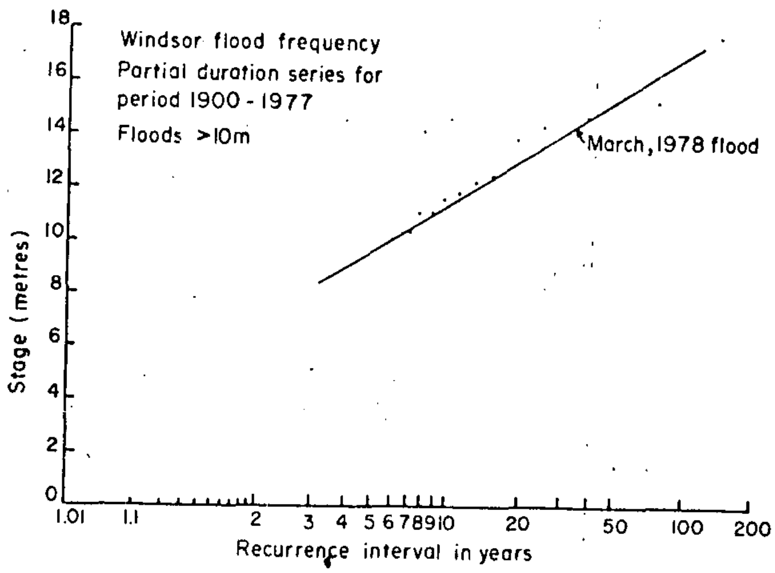
Windsor flood frequency
Partial duration series
for period 1900-1940
Floods >8m
March, 1978
flood
Stage (metres)
18
16
14
12
10
8
6
4
2
0
1.01
1.1
2
3
4
5
6
7
8
9
10
20
50
100
200
Recurrence interval in years

Fig. 8B.



Windsor flood frequency
Partial duration series for
period 1941-1977
Floods >8m
March, 1978 flood
Stages (metres)
18
16
14
12
10
8
6
4
2
0
1.01
1.1
2
3
4
5
6
7
8
9
10
20
50
100
200
Recurrence interval in years

Fig. 8C.



Windsor flood frequency
Partial duration series for
period 1900 - 1977
Floods >10m
March, 1978 flood
Stage (metres)
18
16
14
12
10
8
6
4
2
0
1.01
1.1
2
3
4
5
6
7
8
9
10
20
50
100
200
Recurrence interval in years

Fig. 8D

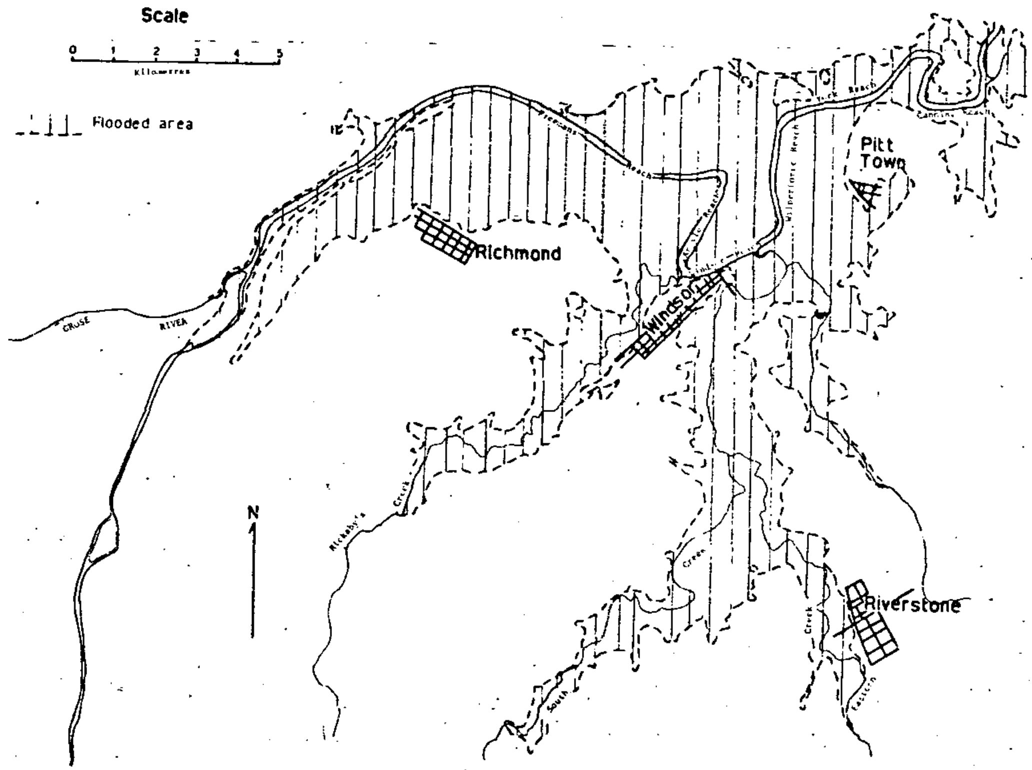
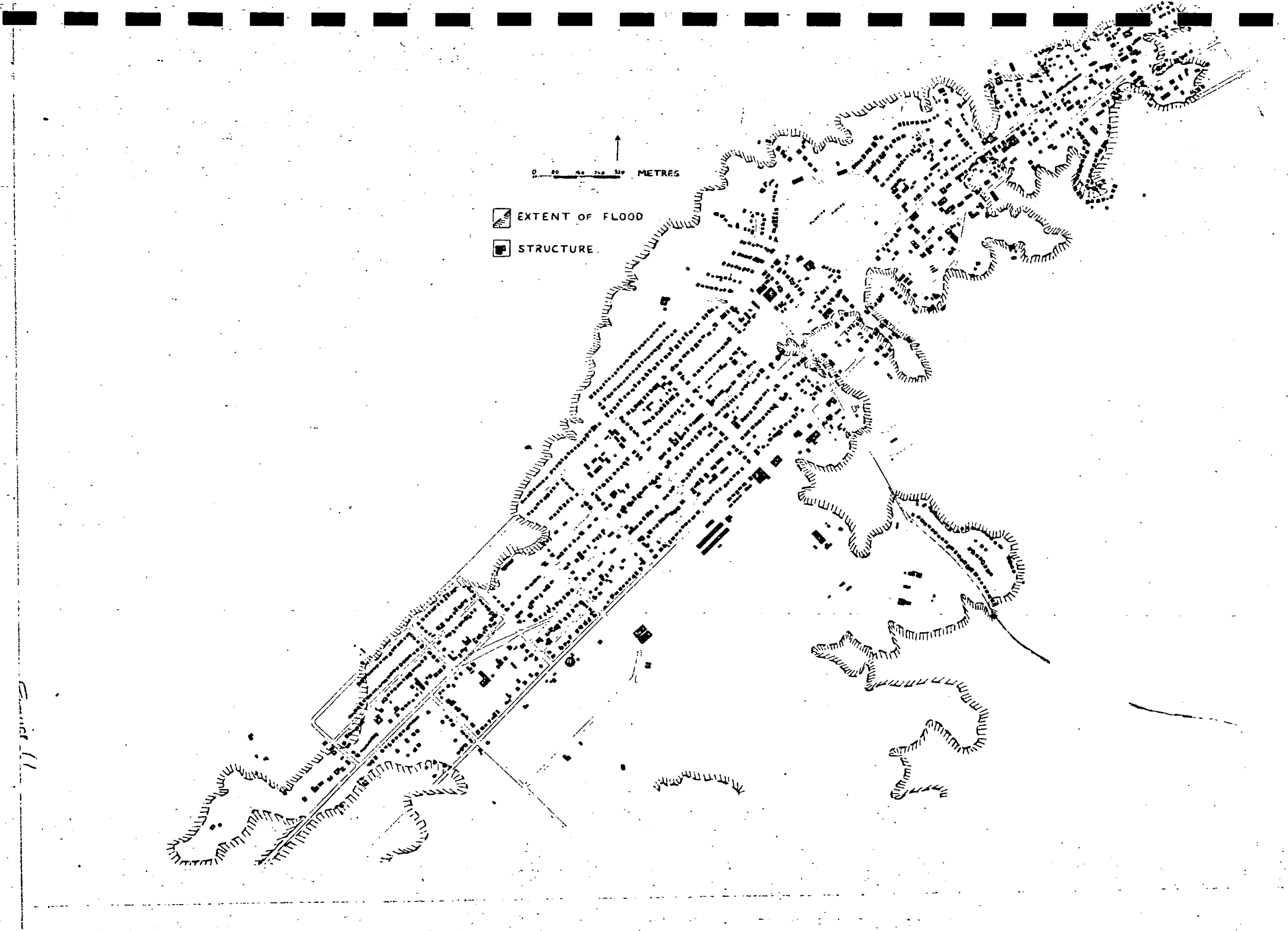

Scale
0 1 2 3 4 5
Flooded area
Richmond
Windsor
Pitt Town
Riverstone
N

Fig. 10.



0 80 160 240 320 METRES
EXTENT OF FLOOD
STRUCTURE

TABLE 1

Average rainfalls (1) for Hawkesbury catchment and catchment at Penrith

Period	Average rainfall (mm) for Catchment (2) of	
	Nepean at Penrith	Hawkesbury
24 hrs to 19th March	91	74
24 hrs to 20th March	143	139
24 hrs to 21st March	80	59
18th to 24th March	327	294
72 hrs to 20th March	238	207

(1) Derived from planimetric measurement and averaging of isohyetal maps.

(2) Areas of catchments are

Nepean at Penrith: 10, 609 km^2
Hawkesbury at Broken Bay: 21,700 km^2

TABLE 2

Percentage area of Hawkesbury catchment receiving more than a given volume of rainfall.

Rainfall (mm)	Percentage of catchment receiving more than given volume of rainfall for period	
	72 hrs to 9am 21st March	6 days to 9am 24th March
600	0.2	0.5
500	0.5	3.4
400	2.5	10.0
300	5.5	44.0
200	49.9	86.5
100	91.5	99.1

Table 3

Summer Rainfall recurrence intervals for 24, 72 and 144 hour periods (1)

Recurrence Interval (years)	Rainfall (mm) for period of		
	24 hrs	72 hrs	144 hrs
100	288 (331)	403 (374)	446
50	252 (293)	353 (360)	403
10	173 (216)	245 (295)	274
5	149 (204)	166 (288)	230
2	108 (180)	144 (259)	173
1	82 (141)	108 (201)	122

(1) Data extracted from Pierrehumbert (1974), Fig.4(e). Note, the data are derived for Sydney and cannot be easily transferred to other localities. They should be used as a guide. The average rainfall at Robertson is 35% greater than that at Sydney and an estimate of the Robertson rainfall for specific recurrence intervals and durationscan be gained by multiply the given depths by 1.35. Estimates for the 24 hrs and 72 hrs depths for Robertson have also been calculated by the procedure outlined in Institution of Engineers, Australia, 1977. These calculated rainfalls are shown in brackets.

Table 4

Time and magnitude of flood peaks on the Hawkesbury River system for March, 1978

Site	Time of peak	Peak stage (m) or discharge (m^3/sec)
Avon Dam	20th, 0300 hrs	777 m^3/sec
Nepean Dam	20th, 1400 hrs	1,027 m^3/sec
Warragamba Dam	21st, 0200 hrs	6,134 m^3/sec
Nepean at Penrith	21st, 0530 hrs	10,162 m^3/sec
Grose River at Burralow	20th, 0930 hrs	9.90 m
Nepean at Menangle	20th, 1500 hrs	13.45 m
Hawkesbury at North Richmond	21st, 1700 hrs	15.25 m
Hawkesbury at Windsor	22nd, 0600 hrs	14.31 m

Table 5

Estimates of the recurrence interval of March, 1978 flood on the Hawkesbury River at Windsor and Nepean River at Penrith

Windsor

Method of frequency analysis	Estimated recurrence interval (years)
Partial duration series, period 1900-1977, base level 8m	44
Partial duration series, period 1900-1940 base level 8m	41
Partial duration series, period 1941-1977 base level 8m	21
Partial duration series, period 1900-1977 base level 10m	35

Penrith

Annual maximum flood series, period 1900-1968	9.6
Annual maximum flood series, period 1900-1940	13
Annual maximum flood series, period 1941-1968	6.7

Table 6

Floods greater than 8m at Windsor for period 1900-1977

Rank of Windsor floods	Date of flood	Stage of flood (m) at	
		Windsor	North Richmond Bridge & Pumping Station
3	1900 July	14.30	NR
5	1904 July	12.44	NR
39	1911 January	8.12	NR
37	1913 May	8.23	NR
10	1916 October	11.04	NR
19	1922 July	9.67	NR
8	1925 June	11.58	14.21
26	1934 February	9.36	NR
11	1943 May	10.34	12.53
6	1949 June	12.19	13.72
29	1950 January	9.18	6.16
24	1950 March	9.42	10.82
24	1950 April	9.42	10.67
19	1950 June	9.67	10.97
36	1950 July	8.45	7.62 ?
16	1950 October	9.82	7.62 ?
26	1951 January	9.36	9.63
22	1952 June	9.60	11.58
7	1952 July	11.83	12.8
18	1952 August	9.70	11.41
14	1955 May	9.97	11.58
4	1956 February	13.83	14.26
13	1956 March	10.02	10.52
17	1956 June	9.74	11.67
1	1961 November	15.30	16.64
34	1962 January	8.62	10.39
33	1963 April	8.75	10.33
38	1963 May	8.14	9.54
31	1963 June	9.00	10.64
21	1963 August	9.64	11.52
2	1964 June	14.72	15.99
30	1967 August	9.03	11.0
15	1969 November	9.84	12.12
35	1974 April	8.53	10.59
12	1974 May	10.26	12.38
23	1974 August	9.45	11.86
9	1975 June	11.05	13.70
28	1976 January	9.26	11.20
32	1977 March	8.80	10.80

? Possible error in North Richmond gauge

NR No records available

Source Bureau of Meteorology