EA - South West Box 4

ENVIRONMENT AGENCY

Bath Sewer Overflow Study

NWI/99/159-b

Final Report
North Wessex Investigations Team

February 2000

SUMMARY

There has for many years been a problem of sewage debris along the banks of the River Avon. It is suspended in bankside vegetation and from overhanging trees downstream of Bath and is a justifiable source of complaint.

Two previous investigations had concluded that the majority of the sewage debris entered the river from CSO's between Pulteney Weir and Twerton Sluice. This survey's aim was to identify which CSO's performed badly along the River Avon and was executed with the full assistance of Wessex Water.

A number of CSO's were identified as problematical, one leading to remedial action by Wessex Water. The consequential improvement in the quantity of debris discharged lead to the conclusions that the maintenance program needs improving and storage capacity must be included within plans for upgrading the system.

CONTENTS

1.0 INTRODUCTION

For many years there has been a problem with sewage debris and litter along the banks of the River Avon downstream of Bath. The debris often becomes suspended in the bankside vegetation and from overhanging trees and many of the residents and users of the river find this justifiably objectionable.

During 1999 an aesthetics survey (report NWI/99/159-a) was carried out along the banks of the River Avon from Lam Brook upstream of Bath to Newbridge downstream. A site further downstream at Saltford was also monitored. The report concluded that the majority of the sewage debris found along the banks of the river originated from Combined Sewer Overflows (CSOs) in the Pulteney Weir to Twerton Sluice stretch. There were also indications of misconnections within the drainage system that were adding to the volume of debris entering the river.

Much of the sewage debris that was visible to users of the river was suspended high above the normal river flow height from over hanging trees and shrubs. This was particularly evident in the stretch of the river downstream of Twerton Sluice. There is less variation in river level above the sluice.

Much of the City Bath is built on steep valley sides close to the river, and heavy rain can quickly result in a large amount water entering the sewer system and overloading sewers that run along the riverside. During such storms debris is often discharged to the river along with excess sewage flows. But while the sewage is quickly diluted and carried away by high river flows, the debris gets caught in overhanging vegetation, and is left 'High and dry' when river levels fall again.

The aesthetics survey also highlighted a number of CSOs that appeared to be discharging during dry weather conditions, indicating problems in the construction of the CSO or the sewer itself.

A similar survey to this one was carried out by the North Wessex investigations team in 1995 (report NWI/95/9). Ten CSOs between the Kennet and Avon canal and Twerton Sluice were monitored and the report concluded that:-

1. Large amounts of debris(both sewage and litter) entered the river via CSOs, mainly during periods of high rainfall and
2. Some outfalls discharged sewage related debris and others produced more general litter.

The findings of the report were presented to Wessex Water with a view to prompting further investigations by them, leading to capital investment or increased maintenance of the system. Some of these outfalls were re-monitored in the current survey.

1.1 What is a CSO?

The provision of a sewerage system within the urban area has a two-fold effect on the natural drainage of that area. The natural permeation is reduced and the volume of run off increased, and the artificial surfaces and gulleys transfer run-off more swiftly, making drainage areas more vulnerable to short duration, high intensity storms, thereby increasing the risk of flooding.

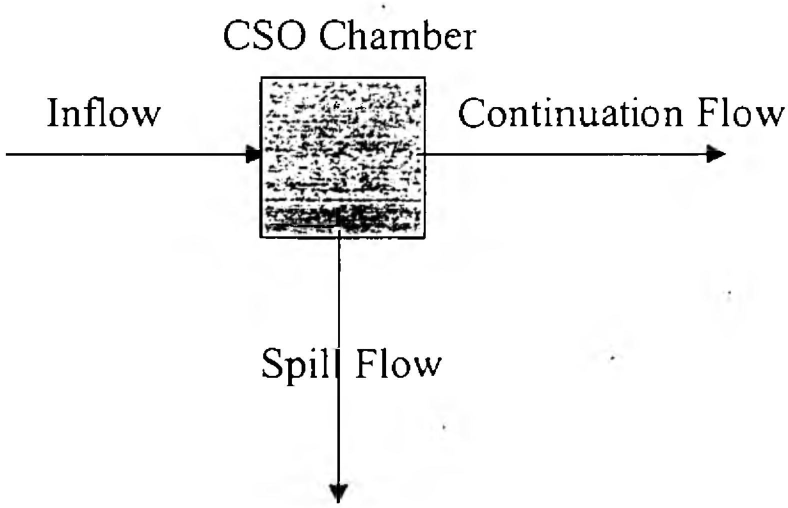
Urban areas also create wastewater from domestic and industrial usage, which mix with surface run-off and, if left untreated, will pollute watercourses. Approximately 70% of sewerage systems in Great Britain are combined, that is, they drain foul and surface water away from urban areas via a single pipe to a sewage treatment works. In newer urban developments, surface water is transported in a separate pipe direct to a receiving water and only the foul water goes for treatment. This system is vulnerable to misconnections into both pipe systems and these can negate some of its positive aspects.

Sewerage systems are designed to:-

Transport wastewater to a point of treatment and/or disposal,
drain paved areas,
protect receiving waters from pollution.

CSOs are designed to prevent surcharging of the sewerage system and flooding during periods of heavy rain. There are a number of different designs that can be used and a typical design usually consists of a weir type structure set into the side of the sewer channel. Under normal conditions the flow level within the sewer is well below the overspill point of the weir. When flow in the sewer increases to a level exceeding the height of the weir, due to for example, heavy rain entering the system via road gulleys, the CSO discharges. This discharge is a combination of sewage effluent and gulley water and will contain sewage solids and litter from the kerbside, washed down into the system by the rain.

Fig 1 A typical example of an On-line layout CSO.



Formula A is currently used in contemporary CSO design and is based on
Dry Weather Flow + 1350 Population + 2 Industrial Effluent litres/day. At present the CSO is an integral part of the sewerage system and is likely to remain so for a number of years.

1.1.1 Pollution Problems Related With CSOs

The spillage from a CSO contains a mixture of domestic sewage and industrial effluent which may be diluted by surface run-off. The surface run-off itself contains oil, grit and suspended solids. Pollutants contained within the CSO discharge deplete the oxygen concentration in the receiving water when micro-organisms feed on carbon compounds in the effluent and consume dissolved oxygen (this is known as the BOD – the Biochemical Oxygen Demand).

Nutrients released into the river can cause eutrophication, which can lead to the excessive growth of algae and undesirable plants. The Avon has been designated as a Sensitive Area (eutrophic) under the Urban Waste Water Treatment in recognition of the impact that discharges from large STW's have on the river's ecology.

Gross solids discharged from CSOs contain a large concentration of sewage based items which lead to aesthetic problems and complaints from members of the public.

CSOs may discharge before flows in the receiving water have begun to increase and thus increase the concentration of pollutants in the watercourse. Frequent discharges from CSOs can be tackled in a number of ways, and these will be covered later in the report.

2.0 AIMS AND OBJECTIVES

The primary aim of this survey was to monitor a number of specific CSOs that have been identified from the previous aesthetic survey or by the Agency as potentially contributing to the problem of sewage debris and litter within the River Avon.

The intention was to identify which CSOs performed badly and/or discharged during dry weather, and to quantify the amount and nature of debris discharged from each under a variety of weather conditions.

3.0 METHODS

Eight sites were chosen for monitoring.

1. London Road West (Lambridge). Approx 100 metres downstream Batheaston Bypass bridge.
2. Norfolk Crescent. North bank immediately below end of Norfolk Crescent.
3. Twerton Storm Tanks. Immediately upstream of Midland Road bridge on south bank.
4. Windsor Villas Upstream. Adjacent to Windsor Villas set in concrete wall on north bank.
5. Windsor Villas Downstream. Adjacent to Windsor Villas set in stone gabion on north bank.
6. Locksbrook Overflow. 10 yards downstream of Windsor Villas.
7. The Shallows, Saltford. Downstream end of Shallows picnic area.
8. Saltford Sewage Treatment Works. Final chamber within the STW.

An outfall at the back of the London Road bus depot was also considered for monitoring, but was found to be impracticable because of access issues. Safeway Supermarkets also developed this site during the summer of the survey.

All of the sites were CSOs except Twerton storm tanks, which were monitored on an unscreened overspill channel at the storm overflow; The Shallows, which was a storm overflow for a sewage pumping station; and Locksbrook overflow, which was a relief channel for the culverted section of the Locksbrook.

Once the project was started another potential source of debris was identified at The Shallows, Saltford. This was a stream that entered the River Avon twenty metres upstream of the old railway bridge, now part of the Bitton-Bath cycle route.

Because of the differing nature of each outfall, screens were designed for each site individually.

London Road West (Lambridge). One metre square heavy duty wooden frame with one inch netting fixed between, fitted at a shallow angle below the outfall pipe using cables fixed to header wall (see photo).
Norfolk Crescent. Sixty centimetre Square frame, with one inch netting forming a long 'sock' which was clamped at the end to allow access. Bolted to header wall allowing unhindered operation of flap on outfall (see photo).
Twerton Storm Tanks. Wooden frame fixed over the exit of the unscreened channel, a wire mesh six centimetres apart on the vertical was created with much wider horizontal spacing only for support (see photo).
Windsor Villas Upstream. Sixty centimetre square frame, with one inch netting forming a closed bag. This was suspended from railings above the pipe and held in place using a heavy weight in the river below the pipe.
Windsor Villas Downstream. Sixty centimetre square frame, with one inch netting forming a long 'sock' clamped to allow access. Fixed over the entire end of the pipe.
Locksbrook Overflow. Heavy duty wooden frame fitted to bottom half of security screen at end of pipe again using 'sock' and clamp to catch debris (see photo).
The Shallows, Saltford. Wooden frame and 'sock' fitted over the entire overflow (see photo).
Stream, The Shallows, Saltford. Strong wooden frame with one inch netting suspended between, hung from metal pilings in stream flow.
Saltford Sewage Treatment Works. A heavy metal grill was suspended over the outlet pipe by Wessex Water staff.

These screens were designed to capture debris and gross solids discharging from the CSOs.

Visits were made on a regular basis to remove, quantify and categorise accumulated debris which was then divided into the following categories:-
Condoms
Sanitary Products (Sanitary towels and Tampons)
Cotton Buds
Plastics (non sewage related)
Bio-degradable

Wessex Water supplied flow data for CSOs and rainfall data from three sites.

4.0 RESULTS

The results are shown in **APPENDIX II**

For some sites, bio-degradable items were estimated as this material tends to form into a mash within the screen, making accurate quantification difficult.

4.1 London Road West (Lambridge)

The screen was installed at this site in early June. It is a relatively new CSO that has a small watercourse discharging through it. There was evidence of sewage debris on the concrete and stone spillway.

The screen remained clear of debris until rain at the end of June, when heavy debris deposits were found along with a number of large stones that appeared to have dropped out from the sewer. Individual stones had been found previously and continued to be discharged until Wessex Water found that a sump in the sewer had been left filled with stones by contractors. These were removed and it was hoped that the CSOs performance would improve.

During July the screen remained clear of debris. In August there was considerable rainfall and the screen trapped a substantial amount of debris. Towards the end of September there was again considerable rainfall and the river level rose to partially submerge the screen. When river levels returned to normal the screen had been blinded with a mash of bio-degradable material both sewage and natural based. Sanitary towels were stranded in the spillway and on the bank around the CSO.

Comparisons between flow and rainfall data illustrated that this CSO was prone to discharge after relatively small amounts of rain (13 mm peak) and during flash showers.

Table 1 Debris found at London Road West (Lambridge)

Date	Condoms	Sanitary Products	Cotton Buds	Bio-degradable	Plastic
30 June	-	20+	2	50+	6
13 August	2	25	5	75+	15
30 August	-	18	2	75+	12
18 September	-	12	2	35	-

4.2 Norfolk Crescent

This site is known to discharge frequently and this was confirmed by the considerable amount of debris that was found to be associated with this CSO during the initial aesthetics study.

The screen was fitted towards the end of May but this was ripped out of the wall by the storms on 27/29 May. The screen was found on the bank opposite Windsor Villas, full of debris from the CSO. It appeared that the netting had blinded with debris and that hydraulic pressure had caused it to detach from it's fixings on the header wall.

The screen was replaced and longer bolts used to fix it to the wall. Although June and July were seasonally dry, considerable amounts of debris were found in the screen. On more than one occasion the volume of debris rendered it impossible to quantify the contents of the screen. On 21 July Environment Protection staff tripartite sampled the CSO when it was found to be discharging in dry weather. Within three weeks the pipe had been bunged and contractors brought in to jet the sewer. This is a process where sediment that has built up within the sewer pipe is removed and the pipe restored to its designed capacity.

Once this work had been completed the CSO's performance improved dramatically. Some light bio-degradable debris was found in mid September after a period of rain then nothing further until after the very heavy rain over the Christmas period when the river was in spate. When the river level lowered, the screen netting was left buried under a large amount of silt. When the contents were removed from the screen they were found to consist almost entirely of leaves.

Flow monitoring restarted during October and indicated that the CSO only discharged during periods of rain.

Table 2 Debris found at Norfolk Crescent

Date	Condom	Sanitary Products	Cotton Buds	Bio-degradable	Plastic
22 June	-	25	3	100+	20
30 June	1	15	1	100+	13
20 July	-	5	-	6	4
23 July	-	12	3	75+	15
24 September	-	-	-	3	-

4.3 Twerton Storm Tanks

The screen at Twerton Storm Tanks was positioned so it would catch any unscreened material that entered the overspill channel during periods of high flow at the storm discharge. It appears that this happens rarely. In the period between the end of May and the beginning of January 2000 only two light deposits of debris were recorded.

Whilst the screen was being inspected it was noted that there was a large amount of sewage debris suspended from the back of the mechanical screen in the storm overflow.

4.4 Windsor Villas Upstream

This site proved difficult to monitor and the results were under-representative of the amount of material the CSO discharged. The problem being that the hydraulic pressure pushed the screen out of the way despite it being secured by a heavy weight on the bed of the river. The force of the flow was so strong on occasions that it tore the jointed frame apart.

The CSO discharges from a concrete wall on the bank of the river. The concrete below the outfall was covered in a thick fat layer that had dribbled from the CSO over a period of time.

Flow monitoring confirmed that this CSO discharged during periods of dry weather and short duration low total rain events.

Table 3 Debris found at Windsor Villas Upstream

Date	Condom	Sanitary Products	Cotton Buds	Bio-degradable	Plastic
30 June	-	1	-	3	1
20 July	-	5	1	8	3
13 August	-	5	3	1	11
30 August	-	2	-	4	2

Local residents commented that this CSO often discharged large amounts of sewage to the river during wet and dry weather conditions.

4.5 Windsor Villas Downstream

From the aesthetic survey it was evident that this CSO discharged during dry weather flow conditions. The outfall is set into stone gabions, beneath which is an area of concrete sloping into the water. Some vegetation has established itself in this concrete and there was a considerable amount of sewage material entangled with this vegetation. There was also staining on the concrete leading from the pipe.

The screen was fitted two days before the storms on 27/29 May and was destroyed by the force of hydraulic pressure from the CSO that followed the rain. The screen was replaced in early June.

The screen trapped considerable amounts of what appeared to be entirely sewage based debris throughout the long dry period in June and July (see photos). On many occasions there was too much material to itemise and there was always faecal material among the debris.

The table below gives an idea of the quantity of material that this CSO was discharging, though it only shows results from the dates where itemisation was possible. On other days there was too much debris to itemise.

Table 4 Debris found at Windsor Villas Downstream

Date	Condoms	Sanitary Products	Cotton Buds	Bio-degradable	Plastics
22 June	-	21	3	100+	12
06 July	-	12	1	50+	14
20 July	-	16	2	100+	8
13 August	-	28	-	125	25

4.6 Locksbrook Outfall

For most of its length, the Locksbrook is culverted. In order to reduce the risk of flooding, an overflow pipe that discharges just downstream of Windsor Villas has been built into the system. This pipe is also fitted with an overflow for times of extreme flow. The outfall end of each pipe is fitted with a security grill to prevent unwanted entry.

The Locksbrook is believed to have a number of inappropriately operating CSOs misconnections discharging into it, and the aesthetic survey confirmed that there was a large amount of sewage debris among the litter caught around the security grills.

A screen was fitted over the bottom half of the security grill on the overflow pipe after the litter and debris already present was removed on 24 May.

On 27 and 29 May there were severe storms which peaked at 132 mm/h during 29 May. The flow through the pipe was so great that the screen was destroyed. However, a considerable amount of debris remained trapped on the security grill (see photo). A new screen was installed on 4 June.

During the remainder of June and July there was very little rain and the screen remained clean. On 20 July it was discovered that the screen had been stolen. It was replaced again using a simpler design of open wire mesh, similar to the one at Twerton, in time for a wet spell at the beginning of August. On 9 August the site was visited as it started to rain. The overflow pipe was found to be discharging and there was a large amount of debris trapped on the wire. This material was counted when the screen was visited on 13 August. A large amount of the material found was of non-sewage origin, ie leaves, general litter, etc although there was a variety of sewage debris, sanitary products and bio-degradable material mixed among the litter.

The screen remained clean until 27 October when light deposits of tissue where found entangled in the wires along with some leaves. This was despite there being some heavy rain in the intervening period.

4.7 The Shallows, Saltford

The Shallows Pumping Station overflow was monitored because sewage debris had been observed in the bankside vegetation immediately downstream of the outfall. The source of this debris was unknown and monitoring of the outfall was intended to confirm whether it was discharged from the pumping station or originated upstream.

The screen was fitted to the outfall in mid June and removed in early September.

No debris was found in the screen until the week beginning 9 August when a moderate amount of debris (both sewage and non-sewage based) was found. It appeared that the clamp closing the bag had been tampered with so there may have been more debris than was quantified. This discharge relates to a rain event that peaked at 42 mm/h in the Saltford area on 8 August. Amongst the debris was the remains of a substantial fat ball.

More debris was found at the beginning of September when the screen was removed. It was again a mixture of sewage and of non-sewage origin and could be related to a rainfall event on 24-25 August which peaked at 36 mm/h in the Saltford area. Again the clamp had been removed, so some trapped debris may have been lost.

Flow data indicated that the overflow discharged more often than the debris found alluded to, though it was always associated with rainfall.

Table 5 Debris found at The Shallows, Saltford

Date	Condoms	Sanitary Products	Cotton Buds	Bio-degradable	Non-sewage Plastics
9 August	4	13	18	20	7
1 September	2	7	4	18	14

4.8 Stream, The Shallows, Saltford

This site was added to the project after members of the public identified it as a source of sewage debris discharged into the river. The screen was placed in the flow of the stream towards the end of June.

The screen trapped a small amount of material following rainfall on 28/29 June, most of which was sewage-based including a bag of what appeared to be drug-related material. The screen remained clear during the dry period of July. The screen was destroyed before the next rain event in early August. The screen was not replaced as it was considered to vulnerable to the attention of vandals.

4.9 Saltford Sewage Treatment Works

This site was monitored to confirm that it was not the cause of any debris pollution of the river. It was not considered to be a problem but its proximity to the length of the River Avon that suffers from the greatest quantity of sewage debris made it a prudent site to eliminate from subsequent studies.

During monitoring at this site, no debris was deposited in the screen, which was unsurprising given that the effluent had passed through the STW.

5.0 DISCUSSION

The survey confirmed that large quantities of debris, mainly of sewage origin, enter the River Avon from CSOs through Bath, including from some of those investigated.

Three of the CSOs surveyed were found to discharge during dry weather. These were Norfolk Crescent, Windsor Villas upstream and Windsor Villas downstream. Considerable amounts of debris were recovered from the Norfolk Crescent and Windsor Villas downstream sites. Problems already mentioned prevented comprehensive results being obtained at the Windsor Villas upstream site, but Wessex Water's own flow data and local residents accounts indicated that this CSO discharged during dry weather conditions.

The Norfolk Crescent site was very poor until Wessex Water were threatened with legal action, when maintenance work was initiated to clean the sewer and remove silt build-up from the pipe. This action drastically improved the operation of the CSO with little debris being released to the river after this maintenance work. Wessex Water's flow data indicated that the CSO had discharged during periods of moderate to heavy rain but no sewage debris was found in the screen. It could be concluded from this that a lack of maintenance was a considerable factor in the number of discharges that have occurred at this CSO, and possibly at others in the system.

The site at Windsor Villas downstream was another very poor quality CSO, the pipe itself being very poorly maintained. The discharge contained a very high concentration of sewage debris and was clearly visible to users of the towpath as it discharged onto concrete banking before entering the river. There was an indication from Wessex Water that this CSO should have been sealed up previously.

The remainder of the sites monitored discharged during periods of rainfall but appeared to perform satisfactorily during dry weather.

Wessex Water's own flow data indicates that the London Road West CSO at Lambridge discharged more frequently than any of the other CSOs studied. By comparing the flow data with rainfall it was apparent that this CSO can discharge after only small amounts of rain (approx 13 mm) or during flash showers. The frequency of the discharges did not appear to diminish after stones had been removed from the sump of the CSO. When the CSO discharged the deposits of debris were relatively heavy and predominantly sewage-based.

The screen at Twerton Storm Tanks indicated that the unscreened channel of the overflow was rarely used, suggesting that the main screened overflow channel is adequate to deal with all but the most exceptional of conditions. However, an inspection of the rear of the screen on the main channel identified that a fair amount of gross solids had passed through the screen.

The Locksbrook overflow initially discharged considerable amounts of debris, of both sewage and non-sewage origin, but as the investigation continued the frequency and volume discharged appeared to tail off. The nature of the debris also changed from mainly sewage-based to predominantly run-off based. The reason for this is not clear but it may indicate remedial work had been carried out further up in the Locksbrook catchment. Debris caught in the second overflow pipe remained in place for the entire period of the survey identifying a lack of maintenance in this part of the system.

The screen at The Shallows Sewage Pumping Station storm overflow only trapped debris after significant rainfall. The discharge appeared to contain few solids, although the screens had been tampered with before each spillage, so it was difficult to say whether this was the full quantity discharged. Flow figures indicated that only small volumes were discharged.

The screen placed across the mouth of the stream that enters the River Avon at Saltford gave an indication that there was a misconnection problem associated with this watercourse but the screen was vandalised before a true picture could be gained. Local residents implied that this stream was capable of discharging considerable amounts of debris into the river. Further investigations would be needed to identify the locations of the misconnections.

During a period of heavy showers on 9 August the majority of the CSOs along the River Avon through Bath were seen to be discharging, many of which had sewage debris clearly visible in the discharge.

This survey only dealt with the gross solids content of the discharges and did not try to quantify their localised or long-term chemical or biological impacts.

The performance of the CSOs in the Bath sewerage system could be improved if a number of actions were taken :-

a. The existing sewerage system should be subject to a more frequent pattern of maintenance, to prevent the build up of silt and debris within sewer pipes; which reduce their capacity.
b. The capacity of the system should be increased by the usage of storage tanks, either on or off-line.
c. Where possible, new sewers should be laid to take surface water out of the foul sewerage system and direct to watercourse, so reducing the volume of water entering the foul system during periods of rain. It is understood that this is an expensive option and liable to cause disruption.
d. Older designs of CSOs should be replaced with newer, more efficient designs to keep suspended material within the continuation flow by using expanded chambers and scum and baffle boards.

Less gross solids would be discharged from CSOs if members of the public took more care over their disposal of items down the toilet.

6.0 CONCLUSIONS

The survey of the nine overflows and watercourses confirmed that large quantities of debris reach the River Avon from these and similar sources.

Three of the CSOs investigated discharged during dry weather conditions. At least two of these discharged very large amounts of sewage-related debris.

Remedial work carried out on the Norfolk Crescent section of sewer had an immediate and dramatic effect on the performance of the CSO. After the work was completed the CSO discharged only in extreme conditions with very little debris reaching the river.

The CSO at London Road West, Lambridge discharged after small amounts of rainfall or during flash shower events. On occasions, it was found to discharge considerable amounts of sewage-related debris.

The outfalls at Saltford STW, The Shallows Pumping Station and Twerton Unscreened Storm appeared to work satisfactorily. The Shallows only discharged after prolonged heavy rainfall.

Though the unscreened storm channel at Twerton rarely operated during this study, debris appeared to enter the river by passing through the screen on the screened channel.

Foul water appears to enter the culverted section of the Locksbrook Watercourse and the stream entering the River Avon near the Shallows, Saltford. This contaminated is likely to arise from either misconnections or the operation of CSOs further up these systems.

Many of the events described in this report could have been prevented or the impact reduced if the sewers and CSOs had been subject to a stringent programme of maintenance. The Agency would prefer the problems to be prevented rather than be resolved only after a threat of legal action.

An increase in the effective capacity of the system, via the introduction of storage tanks or the reduction of run-off entering the foul sewers, would greatly enhance the performance of the sewerage system in Bath.

7.0 RECOMMENDATIONS

7.1 Work must be carried out urgently on the sewers connected to the CSOs that discharge during dry weather conditions (London Road West, Windsor Villas Upstream and Windsor Villas downstream) regardless of long term plans for the system.

7.2 The period of time that elapses between sewer cleaning or jetting should be monitored closely and a flexible approach adopted to prevent unnecessary discharges from CSOs to the River Avon.

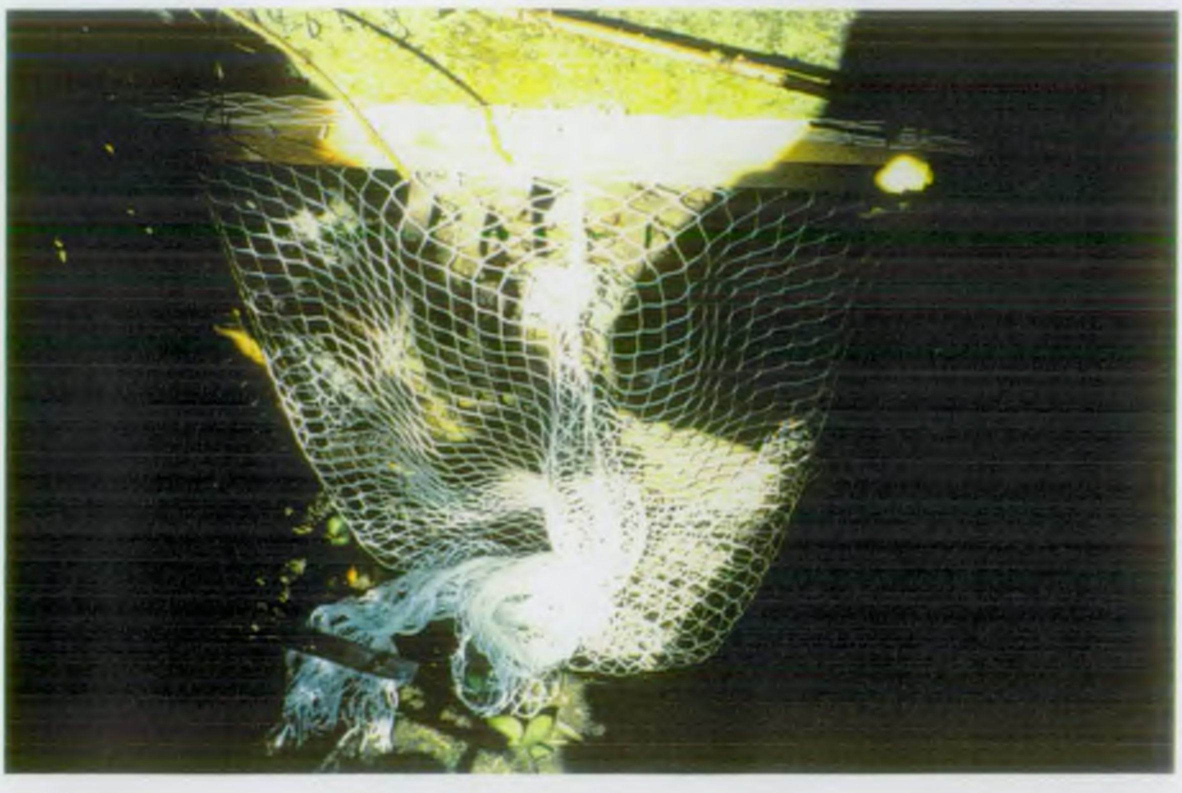
7.3 The capacity of the sewer system should be increased by the use of storage tanks to relieve the pressure on the foul sewerage system during periods of rain.

7.4 Foul water entering the Locksbrook and Saltford watercourses should be traced and redirected to the foul sewerage system.

APPENDIX I **Photographs of CSOs, screens and debris caught within screens**

London Road West, Lambridge
Screen in-situ below CSO. →

Norfolk Crescent
Screen in-situ over CSO. ↓

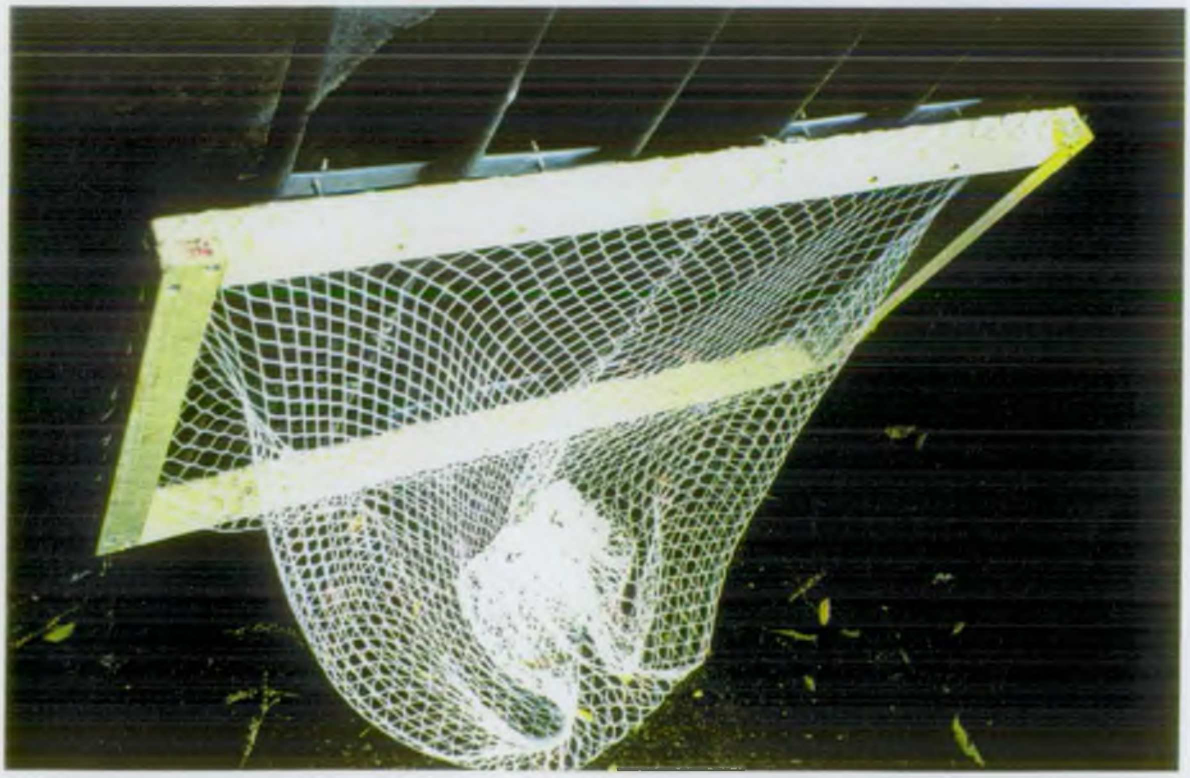


Twerton Storm Unscreened
Bypass Channel
Screen in-situ. ↑

The Shallows, Saltford
Screen in-situ. →

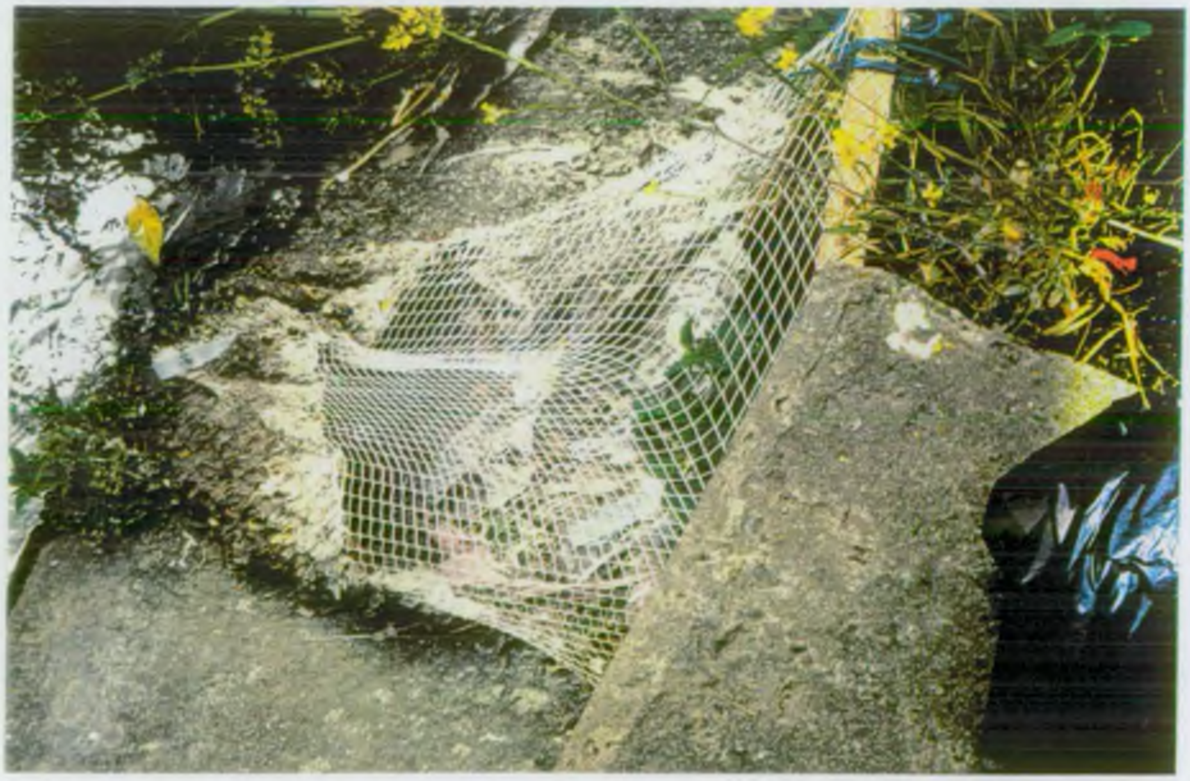
Locksbrook Overflow
Sewage debris and litter
caught behind security screen. →

Locksbrook Overflow
Screen in-situ. ↓



Windsor Villas Upstream
Discharging on 9 August. ↑→

Windsor Villas Downstream
Collected debris different events.
↑ ↓



London Road West, Lambridge
Debris caught in screen. ↑

London Road West, Lambridge
Sewage debris caught in spillway. ↓

APPENDIX II   Comparison of rainfall data with flow and debris data.

London Road West (Lambridge)

Sewer Overflow					Rain			
Date	**Start Time**	**Duration**	**Peak Spill**	**Volume**	**Duration**	**Peak**	**Debris**	**Debris**
		(mins)	**Rate (l/s)**	**(M^3)**	**(approx mins)**	**(mm)**	**Sewage Based**	**Non Sewage**
27-May	21:50	180	56	252	-	-	-	-
29-May	13:45	255	92	932	-	-	-	-
01-Jun	00:00	480	82	542	-	-	-	-
05-Jun	14:15	405	31	613	180	18	-	-
29-Jun	04:20	340	59	917	300	18	72+	6
04-Aug	22:00	120	47	321	240	24	-	-
06-Aug	21:30	180	26	184	420	13.3	-	-
08-Aug	10:00	2760	139	2645	630	120	-	-
11-Aug	22:00	120	30	-	330	5.3	107+	15
18-Aug	09:00	20	1	1	180	18	-	-
24-Aug	08:45	105	29	71	360	3	-	-
24-Aug	23:00	150	58	339	120	23	-	-
25-Aug	13:00	240	63	642	180	30	95+	12
16-Sep	08:15	120	45	251	180	24	-	-
18-Sep	18:45	315	41	529	1470	30	14	35
19-Sep	03:30	360	64	637	1470	48	-	-
23-Sep	02:30	60	25	42	60	24	-	-
24-Sep	15:30	60	28	70	60	36	-	-
26-Sep	20:30	330	87	955	330	12	-	-
29-Sep	15:00	120	43	176	360	48	-	-
02-Oct	04:15	135	28	160	210	30	-	-
21-Oct	19:30	120	50	300	120	12	-	-
24-Oct	05:30	870	70	1998	180	12	-	-
30-Oct	14:30	60	28	61	60	54	-	-
05-Nov	09:00	900	74	1970	510	60	-	-
26-Nov	02:15	45	28	51	120	18	-	-
28-Nov	22:30	240	22	177	360	12	-	-

Norfolk Crescent

Sewer Overflow					Rain			
Date	Start Time	Duration	Peak Spill	Volume	Duration	Peak	Debris	Debris
		(mins)	Rate (l/s)	(M^3)	(approx mins)	(mm)	Sewage Based	Non Sewage
27-May	21:35	110	56	94	60	100	-	-
29-May	13:45	255	147	218	180	132	-	-
02-Jun	02:45	195	15	31	390	42	-	-
05-Jun	13:45	135	13	38	360	10	-	-
05-Jun	17:45	120	9	28	360	10	128+	20
29-Jun	03:30	390	16	123	-	-	117+	13
05-Jul	17:00	60	3	5	150	48	-	-
20-Jul	07:00	30	8	10	30	18	11	4
21-Jul	11:30	720	4	56	-	-	90+	15
24-Sep	-	-	-	-	-	-	3	-
21-Oct	19:15	105	6	19	120	12	-	-
24-Oct	05:30	180	8	45	210	12	-	-
24-Oct	11:45	210	8	47	180	12	-	-
05-Nov	11:30	60	33	33	510	36	-	-
28-Nov	22:00	210	5	43	600	12	-	-

Windsor Villas Upstream

Sewer Overflow					Rain			
Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)	Duration (approx mins)	Peak (mm)	Debris Sewage Based	Debris Non Sewage
27-May	21:35	120	117	402	60	100		
29-May	14:30	60	106	58	120	132		
05-Jun	13:30	630	85	936	360	12		
28-Jun	05:00	60	32	47	-	-		
29-Jun	03:30	480	94	1268	-	-		
30-Jun	-	-	-	-	-	-	4	1
05-Jul	15:00	120	81	397	120	48		
20-Jul	06:00	30	7	6	30	18	14	3
04-Aug	21:00	120	33	107	120	6		
06-Aug	20:15	345	46	242	420	6		
08-Aug	09:30	270	95	801	180	30		
08-Aug	16:00	2880	124	7091	240	114		
13 Aug	-	-	-	-	-	-	9	11

The Shallows PS, Saltford

Sewer Overflow					Rain			
Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)	Duration (approx mins)	Peak (mm)	Debris Sewage Based	Debris Non Sewage
27-May	21:30	30	5	3	60	108	-	-
29-May	13:40	20	6	3	180	95	-	-
28-Jun	04:00	300	-	-	120	12	-	-
29-Jun	01:00	660	-	-	900	12	-	-
06-Aug	20:30	390	-	-	540	5	-	-
08-Aug	09:45	240	-	-	180	30	-	-
08-Aug	16:00	270	8	16	300	114	-	-
09-Aug	12:20	100	-	-	300	24	55	7
18-Aug	08:00	180	-	-	30	18	-	-
24-Aug	22:00	240	-	-	120	30	-	-
25-Aug	12:00	180	-	-	120	36	-	-
01-Sep	-	-	-	-	-	-	31	14

APPENDIX III Wessex Water CSO flow data

Bath Pollution Prevention - CSO Monitoring

Overflow Events 17th May - 30th November 1999

Site 2 - Windsor Bridge Road - Monitoring Stopped 7/9/99

Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)
27-May	21:35	120	117	402
29-May	14:30	60	106	58
05-Jun	13:30	630	85	936
28-Jun	05:00	60	32	47
29-Jun	03:30	480	94	1268
05-Jul	15:00	120	81	397
20-Jul	06:00	30	7	6
04-Aug	21:00	120	33	107
06-Aug	20:15	345	46	242
08-Aug	09:30	270	95	801
08-Aug	16:00	2880	124	7091

Site 7 - Norfolk Crescent - Monitor Removed 13/8/99 - Re installed 15/10/99

Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)
27-May	21:35	110	56	94
29-May	13:45	255	147	218
02-Jun	02:45	195	15	31
05-Jun	13:45	135	13	38
05-Jun	17:45	120	9	28
29-Jun	03:30	390	16	123
05-Jul	17:00	60	3	5
20-Jul	07:00	30	8	10
21-Jul	11:30	720	4	56
21-Oct	19:15	105	6	19
24-Oct	05:30	180	8	45
24-Oct	11:45	210	8	47
05-Nov	11:30	60	33	33
28-Nov	22:00	210	5	43

Site 8 - Norfolk Buildings - (Unable To Install Due To Jetting)

Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)
-	-	-	-	-
-	-	-	-	-

Overflow Events 17th May - 30th November 1999

Site 24 - The Shallows PS Saltford - Monitoring Stopped 7/9/99

Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)
27-May	21:30	30	5	3
29-May	13:40	20	6	3
28-Jun	04:00	300	-	-
29-Jun	01:00	660	0	0
06-Aug	20:30	390	-	-
08-Aug	09:45	240	-	-
08-Aug	16:00	270	8	16
09-Aug	12:20	100	-	-
18-Aug	08:00	180	-	-
24-Aug	22:00	240	-	-
25-Aug	12:00	180	-	-

Site 25 - Widcombe Baptist Church - Monitor Installed 7/9/99

Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)
16-Sep	19:45	30	51	31
19-Sep	03:15	60	143	149
24-Sep	14:45	15	125	21
05-Nov	11:30	30	202	244

Site 27 - London Road West (Lambridge)

Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)
27-May	21:50	180	56	252
29-May	13:45	255	92	932
01-Jun	00:00	480	82	542
05-Jun	14:15	405	31	613
29-Jun	04:20	340	59	917
04-Aug	22:00	120	47	321
06-Aug	21:30	180	26	184
08-Aug	10:00	2760	139	2645
11-Aug	22:00	120	30	-
18-Aug	09:00	20	1	1
24-Aug	08:45	105	29	71
24-Aug	23:00	150	58	339
25-Aug	13:00	240	63	642
16-Sep	08:15	120	45	251
18-Sep	18:45	315	41	529
19-Sep	03:30	360	64	637
23-Sep	02:30	60	25	42
24-Sep	15:30	60	28	70
26-Sep	20:30	330	87	955
29-Sep	15:00	120	43	176
02-Oct	04:15	135	28	160
21-Oct	19:30	120	50	300
24-Oct	05:30	870	70	1998
30-Oct	14:30	60	28	61
05-Nov	09:00	900	74	1970
26-Nov	02:15	45	28	51
28-Nov	22:30	240	22	177

Overflow Events 17th May - 30th November 1999

Site 28 - London Road Bus Depot

Date	Start Time	Duration (mins)	Peak Spill Rate (l/s)	Volume (M^3)
08-Aug	18:15	45	-	-
-	-	-	-	-

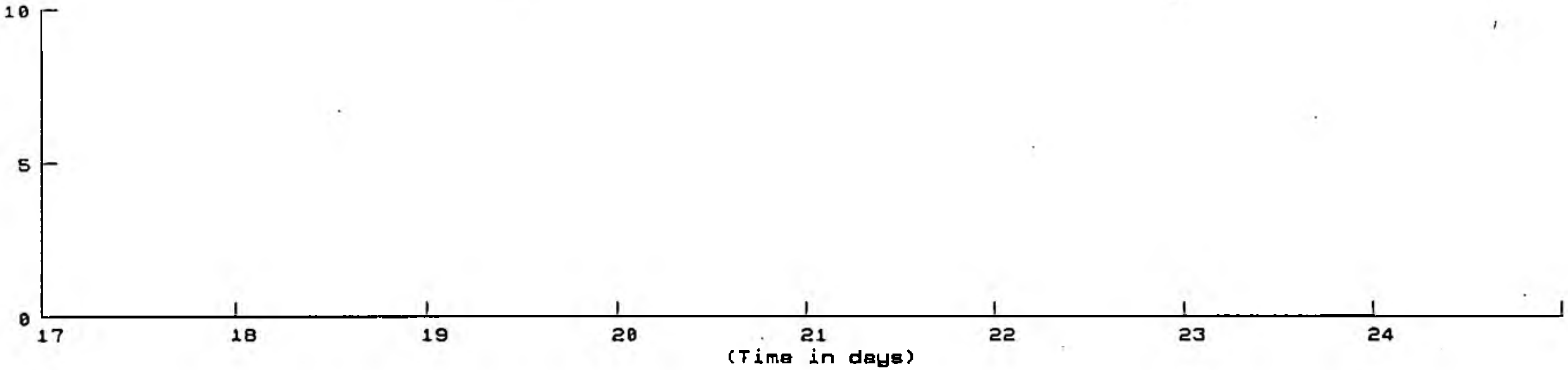
Site 30 - Twerton Storm Tanks (Screen Alarm) - Monitoring Stopped 1/9/99

Date	Start Time	Duration (mins)
29-May	20:42	23
29-May	23:06	191
02-Jun	03:30	143
02-Jun	08:54	215
02-Jun	14:54	95
05-Jun	19:18	23
29-Jun	07:06	12
29-Jun	12:06	24
08-Aug	14:10	110
09-Aug	02:10	170
09-Aug	17:35	25
10-Aug	00:25	230
10-Aug	12:30	180
25-Aug	17:30	35
26-Aug	03:00	155

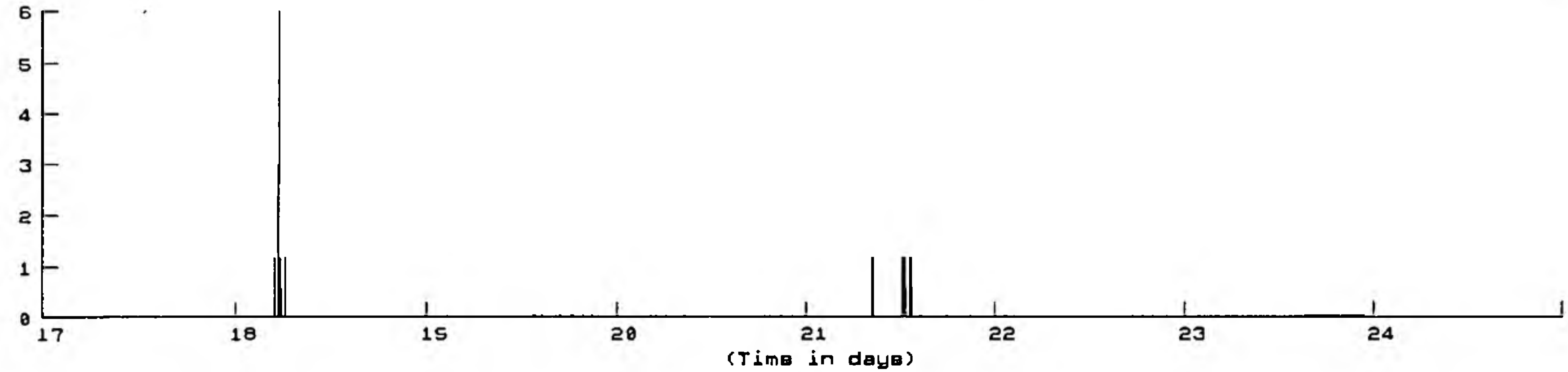
APPENDIX IV Wessex Water rainfall data

BATH POLLUTION STUDY

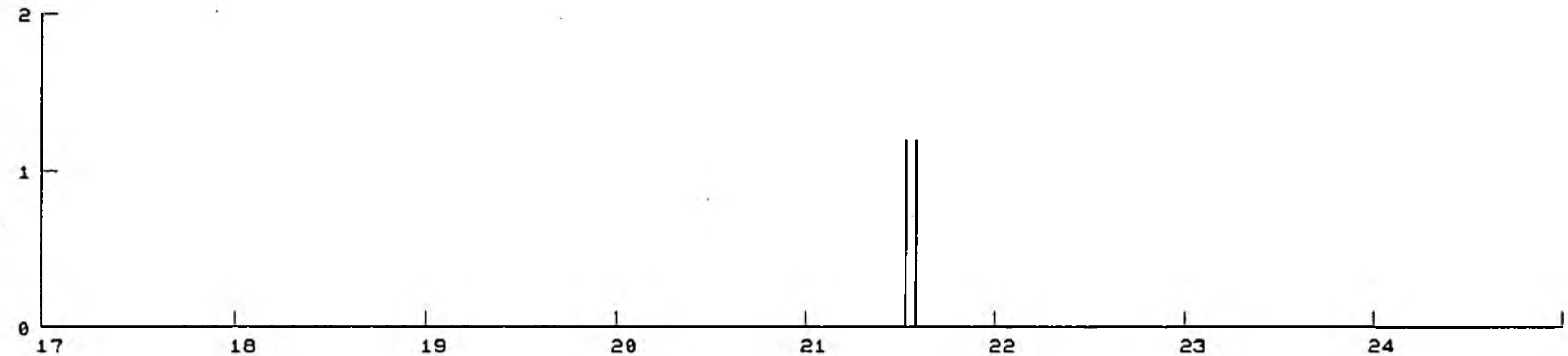
RAINFALL (mm/h) [RG 001]   Total rain =   0.0 mm   Peak =   0.0



RAINFALL (mm/h) [RG 002]   Total rain =   1.8 mm   Peak =   6.0

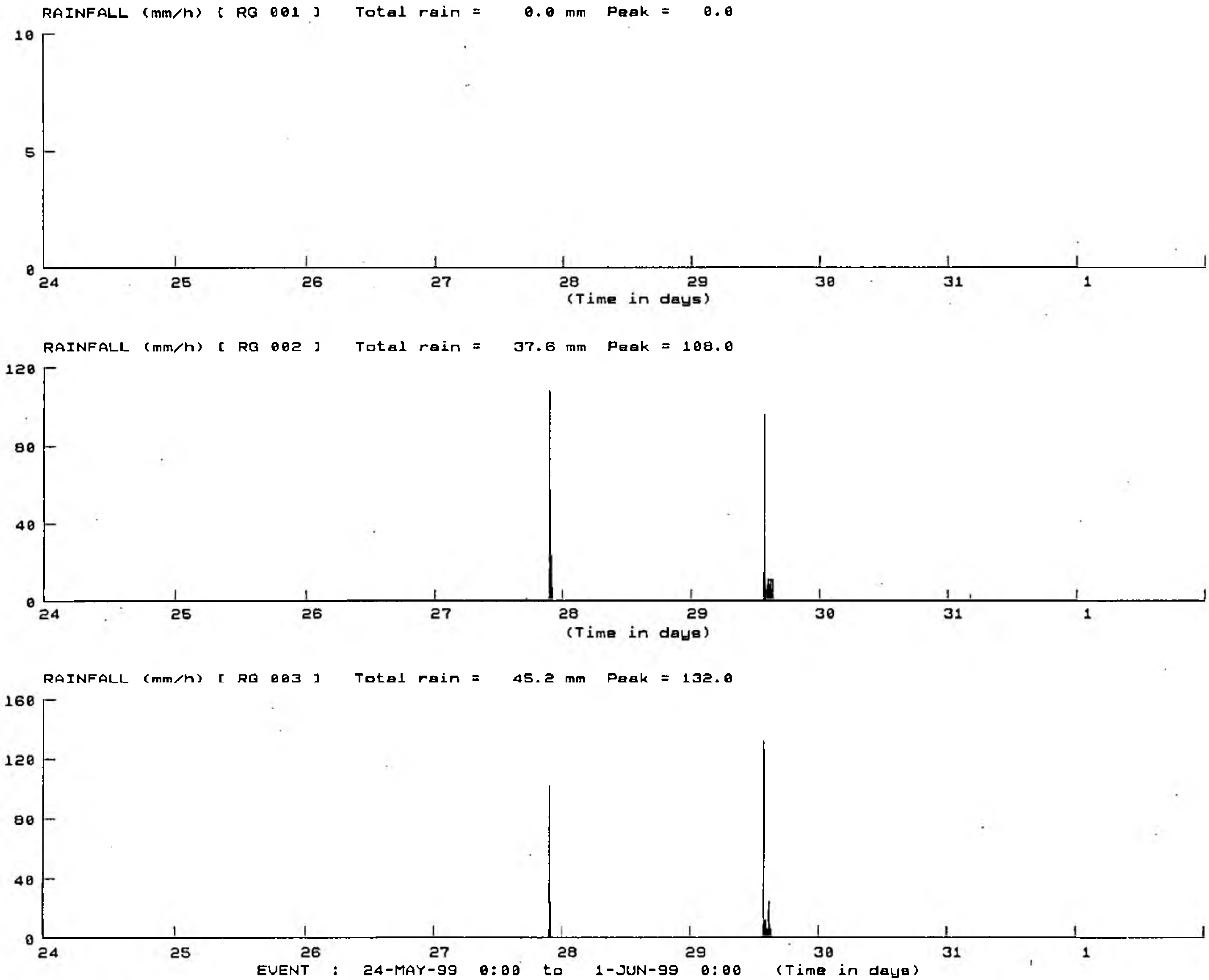


RAINFALL (mm/h) [RG 003]   Total rain =   0.4 mm   Peak =   1.2

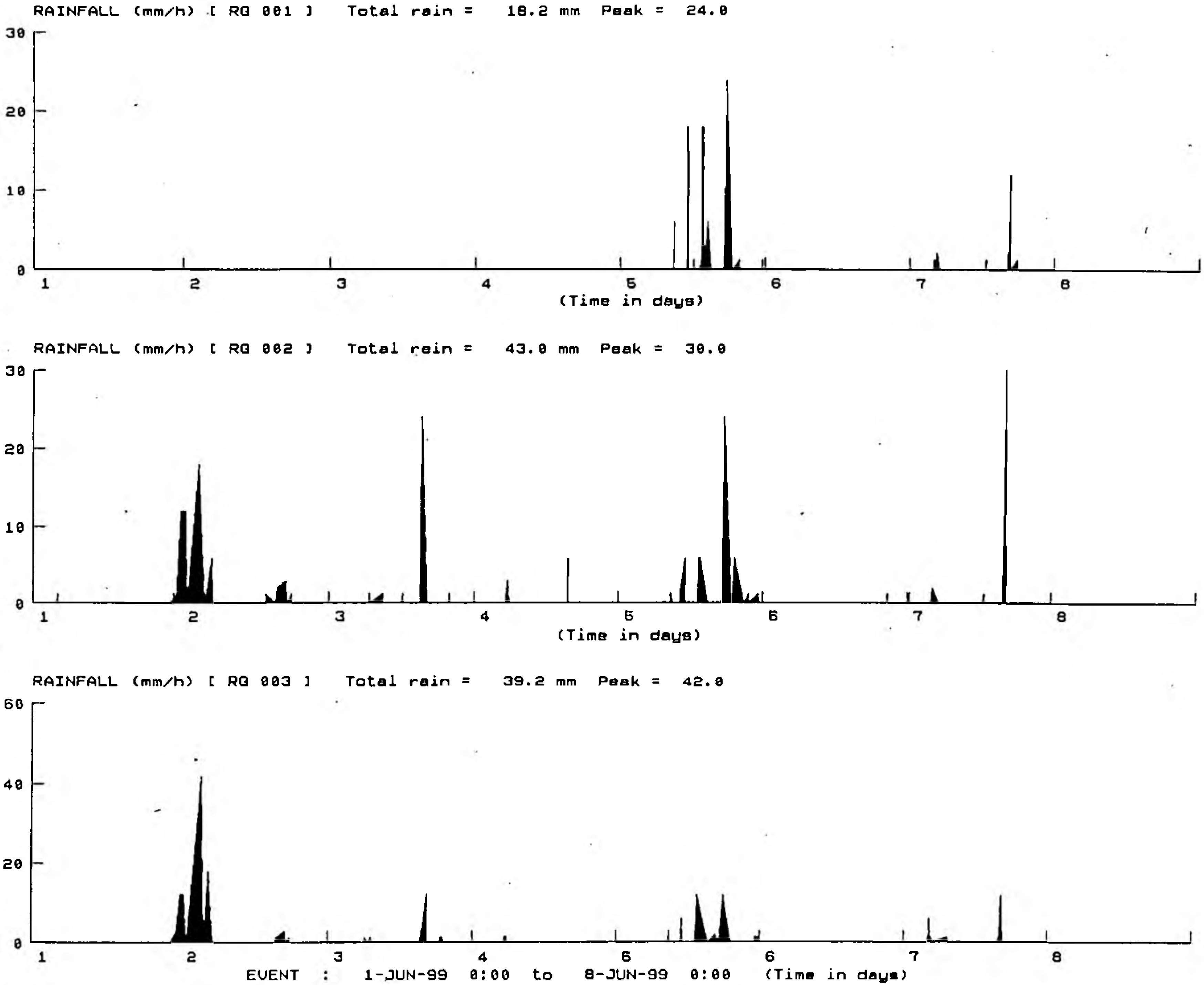


EVENT : 17-MAY-99 0:02 to 24-MAY-99 0:00 (Time in days)

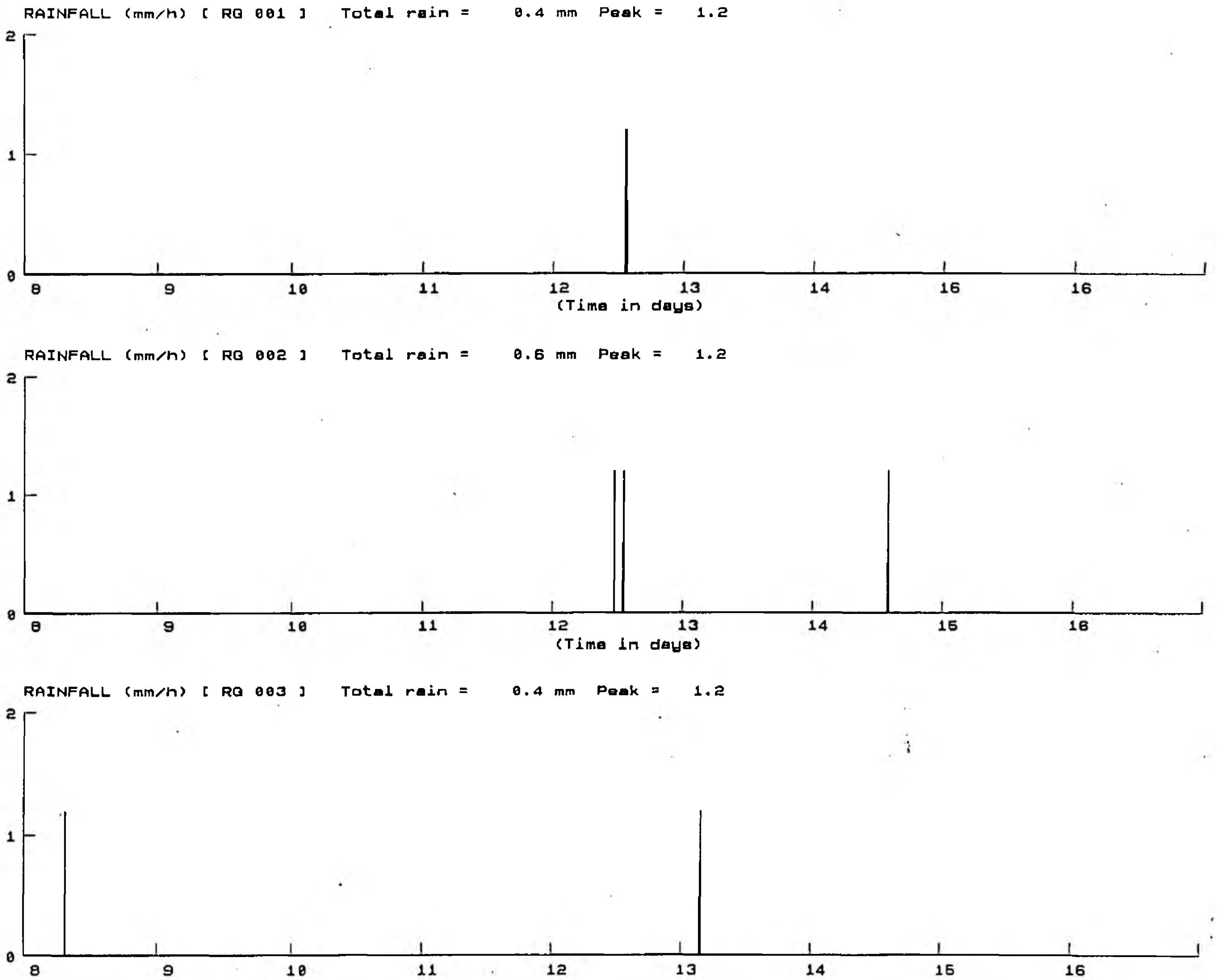
BATH POLLUTION STUDY



BATH POLLUTION STUDY

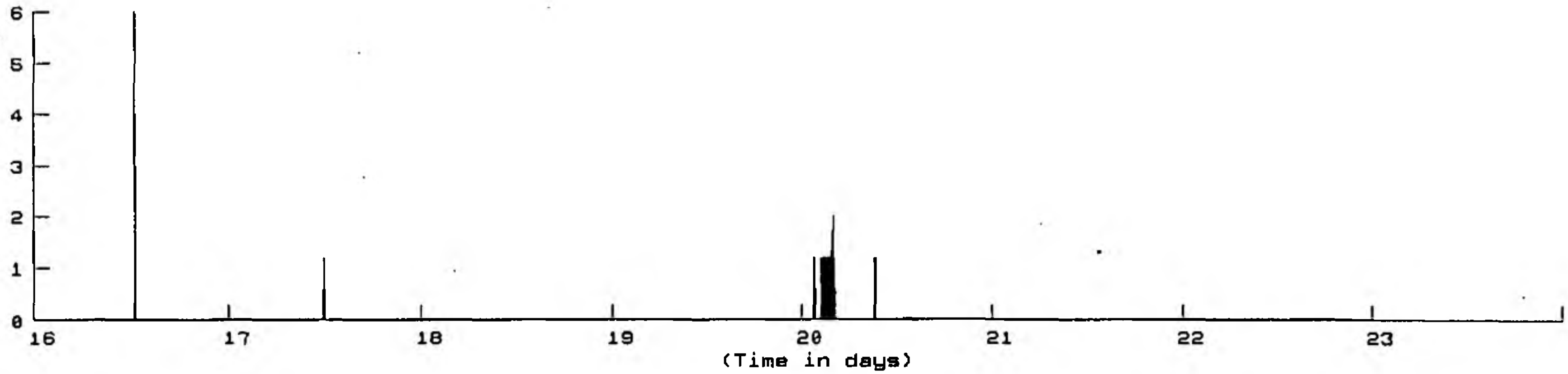


BATH POLLUTION STUDY

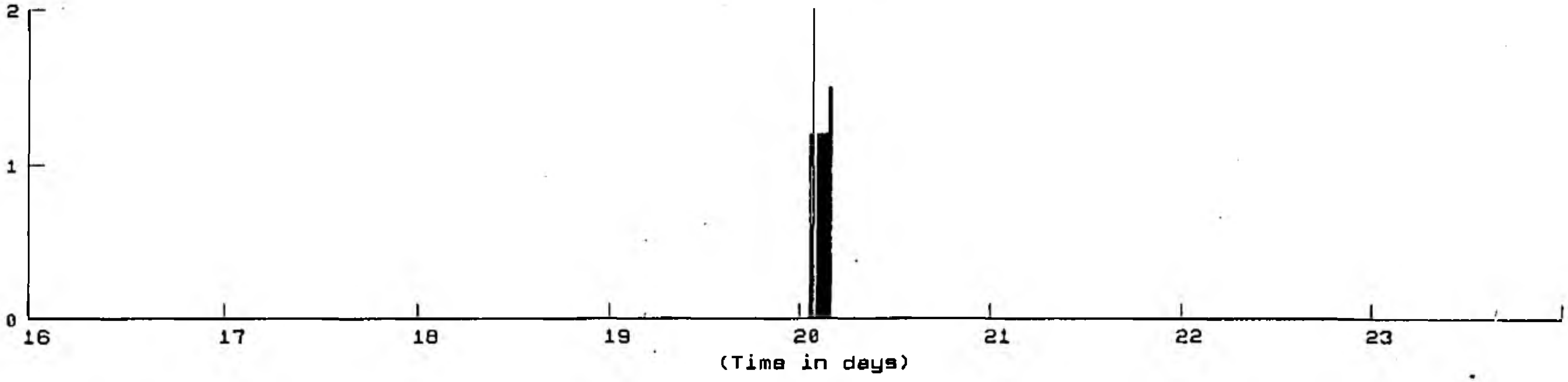


EVENT : 8-JUN-99 0:00 to 16-JUN-99 0:00 (Time in days)

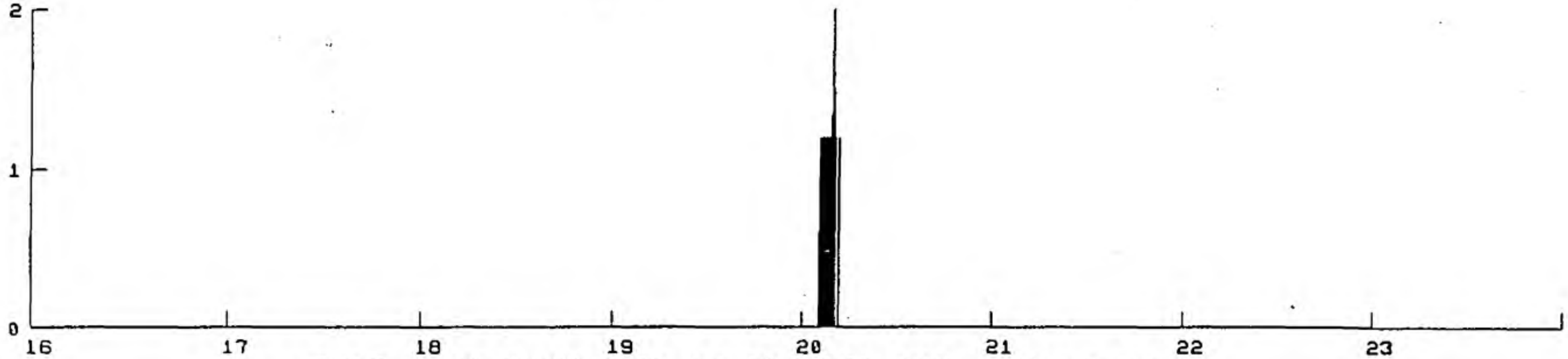
RAINFALL (mm/h) [RG 001]   Total rain = 2.8 mm   Peak = 6.0



RAINFALL (mm/h) [RG 002]   Total rain = 2.6 mm   Peak = 2.0

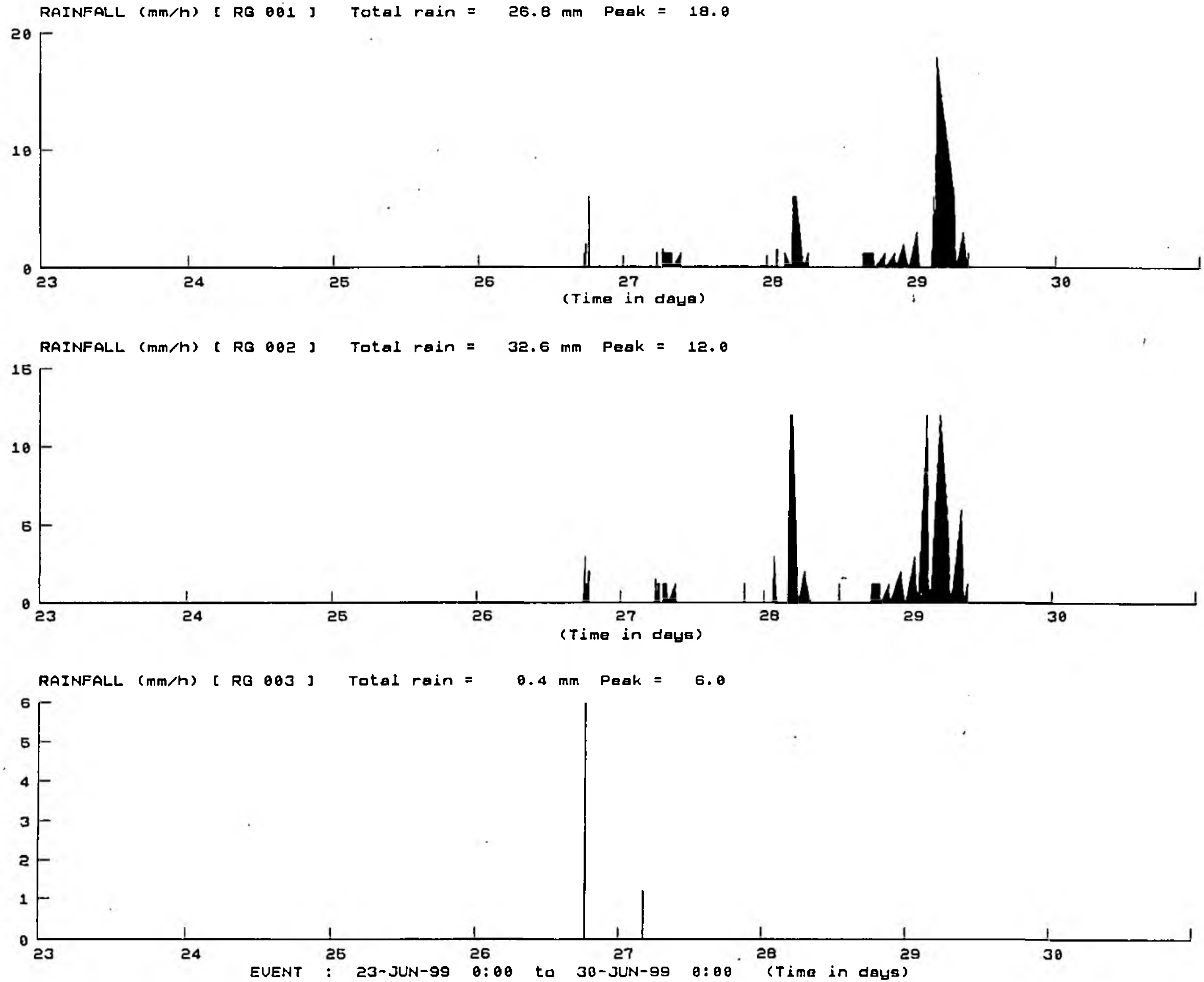


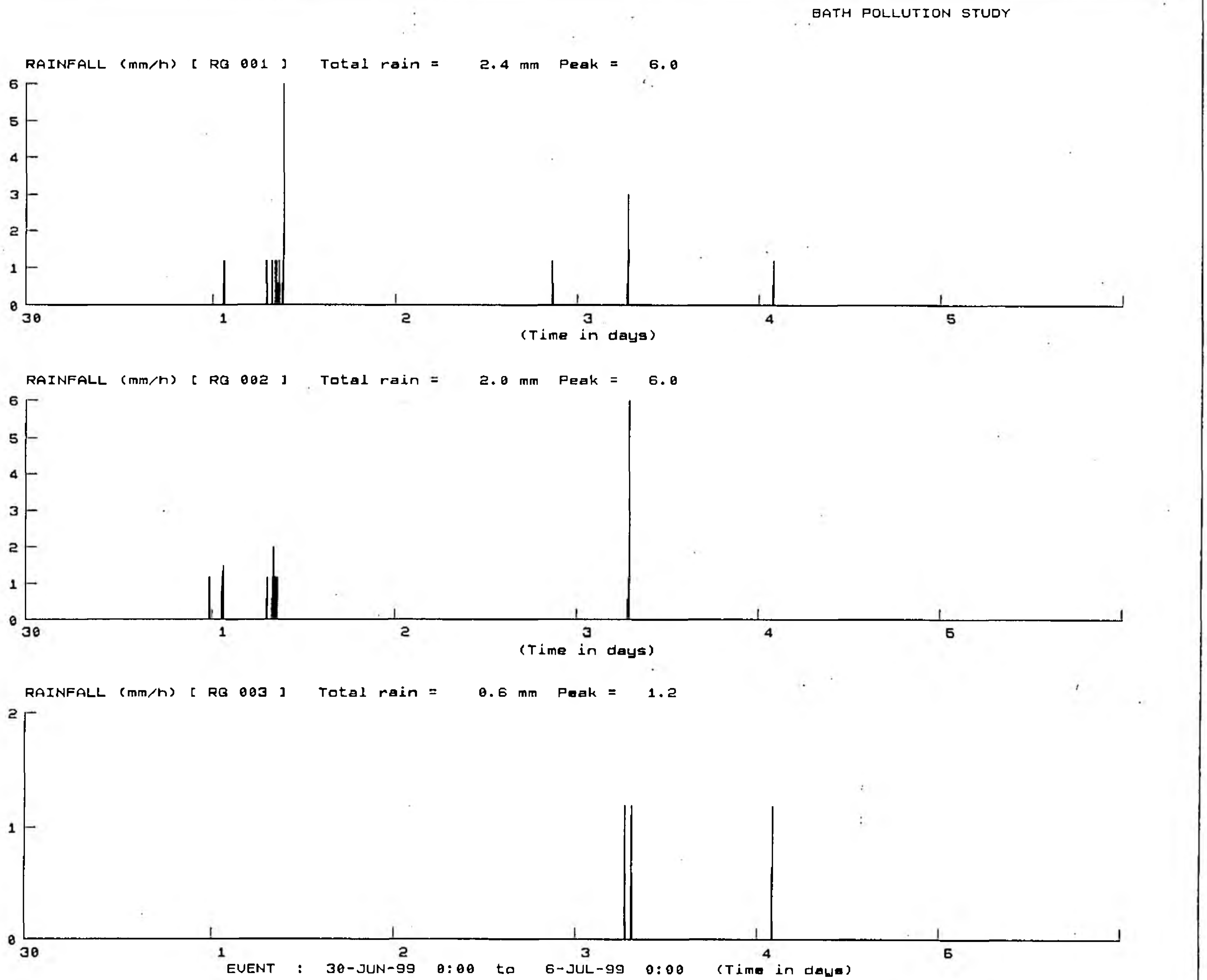
RAINFALL (mm/h) [RG 003]   Total rain = 2.4 mm   Peak = 2.0



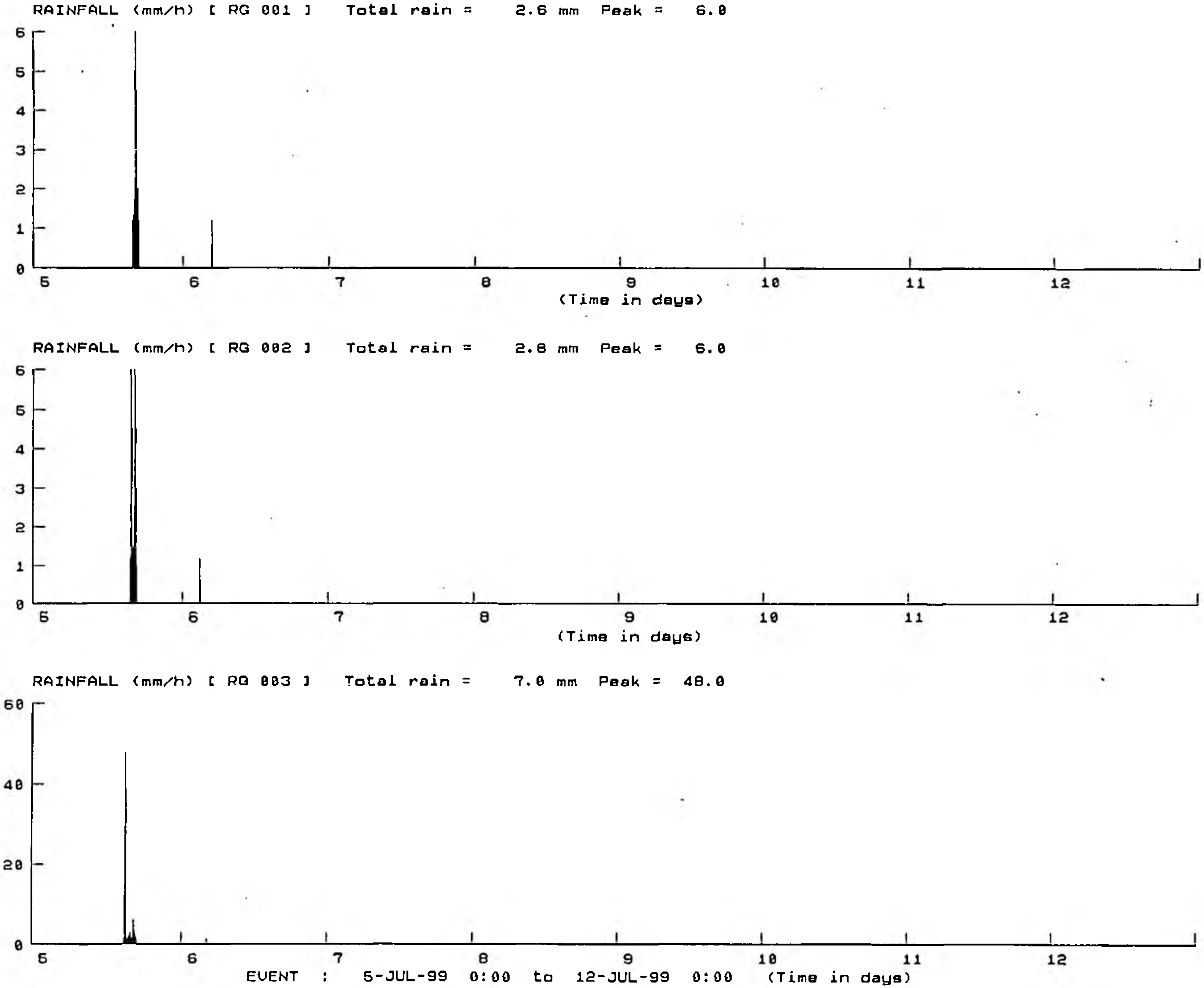
EVENT : 16-JUN-99 0:00 to 23-JUN-99 0:00 (Time in days)

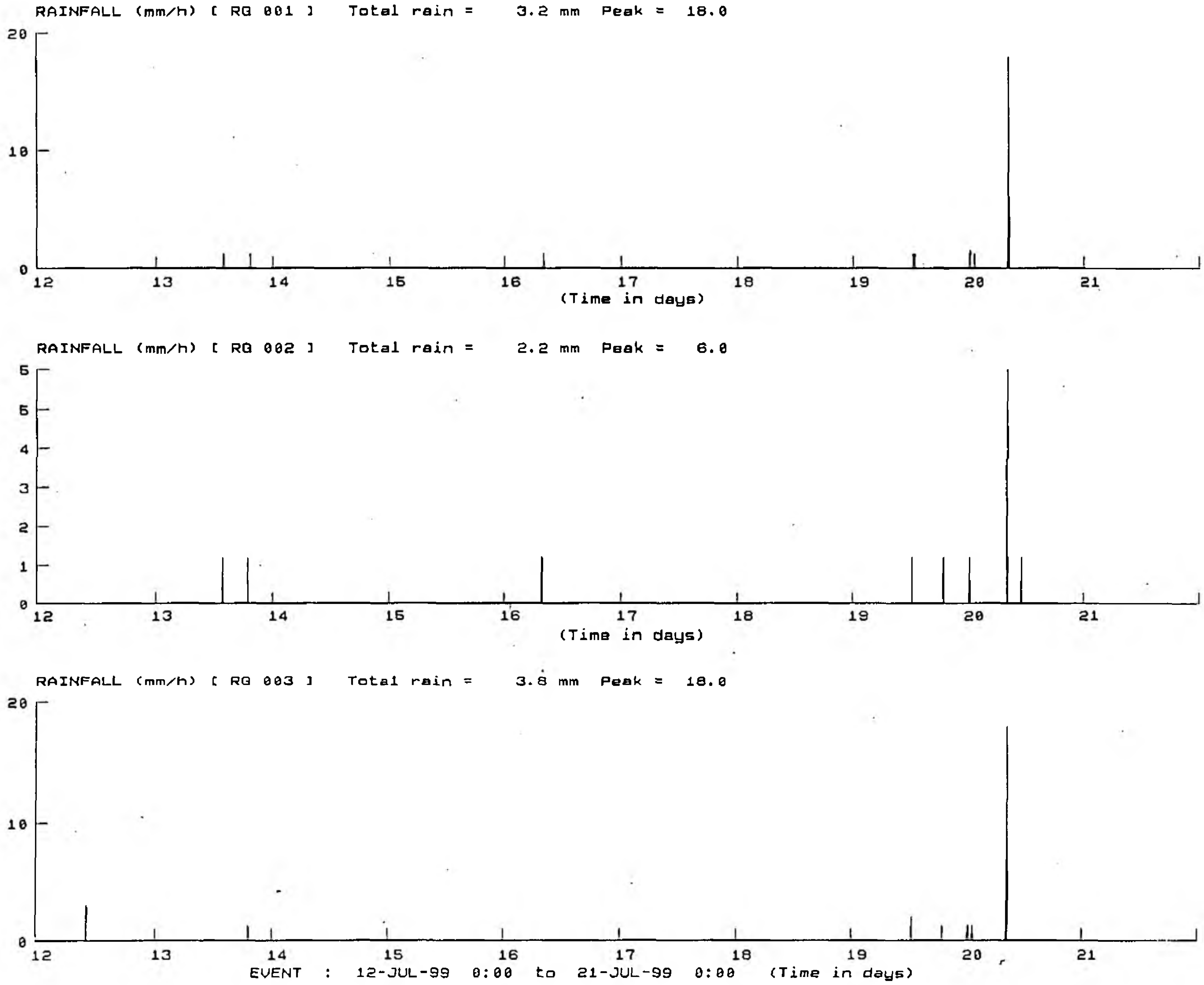
BATH POLLUTION STUDY



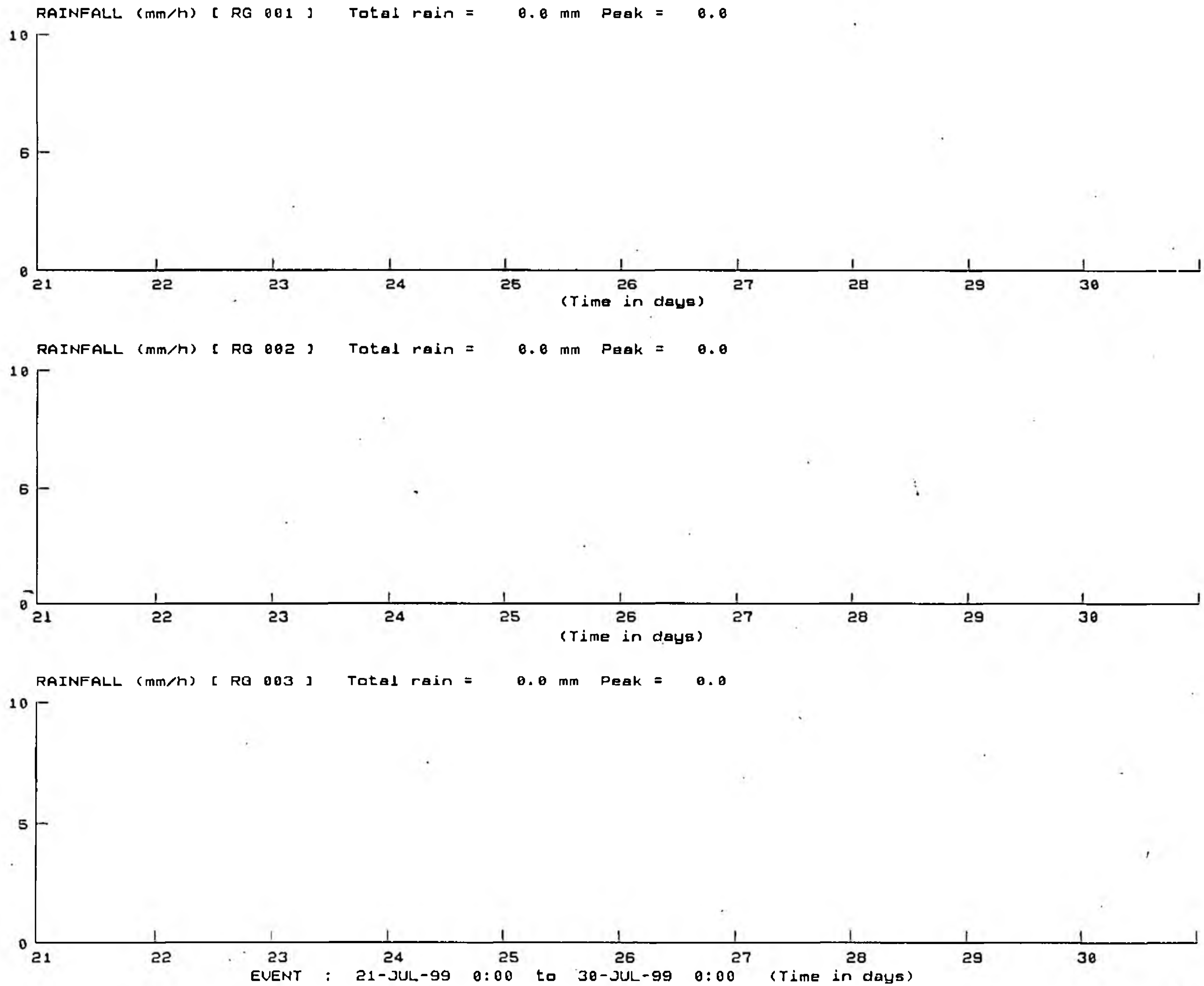

BATH POLLUTION STUDY
RAINFALL (mm/h) [RG 001] Total rain = 2.4 mm Peak = 6.0
6
5
4
3
2
1
0
30
1
2
3
4
5
(Time in days)
RAINFALL (mm/h) [RG 002] Total rain = 2.0 mm Peak = 6.0
6
5
4
3
2
1
0
30
1
2
3
4
5
(Time in days)
RAINFALL (mm/h) [RG 003] Total rain = 0.6 mm Peak = 1.2
2
1
0
30
1
2
3
4
5
EVENT : 30-JUN-99 0:00 to 6-JUL-99 0:00 (Time in days)

BATH POLLUTION STUDY

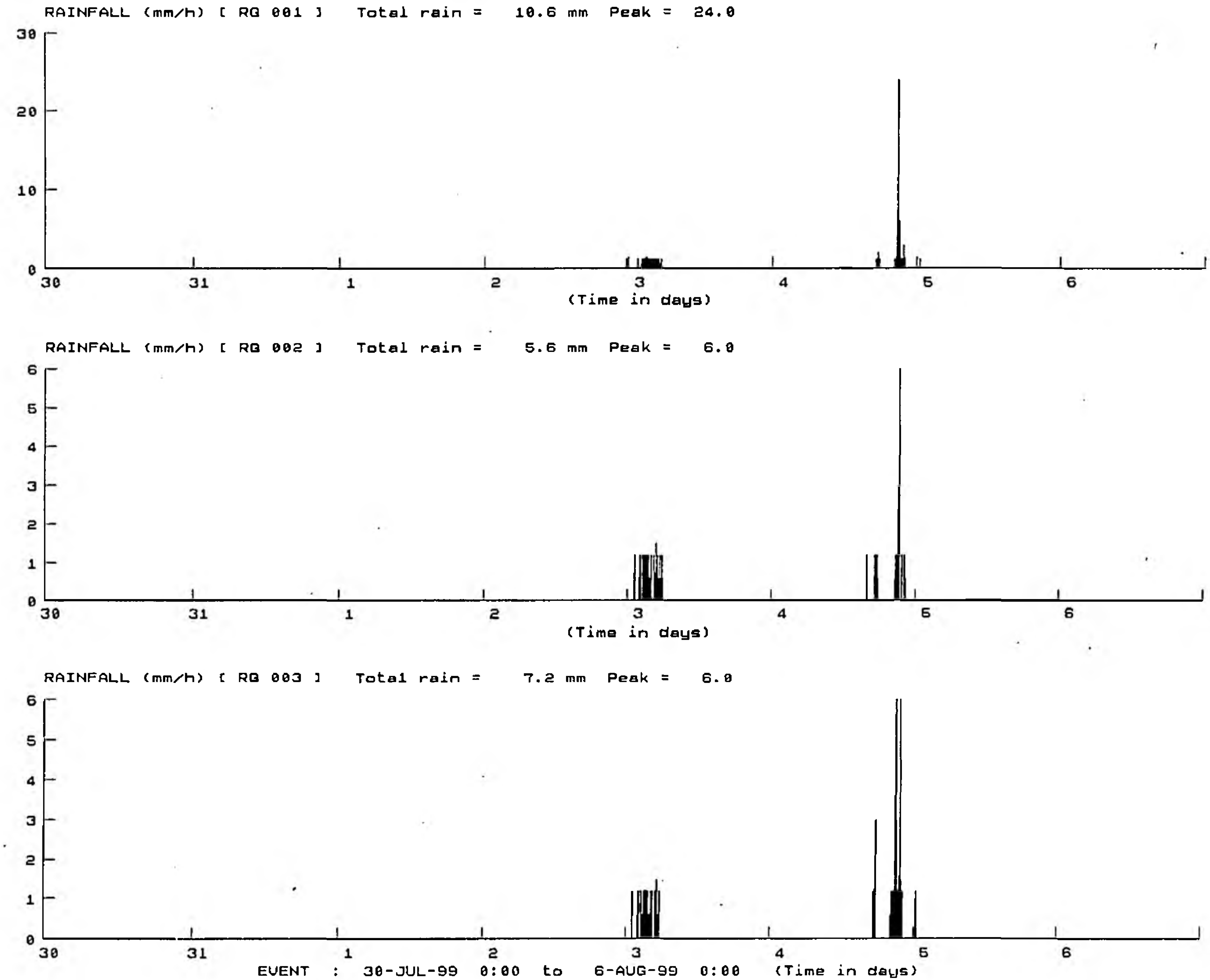



RAINFALL (mm/h) [RG 001]   Total rain =   3.2 mm   Peak = 18.0
(Time in days)
RAINFALL (mm/h) [RG 002]   Total rain =   2.2 mm   Peak =   6.0
(Time in days)
RAINFALL (mm/h) [RG 003]   Total rain =   3.8 mm   Peak = 18.0
EVENT : 12-JUL-99 0:00 to 21-JUL-99 0:00   (Time in days)

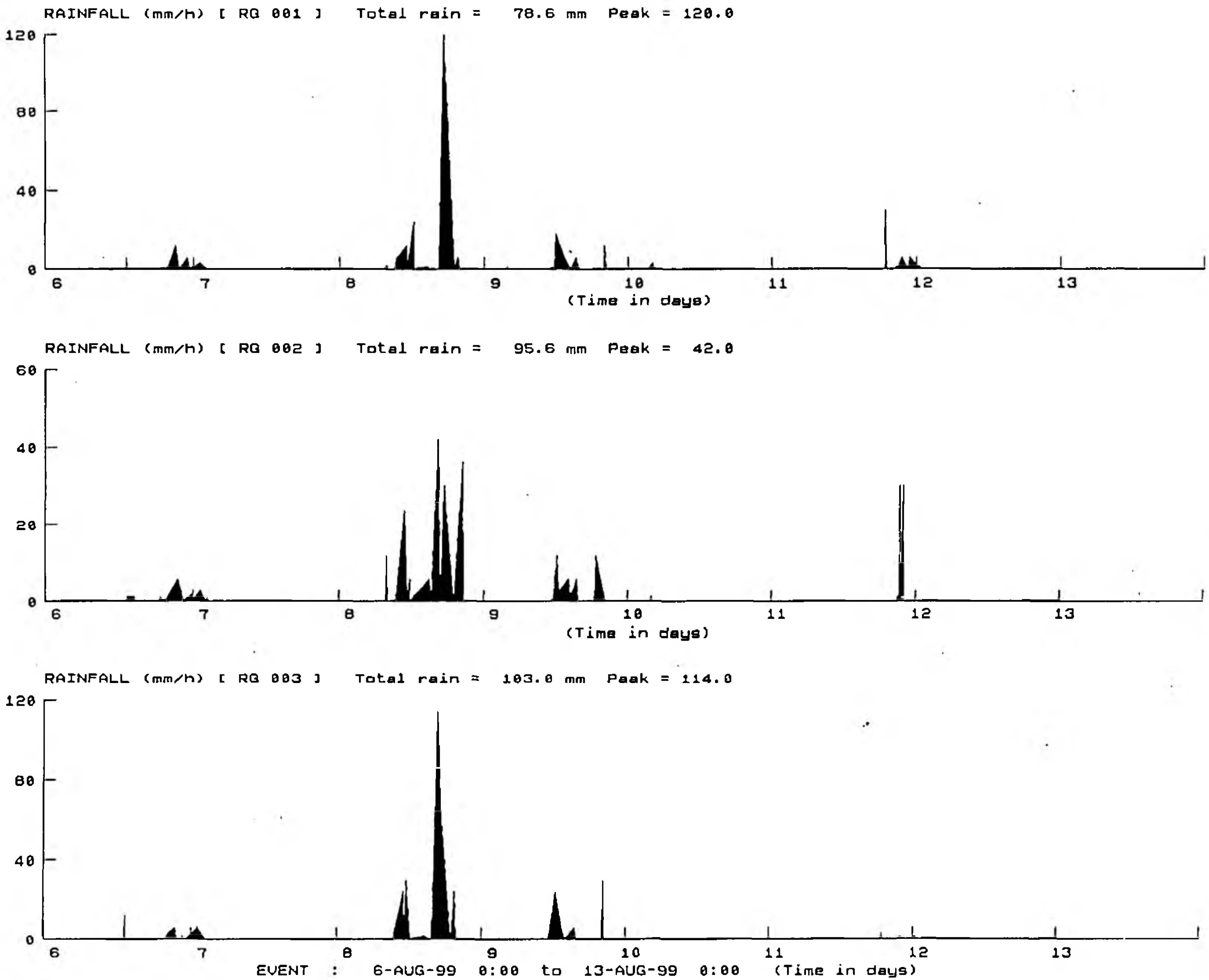
BATH POLLUTION STUDY



BATH POLLUTION STUDY

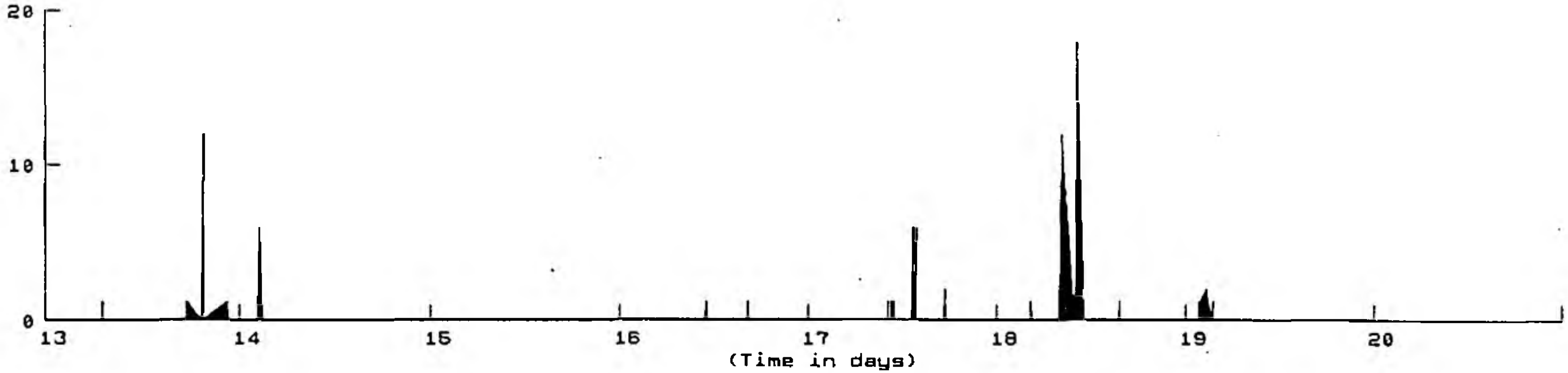


BATH POLLUTION STUDY

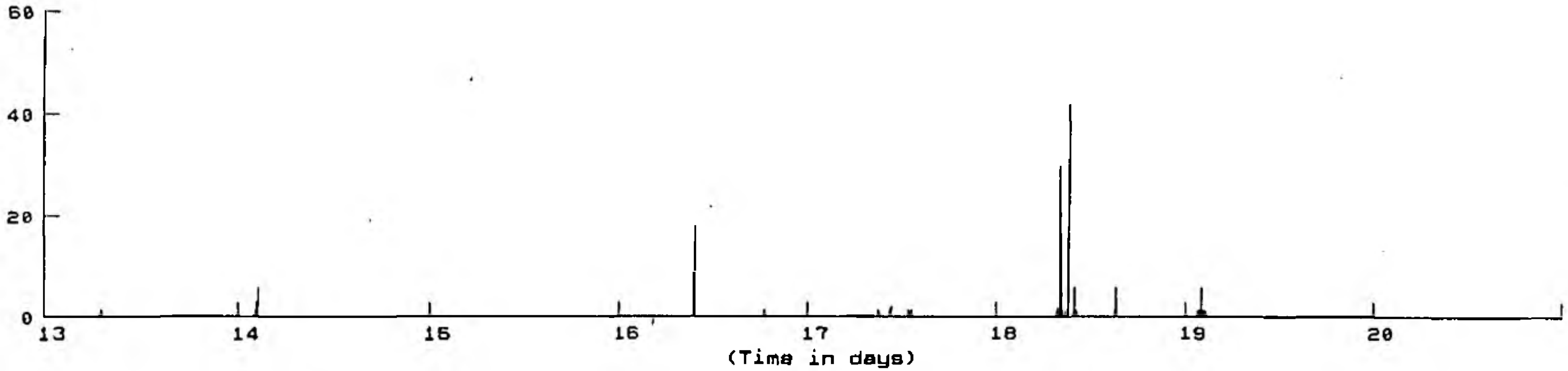


BATH POLLUTION STUDY

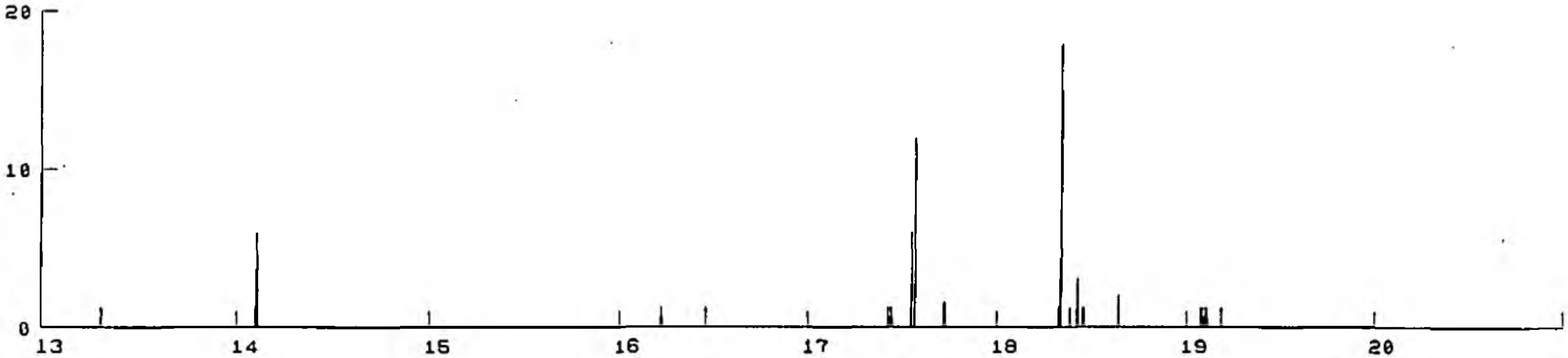
RAINFALL (mm/h) [RG 001]   Total rain =   10.6 mm   Peak =   18.0



RAINFALL (mm/h) [RG 002]   Total rain =   14.2 mm   Peak =   42.0

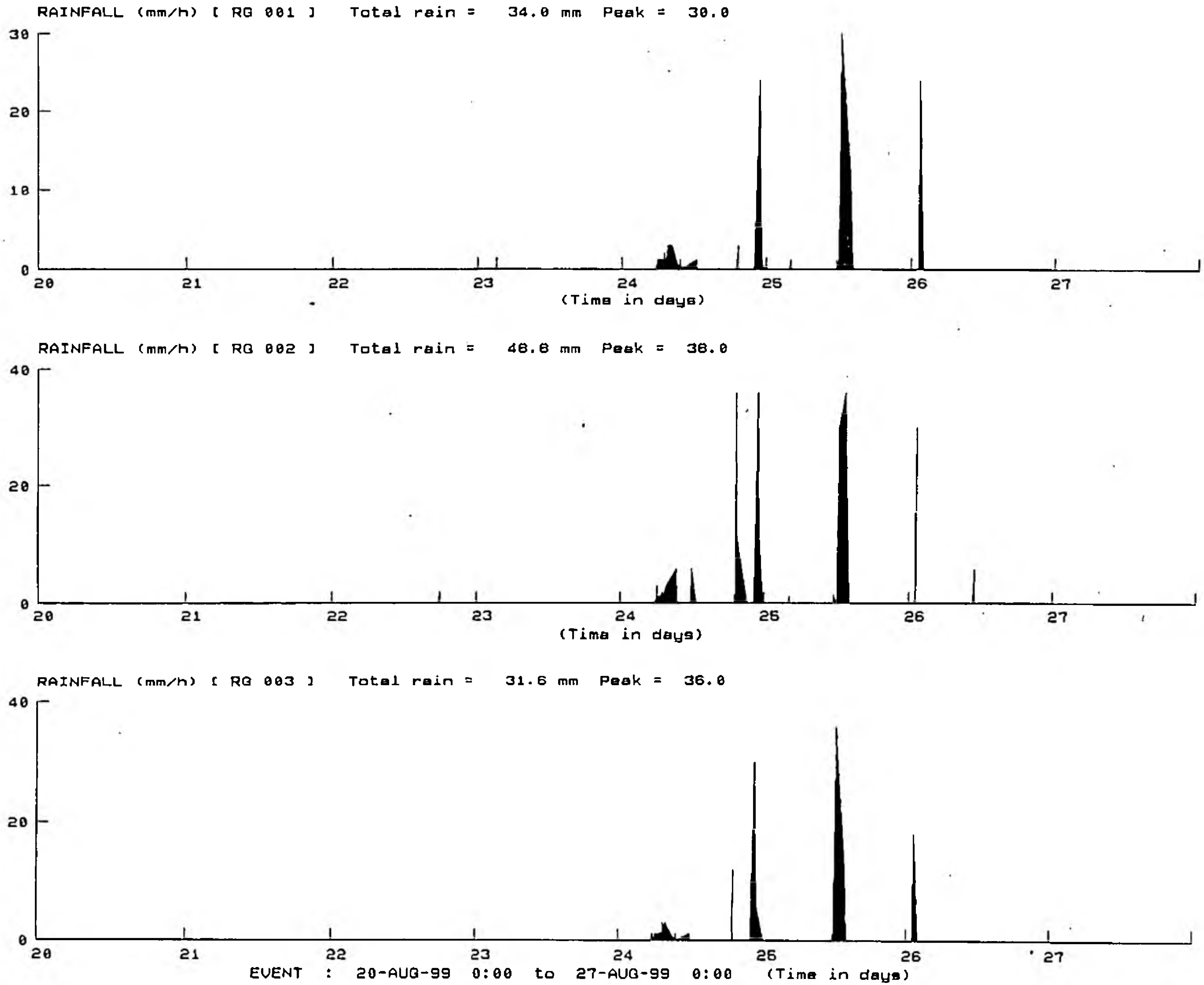


RAINFALL (mm/h) [RG 003]   Total rain =   8.0 mm   Peak =   18.0



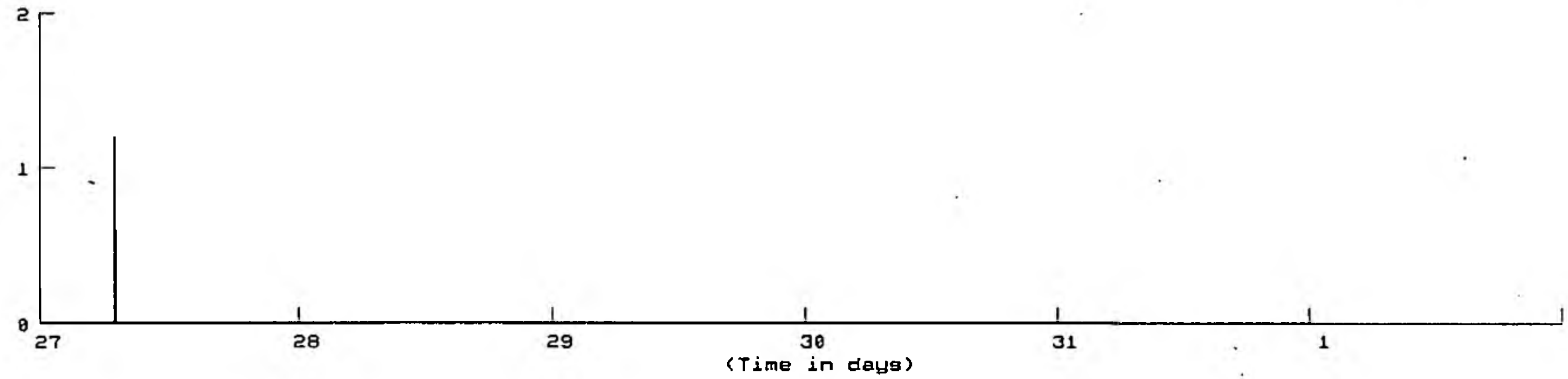
EVENT : 13-AUG-99 0:00 to 20-AUG-99 0:00 (Time in days)

BATH POLLUTION STUDY

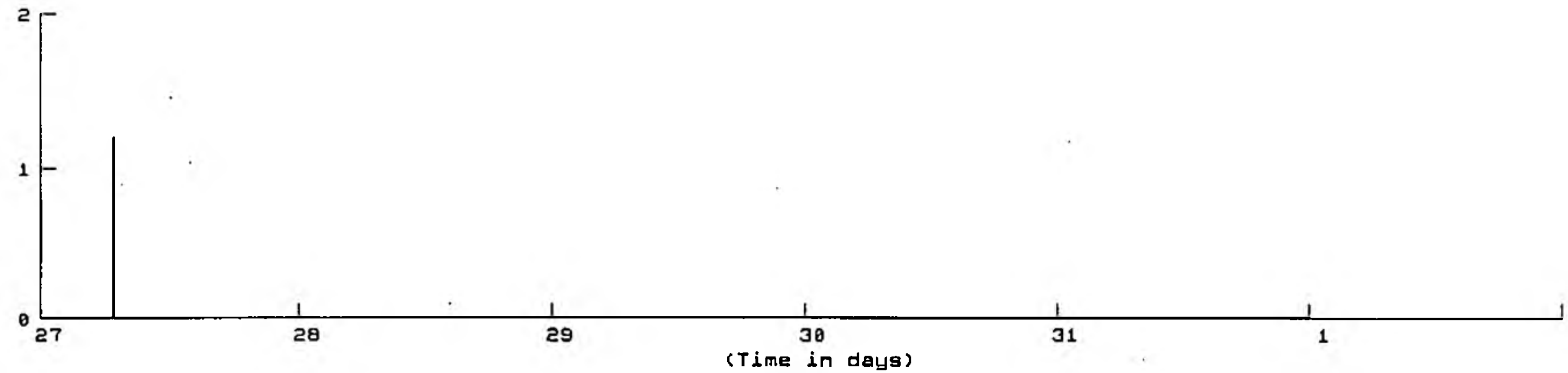


BATH POLLUTION STUDY

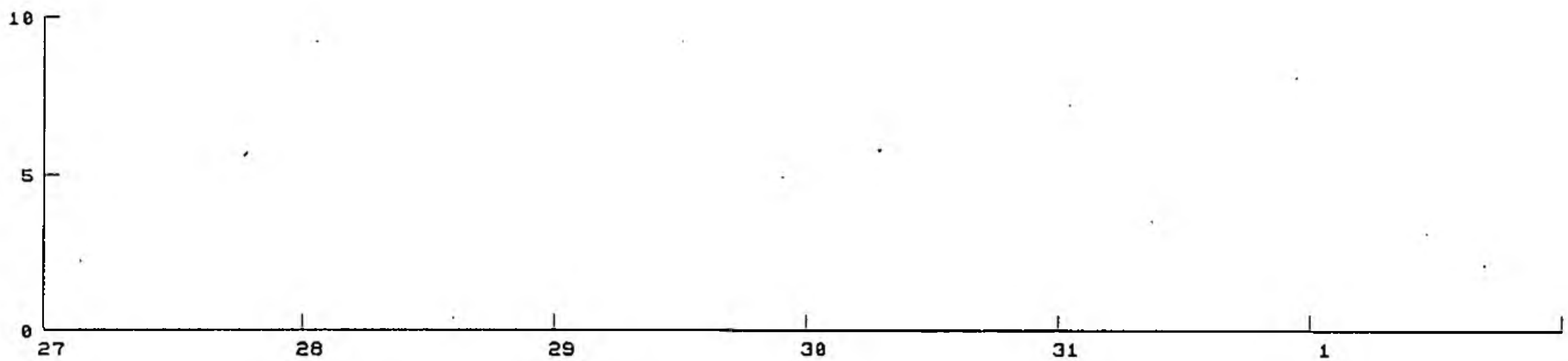
RAINFALL (mm/h) [RG 001]   Total rain =   0.2 mm   Peak =   1.2



RAINFALL (mm/h) [RG 002]   Total rain =   0.2 mm   Peak =   1.2

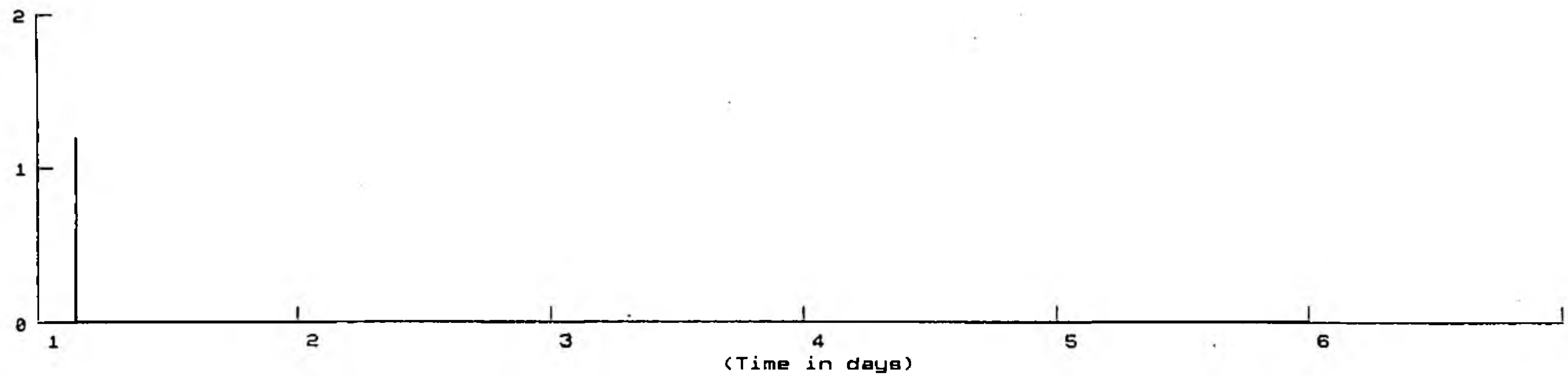


RAINFALL (mm/h) [RG 003]   Total rain =   0.0 mm   Peak =   0.0

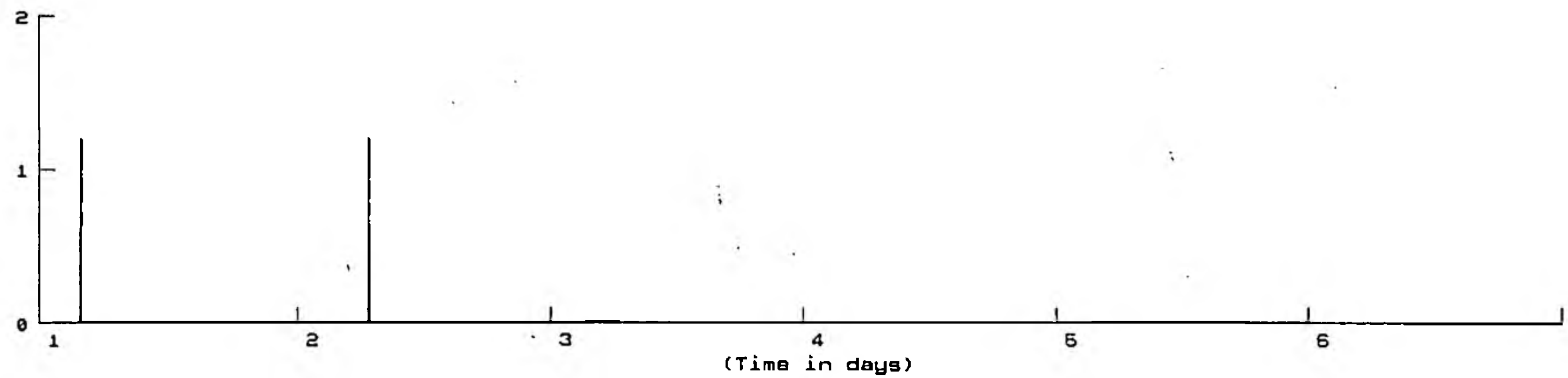


EVENT : 27-AUG-99 0:00 to 1-SEP-99 0:00 (Time in days)

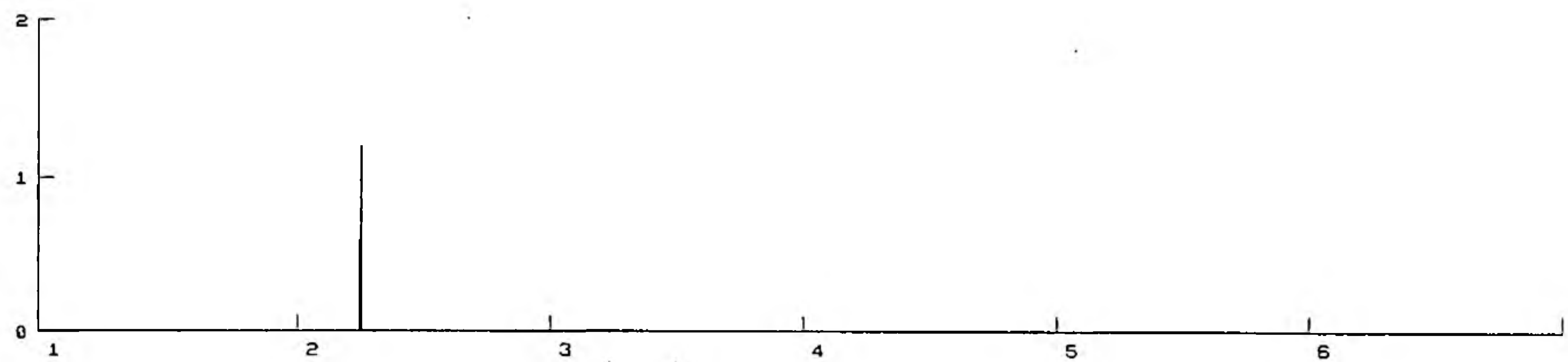
RAINFALL (mm/h) [RG 001]   Total rain =   0.2 mm   Peak =   1.2



RAINFALL (mm/h) [RG 002]   Total rain =   0.4 mm   Peak =   1.2

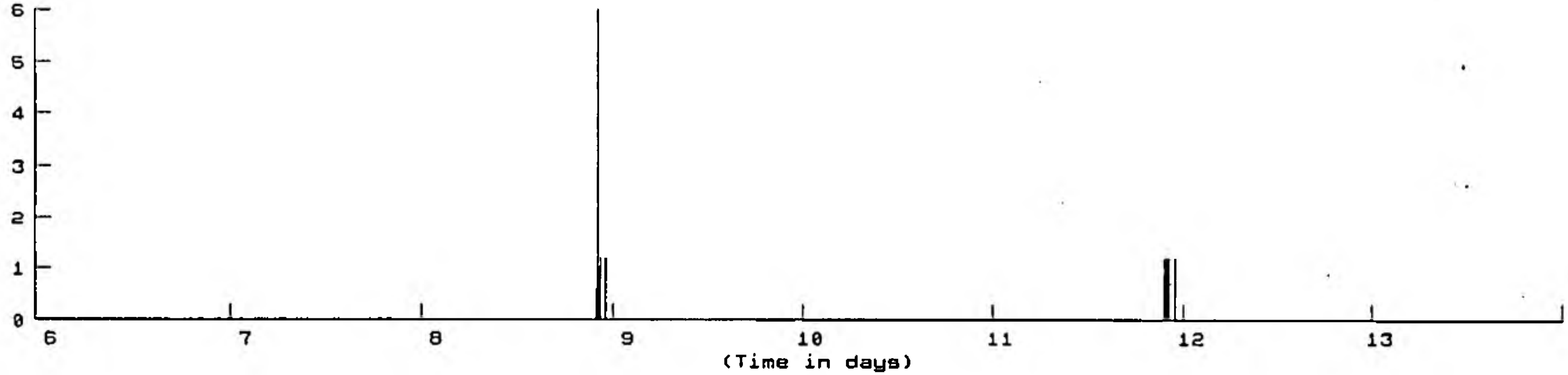


RAINFALL (mm/h) [RG 003]   Total rain =   0.2 mm   Peak =   1.2

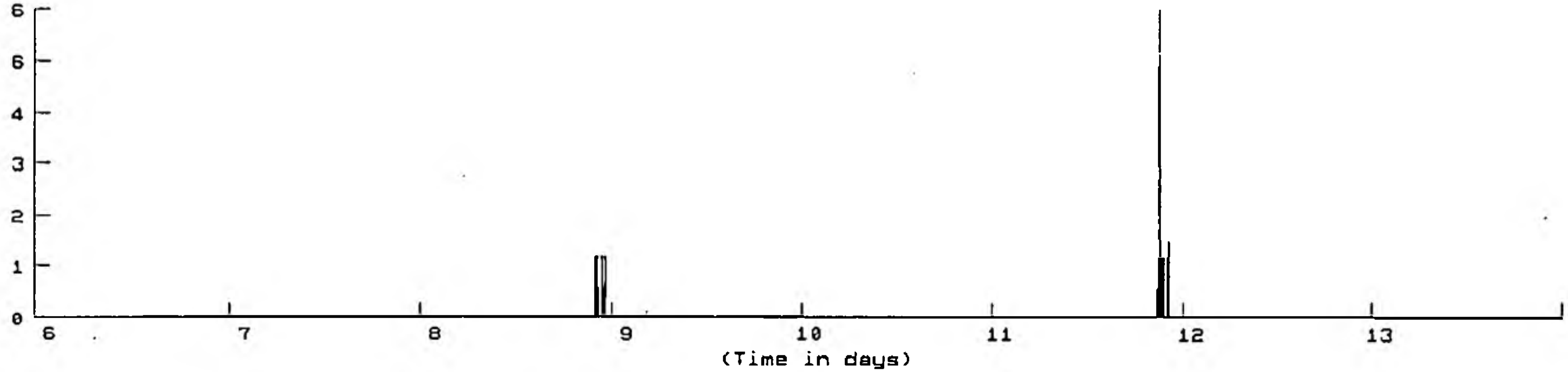


EVENT : 1-SEP-99 0:00 to 6-SEP-99 0:00 (Time in days)

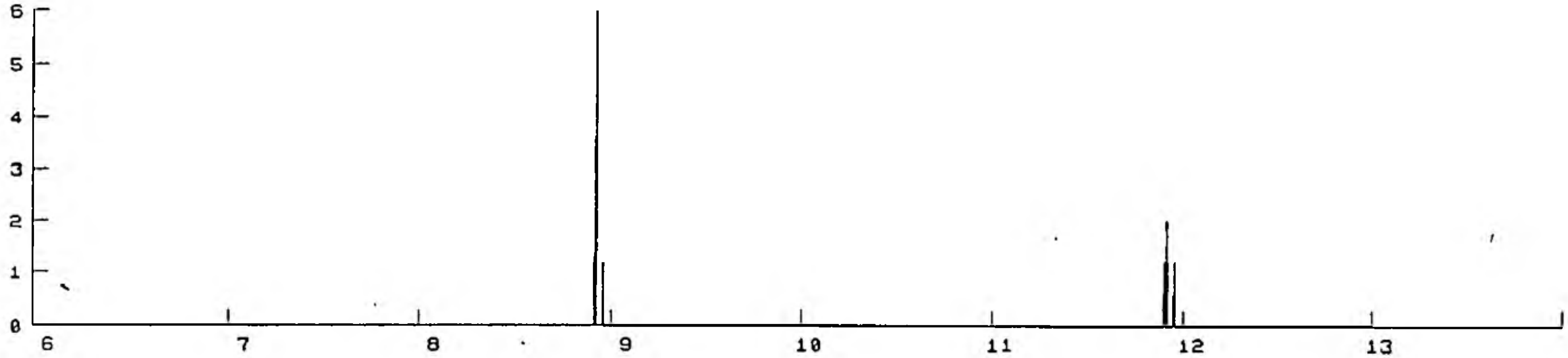
RAINFALL (mm/h) [RG 001]   Total rain =   1.8 mm   Peak =   6.0



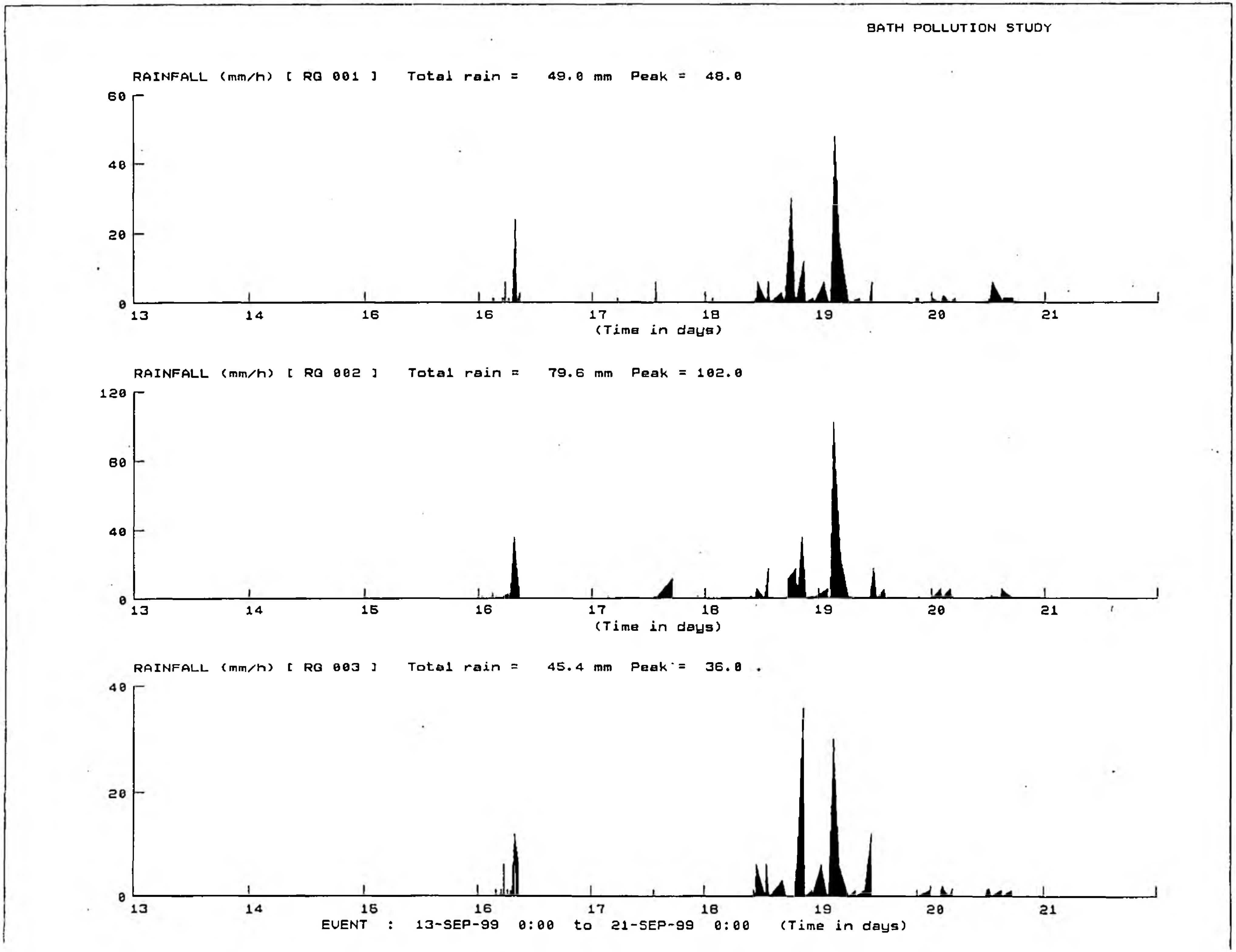
RAINFALL (mm/h) [RG 002]   Total rain =   2.6 mm   Peak =   6.0



RAINFALL (mm/h) [RG 003]   Total rain =   1.8 mm   Peak =   6.0

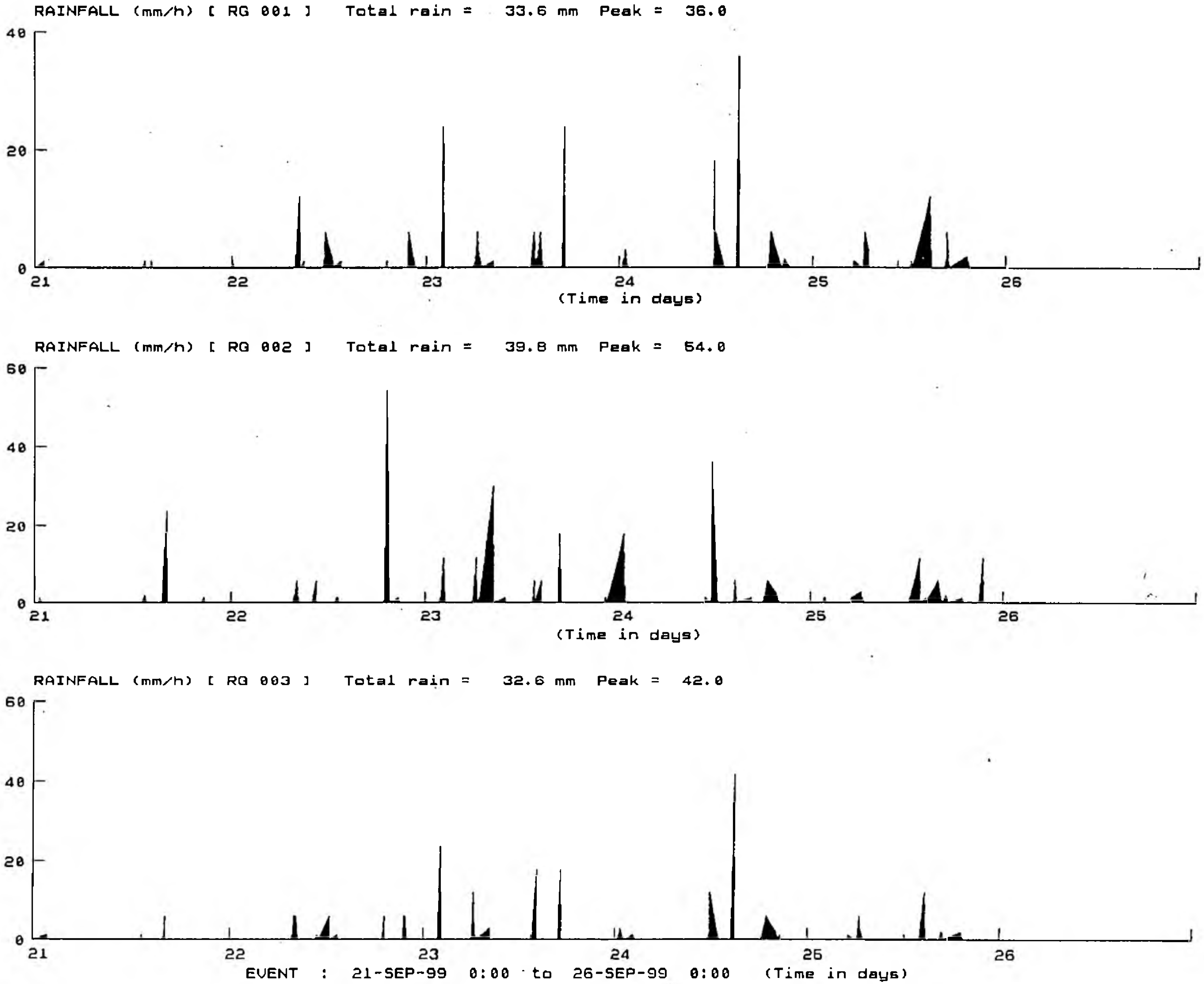


EVENT : 6-SEP-99 0:00 to 13-SEP-99 0:00 (Time in days)

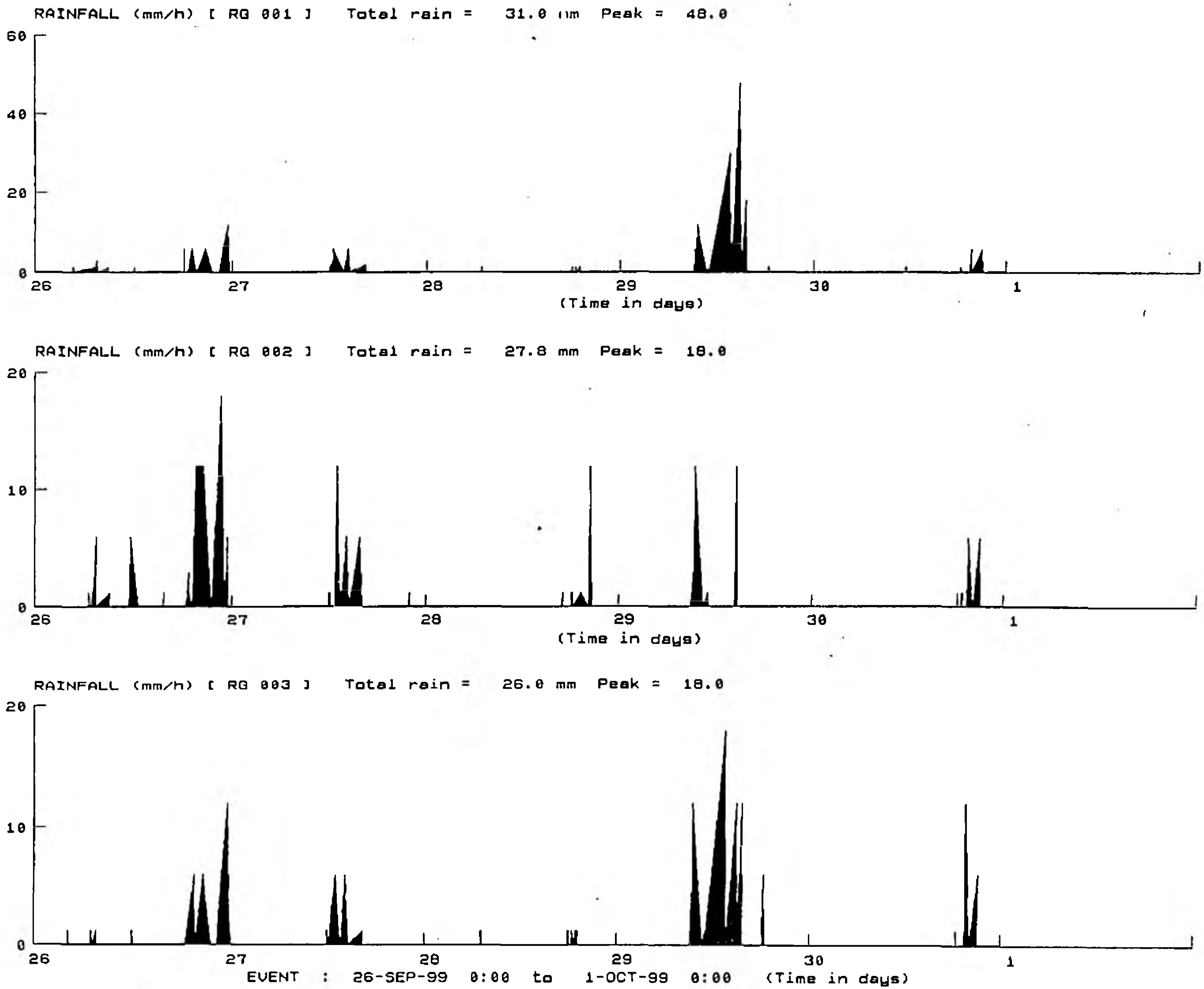


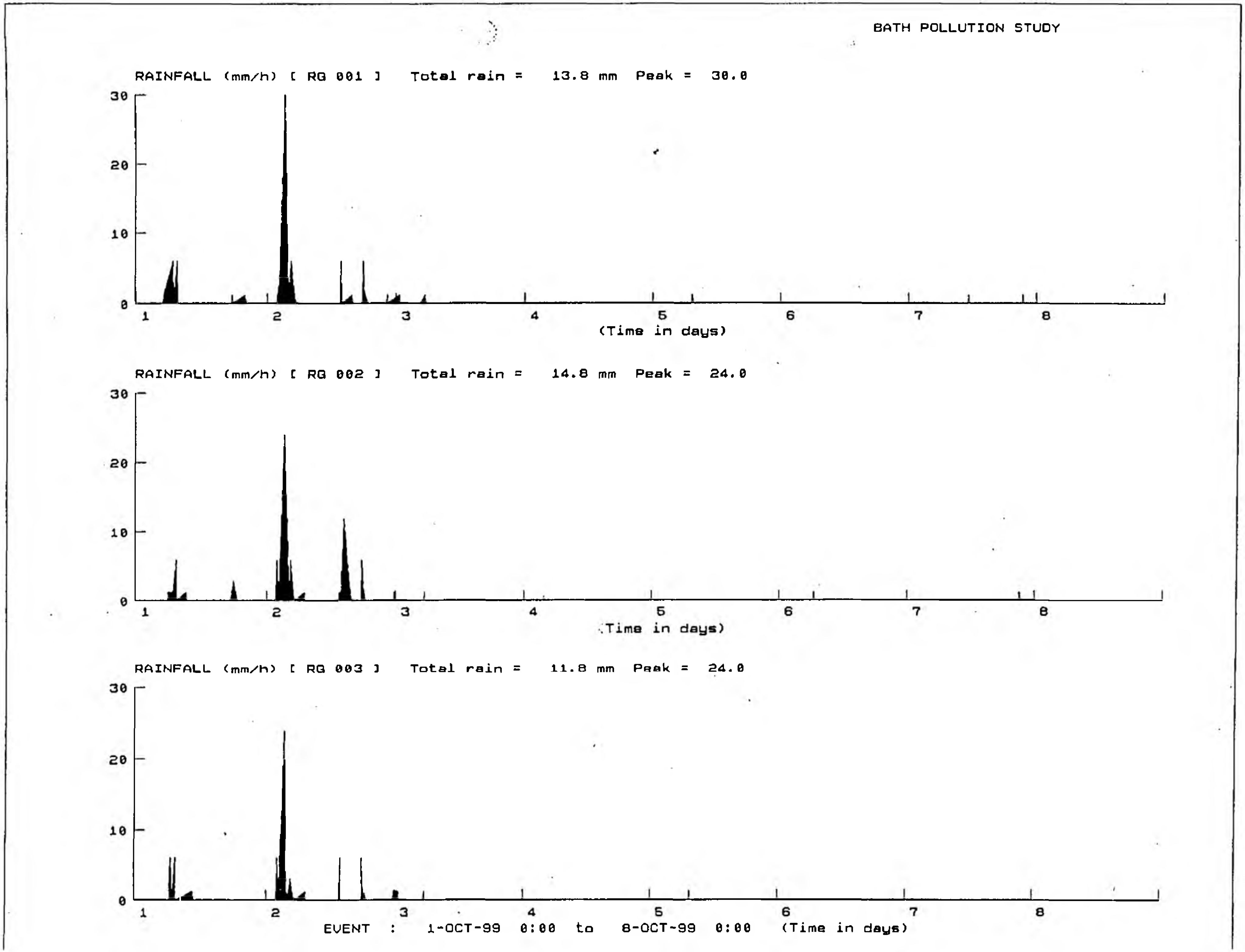
BATH POLLUTION STUDY
RAINFALL (mm/h) [RG 001] Total rain = 49.0 mm Peak = 48.0
60
40
20
0
13 14 16 16 17 18 19 20 21
(Time in days)
RAINFALL (mm/h) [RG 002] Total rain = 79.6 mm Peak = 102.0
120
80
40
0
13 14 15 16 17 18 19 20 21
(Time in days)
RAINFALL (mm/h) [RG 003] Total rain = 45.4 mm Peak = 36.0
40
20
0
13 14 15 16 17 18 19 20 21
EVENT : 13-SEP-99 0:00 to 21-SEP-99 0:00 (Time in days)

BATH POLLUTION STUDY

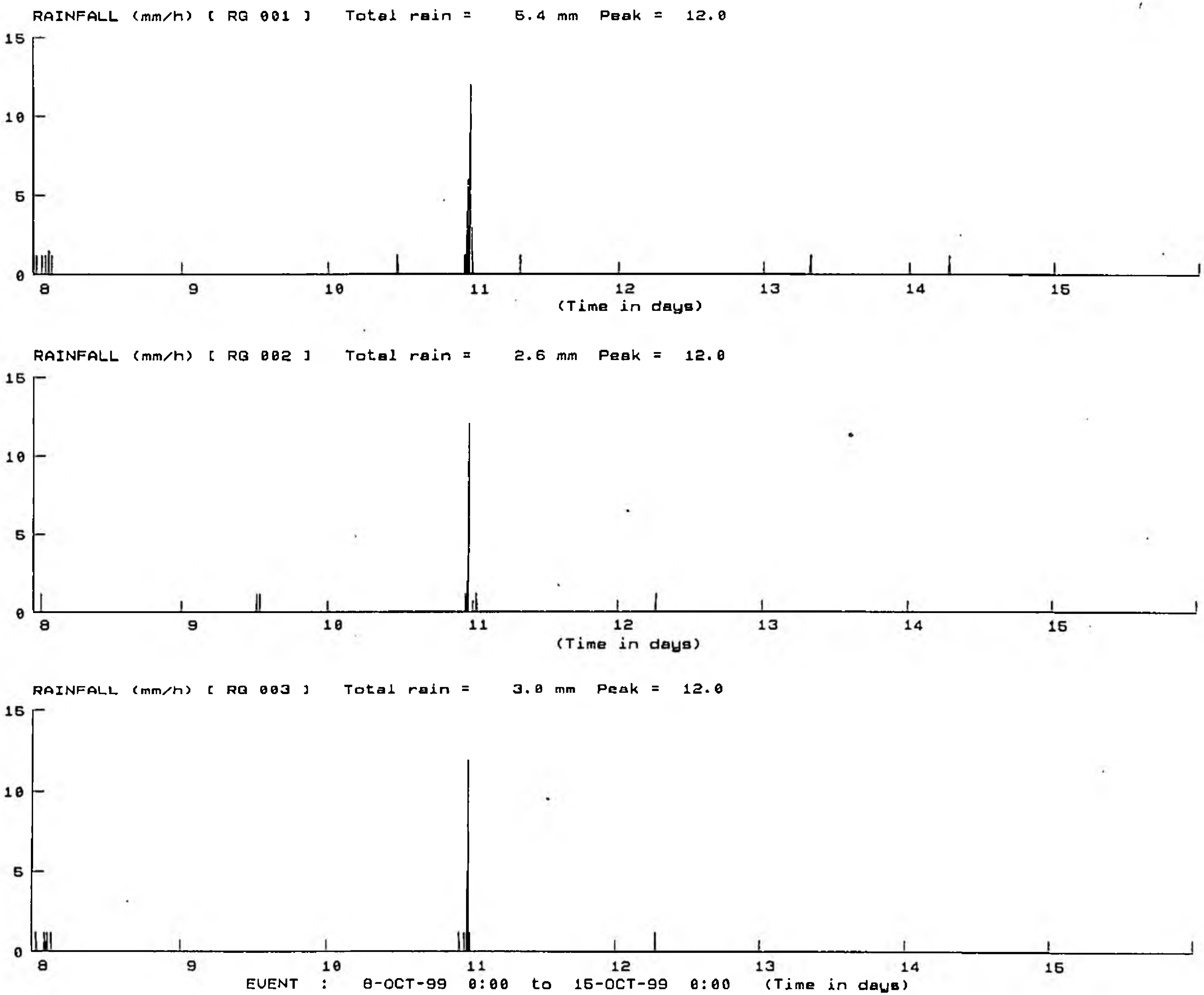


BATH POLLUTION STUDY

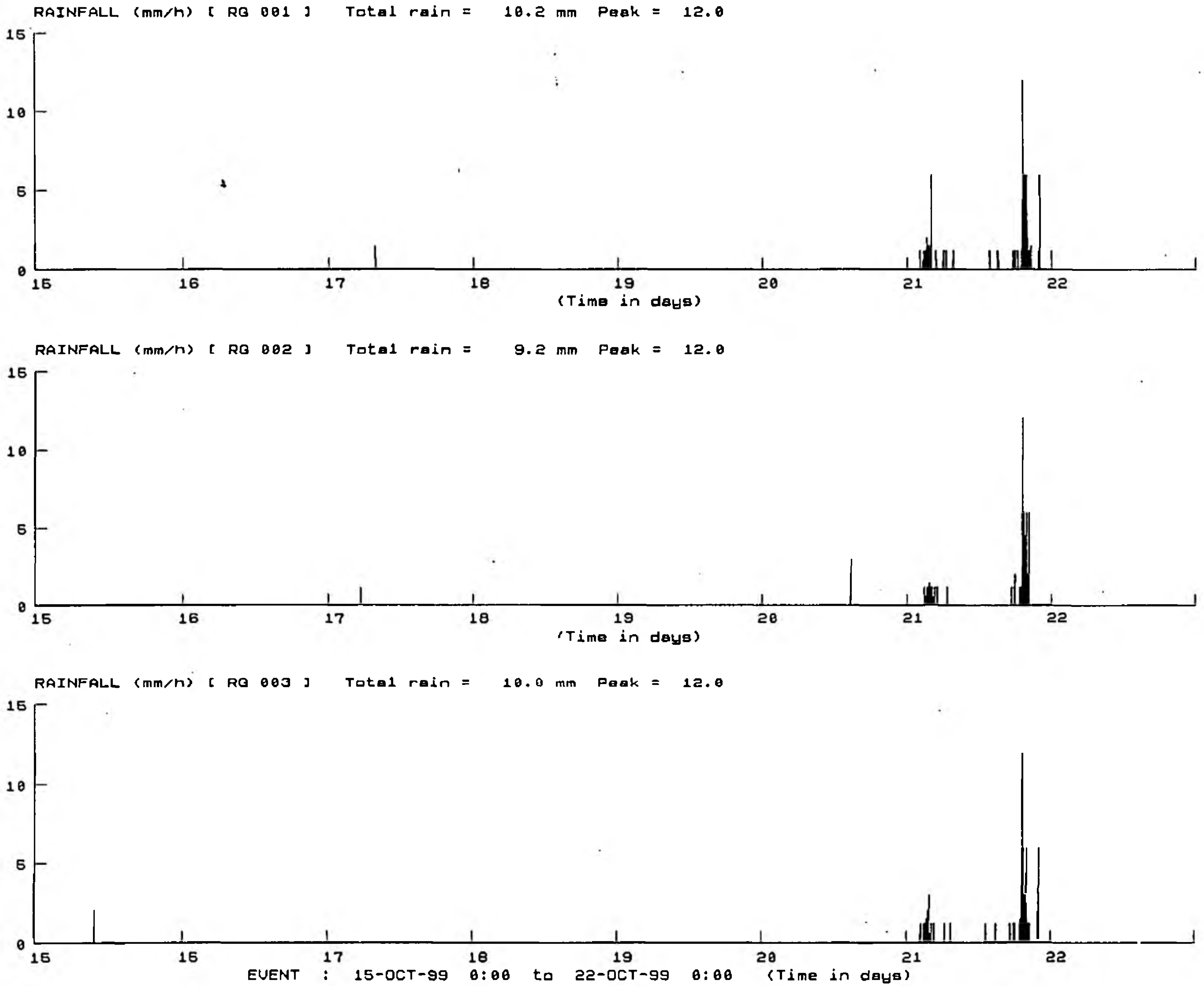


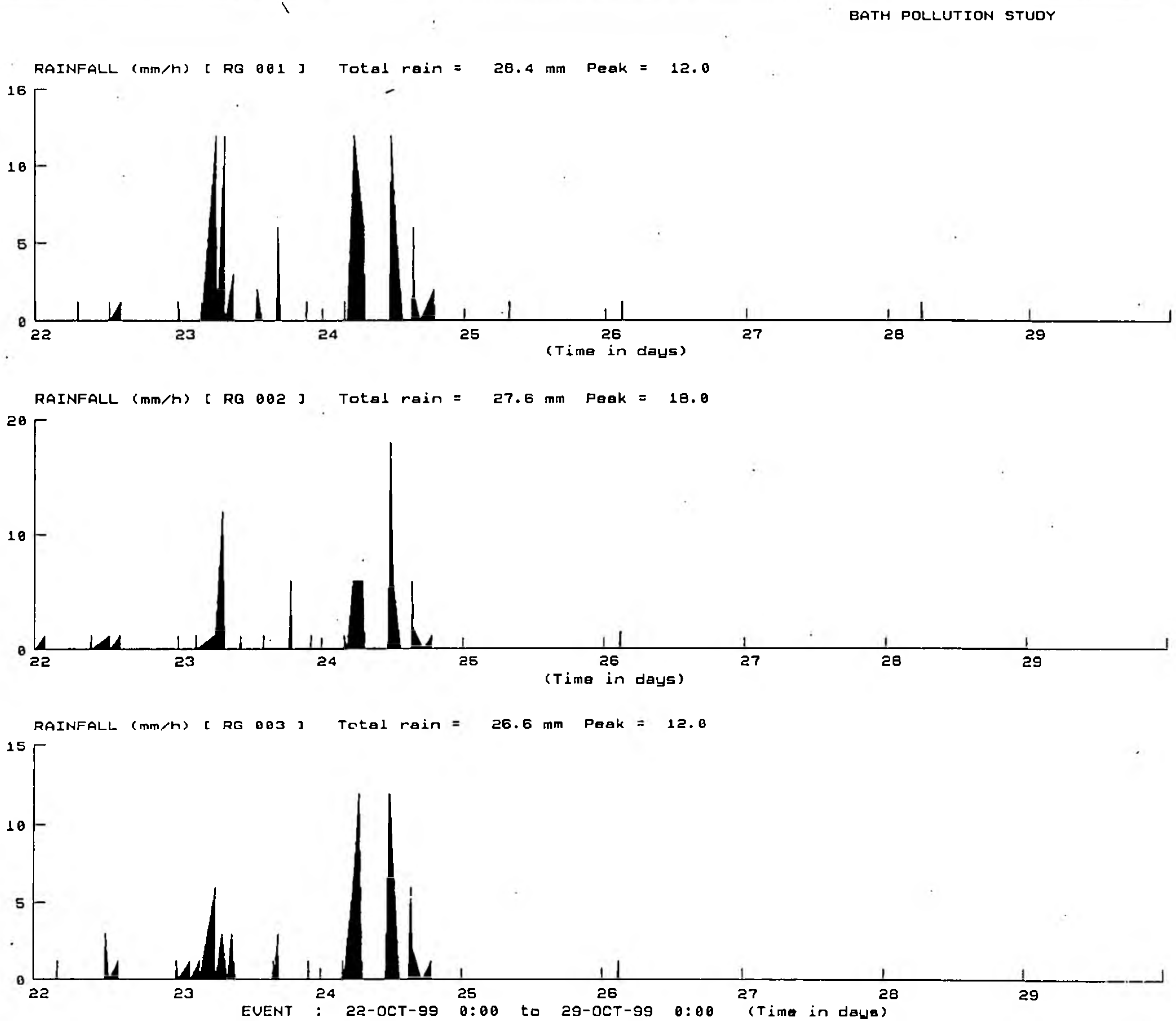

BATH POLLUTION STUDY
RAINFALL (mm/h) [RG 001] Total rain = 13.8 mm Peak = 30.0
30
20
10
0
1 2 3 4 5 6 7 8
(Time in days)
RAINFALL (mm/h) [RG 002] Total rain = 14.8 mm Peak = 24.0
30
20
10
0
1 2 3 4 5 6 7 8
(Time in days)
RAINFALL (mm/h) [RG 003] Total rain = 11.8 mm Peak = 24.0
30
20
10
0
1 2 3 4 5 6 7 8
EVENT : 1-OCT-99 0:00 to 8-OCT-99 0:00 (Time in days)

BATH POLLUTION STUDY

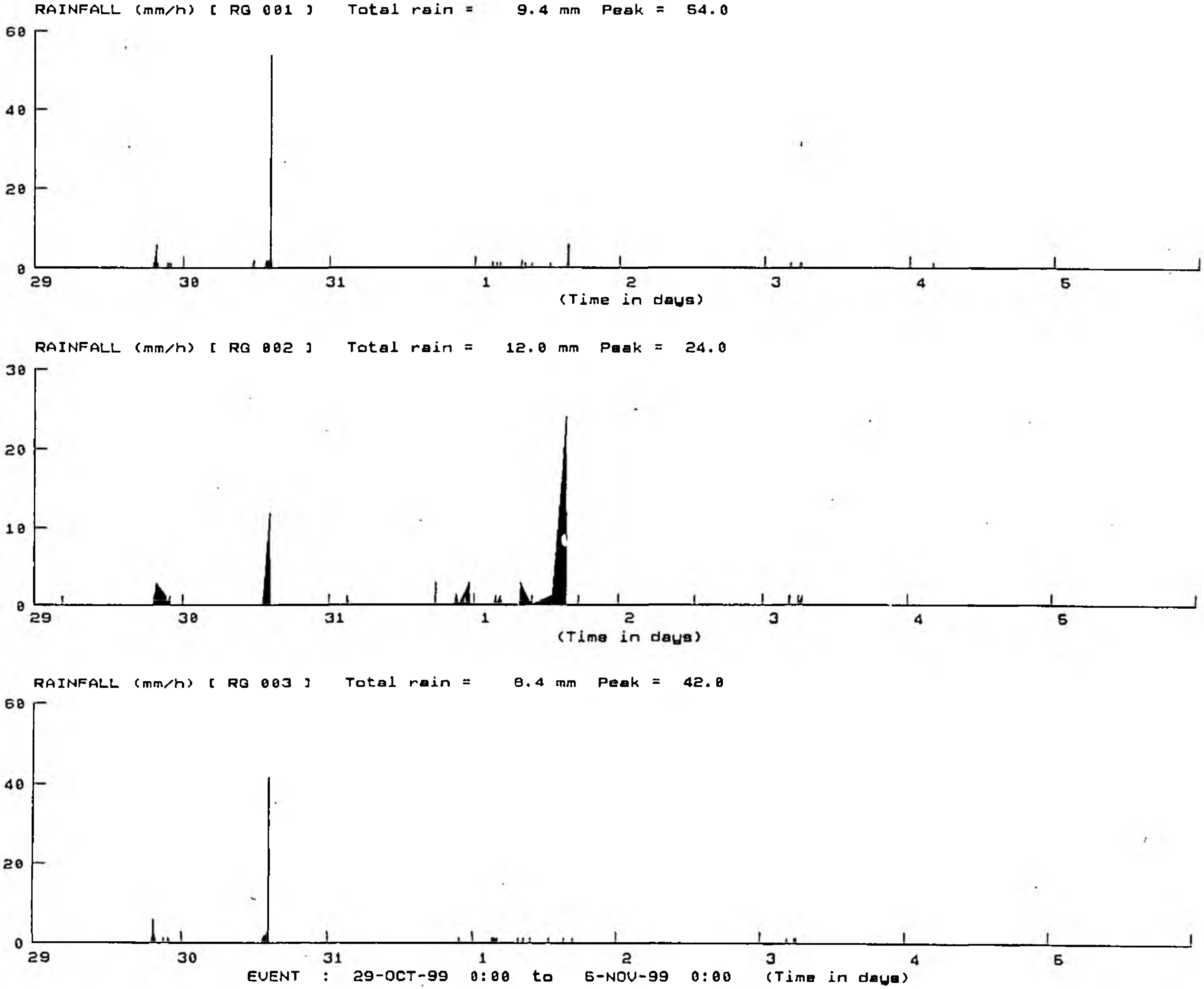


BATH POLLUTION STUDY



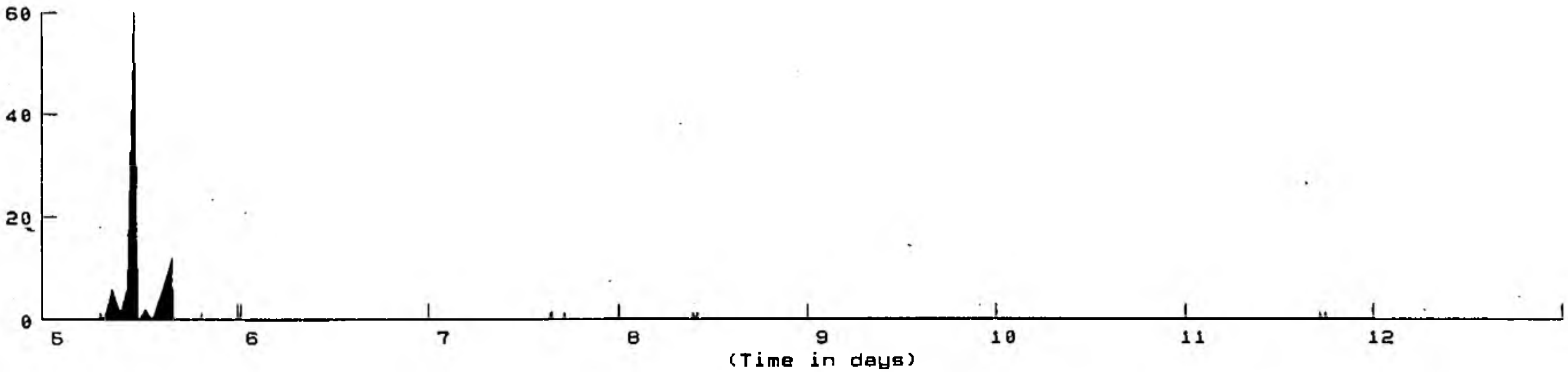

BATH POLLUTION STUDY
RAINFALL (mm/h) [RG 001] Total rain = 28.4 mm Peak = 12.0
16
10
5
0
22
23
24
25
26
27
28
29
(Time in days)
RAINFALL (mm/h) [RG 002] Total rain = 27.6 mm Peak = 18.0
20
10
0
22
23
24
25
26
27
28
29
(Time in days)
RAINFALL (mm/h) [RG 003] Total rain = 26.6 mm Peak = 12.0
15
10
5
0
22
23
24
25
26
27
28
29
EVENT : 22-OCT-99 0:00 to 29-OCT-99 0:00 (Time in days)

BATH POLLUTION STUDY

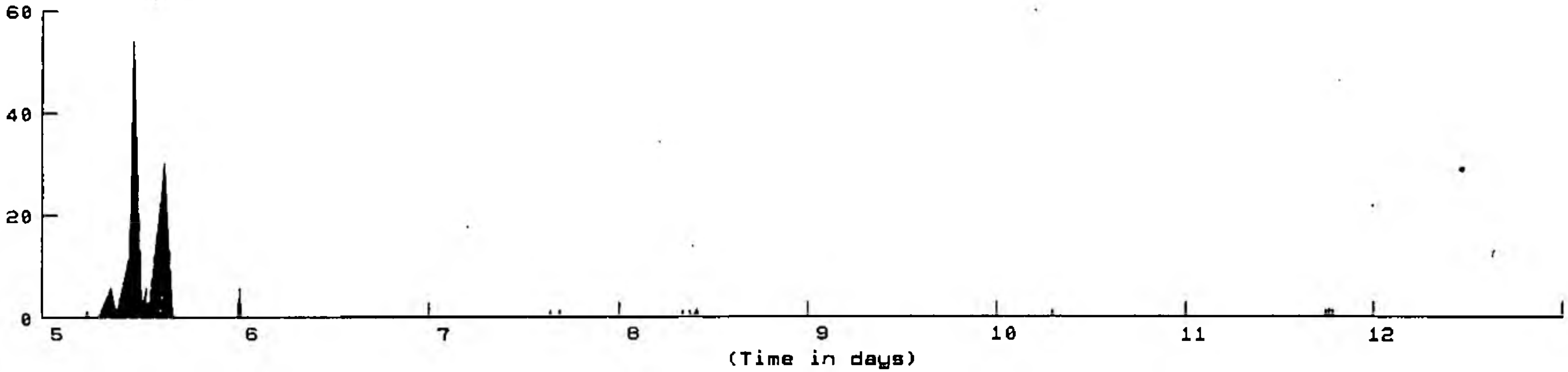


EVENT : 29-OCT-99 0:00 to 6-NOV-99 0:00

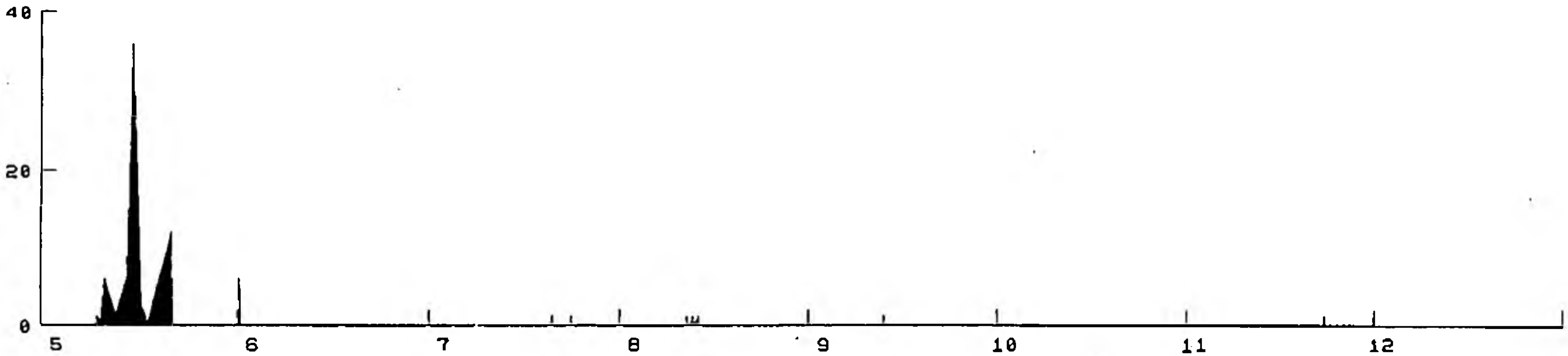
RAINFALL (mm/h) [RG 001]   Total rain =   24.8 mm   Peak =   60.0



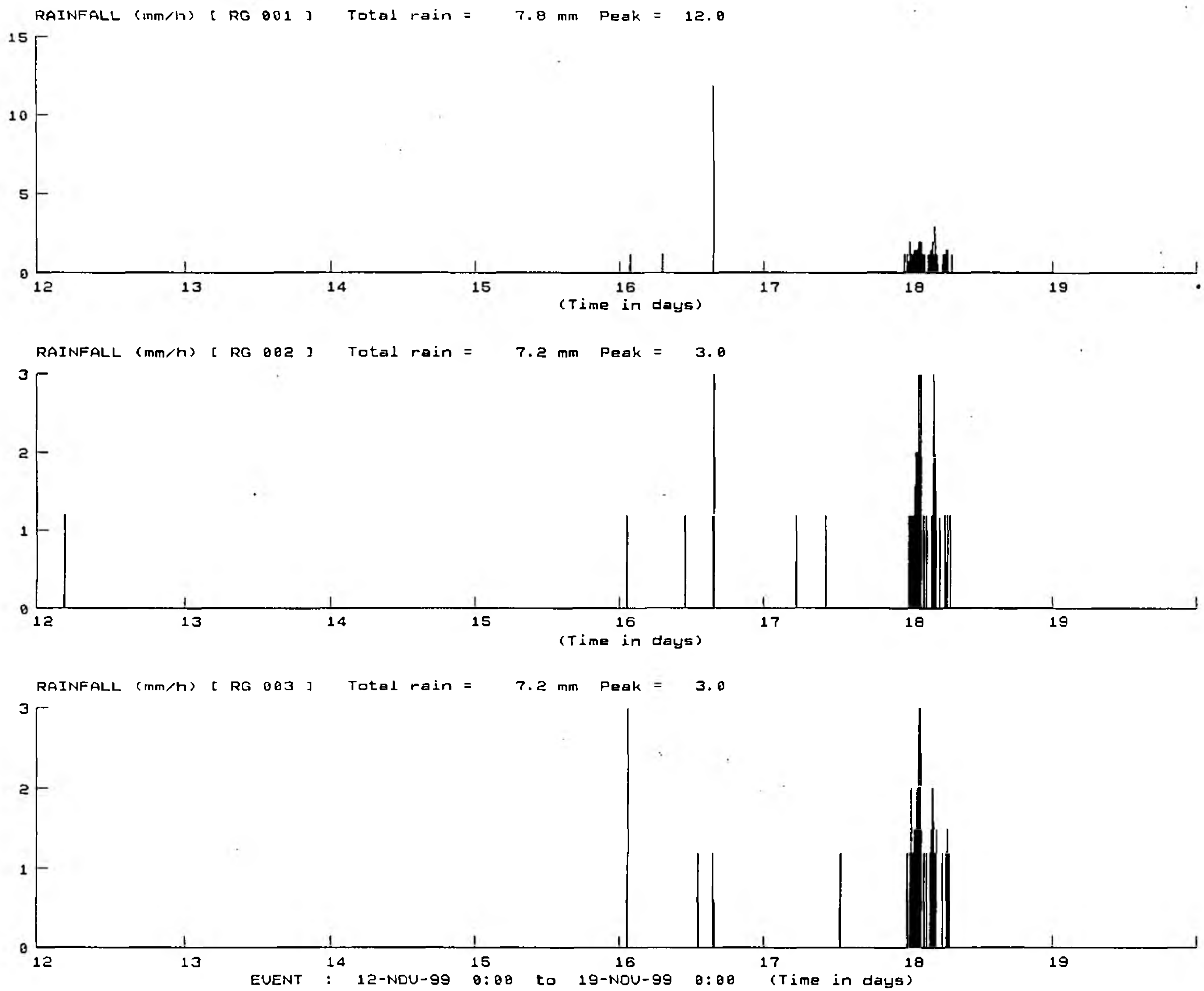
RAINFALL (mm/h) [RG 002]   Total rain =   39.6 mm   Peak =   54.0



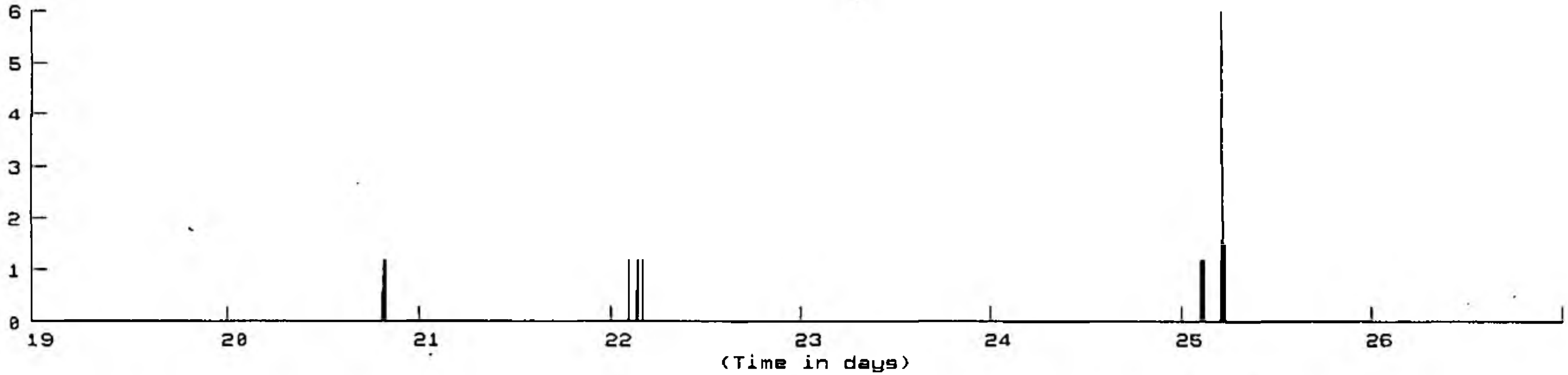
RAINFALL (mm/h) [RG 003]   Total rain =   25.4 mm   Peak =   36.0



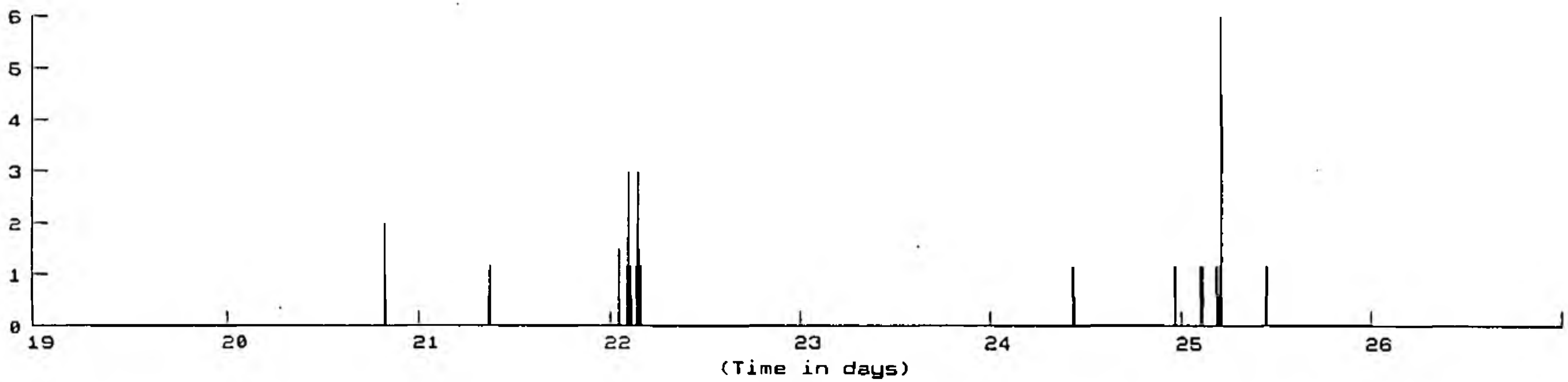
EVENT : 5-NOV-99 0:00 to 12-NOV-99 0:00 (Time in days)


RAINFALL (mm/h) [RG 001] Total rain = 7.8 mm Peak = 12.0
15
10
5
0
12
13
14
15
16
17
18
19
(Time in days)
RAINFALL (mm/h) [RG 002] Total rain = 7.2 mm Peak = 3.0
3
2
1
0
12
13
14
15
16
17
18
19
(Time in days)
RAINFALL (mm/h) [RG 003] Total rain = 7.2 mm Peak = 3.0
3
2
1
0
12
13
14
15
16
17
18
19
EVENT : 12-NOV-99 0:00 to 19-NOV-99 0:00 (Time in days)

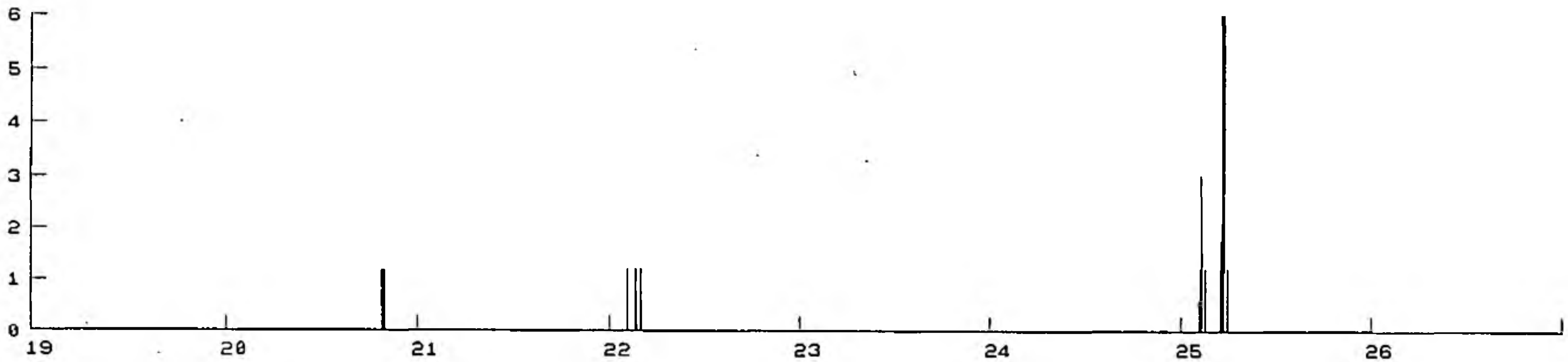
RAINFALL (mm/h) [RG 001]   Total rain =   2.8 mm   Peak =   6.0



RAINFALL (mm/h) [RG 002]   Total rain =   4.8 mm   Peak =   6.0



RAINFALL (mm/h) [RG 003]   Total rain =   3.4 mm   Peak =   6.0



EVENT : 19-NOV-99 0:00 to 26-NOV-99 0:00 (Time in days)

BATH POLLUTION STUDY