NATIONAL RIVERS AUTHORITY
SOUTHERN REGION
WATER RESOURCES DEPARTMENT

REVIEW OF CONTROL AREA RESULTS AND ESTIMATION OF DOMESTIC WATER CONSUMPTION IN 1991

CONTENTS

APPENDICES:

ACORN property and population profiles and plots of daily water consumption in control areas:-

PJS/AC
23 September 1992

1. INTRODUCTION

1.1 As part of its duties under the 1991 Water Resources Act NRA Southern produces biannual forecasts of potable water demand for the water company supply areas within the region. The forecasting methodology follows a component based approach in which the unmetered domestic per capita water consumption is estimated using data obtained from a network of control areas. The control areas being groups of unmetered domestic properties for which detailed flow records are obtained on data loggers sited in the main supplying the group. The operation of the control areas and the data analysis is a co-operative effort between the water companies and NRA Southern. At the present time there are over 70 control areas in operation. Data from control areas on the Isle of Wight is still collected but has not been incorporated in the analysis of unmetered domestic water consumption because these properties are now individually metered.

1.2 This report is the first in an annual series of summaries intended to provide a reference to the current status of control area monitoring and data analysis. The need for a more complete reference, rather than the usual dissemination of results tables and plots, was identified at a meeting between NRA Resources staff and water company representatives 8th July 1992 at Guildbourne House, Worthing.

1.3 The criteria for the selection of control areas were that they should consist entirely of domestic properties and that the residents in each area should fall into a single socio-economic class (The ACORN property classification has been used in this study). Also the total number properties within the control area network should represent 1 percent of the regional population. In practice each metered control area varies in size and most do not contain a single socio-economic class but as a group they can still be analysed to provide average water consumption estimates for the

socio-economic groups represented. The population in control areas ranges from less than 100 to over 2000 but typically is about 500.

1.4 It is important to be able to distinguish between net domestic consumption and leakage. This has been achieved with frequent flow measurements and data loggers are attached to the control area flow meters to record flows continuously at 15-minute intervals throughout each 24 hour period.

2. DATA PROCESSING

2.1 Software was produced in-house in 1985 by Southern Water Authority to handle the large volume of logger flow data from the control areas. The package for Water Supply Information Retrieval (WASIR) runs on IBM PC-AT compatible microcomputers and can be used for a variety of applications including district waste control metering, waste district step testing, flow and pressure logging for network analysis, source meter logging, consumer meter logging and of course domestic consumption monitoring for demand forecasting. WASIR is now marketed by Information Technology Southern.

2.2 Data from a choice of loggers can be downloaded to WASIR. These include DTS Celia, Spectrascan, Golden River, Wessex and Sarasota Sherpa. The basic data unit for domestic consumption monitoring in the control areas is 15-minute flow although WASIR can process data at intervals from 1 minute to 24 hours. The raw data from the control area loggers is downloaded to floppy disk and quality controlled by the participating water companies and is then forwarded to the NRA together with a report on any problems associated with the period logged. Data is thus received by the NRA in the form of intermediate data files containing 15-minute flows for each logger. This is loaded on the NRA copy of WASIR and edited using screen plots and data logger reports to remove any further incorrect data. Corrected intermediate files are returned to water companies and then the data is finally archived. The archiving process can combine the results from multiple loggers, where for example combination meters are used, and stores information to disk in the form of 15-minute flows for each complete control area. Archived files are stored in a compressed data format which can be interrogated to produce a variety of screen plots and reports.

2.3 It is important to estimate the net domestic water consumption in the control areas having allowed for leakage. The method used in WASIR is to subtract the minimum night flow from each daily total

flow using the two lowest consecutive night flows between the hours of midnight and 6 am. This was designed to identify leakage net of legitimate night use, and the computer system searches the record for each night and identifies the minimum 30 minute flow between these hours.

3. RELATING CONTROL AREA RESULTS TO WATER SUPPLY AREAS

Control area results are related to water company supply areas using the ACORN (A Classification of Residential Neighbourhoods) socio-economic classification of property types. The ACORN groupings were established by CACI Market Research Ltd. from a cluster analysis of the 1981 census information and comprise the following main categories.

ACORN group	Property description
A	Agricultural areas
B	Modern family housing, higher incomes
C	Older housing of intermediate status
D	Poor quality older terraced housing
E	Better-off council estates
F	Less well-off council estates
G	Poorest council estates
H	Multi racial areas
I	High status non-family areas
J	Affluent suburban housing
K	Better-off retirement areas

Table 1. ACORN socio-economic groups

3.2 A profile of the number of properties within each of the above ACORN groups has been established for each of the control areas and for the water company supply areas. CACI Ltd. provided reports for each water supply area giving the ACORN profiles by population and by household numbers by relating post codes within the supply areas to the enumeration district data from the 1981 census. Updated profiles were subsequently produced by CACI using demographic modelling. A combination of CACI Ltd. analysis and doorstep survey was used to produce ACORN profiles of each control area.

4. METHODOLOGY FOR DATA ANALYSIS

4.1 The analysis of control area results is performed on annual summaries of net water consumption in the control areas obtained from the WASIR archive. Table 2 shows part of a typical summary table. Although the original intention was to establish control areas containing single ACORN types, in practice this could not be achieved. However, there are sufficient single ACORN-type areas to provide an initial assessment of net domestic per capita consumption by ACORN type and these estimates can then be refined using all control area data for a particular year.

control area	population in each ACORN group B	C	E	F	J	K	total popn.	measured volume (l/d)
1	0	1021	69	1114	0	0	2204	288724
2	0	0	0	0	0	346	346	62899
3	0	0	0	0	0	493	493	91698
4	0	239	18	0	605	0	862	118043
.								
.								
.								
66	1496	0	0	0	0	0	1496	188496

Table 2. Example annual summary of control area results.

4.2 The stages involved in the control area data analysis are:

(a) the calculation of initial estimates of net PCC from the results for control areas of a single ACORN type.

(b) refinement of the initial estimates using the full amount of control area data for the year.

(c) calculation of confidence limits on the final estimates.

(d) application of control area results for ACORN groups to water company supply areas.

4.3 a. Initial net PCC estimates for each ACORN group.

Initial estimates of net domestic per capita consumption (PCC) are obtained using the results from the single ACORN type control areas. The weighted mean estimate of the initial PCC for each ACORN type is given by the total measured consumption (vm) divided by the total population (p) for those control areas:

- initial PCC'= vm / p

where ' denotes by ACORN type.

An example of measured water consumption for single ACORN type control areas is shown in table 3. It can be seen that not all the ACORN groups described in table 1 are represented by the control areas but this is a reflection of the general composition of the population in Southern region and these groups do represent about 90% of the population.

ACORN group											
B		C		E		F		J		K	
p'	vm	p'	vm	p'	vm	p'	vm	p'	vm	p'	vm
107	12519	734	112239	82	13202	32	4480	619	79232	346	6289
306	41310	47	8648	785	94985	26	2990	81	12717	493	91698
837	105512	69	9384	622	67176	564	75576	65	10010	141	14946
321	54570	164	23124	266	35378			177	36816	936	192816
196	37436	62	6882					290	39730	99	20295
250	35500	334	46760							160	23200
269	36853	162	24138							339	53562
520	64480	268	31624								
159	18921		267	42987							
1496	188496										
PCC'	135.1		142.9		120.1		133.5		144.9		182.8

p'= population, vm = measured water consumption (l/d).

Table 3. Example of initial estimates of net PCC

4.4 b. Refinement of initial net PCC estimates.

Since the ACORN population profile is known for each control area, the initial estimates of net PCC can be used to calculate a theoretical annual volume of water consumption for each area which can then be compared to the measured volume:

- calculated volume by ACORN type (vc') = initial PCC'. p'
- calculated volume for each control area (vc) = sum of vc'

The differences between the calculated and measured control area consumptions are then apportioned on a volumetric basis and adjusted estimates of PCC by ACORN type within each control area can then be derived:

- volume adjustment by ACORN group (va') = (vm - vc).(vc'/ vc)
- new vc' = old vc' +/- va'
- adjusted PCC' = vc' / p'

The required final estimates of net domestic PCC by ACORN type are then obtained by dividing the sum of the adjusted volumes in each ACORN group by the population within each group:

- weighted average PCC' = sum of vc' / sum of p'

4.5 c. Calculation of confidence limits on net PCC estimates.

Confidence limits are calculated for the weighted average estimates of net domestic PCC as follows:

- the proportion of the control area population represented by each ACORN group is:

pr' = p' / sum of p'

- the weighted sample variance (sv) is the mean weighted square deviation about the weighted arithmetic mean:

$sv = \text{sum of}(pr'.(\text{adjusted PCC'} - \text{weighted average PCC'})^2)$

- the estimated population weighted variance (pv) is:

$pv = sv \cdot (n/n-1)$

where n is the number of PCC estimates within each ACORN group.

- the standard error being the square root of the population weighted variance divided by n.

- finally, the confidence range is given by the standard error multiplied by Student's t-value at the 95% level with n-1 degrees of freedom.

An example of the statistical results obtained following this procedure is given in table 4.

	ACORN group					
	B	C	E	F	J	K
consumption (l/d)	1344645	1118899	1228498	520676	1182394	1113797
population	9565	7971	9626	4048	7476	6178
n	22	28	16	12	13	16
weighted mean PCC (l/h/d)	140.6	140.4	127.6	128.6	158.2	180.3
sample variance	500.8	320.6	305.3	90.6	405.7	558.2
popn. variance	524.6	332.5	325.7	98.8	439.5	595.5
standard error	4.9	3.4	4.5	2.9	5.8	6.1
Student's t	2.080	2.052	2.131	2.201	2.179	2.131
confidence interval (l/h/d)	10.2	7.0	9.6	6.4	12.6	13.0

PCC in l/h/d, t at 95% level with n-1 degrees of freedom

Table 4. Example summary of results by ACORN group in 1988

4.6 d. Application of ACORN net domestic PCC to water supply areas.

ACORN population profiles are also available for the water supply areas of each of the water companies in Southern region. The estimates of net domestic PCC obtained from the analysis of control area results can be used with these profiles to estimate the average net domestic PCC for a water supply area. The estimates for the water supply areas are then used with data for unmetered population in the demand forecasts for the region.

5. SUMMARY OF AVAILABLE DATA

5.1 The location map shows the distribution of control areas currently in use.

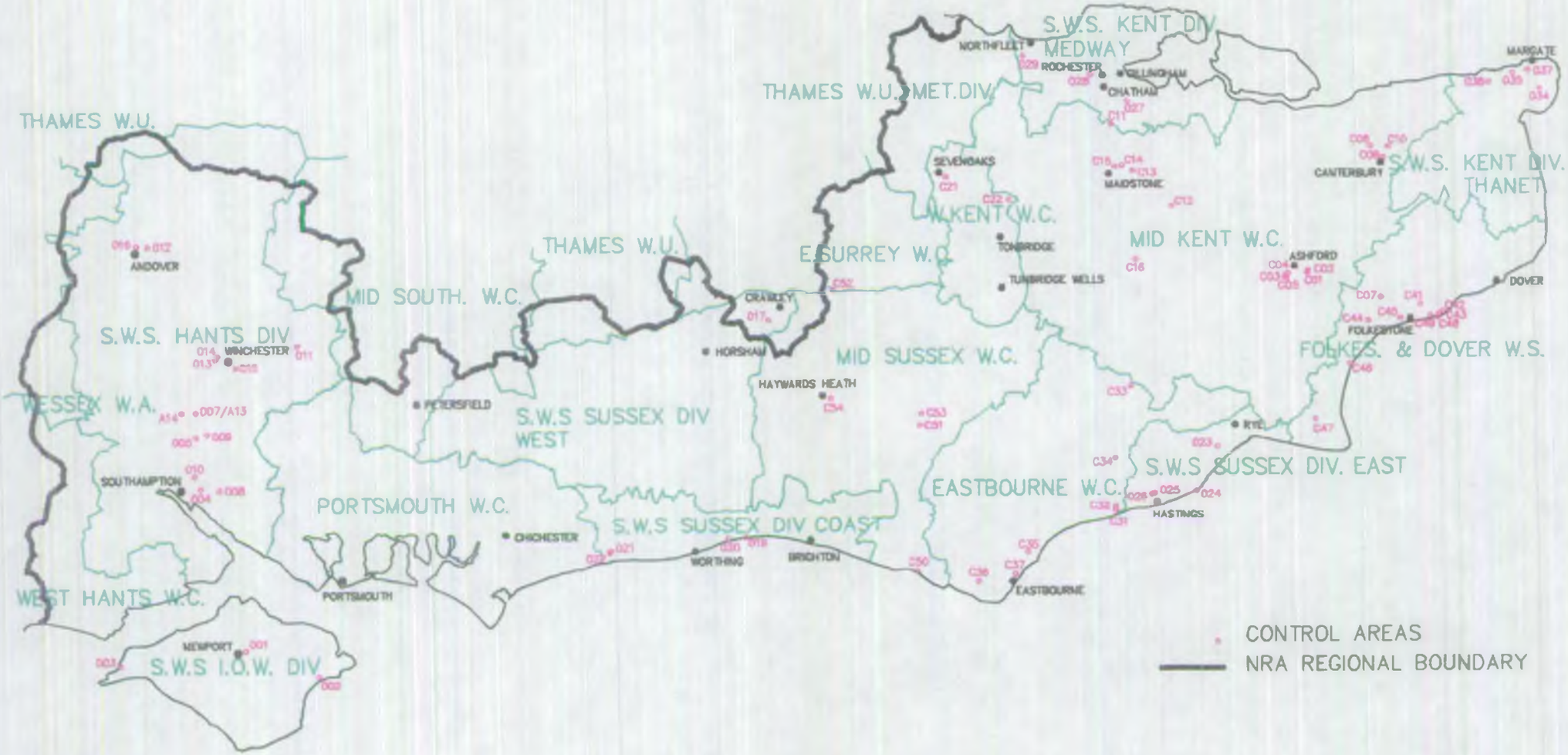
5.2 Water Companies participating in the control area network hold WASIR archives for their own control area results whereas NRA Southern Region maintain a complete archive for all areas. This is used to estimate the net domestic per capita water consumption by ACORN property type.

5.3 In general the control areas now operated by Southern Water Services began to produce data in 1985 and the remaining control areas were on line by 1987. 1988 was the first year in which the combined results for control areas operated by Southern Water Services and all other participating water companies could be used as a single data set.

5.4 All control area data is archived as 15 minute total flows from which data sets for minimum night flow and net flow can be derived. Since the establishment of the control areas the method adopted for the estimation of the minimum night flow in WASIR has been to take the minimum over two consecutive 15 minute values between midnight and 0600h. The net daily flow is then taken to be the total daily flow less the minimum night flow * 40. A factor of 80/2 is used rather than 96/2 to allow for pressure variation. This is in line with Technical Committee report number 26.

5.5 In Section 4 the methodology for estimating net per capita consumption by ACORN property type was described. The analysis is based on annual data derived from monthly flow results. The criterion applied is that control area data for a particular month is included in the analysis if no more than half the daily data for the month is missing.

LOCATION OF CONTROL AREAS IN SOUTHERN REGION



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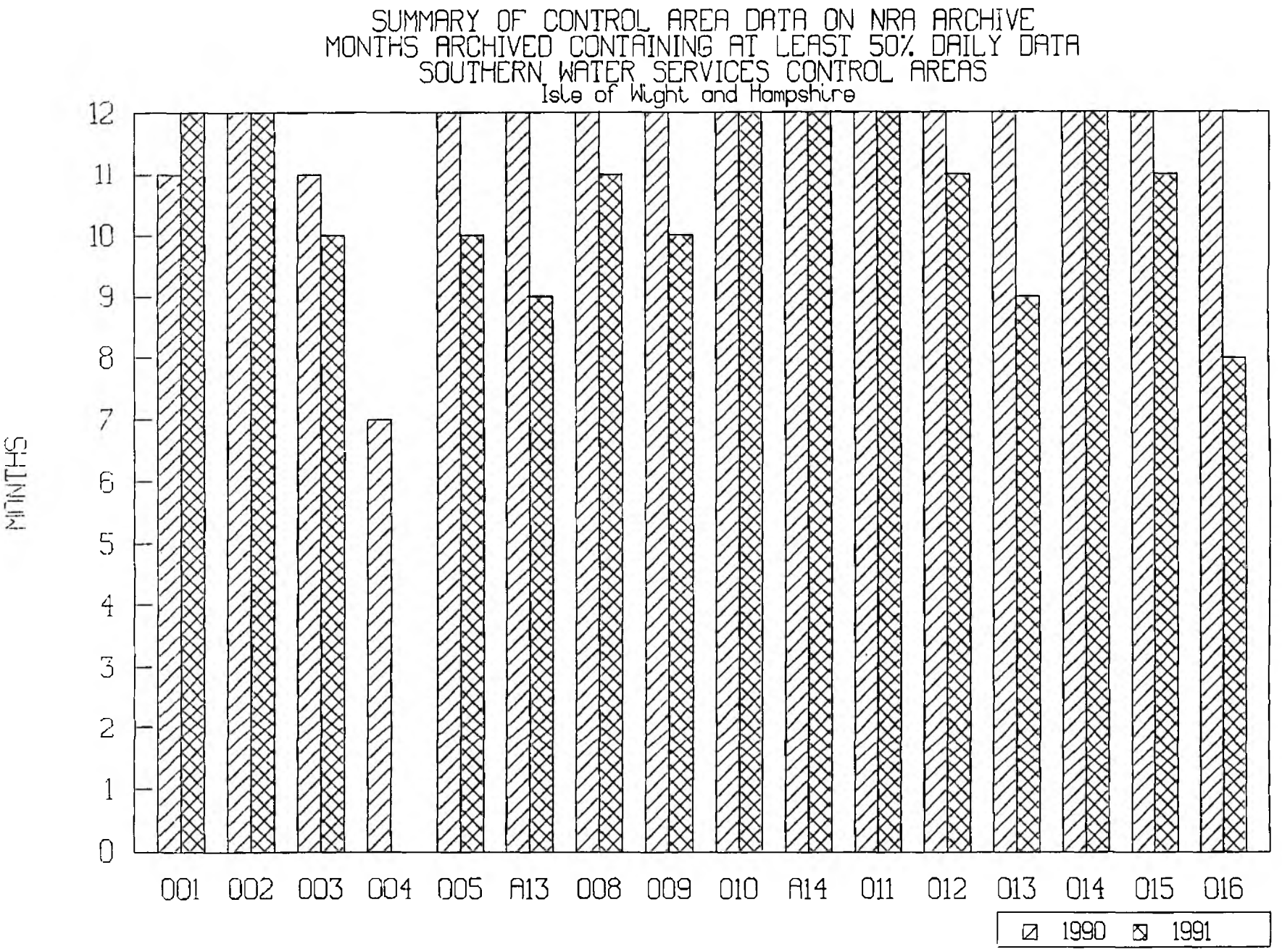
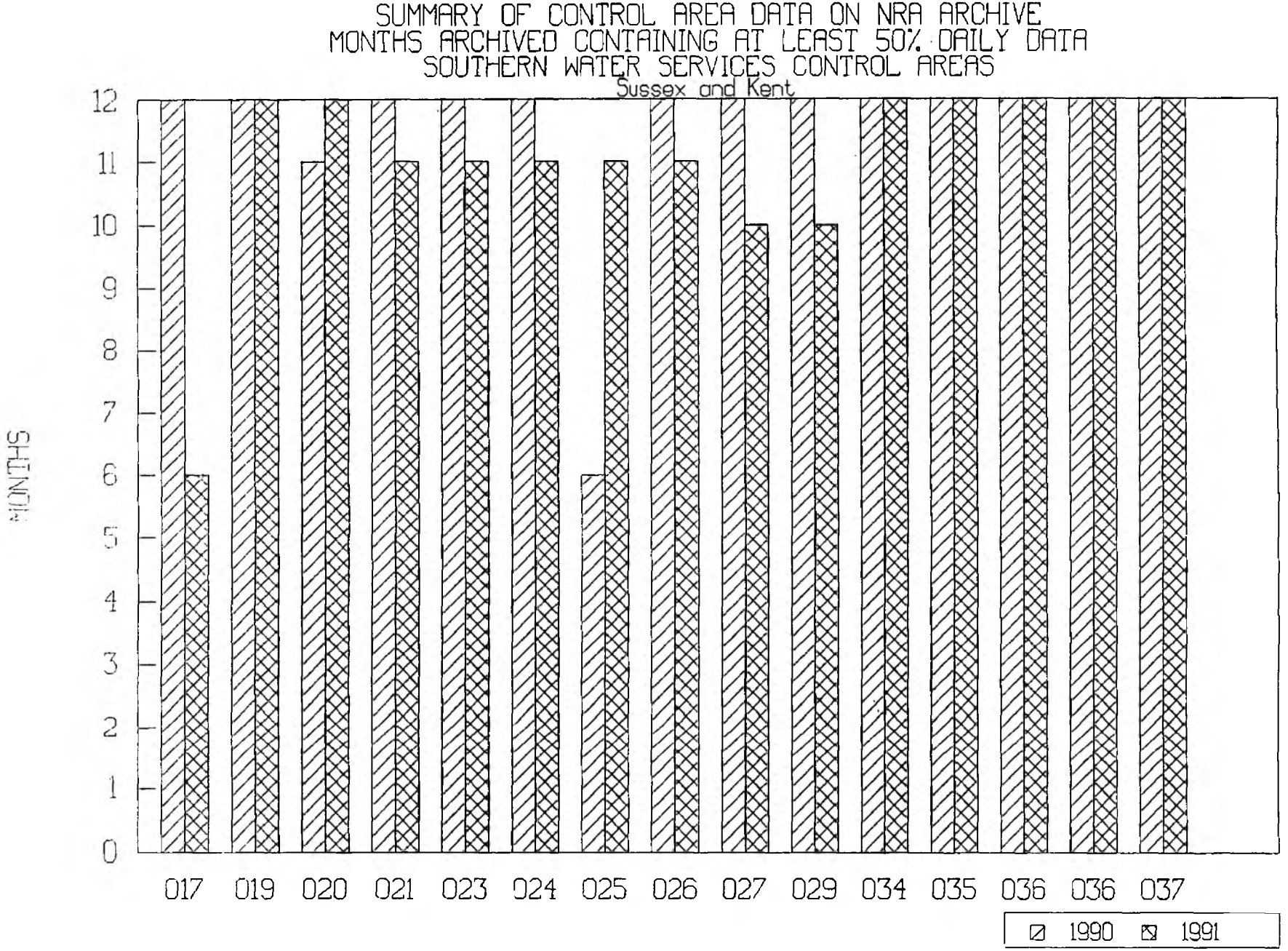
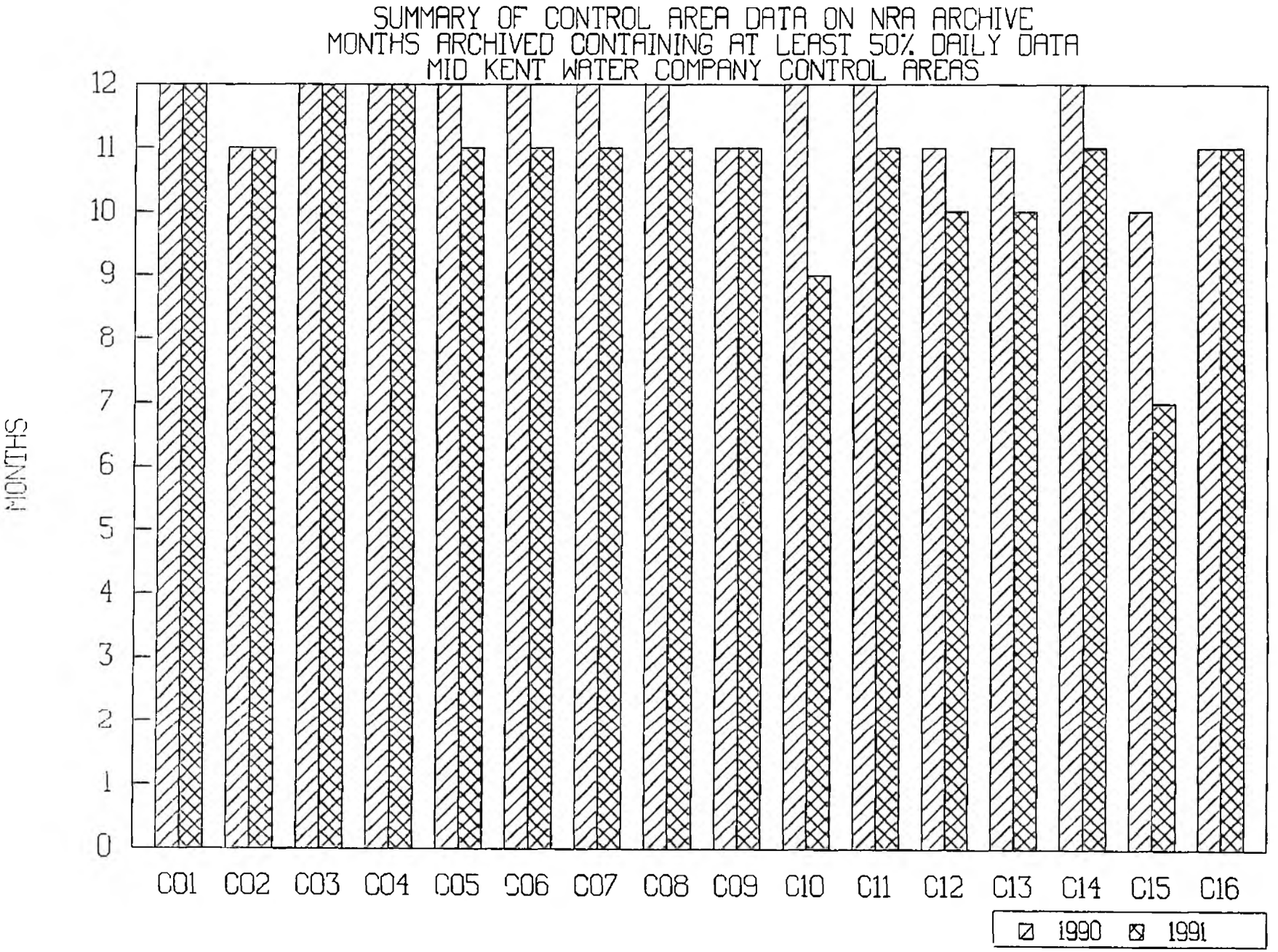
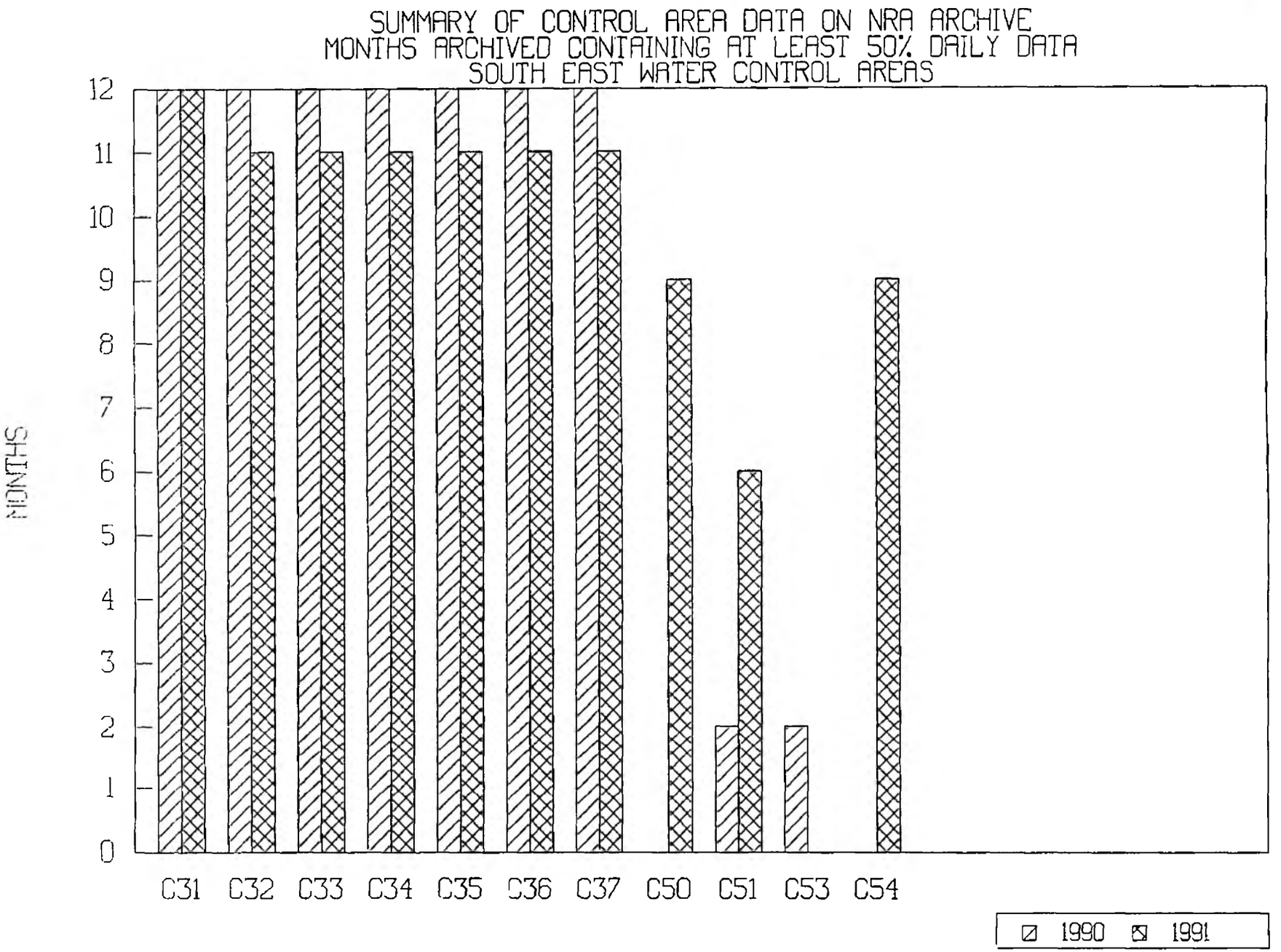
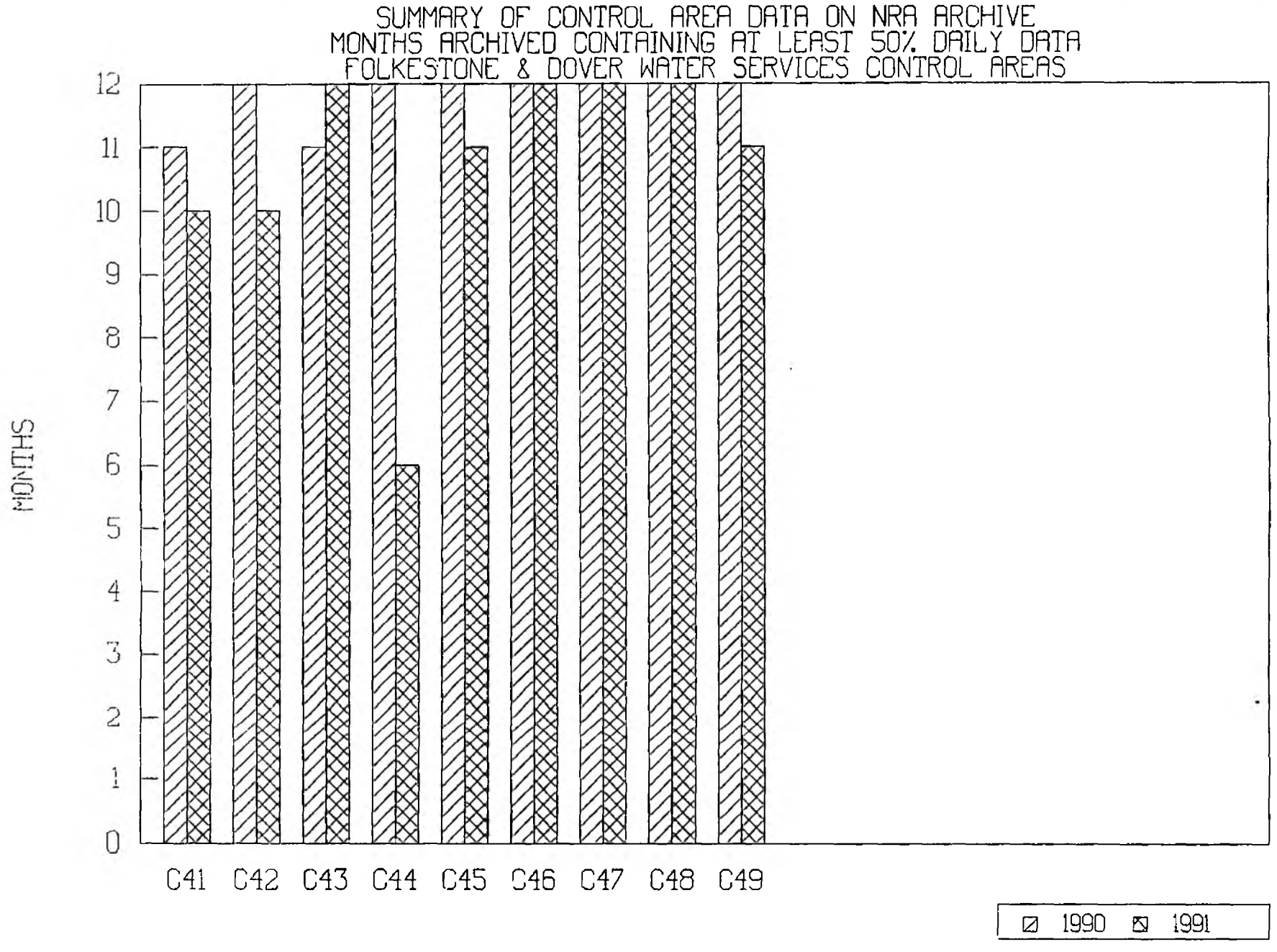

SUMMARY OF CONTROL AREA DATA ON NRA ARCHIVE
MONTHS ARCHIVED CONTAINING AT LEAST 50% DAILY DATA
SOUTHERN WATER SERVICES CONTROL AREAS
Isle of Wight and Hampshire
MONTHS
0
1
2
3
4
5
6
7
8
9
10
11
12
001
002
003
004
005
A13
008
009
010
A14
011
012
013
014
015
016
1990
1991


SUMMARY OF CONTROL AREA DATA ON NRA ARCHIVE
MONTHS ARCHIVED CONTAINING AT LEAST 50% DAILY DATA
SOUTHERN WATER SERVICES CONTROL AREAS
Sussex and Kent
MONTHS
12
11
10
9
8
7
6
5
4
3
2
1
0
017
019
020
021
023
024
025
026
027
029
034
035
036
036
037
1990
1991


SUMMARY OF CONTROL AREA DATA ON NRA ARCHIVE
MONTHS ARCHIVED CONTAINING AT LEAST 50% DAILY DATA
MID KENT WATER COMPANY CONTROL AREAS
MONTHS
0
1
2
3
4
5
6
7
8
9
10
11
12
C01
C02
C03
C04
C05
C06
C07
C08
C09
C10
C11
C12
C13
C14
C15
C16
1990
1991


SUMMARY OF CONTROL AREA DATA ON NRA ARCHIVE
MONTHS ARCHIVED CONTAINING AT LEAST 50% DAILY DATA
SOUTH EAST WATER CONTROL AREAS
MONTHS
12
11
10
9
8
7
6
5
4
3
2
1
0
C31
C32
C33
C34
C35
C36
C37
C50
C51
C53
C54
1990
1991


SUMMARY OF CONTROL AREA DATA ON NRA ARCHIVE
MONTHS ARCHIVED CONTAINING AT LEAST 50% DAILY DATA
FOLKESTONE & DOVER WATER SERVICES CONTROL AREAS
MONTHS
0
1
2
3
4
5
6
7
8
9
10
11
12
C41
C42
C43
C44
C45
C46
C47
C48
C49
1990
1991

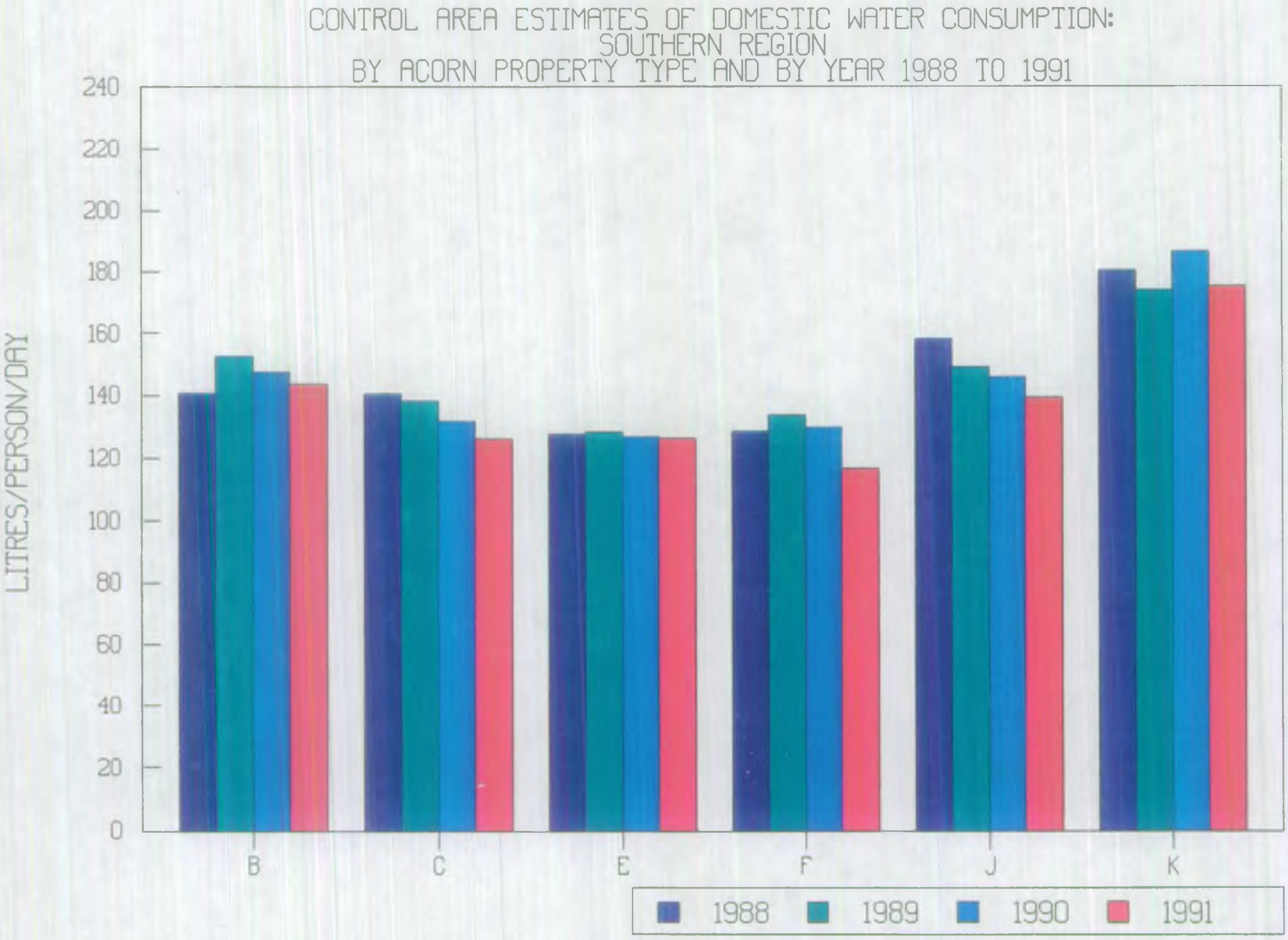
5.6 Bar charts are included to show the availability of monthly control area results in 1991 compared to 1990. Some fall in data availability can be noted due to operational problems. It is important to keep as many control areas in the analysis for any one year in order to ensure that the annual per capita consumption estimates are truly representative of the regional population. The aim is to archive continuous 15 minute flows in all the control areas. Continuous high resolution data with the very little missing data is important for detailed time series analysis. A certain amount of missing data can be tolerated within the analysis used to derive annual per capita consumption estimates but greater confidence can be placed in results when the amount of missing data is minimised.

5.7 Annual plots of daily data for each control area are included in the appendix. The plots show the net daily flow and the daily equivalent night flow during 1991.

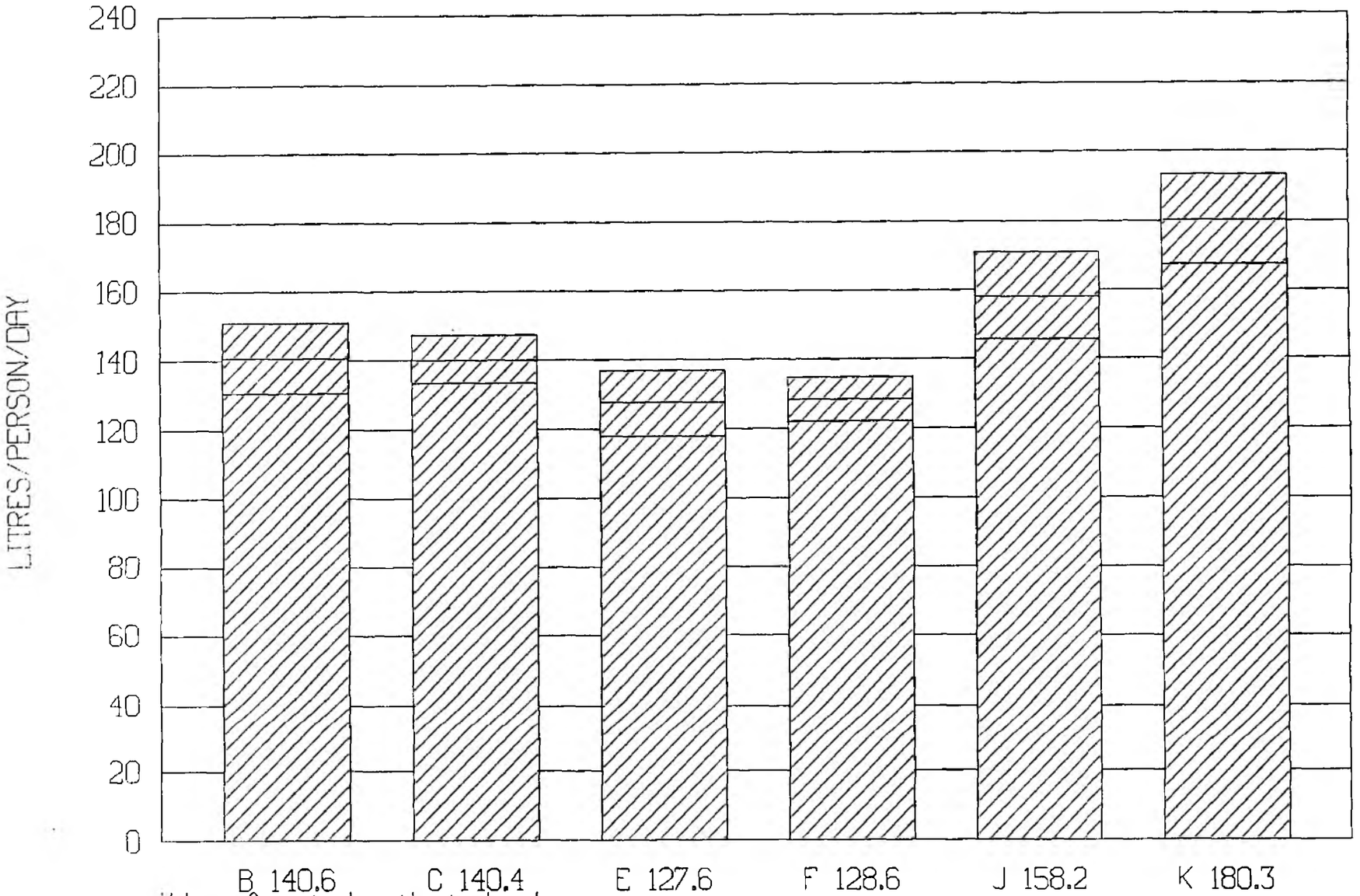
6. CONTROL AREA RESULTS FOR 1991

6.1 A bar chart is included which summarises the estimates of average net domestic per capita consumption by ACORN property type in 1991. These results can be compared to a similar chart for 1988. 1988 was used as the base year for the last NRA review of demand forecasts and was the first year when the full set of control area results could be used.

6.2 Control area results by ACORN type are also summarised in tabular form for each year since 1988. The method of analysis described in Section 4 allows the estimation of confidence limits at the 95% level. It has been found that the method of analysis is stable from year to year. This would not be the case with a multiple regression analysis.

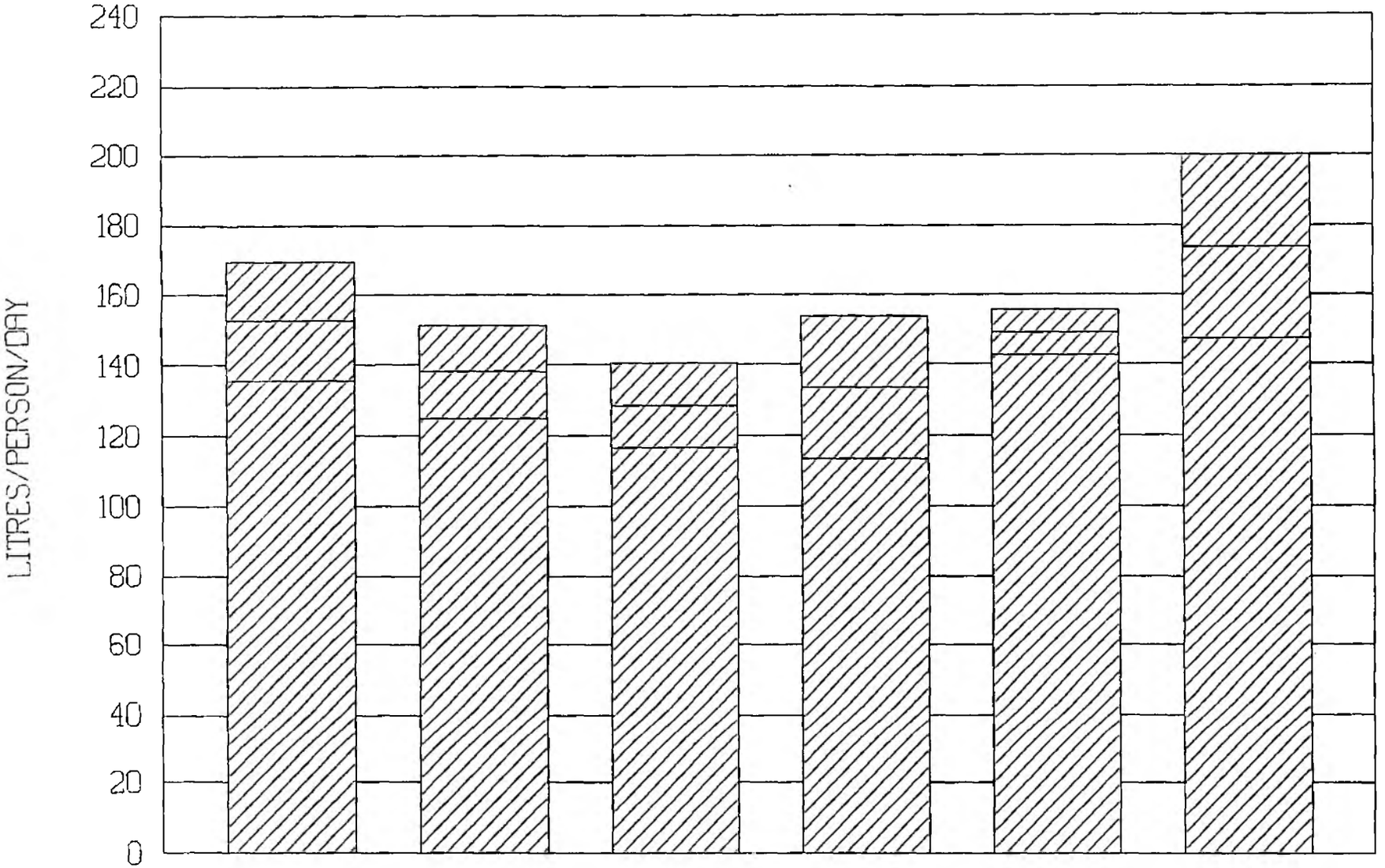

CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
SOUTHERN REGION
BY ACORN PROPERTY TYPE AND BY YEAR 1988 TO 1991
LITRES/PERSON/DAY
240
220
200
180
160
140
120
100
80
60
40
20
0
B
C
E
F
J
K
1988
1989
1990
1991

CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
BY ACORN PROPERTY TYPE FOR 1988



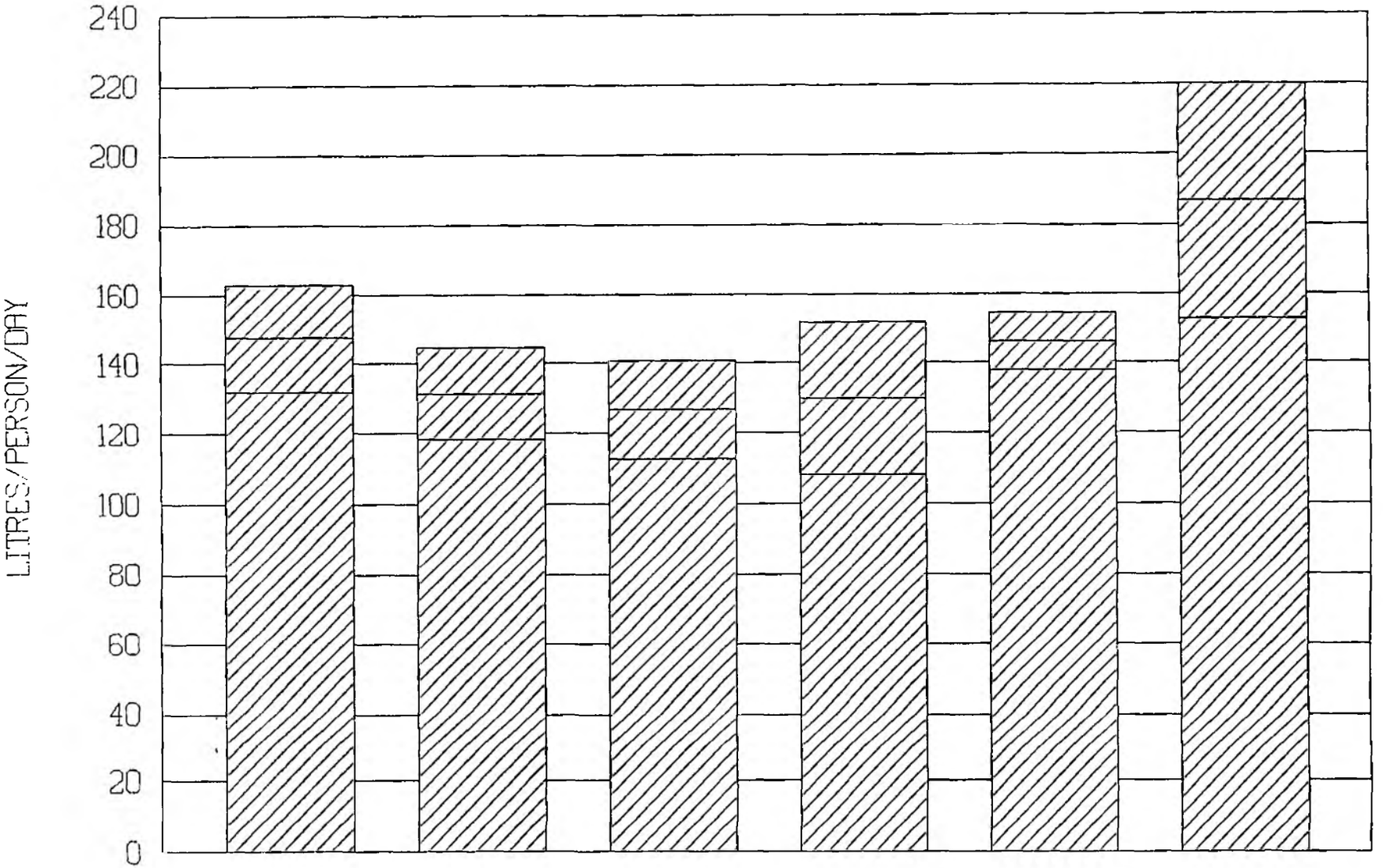
Value of central estimate is shown.
Range in estimates indicated for 95% confidence level.

CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
BY ACORN PROPERTY TYPE FOR 1989



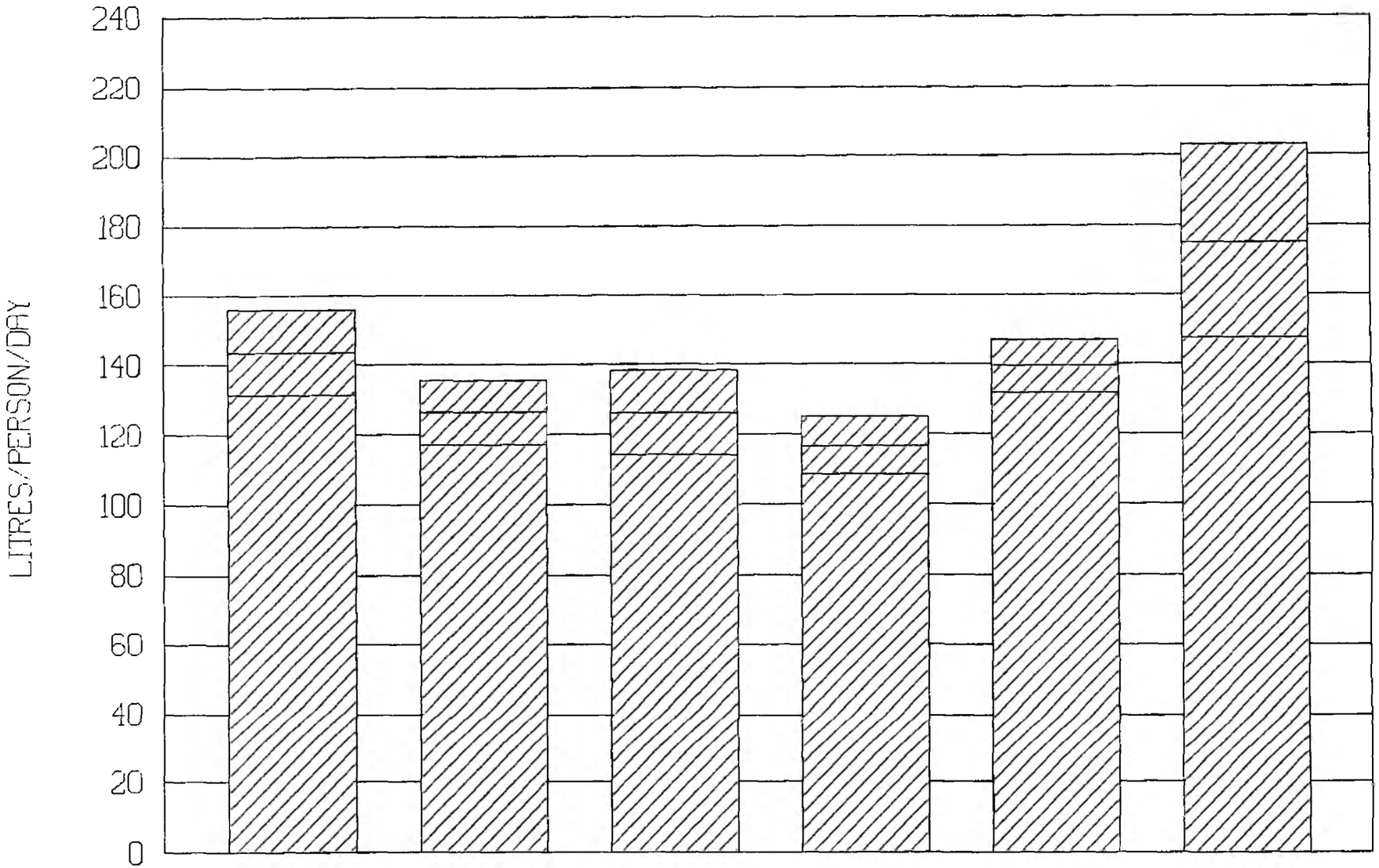
Value of central estimate is shown.
Range in estimates indicated for 95% confidence level.

CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
BY ACORN PROPERTY TYPE FOR 1990



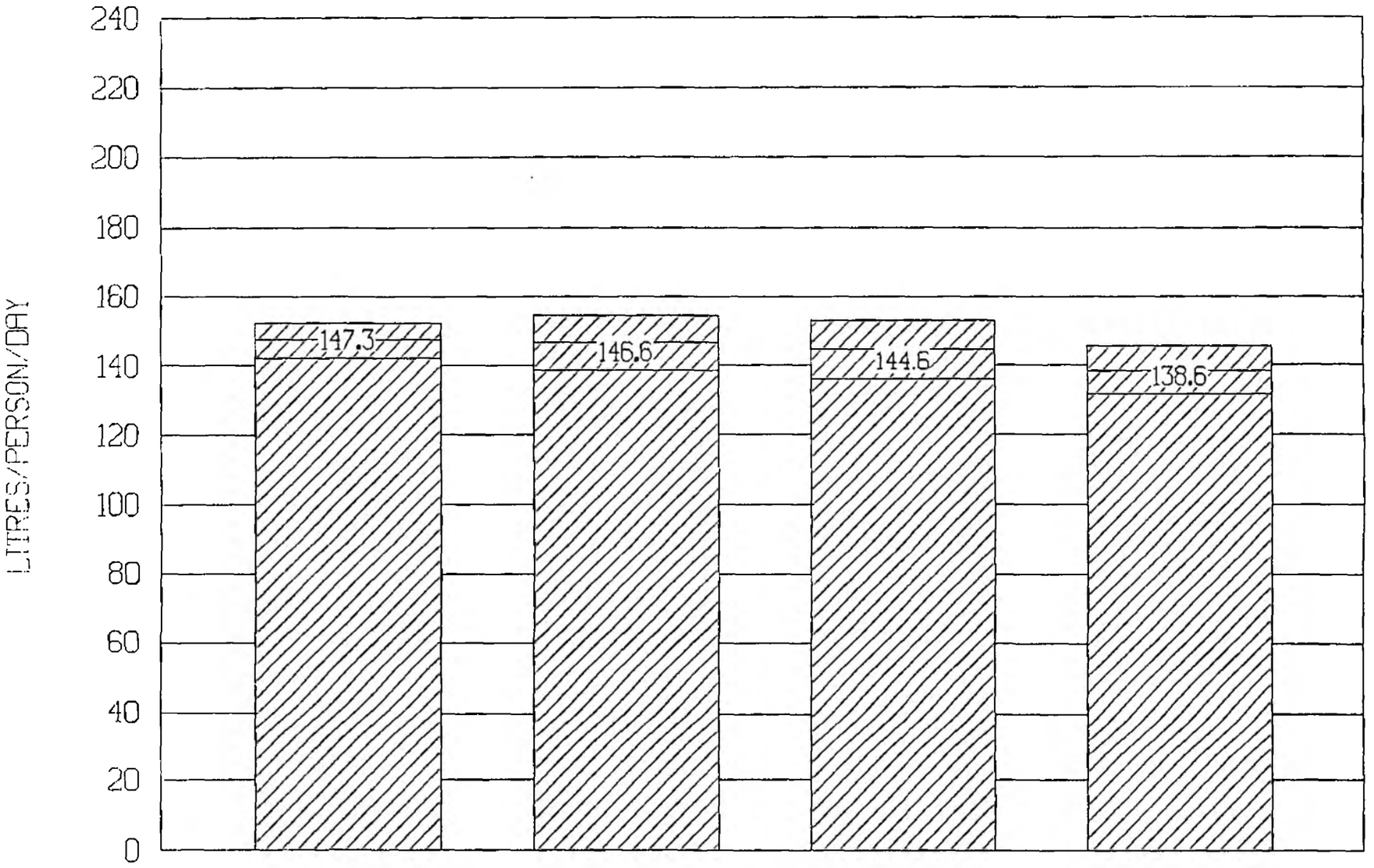
Value of central estimate is shown.
Range in estimates indicated for 95% confidence level.

CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
BY ACORN PROPERTY TYPE FOR 1991



Value of central estimate is shown.
Range in estimates indicated for 95% confidence level.

CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
SOUTHERN REGION



Value of central estimate shown.
Range in estimates indicated for 95% confidence level.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 This summary of control area results for 1991 has demonstrated the stability of the method of analysis used to derive estimates of average annual per capita consumption by ACORN property type.

7.2 The need to obtain good quality continuous high resolution data is emphasised, particularly if the control area results are to be used for detailed time series analysis (for example, effects of domestic metering). This is important when looking at peak demands.

7.3 The first full set of control area results for the region as a whole became available in 1988. The analyses completed for each year from 1988 to 1991 show a steady decline in domestic per capita consumption. This is most likely due to the effects of the recession over this period coupled with drought restrictions on water use and public awareness of the need for conservation.

7.4 The network of control areas was first established to represent approximately 1% of the regional population. Sufficient control areas are still in operation but some increase in the number of areas would be of benefit. The geographical distribution of areas could be improved and additional areas of single ACORN property type would increase the accuracy of consumption estimates.

7.5 At the control area meeting on 8.July 1992, a number of action points were identified:

* Firstly, the use of event record sheets for distribution staff operating the data loggers would be of benefit. The NRA could also send quarterly data reports direct to water managers highlighting any recent problems with data collection.

* A new schedule for return of field data to the NRA was agreed. This would allow data processing to be staged over the year and for the

CONTROL AREA DATA 1992 - 1993

PROCESSING SCHEDULE

All intermediate disks should be sent to Guildbourne House for processing at intervals of 4 months, by each company as follows:-

Mid Kent Water	18th JANUARY 93	18th MAY 92	18th SEPTEMBER 92
Folkestone & Dover Water	18th JANUARY 93	18th MAY 92	18th SEPTEMBER 92
Eastbourne Water	18th FEBRUARY 93	18th JULY 92	18TH OCTOBER 92
Mid Sussex Water	18th FEBRUARY 93	18th JULY 92	18th OCTOBER 92
West Kent Water	18th FEBRUARY 93	18th JULY 92	18th OCTOBER 92
Southern Water	ALL 1992 DATA TO BE RECEIVED BY 1st APRIL 1993.		

PW/07.92

analysis to be completed by 19 May, in time for company returns to OFWAT. The agreed schedule is shown below.

* Water Companies agreed to fund the routine replacement of control area meters and data loggers. For information a guidance note on meter replacement, prepared by the former Southern Water Authority, is included.

* Cross-checking of the control area details provided in the appendix is recommended. However, it was agreed that a new survey was required to update control area population, household and ACORN classification data.

* This could usefully be combined with a questionnaire on household water use similar to a survey already carried out for the Kent area. The survey could be funded by the NRA and carried out with the consent and co-operation of the water companies.

* Water companies are requested to check the control area details held on record by NRA Southern (presented here in the appendices).

7.6 The methodology for deriving net flow estimates from continuous control area flow measurements is described in Section 2 and this way of separating minimum night flows was also used in the national metering trials. However, views are sought on possible improvements to this approach. South East Water have described step tests now being carried out as part of the leakage initiative to provide better estimates of losses from service pipes on customers premises. Further step tests in selected control areas would provide valuable information.

APPENDICES

Water companies are requested to check the control area details held on record by the NRA.

APPENDIX A: SOUTHERN WATER SERVICES

CONTROL AREA CHECK LIST: SOUTHERN WATER SERVICES

Isle of Wight

AREA #	NAME	GRID REF	METER/LOGGER
001	PAN ESTATE, NEWPORT	SZ506890	
002	YAVERLAND, SANDOWN	SZ610854	
003	TOTLAND	SZ325870	

Hampshire South

AREA #	NAME	GRID REF	METER/LOGGER
004	OSTERLEY ROAD, WOOLSTON	SU441120	
005	SURREY HOUSE, EASTLEIGH	SU435193	
007/A13	HOLCOMBE ROAD, CHANDLERS FORD	SU435228	
008	LYDGATE, THORNHILL	SU468118	
009	WHYTEWAYS, EASTLEIGH	SU451198	
010	IVY ROAD, ST DENYS	SU433137	
A14	HOOK ROAD	SU415228	

Hampshire North

AREA #	NAME	GRID REF	METER/LOGGER
011	MAKINS COURT	SU580320	
012	BRACHER CLOSE, ANDOVER	SU366458	
013	TEG DOWN	SU463302	
014	WEEKE, WINCHESTER	SU466306	
015	HIGHCLIFFE	SU492289	
016	KING GEORGE ROAD, ANDOVER	SU350459	

Sussex West

AREA #	NAME	GRID REF	METER/LOGGER
017	BROADFIELDS, CRAWLEY	TQ258354	

Sussex Coast

AREA #	NAME	GRID REF	METER/LOGGER
019	SHOREHAM BEACH, SHOREHAM	TQ224046	
020	THE BROADWAY, LANCING	TQ199044	
021	HIGHDOWN DRIVE, LITTLEHAMPTON	TQ030028	
022	CORNWALL ROAD, LITTLEHAMPTON	TQ028025	

Sussex East

AREA #	NAME	GRID REF	METER/LOGGER
023	WINCHELSEA	TQ905175	
024	FAIRLIGHT COVE	TQ875115	
025	BAIRD DRIVE, HASTINGS	TQ814111	
026	BAYEUX COURT, HASTINGS	TQ810110	

Kent Medway

AREA #	NAME	GRID REF	METER/LOGGER
027	CARLTON CRECENT, CHATHAM	TQ776659	
028	ALLINGTON DRIVE, ROCHESTER	TQ723697	
029	PAINTER ASH	TQ626723	

Kent Thanet

AREA #	NAME	GRID REF	METER/LOGGER
034	NORTHWOOD ROAD, RAMSGATE	TR371675	
035	MICHELLE GARDENS	TR332697	
036	BROADLEY AVENUE	TR297684	
037	ALEXANDRA HOMES, MARGATE	TR354701	

CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

ACORN population profiles and annual consumption in 1991.

SOUTHERN WATER SERVICES CONTROL AREAS

	control area #	population in Acorn Group B	C	E	F	J	K	Total popn	PCC (l/c/d)	Meas Cons (l/d)
HS Surrey House	005				32			32	144.6	4626
Hocombe Road	A13	165				1656		1821	130.4	237515
Lydgate Road	008			847	210			1057	96.1	101570
Wyteways	009	499	132		261			892	124.0	110638
Ivy Road	010		734					734	159.0	116661
Hook Road	A14	670						670	196.1	131390
HN Makins Court	011			82				82	154.2	12647
Bracher Close	012		47					47	104.2	4896
Teq Down	013					619		619	137.1	84855
Weeke	014		309	434	326			1069	139.8	149430
Highcliffe	015			278	484			762	130.2	99224
King George Rd	016	107						107	112.0	11981
SW Broadfields	017	639		3584				4223	153.3	647468
SC Shoreham Beach	019	438	530			2999	120	4086	146.8	599806
The Broadway	020		462			638		1100	139.4	153296
Highdown Drive	021		288				1155	1443	140.9	203338
Cornwall Road	022		385				299	684	124.8	85359
SE Winchelsea Town	023		85				443	528	145.8	77005
Fairlight Cove	024		81				1397	1478	161.0	237895
Baird Drive	025	306						306	122.9	37620
Bayeaux Court	026		69					69	124.0	8556
KM Carlton Crescent	027		164					164	121.5	19926
Allington Drive	028	837						837	116.0	97172
Painters Ash	029	388		1324	615			2328	120.6	280791
KT Northwood	034	1119	220					1339	121.7	162935
Michelle Gardens	035					81		81	136.6	11066
Broadley Avenue	036			69			83	153	110.0	16800
Alexandra House	037		62					62	69.5	4311

Not used in 1991 analysis (areas now metered)

	control area #	population in Acorn Group B	C	E	F	J	K	Total popn	PCC (l/c/d)	Meas Cons (l/d)
IOW Pan Estate	001		1021	69	1114			2204		
Yaverland	002						346	346		
Totland	003						493	493		

CONTROL AREA CALCULATIONS: 1991 HOUSEHOLD BASED

ACORN household profiles

SOUTHERN WATER SERVICES CONTROL AREAS

	control area #	households in Acorn Group B	C	E	F	J	K	Total hh	PHC (l/hh/d)	Meas Cons (l/d)
HS Surrey House	005				29			29	159.5	4626
Hocombe Road	A13	54				541		595	399.2	237515
Lydgate Road	008			307	76			383	265.2	101570
Wyteways	009	189	50		99			338	327.3	110638
Ivy Road	010		297					297	392.8	116661
Hook Road	A14	280						280	469.3	131390
HN Makins Court	011			74				74	170.9	12647
Bracher Close	012		37					37	132.3	4896
Teg Down	013					222		222	382.2	84855
Weeke	014		119	167	125			411	363.6	149430
Highcliffe	015			88	154			242	410.0	99224
King George Rd	016	32						32	374.4	11981
SW Broadfields	017	193		1079				1272	509.0	647468
SC Shoreham Beach	019	129	205			1031	43	1408	426.0	599806
The Broadway	020		216			284		500	306.6	153296
Highdown Drive	021		149				481	630	322.8	203338
Cornwall Road	022		152				126	278	307.0	85359
SE Winchelsea Town	023		44				231	275	280.0	77005
Fairlight Cove	024		36				624	660	360.4	237895
Baird Drive	025	89						89	422.7	37620
Bayeaux Court	026		39					39	219.4	8556
KM Carlton Crescent	027		56					56	355.8	19926
Allington Drive	028	265						265	366.7	97172
Painters Ash	029	146		498	231			875	320.9	280791
KT Northwood	034	369	73					442	368.6	162935
Michelle Gardens	035					40		40	276.7	11066
Broadley Avenue	036			21			25	46	365.2	16800
Alexandra House	037		54					54	79.8	4311

Calculation of divisional PCC according to the Acorn PCC's, based on population profiles in each division or water company

1988 demand data

ACORN GROUP	PCC Ave	PCC Pop Variance	IOW POPN %	H N&S POPN %	SW POPN %	SC POPN %	SE POPN %	KM POPN %	KT POPN %	SWA POPN %
B	140.6	524.6	6.6	23.4	17.7	6.9	4.1	32.9	4.3	17.5
C	140.4	332.5	37.7	19.2	16.2	17.4	29.6	18.0	33.6	21.0
E	127.6	325.7	8.3	16.7	26.6	10.3	11.1	14.7	11.0	14.7
F	128.6	98.8	2.8	7.4	1.7	6.5	7.4	10.4	8.6	7.0
J	158.2	439.5	14.7	21.4	23.3	18.6	10.5	11.2	11.5	17.2
K	180.3	595.5	18.5	2.0	4.9	28.5	28.7	0.4	17.6	11.4
% Population Accounted for			88.6	90.1	90.4	88.2	91.4	87.6	86.6	88.8
Average PCC			150.1	142.2	143.2	154.7	152.5	139.4	148.1	145.9
Variance			411.4	393.2	405.5	437.0	416.2	390.6	385.6	405.3
Standard Error			2.5	2.4	2.5	2.6	2.5	2.4	2.4	2.5
95% Lower Confidence Int			145.1	137.3	138.2	149.5	147.4	134.5	143.2	141.0
95% Upper Confidence Int			155.1	147.1	148.1	159.8	157.5	144.2	152.9	150.9

CONTROL AREA CALCULATIONS: 1989 POPULATION BASED

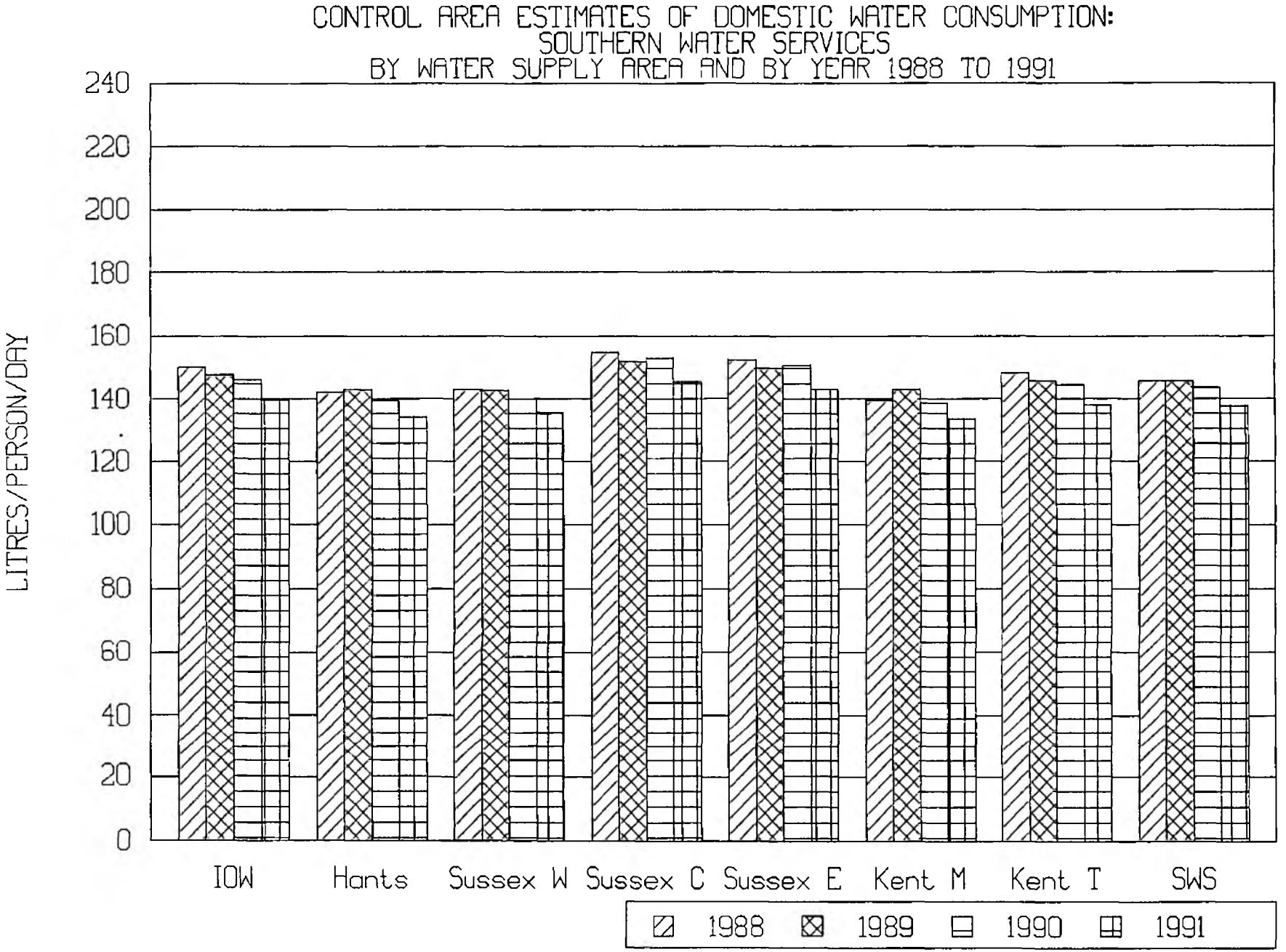
ACORN GROUP	PCC Ave	PCC Pop Variance	IOW POPN %	H N&S POPN %	SW POPN %	SC POPN %	SE POPN %	KM POPN %	KT POPN %	SWS POPN %
B	152.7	1480.5	6.6	23.4	17.7	6.9	4.1	32.9	4.3	17.5
C	138.3	1032.2	37.7	19.2	16.2	17.4	29.6	18.0	33.6	21.0
E	128.5	465.1	8.3	16.7	26.6	10.3	11.1	14.7	11.0	14.7
F	133.7	924.8	2.8	7.4	1.7	6.5	7.4	10.4	8.6	7.0
J	149.3	126.8	14.7	21.4	23.3	18.6	10.5	11.2	11.5	17.2
K	173.7	1908.8	18.5	2.0	4.9	28.5	28.7	0.4	17.6	11.4
% Population Accounted for			88.6	90.1	90.4	88.2	91.4	87.6	86.6	88.8
Average PCC			147.5	143.2	142.9	151.7	149.7	143.1	145.9	145.8
Variance			1041.9	839.1	765.3	1085.5	1146.0	980.9	1029.7	955.4
Standard Error			4.1	3.7	3.5	4.2	4.3	4.0	4.1	4.0
95% Lower Confidence Int			139.2	135.8	135.8	143.2	141.1	135.0	137.7	137.9
95% Upper Confidence Int			155.8	150.6	150.0	160.1	158.4	151.1	154.2	153.7

CONTROL AREA CALCULATIONS: 1990 POPULATION BASED

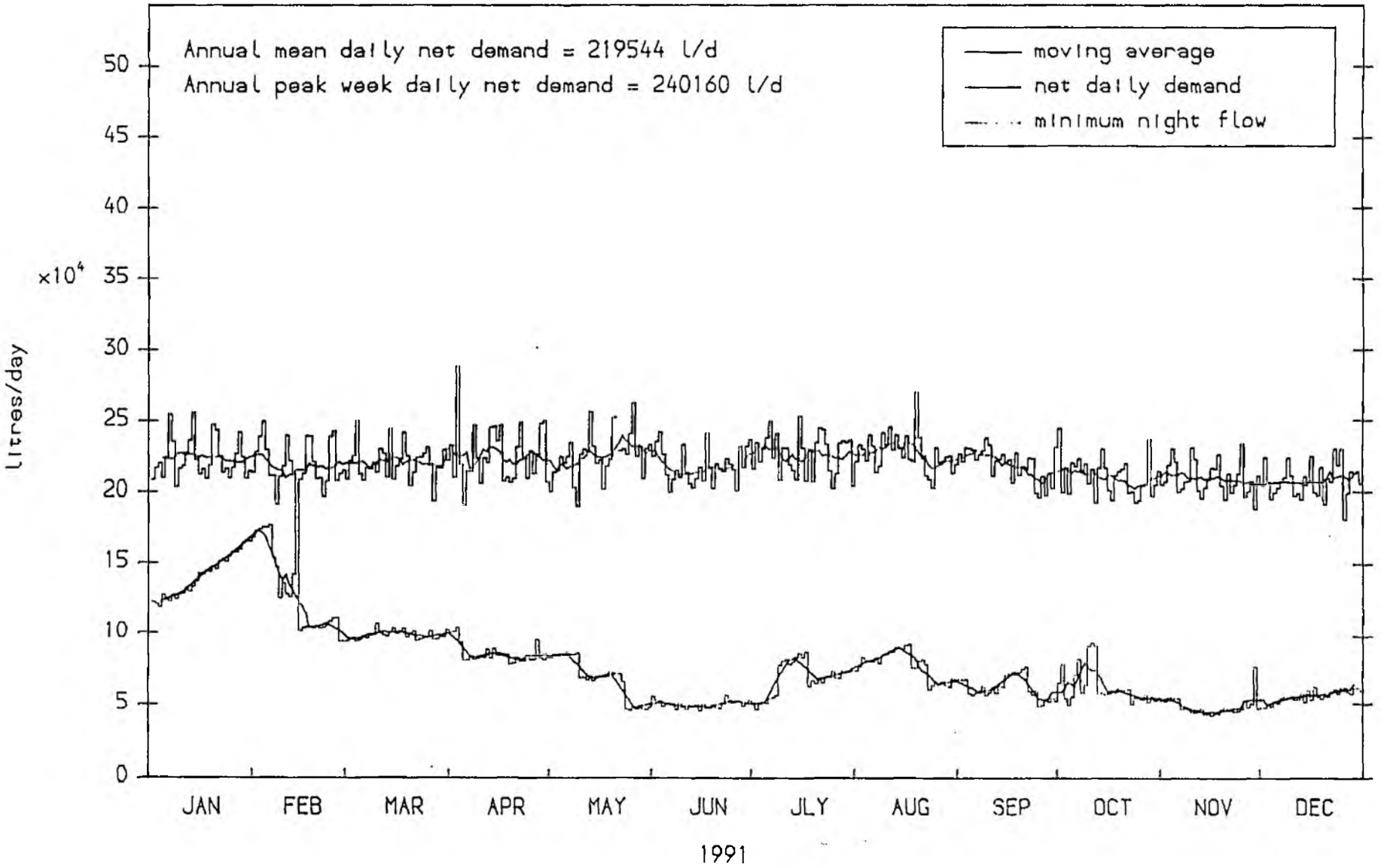
ACORN GROUP	PCC Ave	PCC Pop Variance	IOW POPN %	H N&S POPN %	SW POPN %	SC POPN %	SE POPN %	KM POPN %	KT POPN %	SWS POPN %
B	147.5	1207.2	6.6	23.4	17.7	6.9	4.1	32.9	4.3	17.5
C	131.6	1014.0	37.7	19.2	16.2	17.4	29.6	18.0	33.6	21.0
E	127.0	646.4	8.3	16.7	26.6	10.3	11.1	14.7	11.0	14.7
F	130.0	1081.8	2.8	7.4	1.7	6.5	7.4	10.4	8.6	7.0
J	146.1	214.8	14.7	21.4	23.3	18.6	10.5	11.2	11.5	17.2
K	186.5	3133.5	18.5	2.0	4.9	28.5	28.7	0.4	17.6	11.4
% Population Accounted for			88.6	90.1	90.4	88.2	91.4	87.6	86.6	88.8
Average PCC			146.2	139.4	140.0	153.0	150.5	138.7	144.7	143.7
Variance			1306.1	858.8	853.8	1507.5	1557.2	940.4	1308.3	1113.9
Standard Error			4.6	3.8	3.7	5.0	5.1	3.9	4.6	4.3
95% Lower Confidence Int			136.9	131.9	132.6	143.0	140.4	130.9	135.5	135.2
95% Upper Confidence Int			155.4	146.9	147.5	162.9	160.6	146.6	154.0	152.2

CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

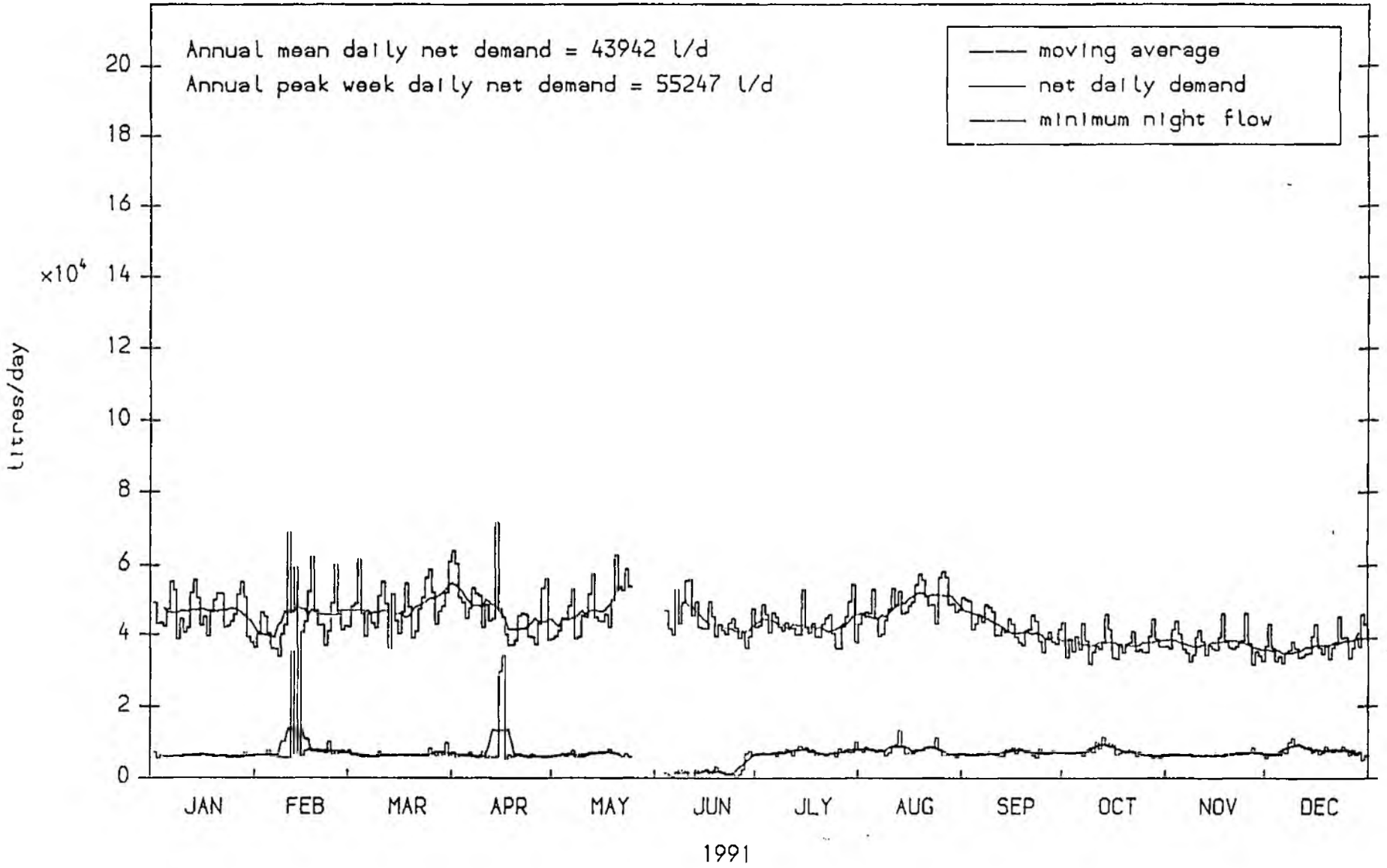
ACORN GROUP	PCC Ave	PCC Pop Variance	IOW POPN %	H N&S POPN %	SW POPN %	SC POPN %	SE POPN %	KM POPN %	KT POPN %	SWS POPN %
B	143.7	808.6	6.6	23.4	17.7	6.9	4.1	32.9	4.3	17.5
C	126.3	523.6	37.7	19.2	16.2	17.4	29.6	18.0	33.6	21.0
E	126.4	450.0	8.3	16.7	26.6	10.3	11.1	14.7	11.0	14.7
F	116.6	163.2	2.8	7.4	1.7	6.5	7.4	10.4	8.6	7.0
J	139.4	157.3	14.7	21.4	23.3	18.6	10.5	11.2	11.5	17.2
K	175.1	2514.7	18.5	2.0	4.9	28.5	28.7	0.4	17.6	11.4
% Population Accounted for			88.6	90.1	90.4	88.2	91.4	87.6	86.6	88.8
Average PCC			139.7	134.2	135.6	145.5	143.1	133.6	137.9	137.8
Variance			861.5	511.6	564.5	1076.9	1081.4	537.8	848.6	723.8
Standard Error			3.7	2.8	3.0	4.1	4.1	2.9	3.7	3.4
95% Lower Confidence Int			132.2	128.5	129.6	137.2	134.9	127.8	130.5	131.0
95% Upper Confidence Int			147.2	139.9	141.6	153.8	151.4	139.5	145.2	144.6


CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
SOUTHERN WATER SERVICES
BY WATER SUPPLY AREA AND BY YEAR 1988 TO 1991
LITRES/PERSON/DAY
240
220
200
180
160
140
120
100
80
60
40
20
0
IOW
Hants
Sussex W
Sussex C
Sussex E
Kent M
Kent T
SWS
1988
1989
1990
1991

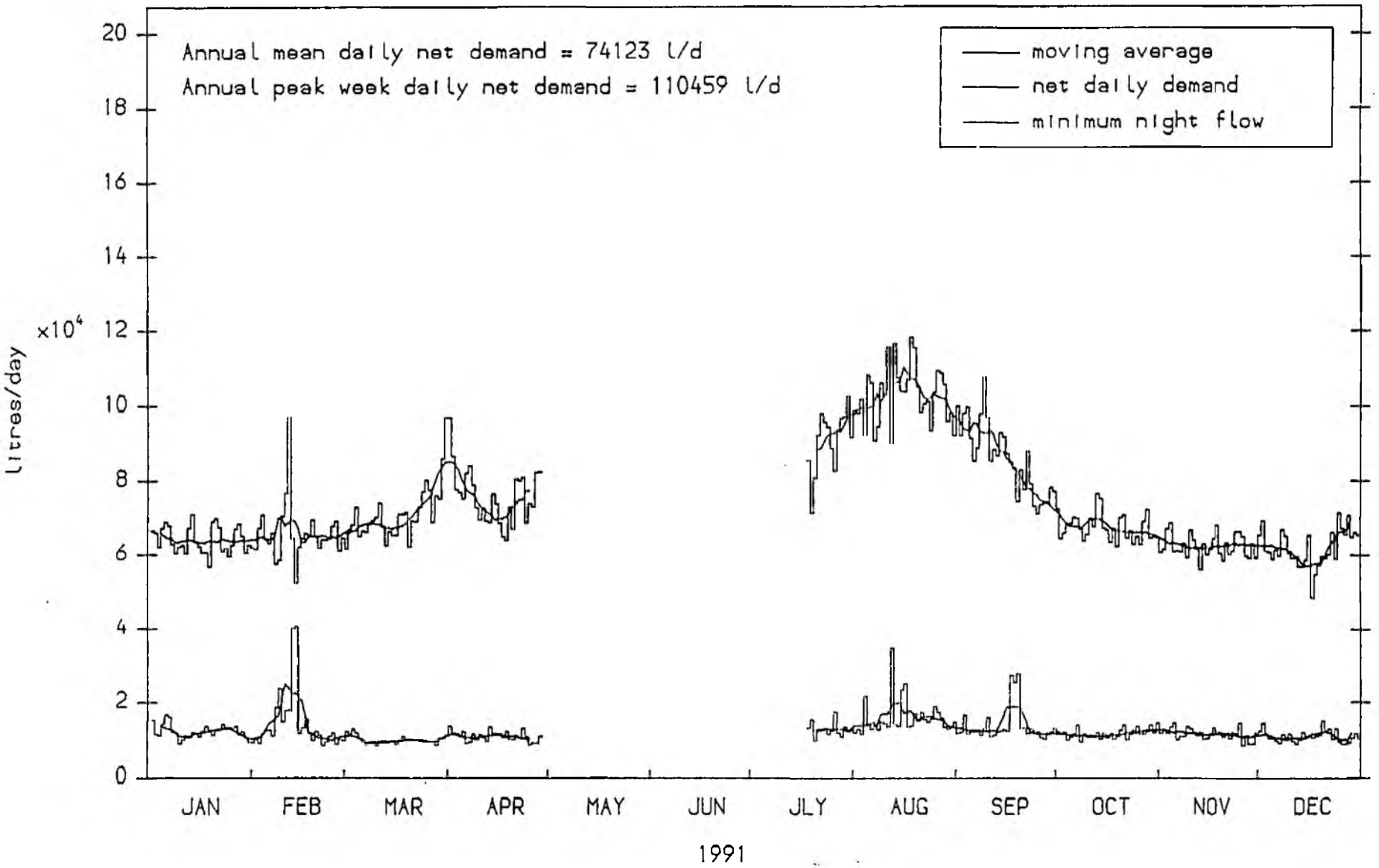
Pan Estate 001: water supply data for 1991 with 7 day moving average



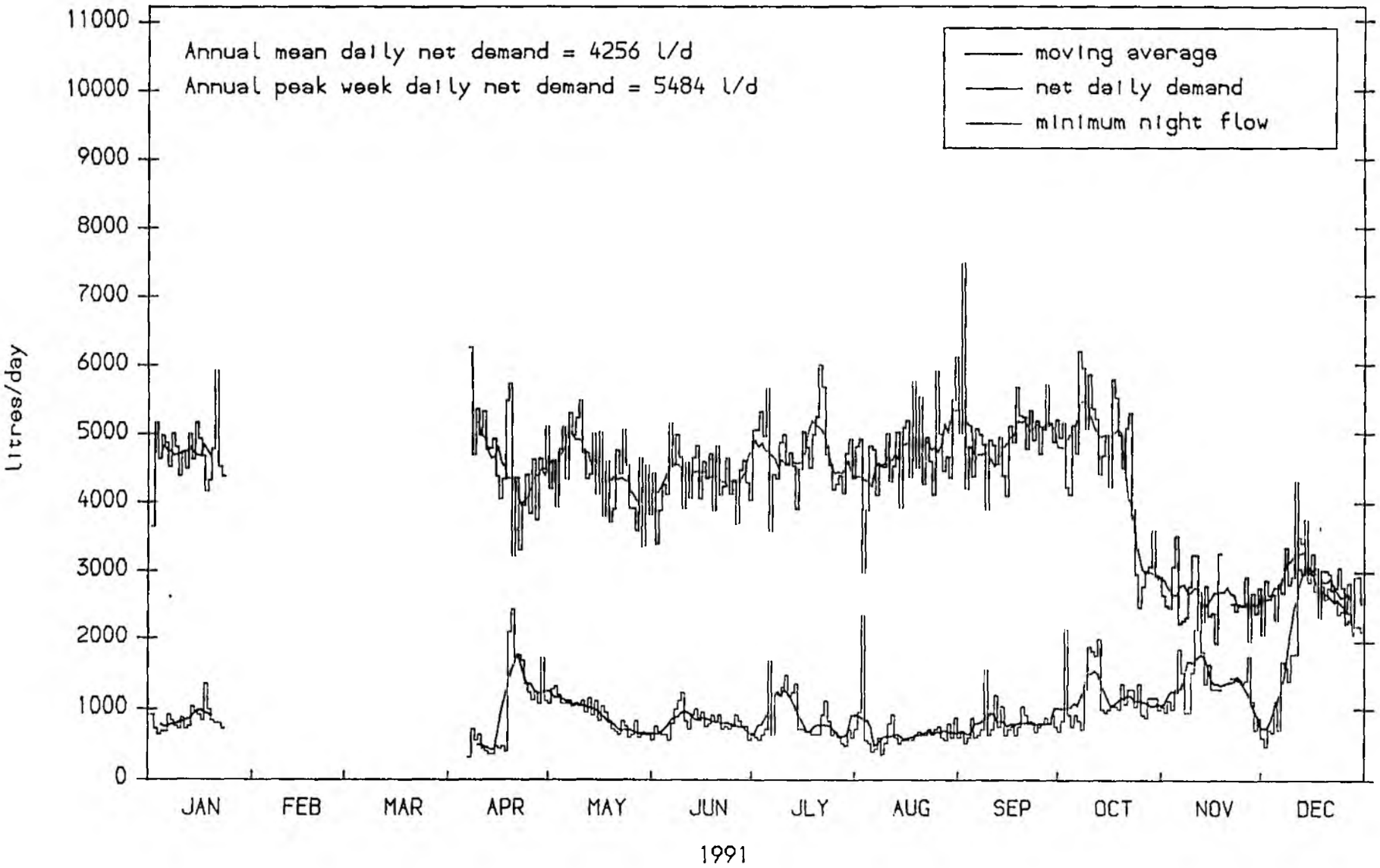
Yaverlande 002: water supply data for 1991 with 7 day moving average



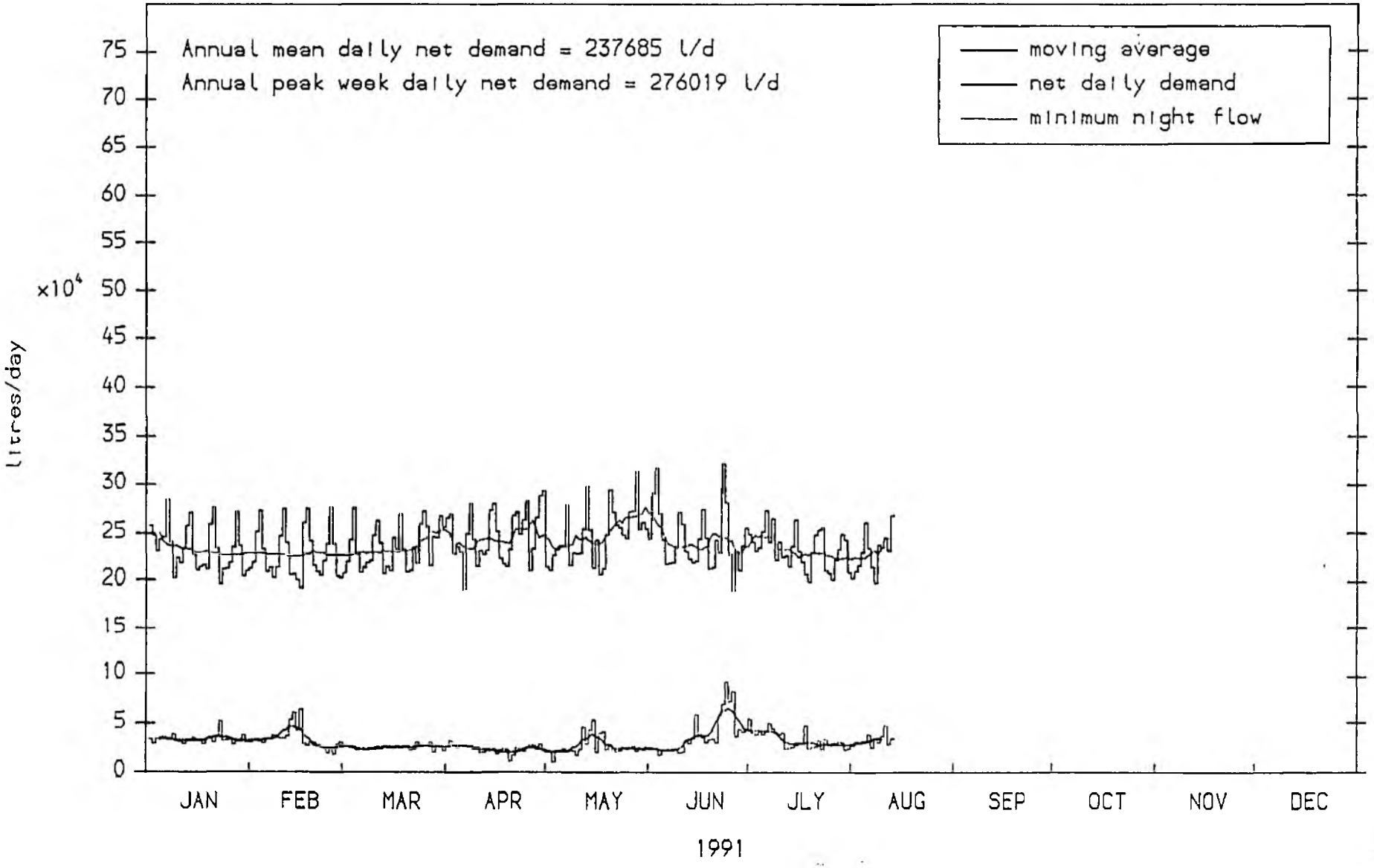
Totland 003: water supply data for 1991 with 7 day moving average



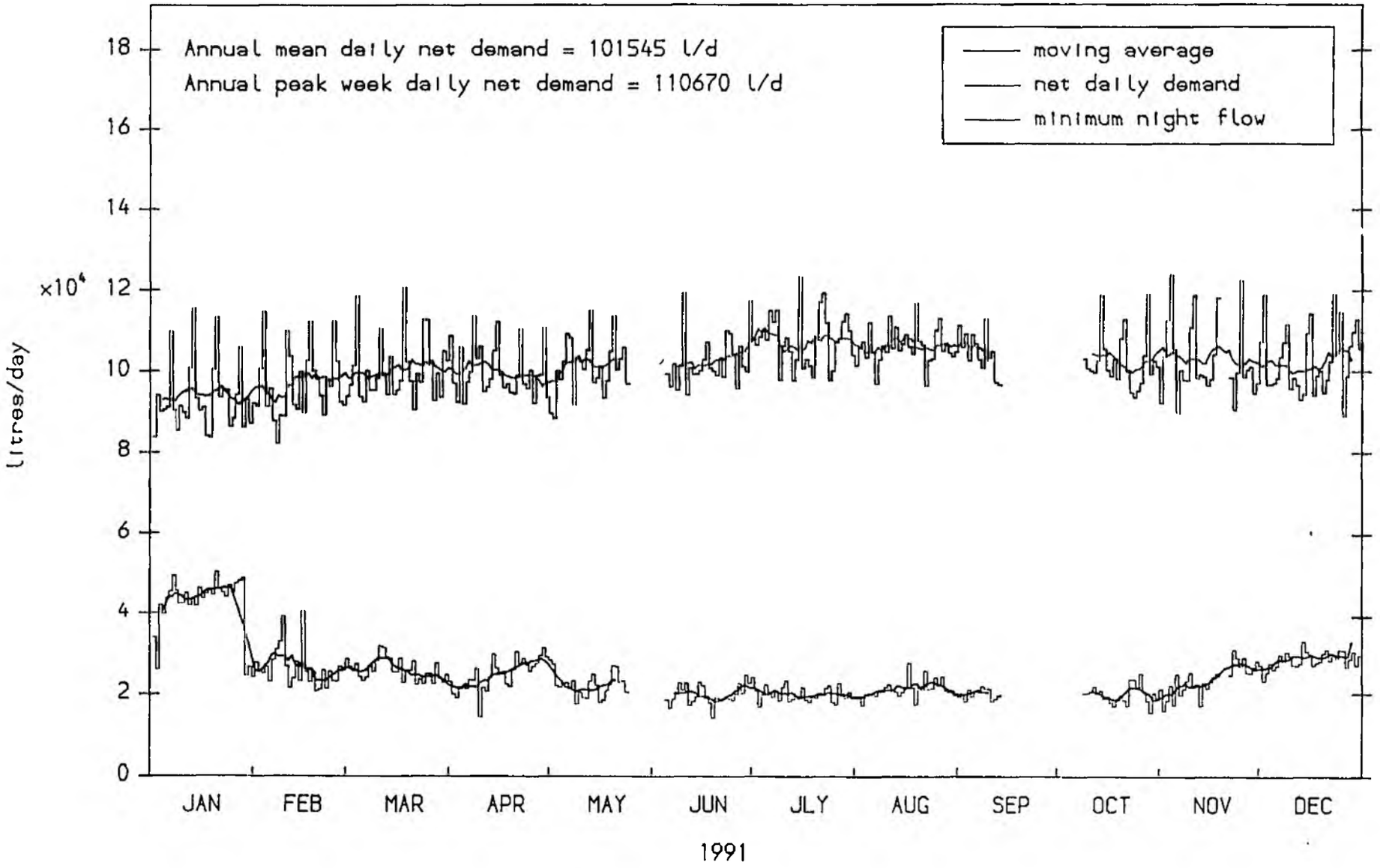
Surrey House 005: water supply data for 1991 with 7 day moving average



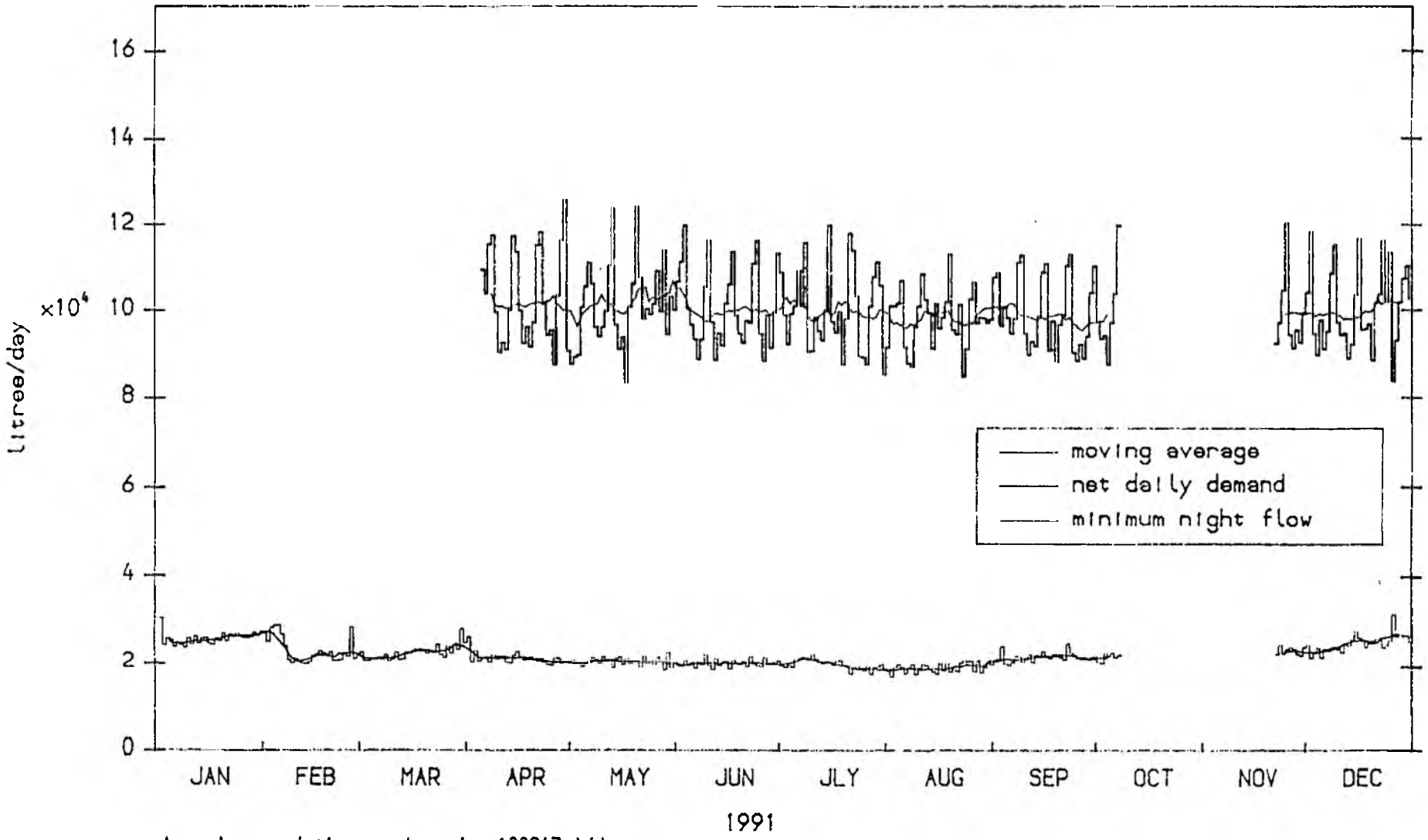
Hocombe Road A13: water supply data for 1991 with 7 day moving average



Lydgate Road 008: water supply data for 1991 with 7 day moving average



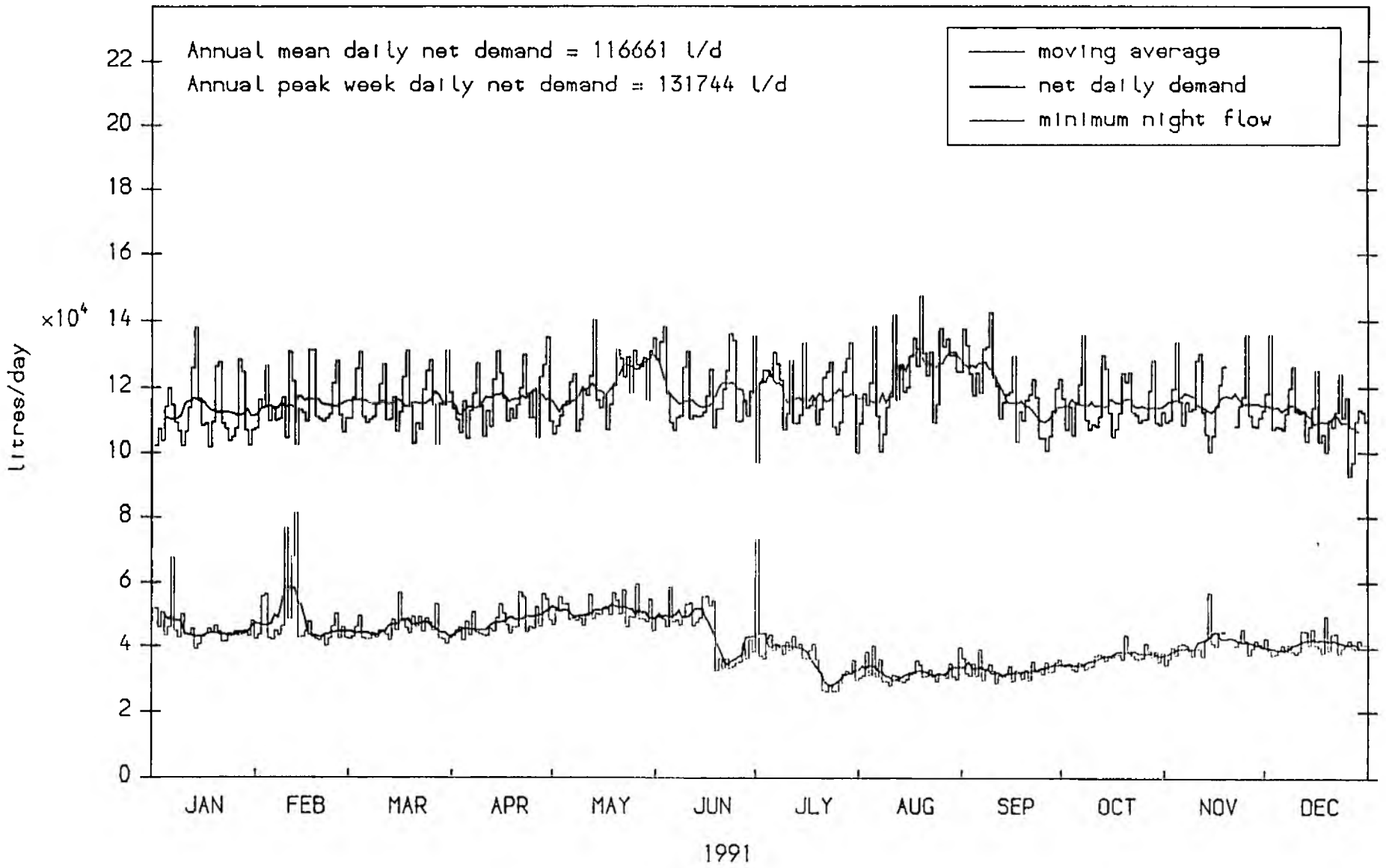
Hampshire(S), Wyteways 009: water supply data for 1991 with 7 day moving average



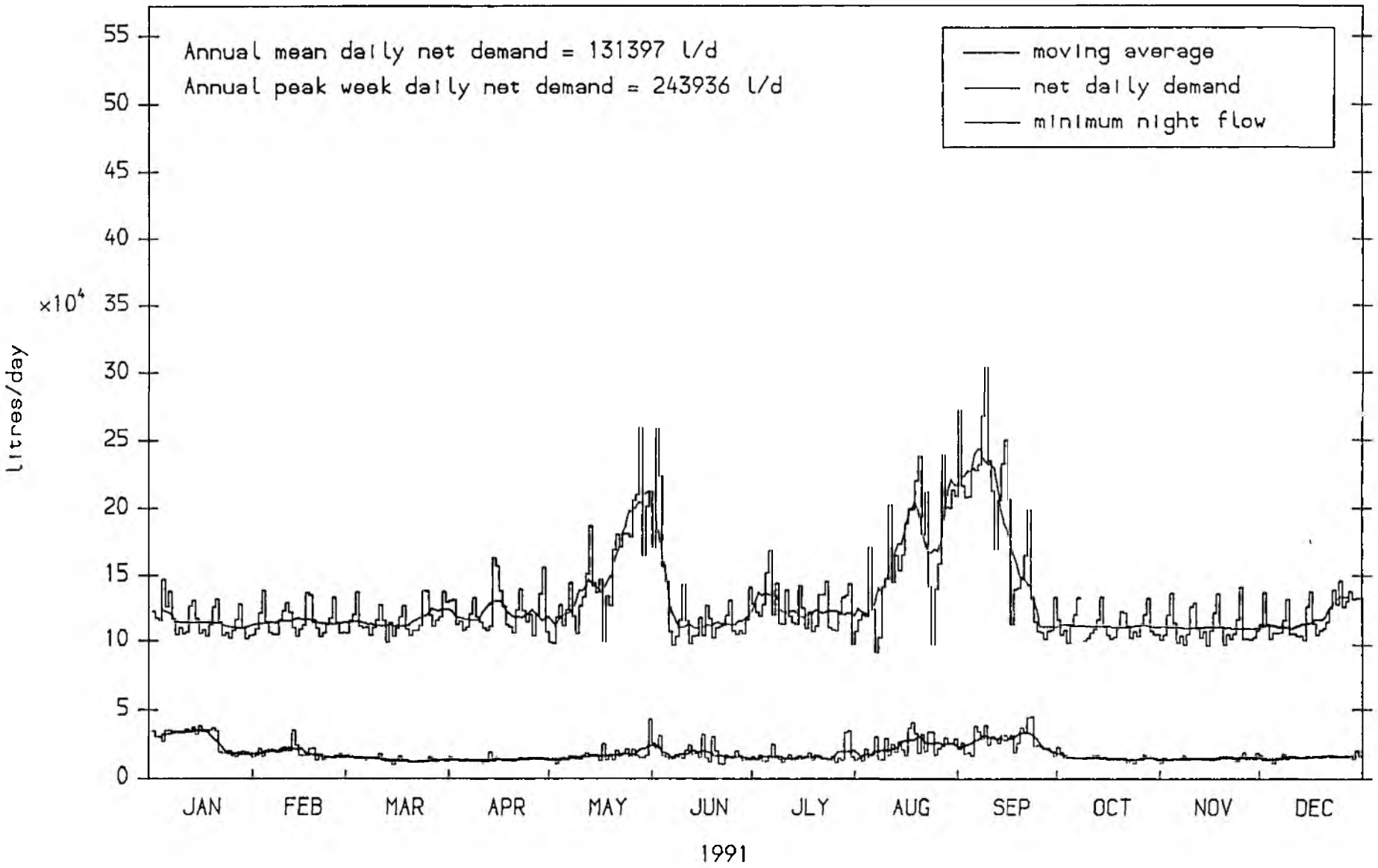
Annual mean daily net demand = 100247 l/d

Annual peak week daily net demand = 107045 l/d

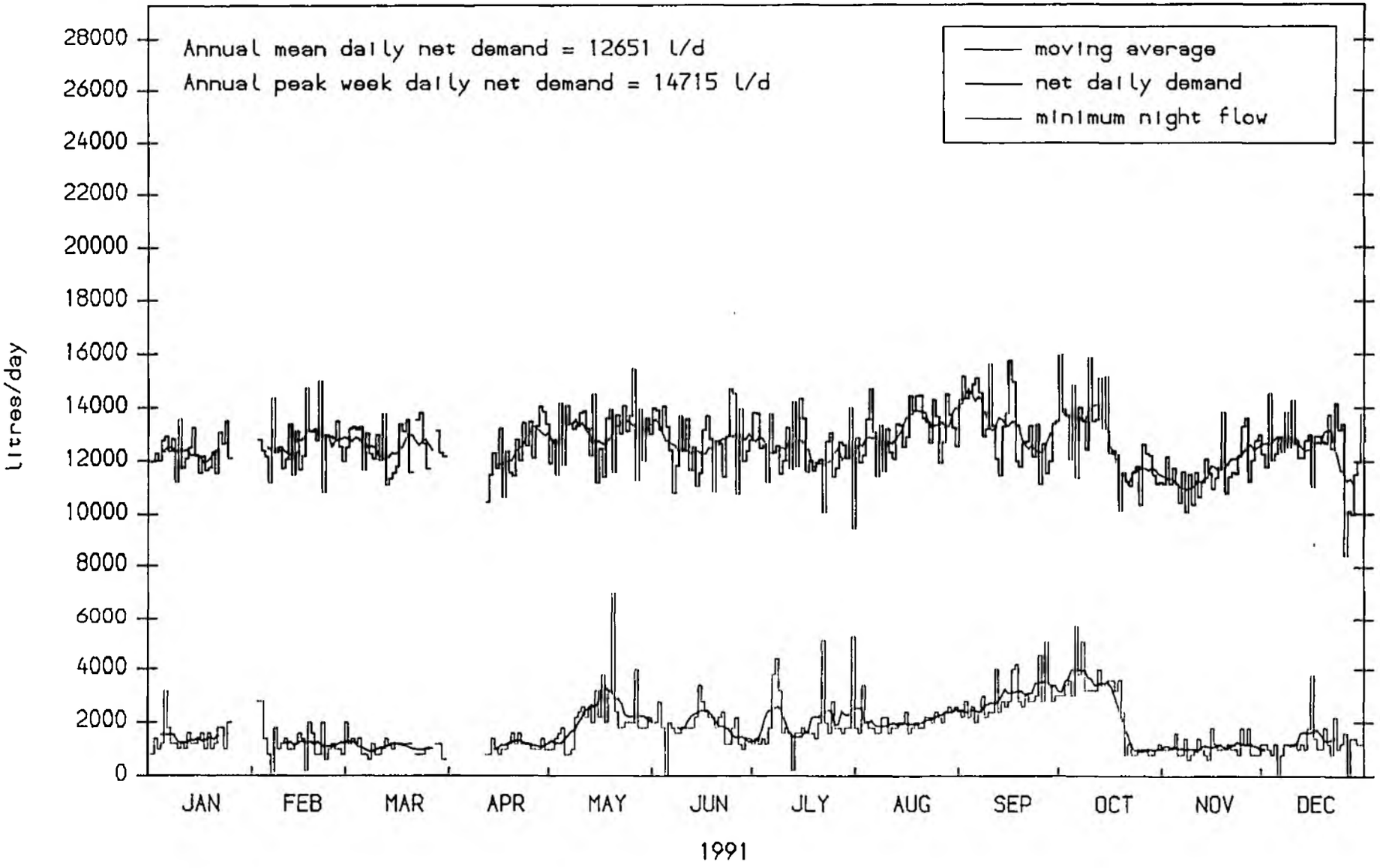
Ivy Road 010: water supply data for 1991 with 7 day moving average



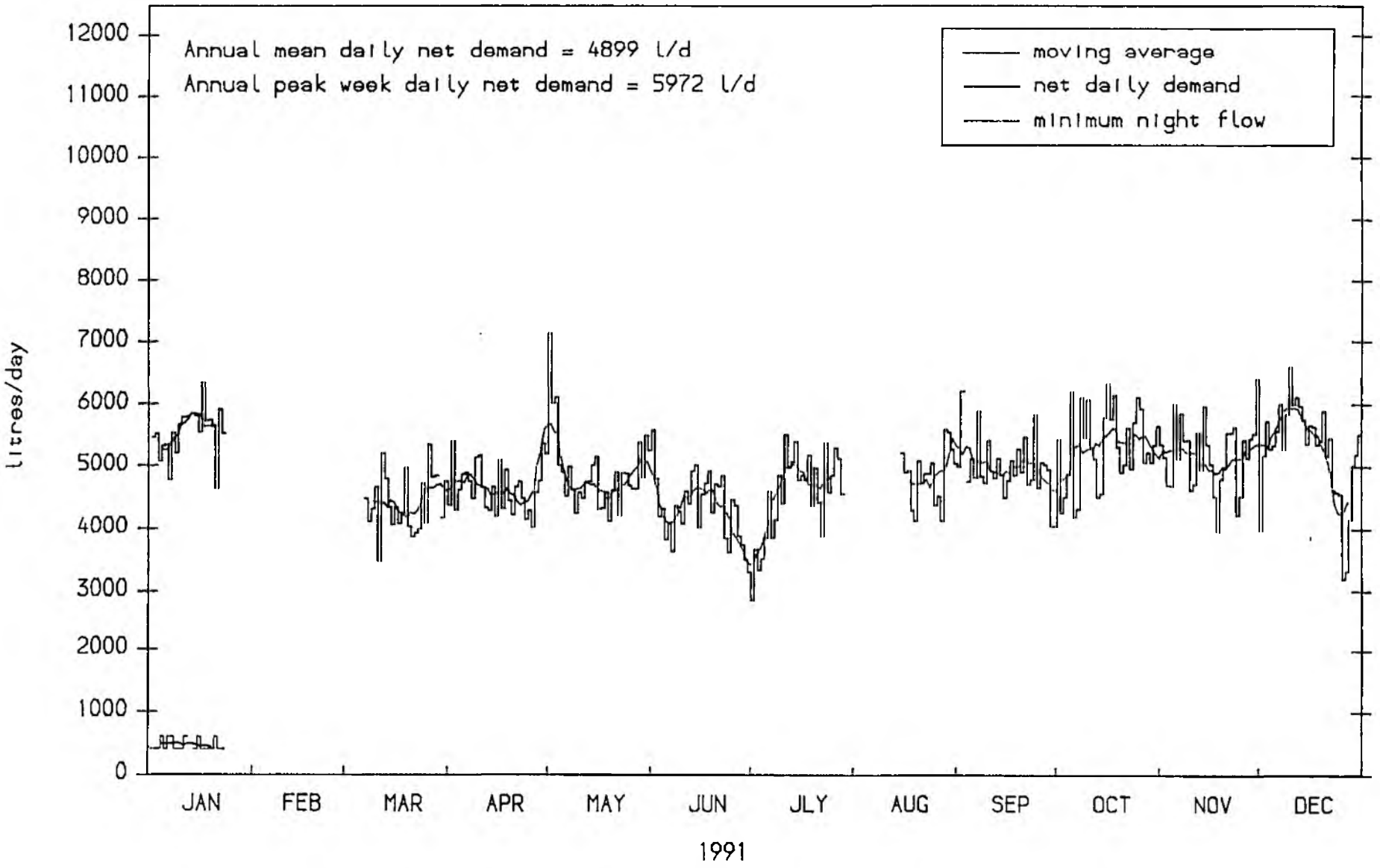
Hook Road A14: water supply data for 1991 with 7 day moving average



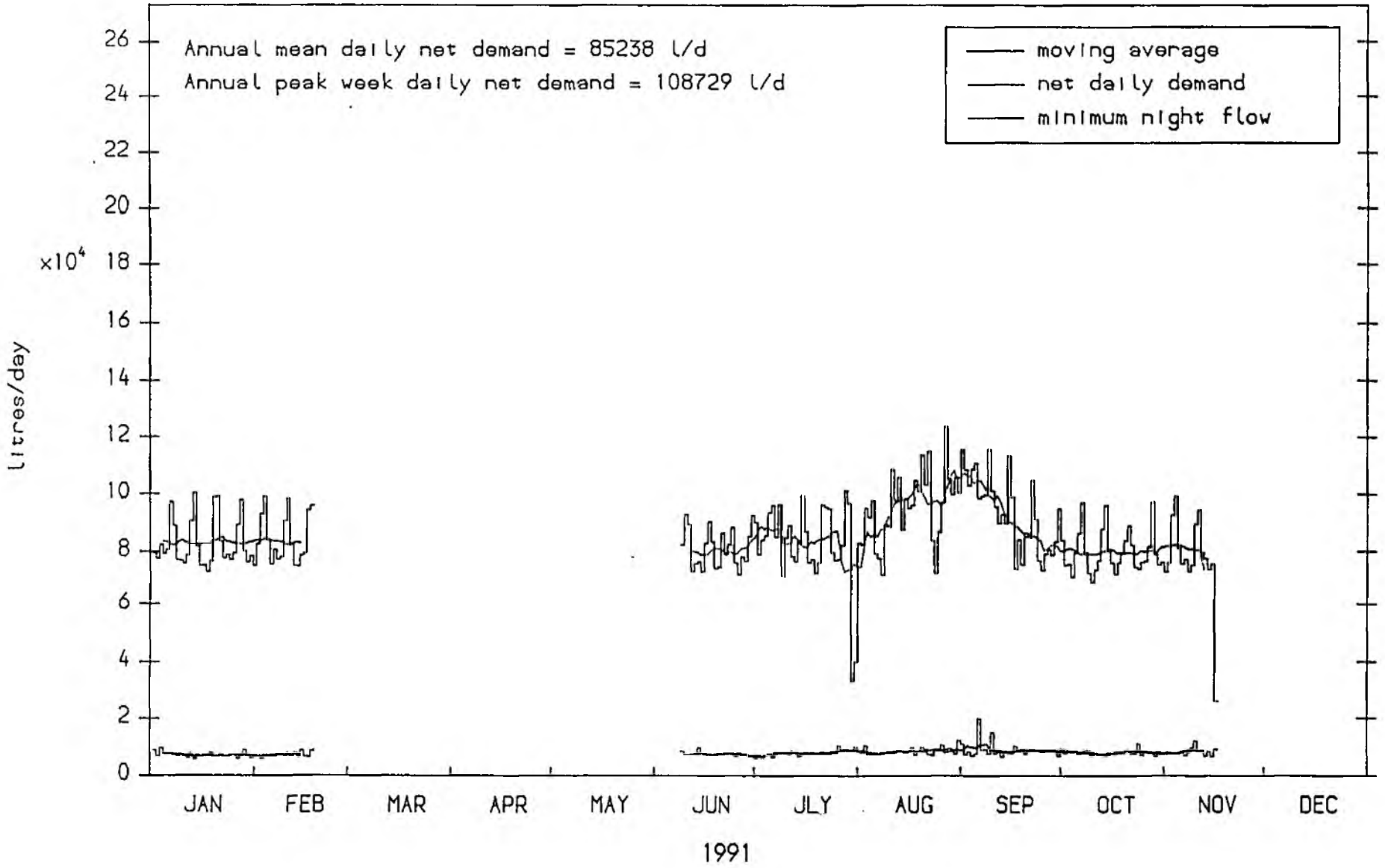
Makins Court 011: water supply data for 1991 with 7 day moving average



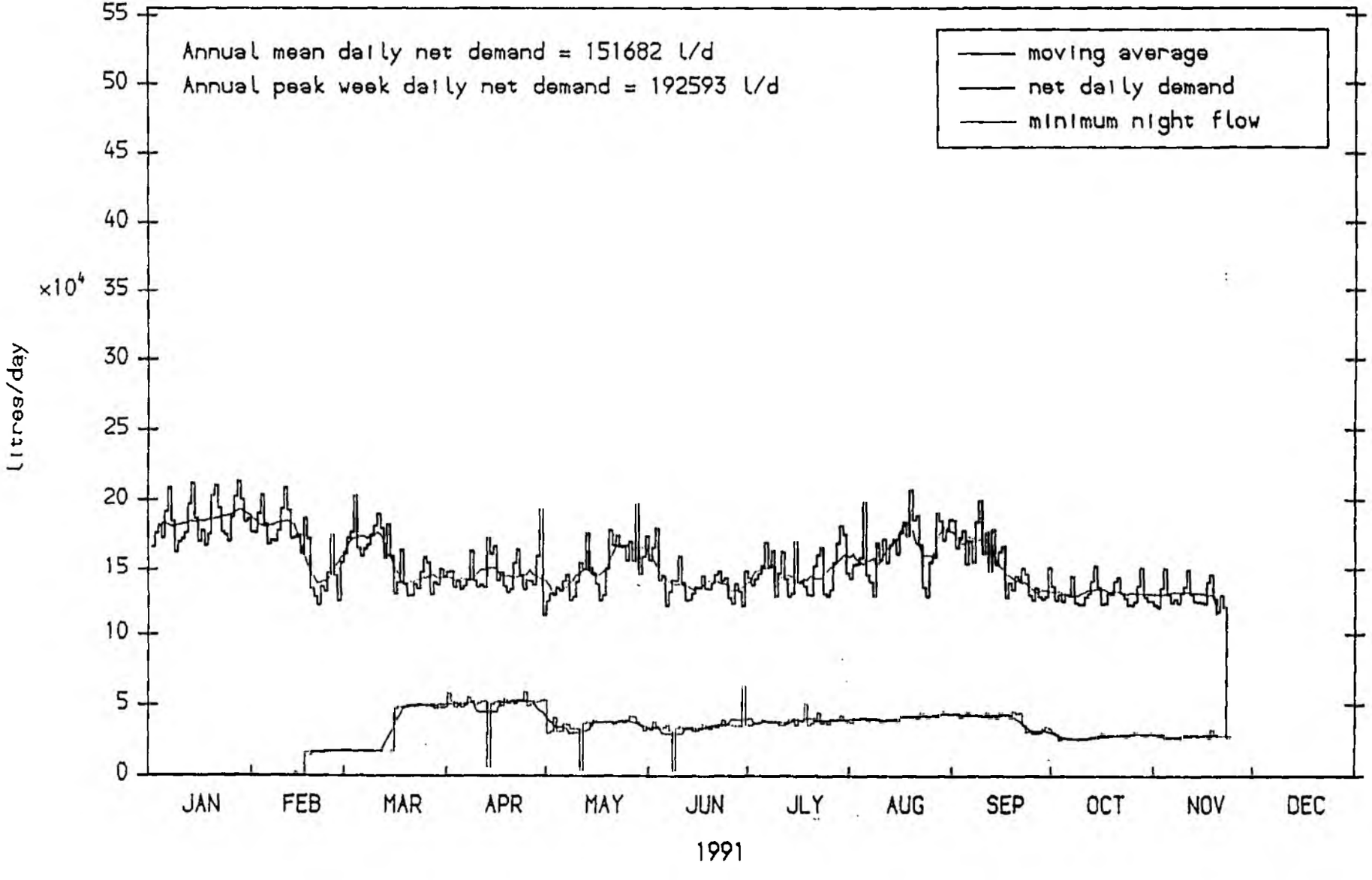
Bracher Close 012: water supply data for 1991 with 7 day moving average



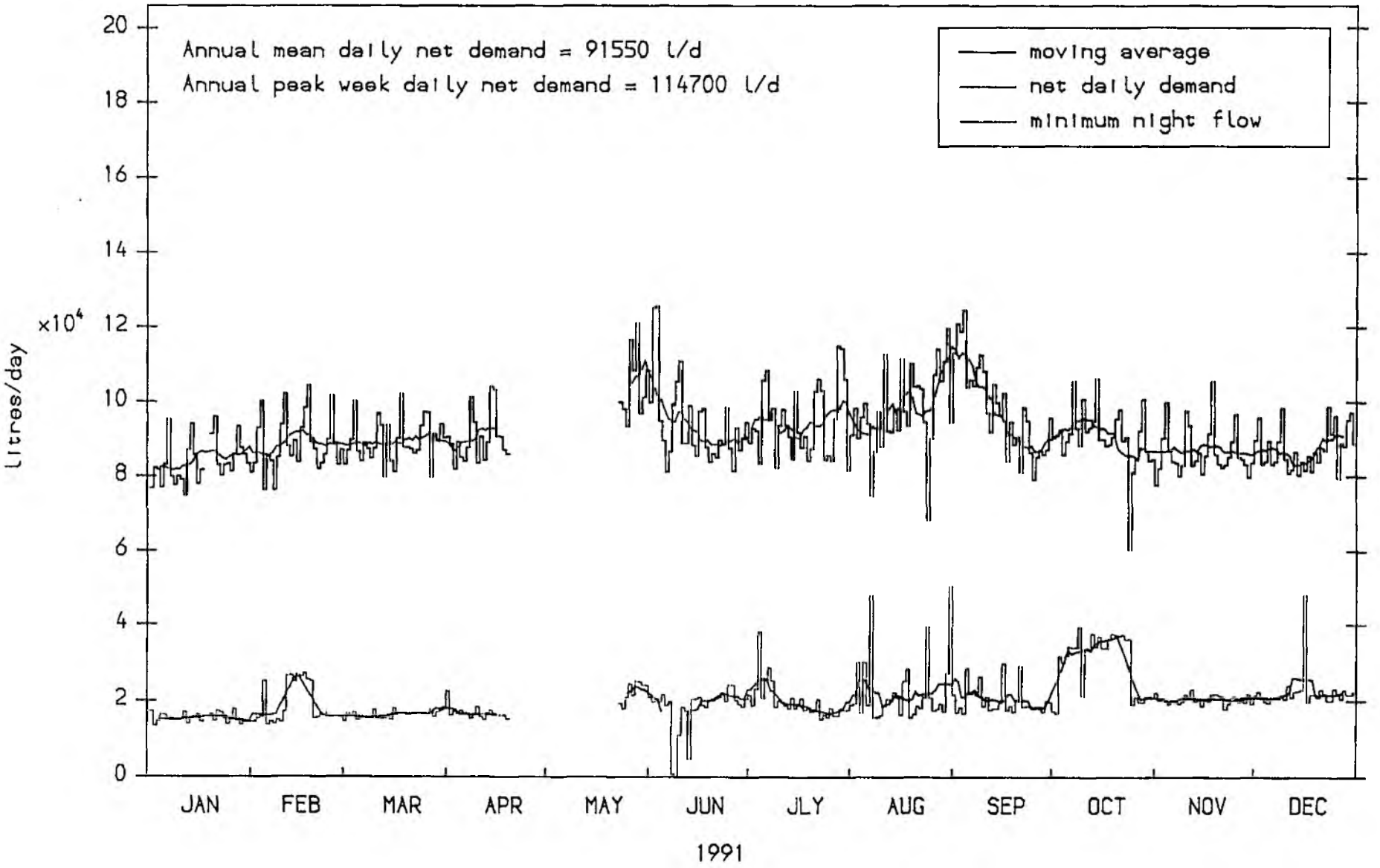
Teg Down 013: water supply data for 1991 with 7 day moving average



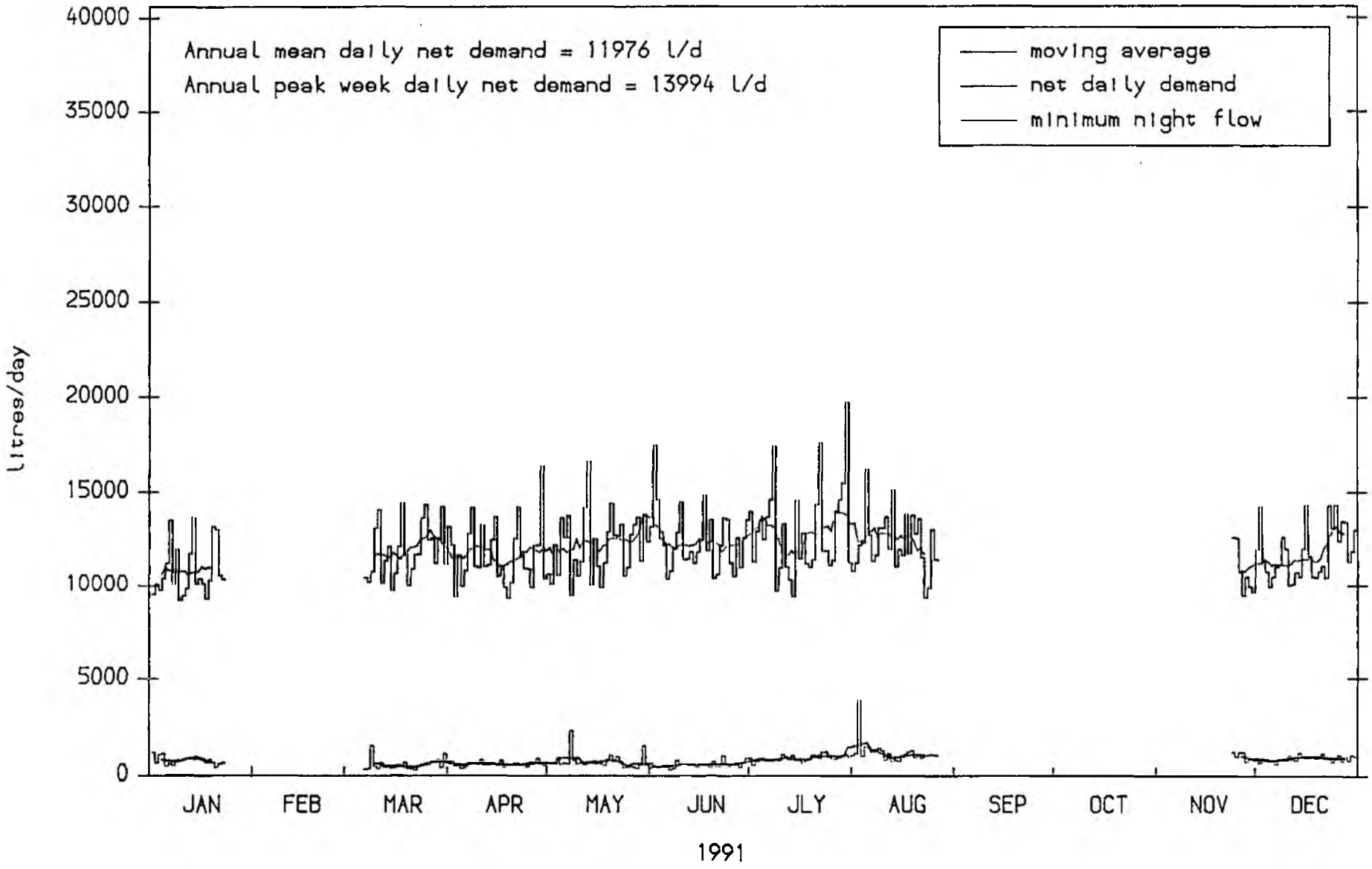
Weeke Winchester 014: water supply data for 1991 with 7 day moving average



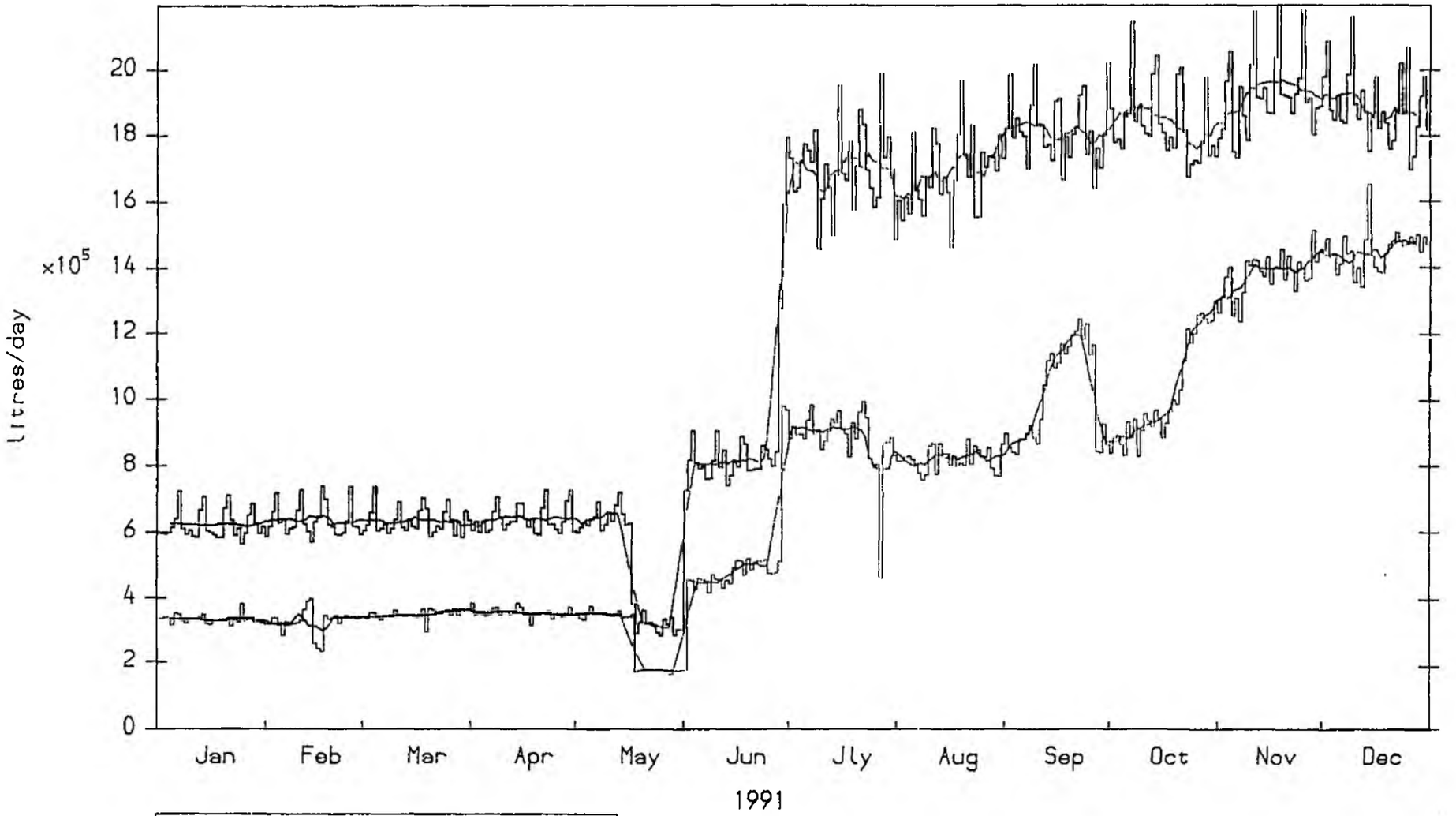
Highcliffe 015: water supply data for 1991 with 7 day moving average



King George 016: water supply data for 1991 with 7 day moving average



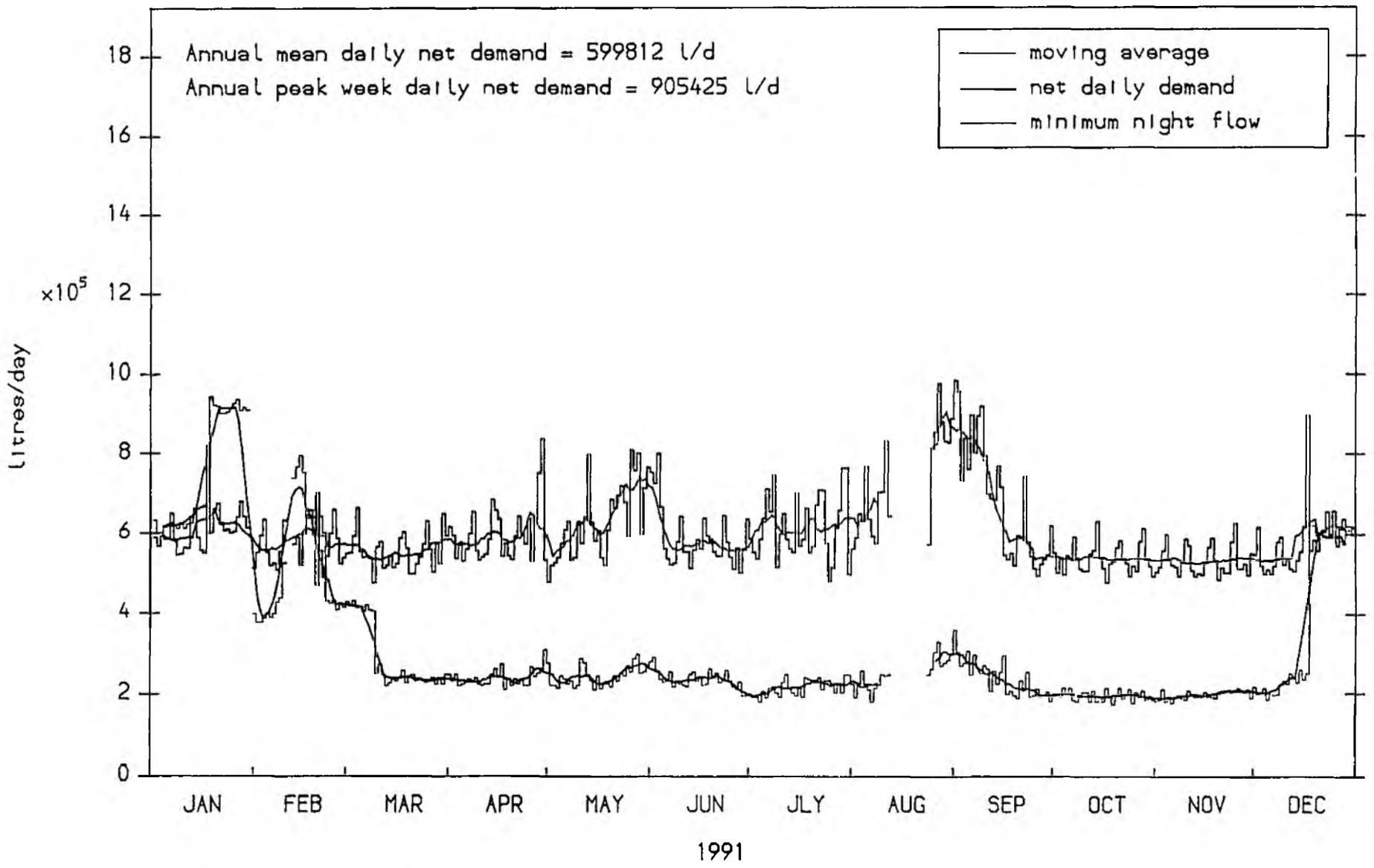
Control Area 017, Broadfields



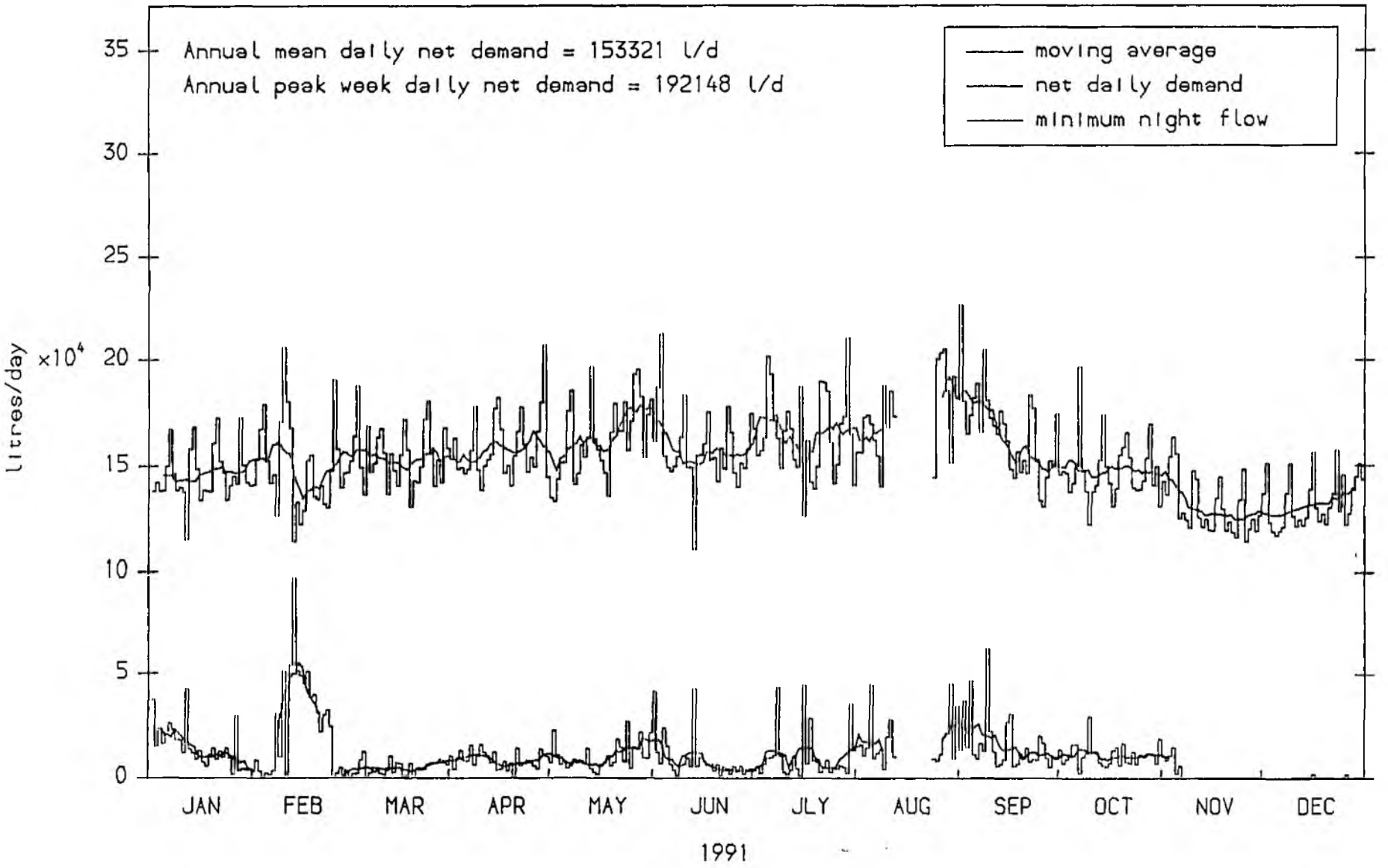
7-day moving average
net daily demand
daily minimum night flow

Annual mean daily net demand = 1234632 l/d
Annual peak week daily net demand = 1969160 l/d on 19 Nov 91

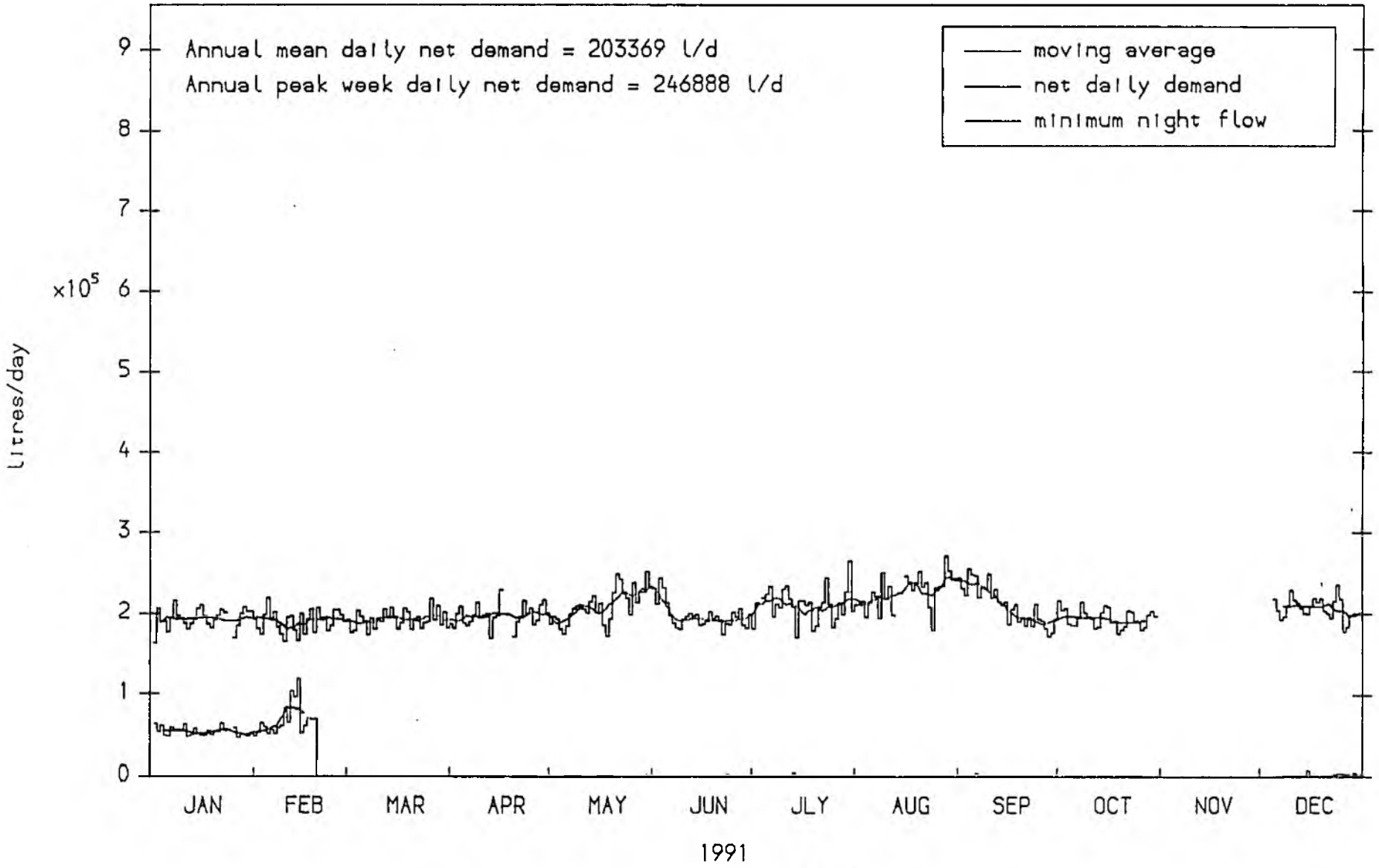
Shoreham Beach 019: water supply data for 1991 with 7 day moving average



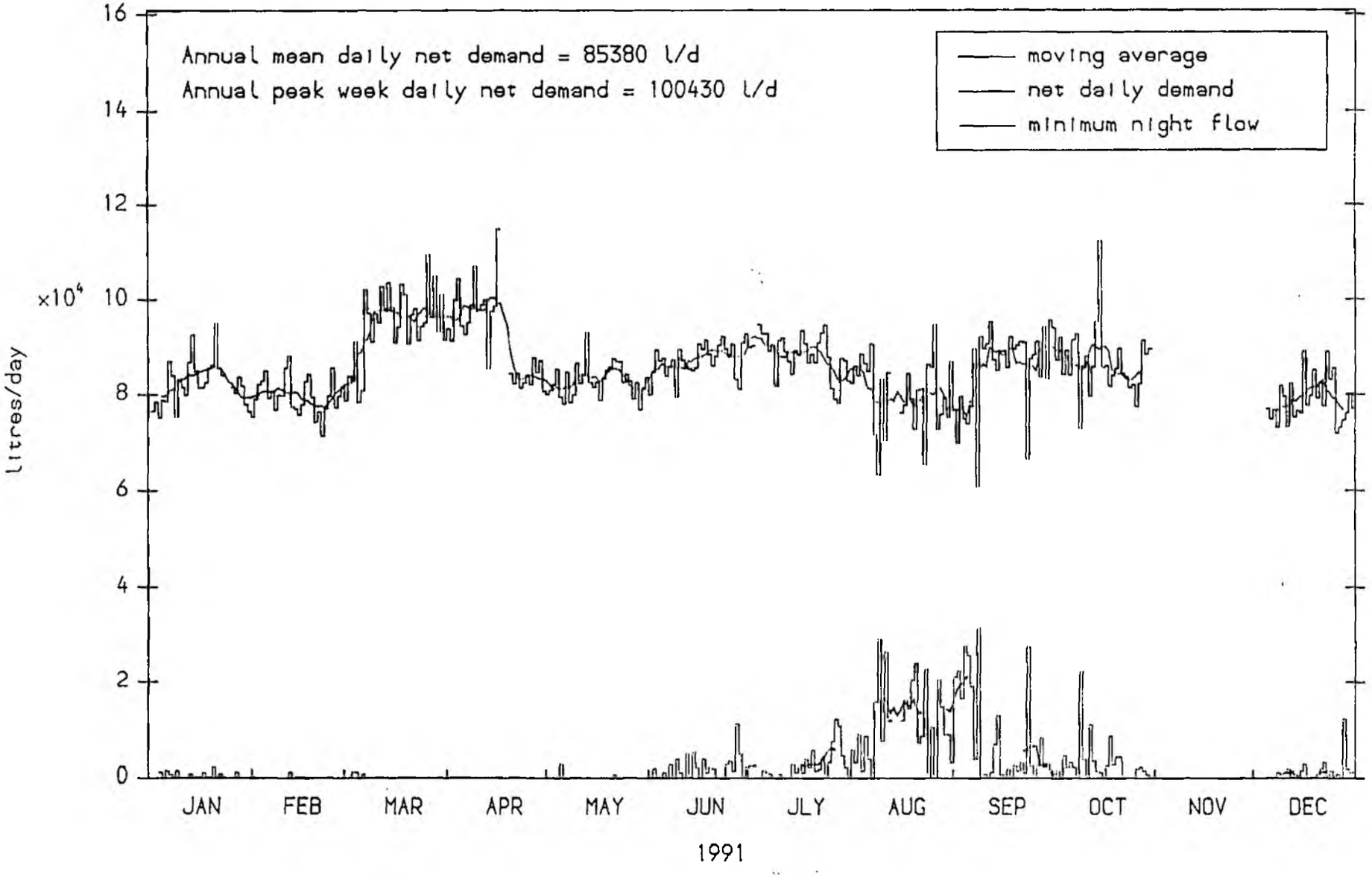
Broadway 020: water supply data for 1991 with 7 day moving average



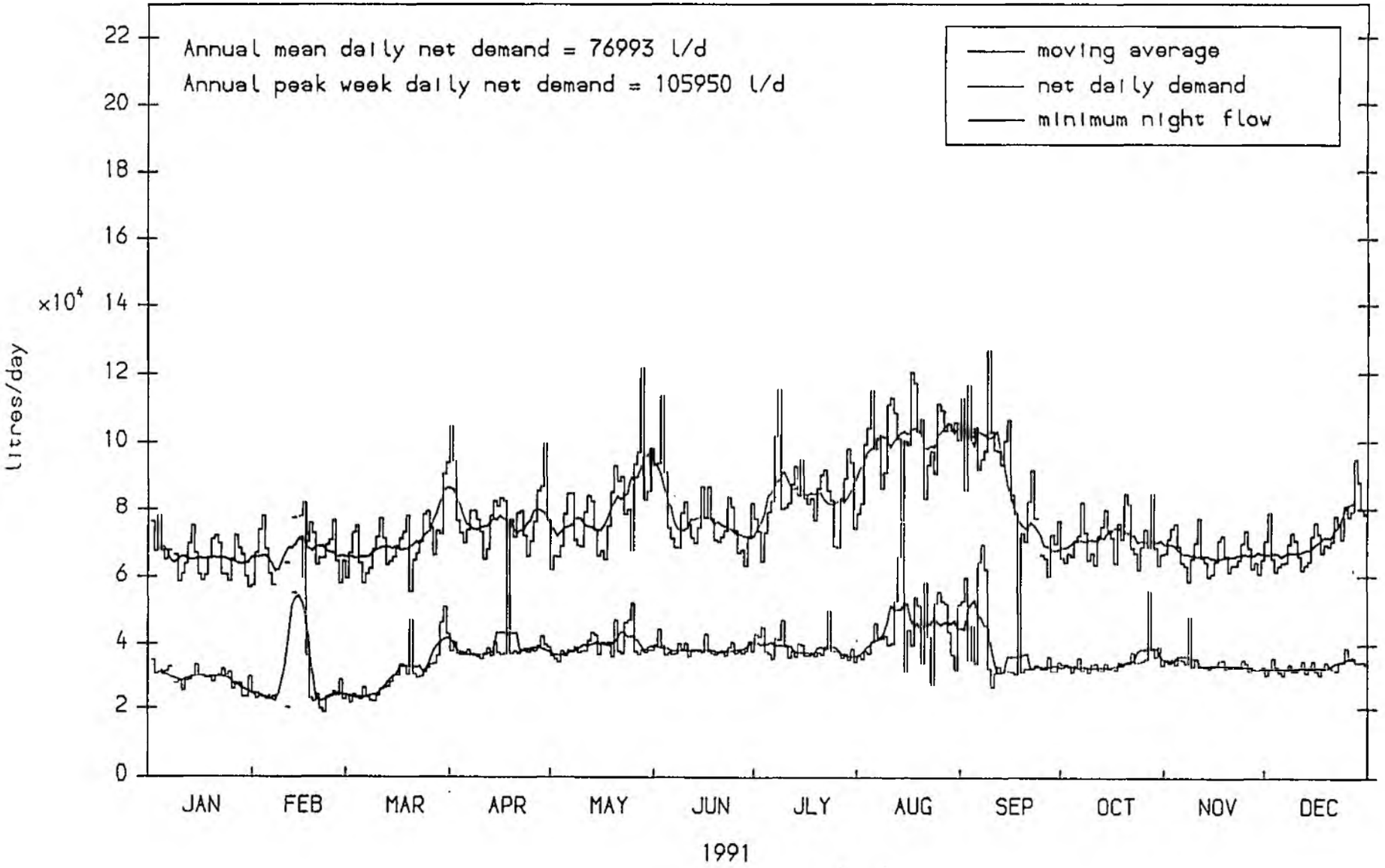
Highdown 021: water supply data for 1991 with 7 day moving average



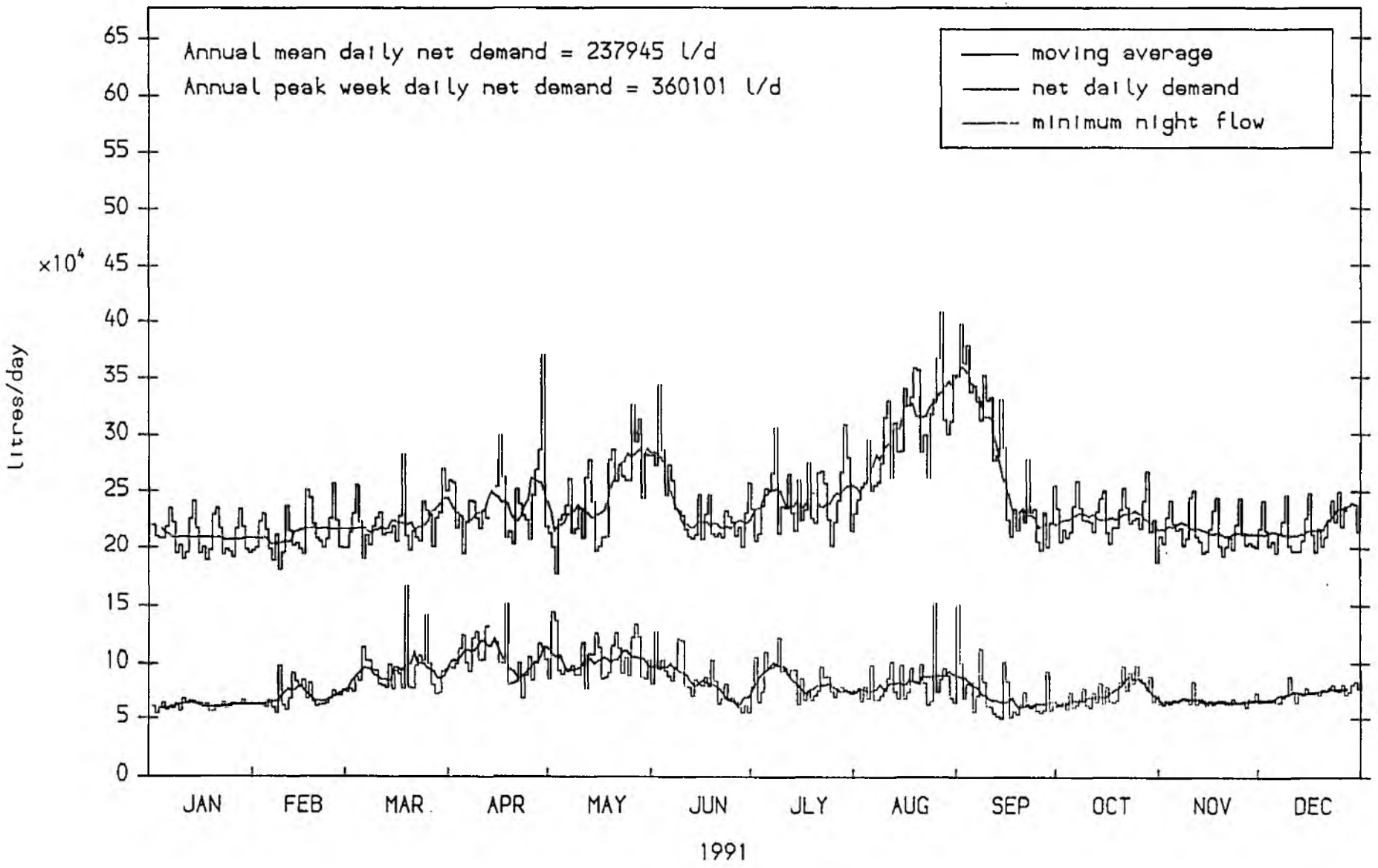
Cornwall Road 022: water supply data for 1991 with 7 day moving average



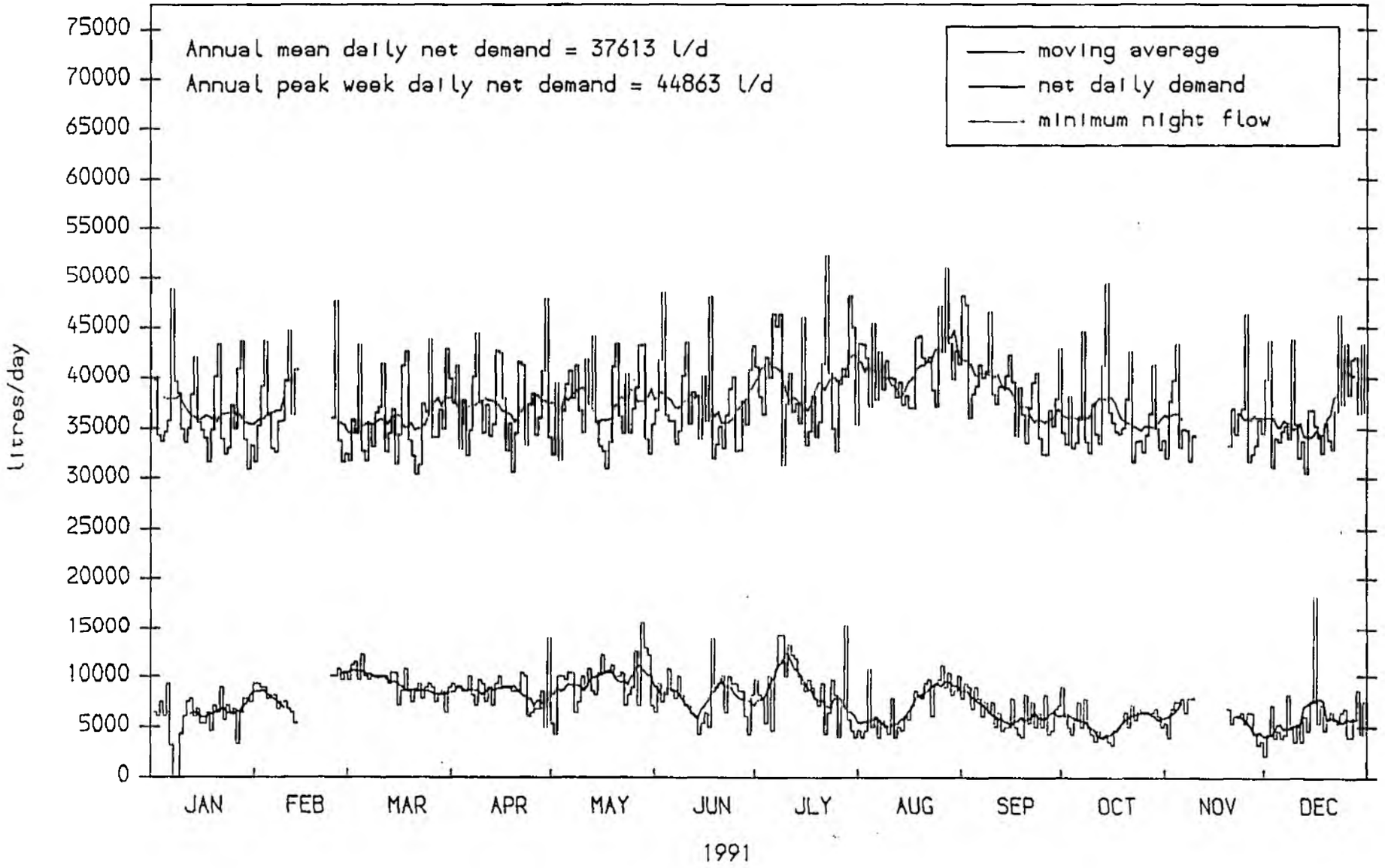
Winchelsea Town 023: water supply data for 1991 with 7 day moving average



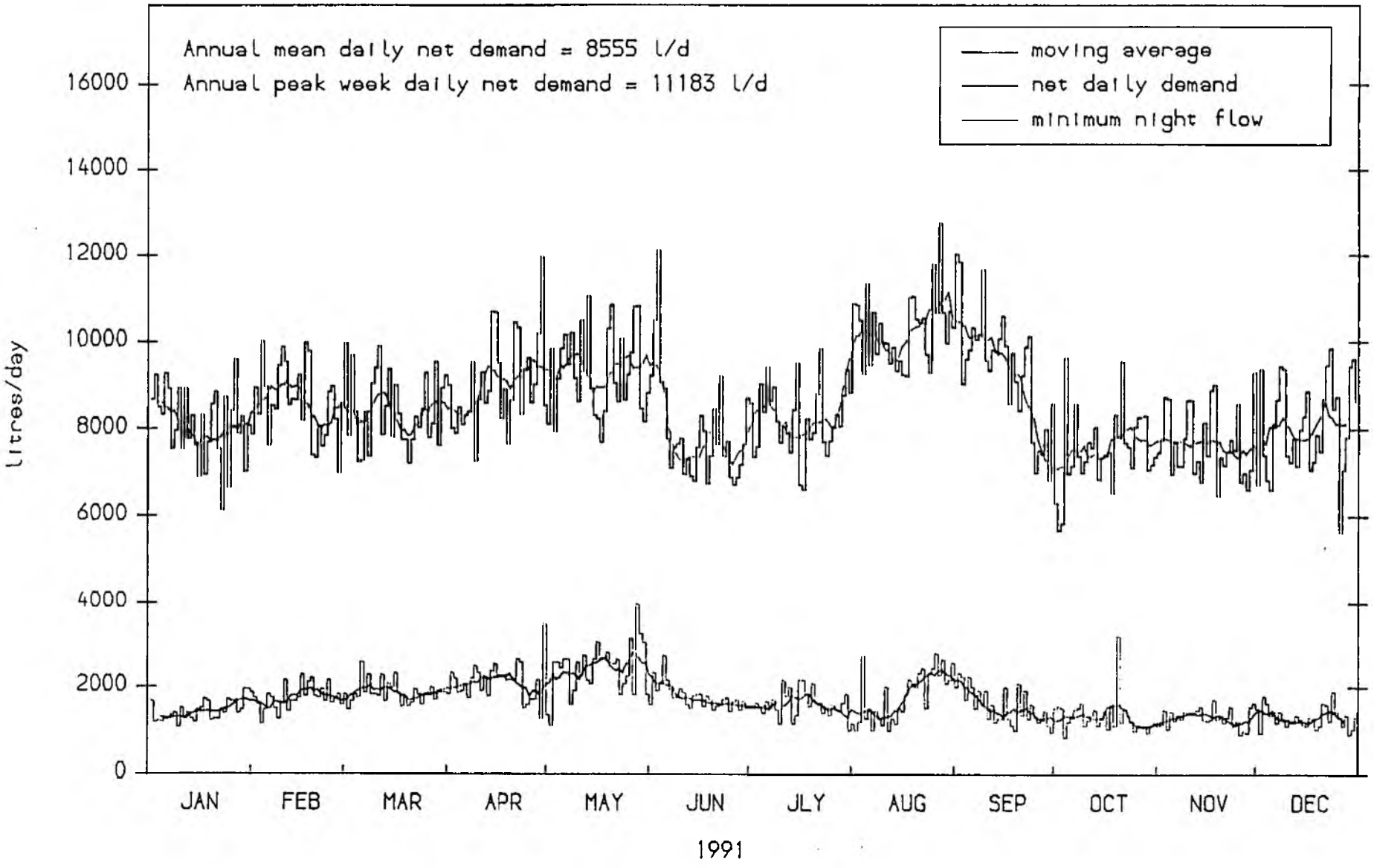
Fairlight Cove 024: water supply data for 1991 with 7 day moving average



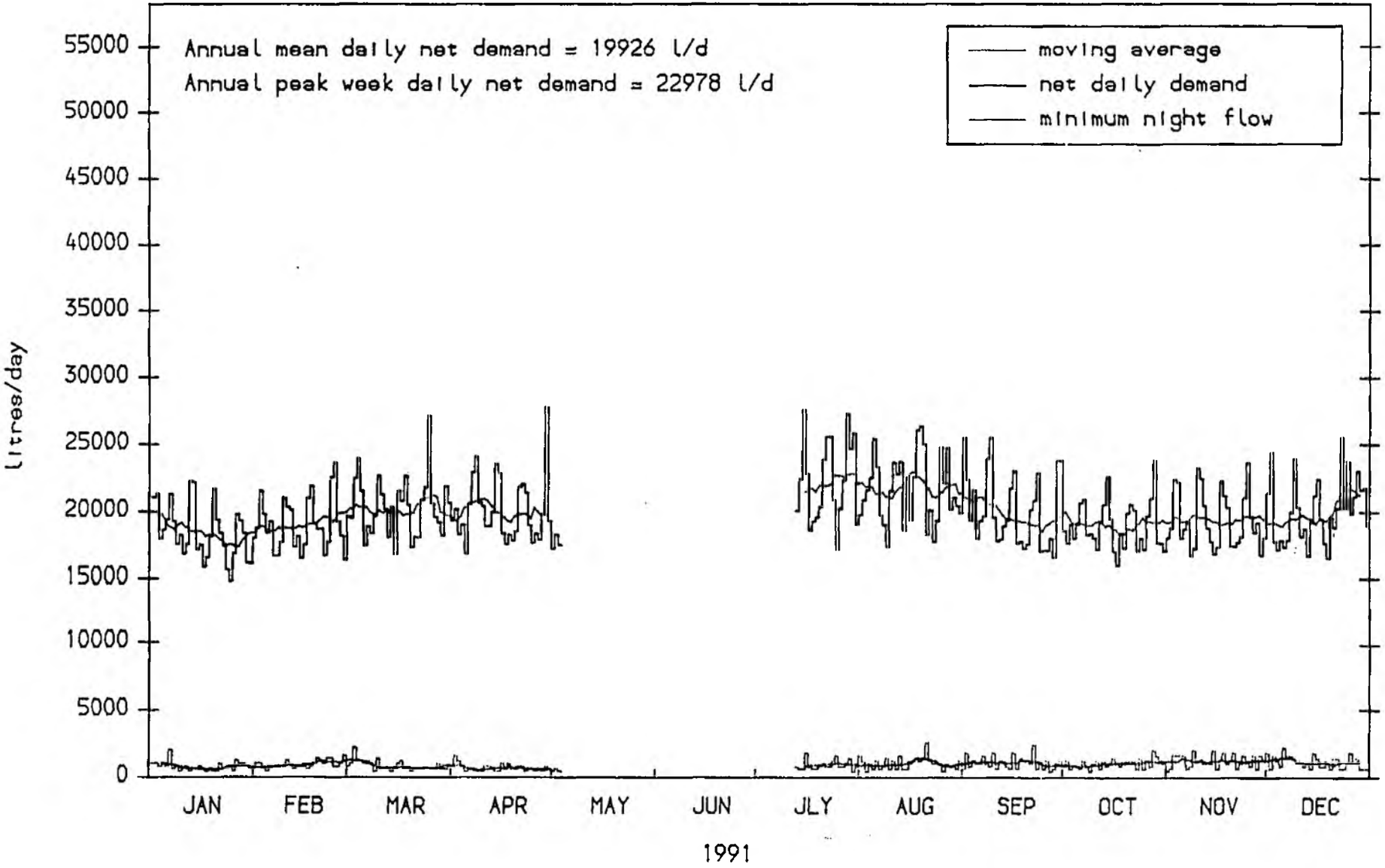
Baird Drive 025: water supply data for 1991 with 7 day moving average



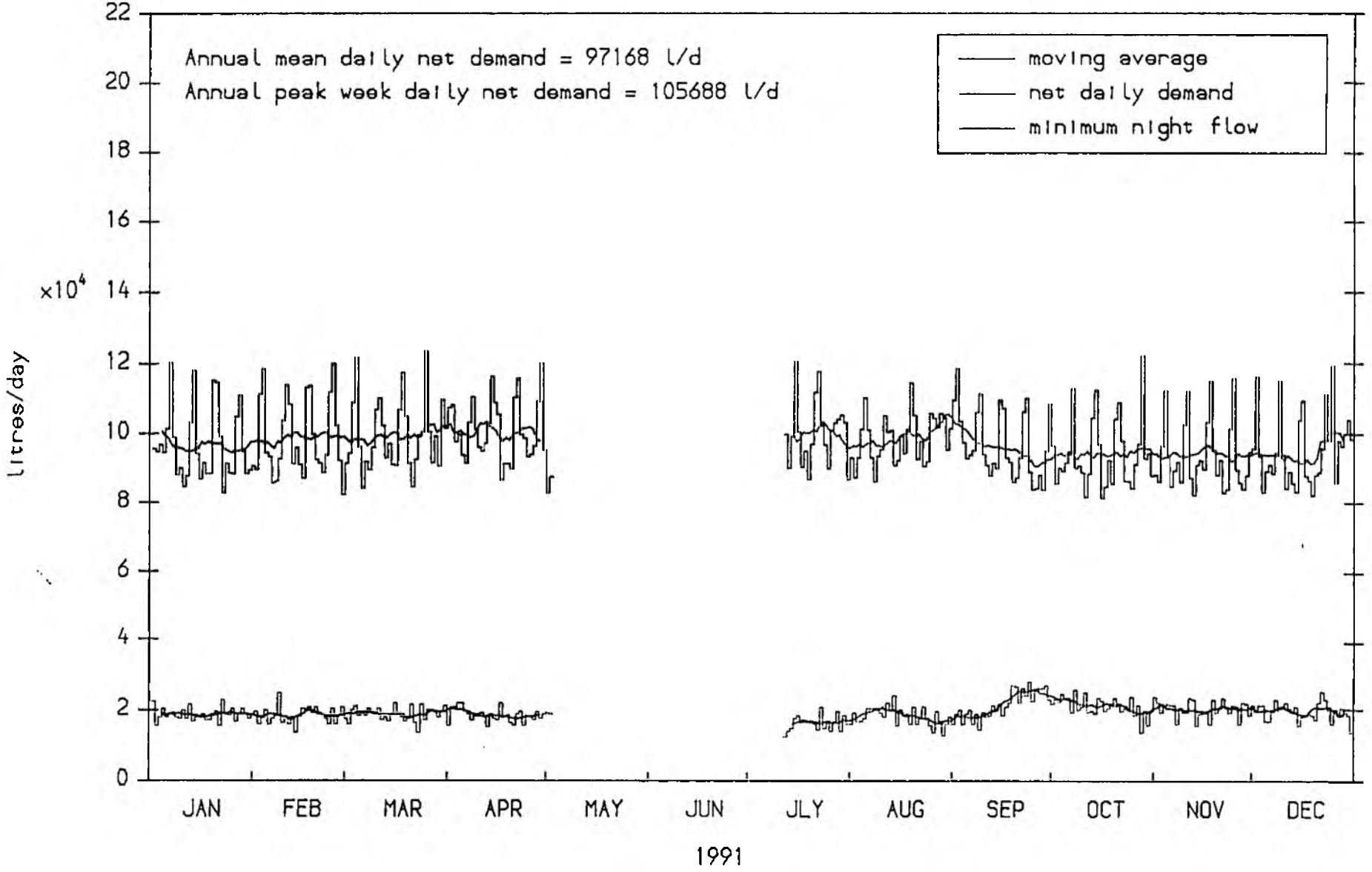
Bayeux Court 026: water supply data for 1991 with 7 day moving average



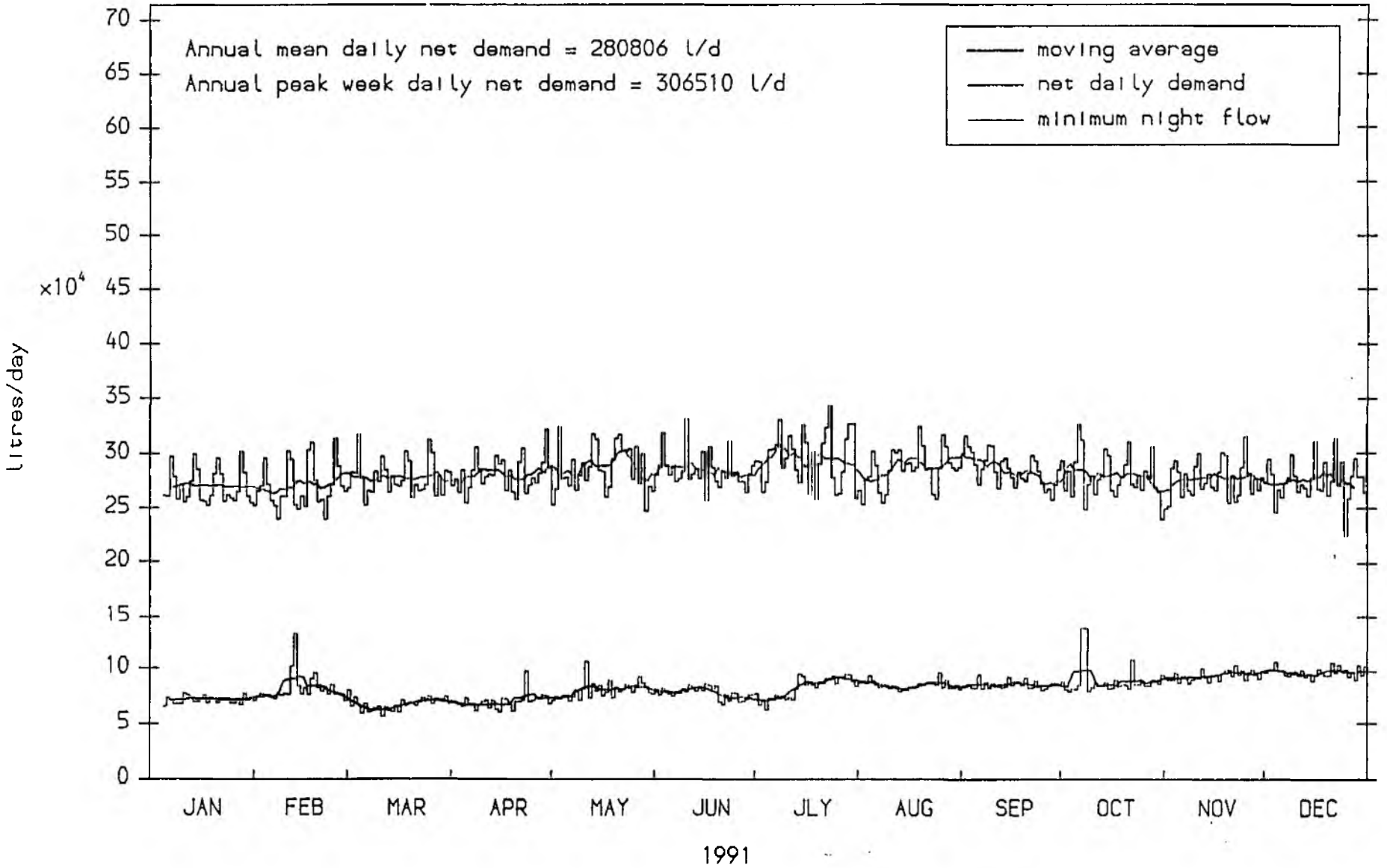
Carlton Crescent 027: water supply data for 1991 with 7 day moving average



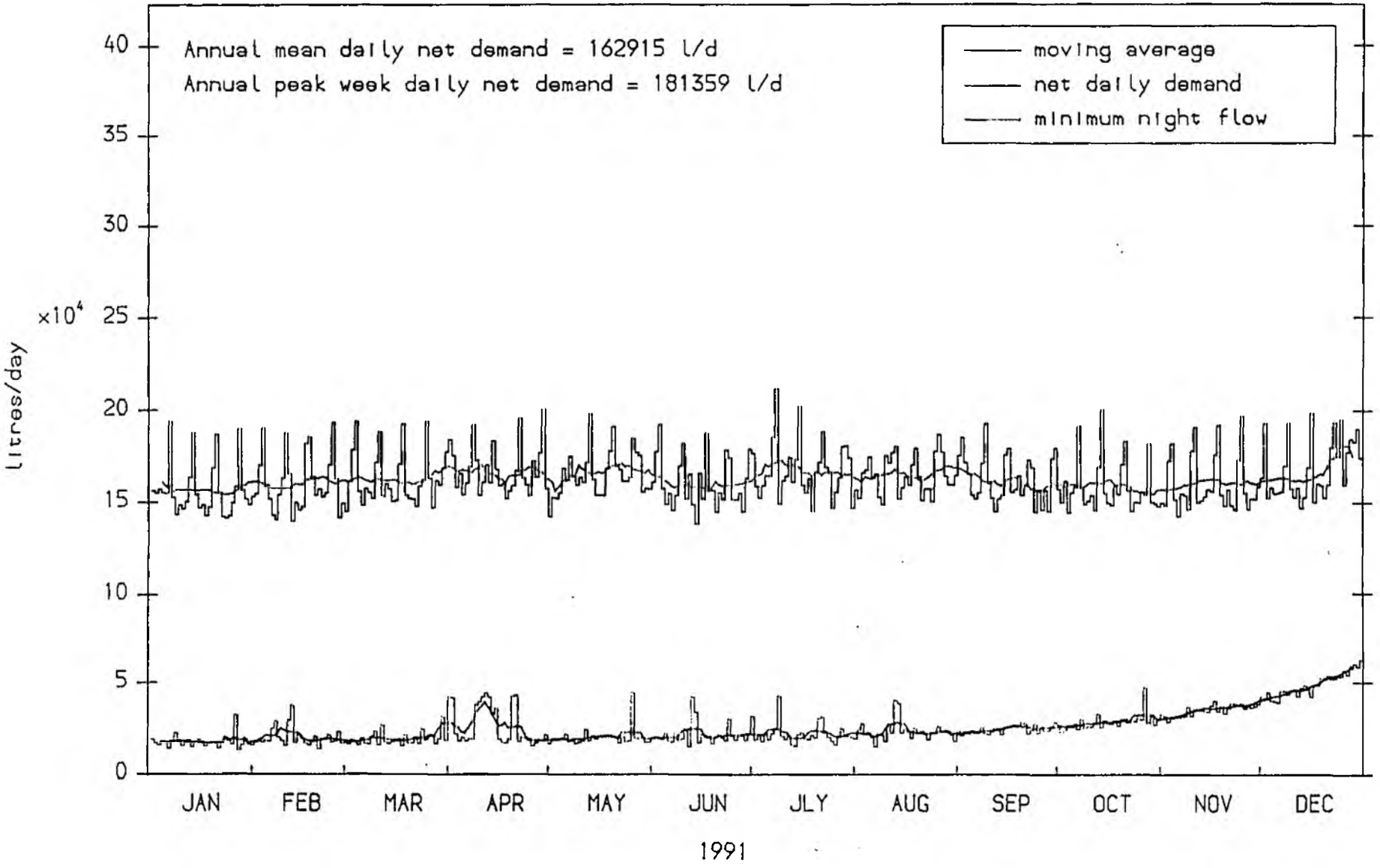
Allington Drive 028: water supply data for 1991 with 7 day moving average



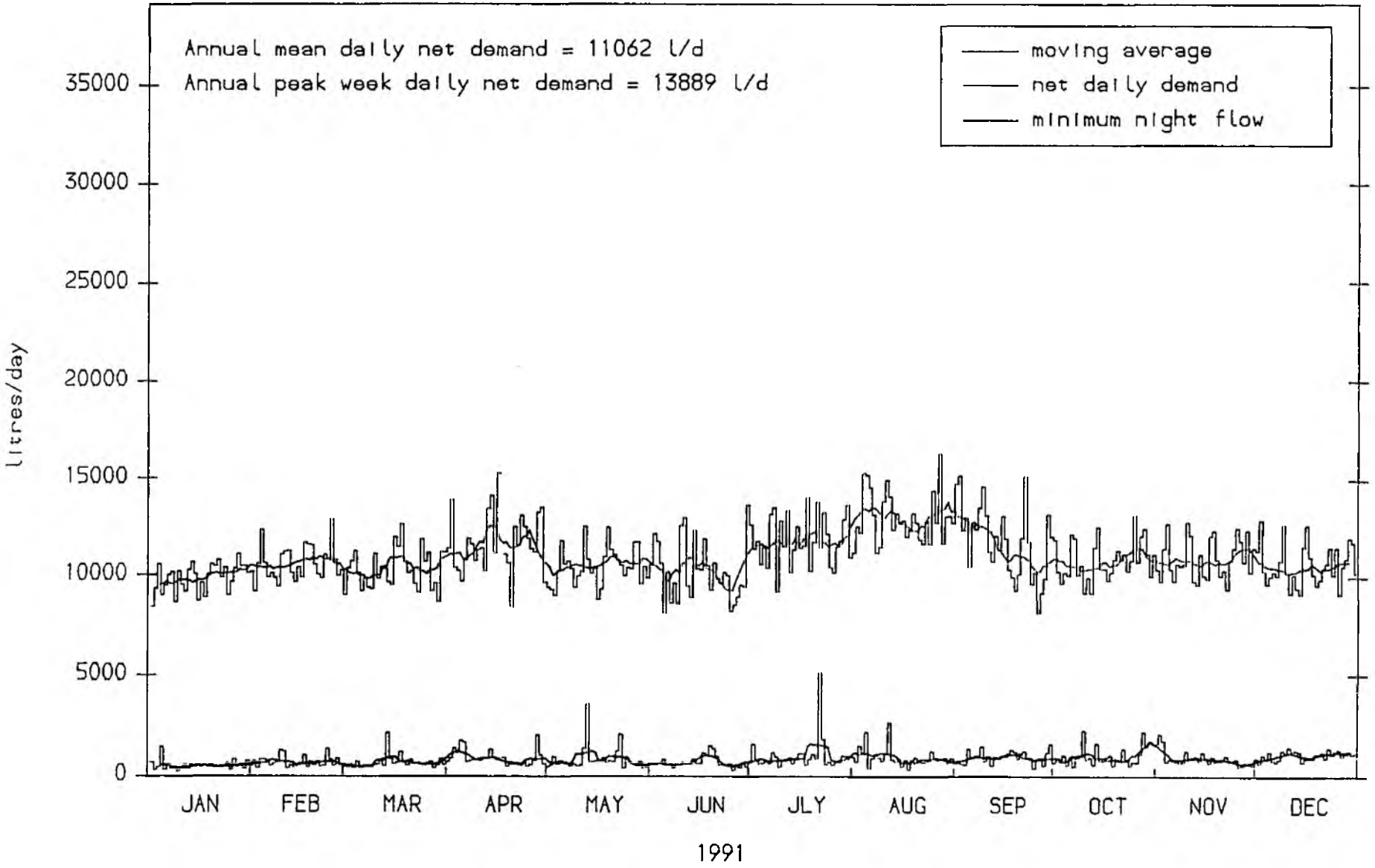
Painters Ash 029: water supply data for 1991 with 7 day moving average



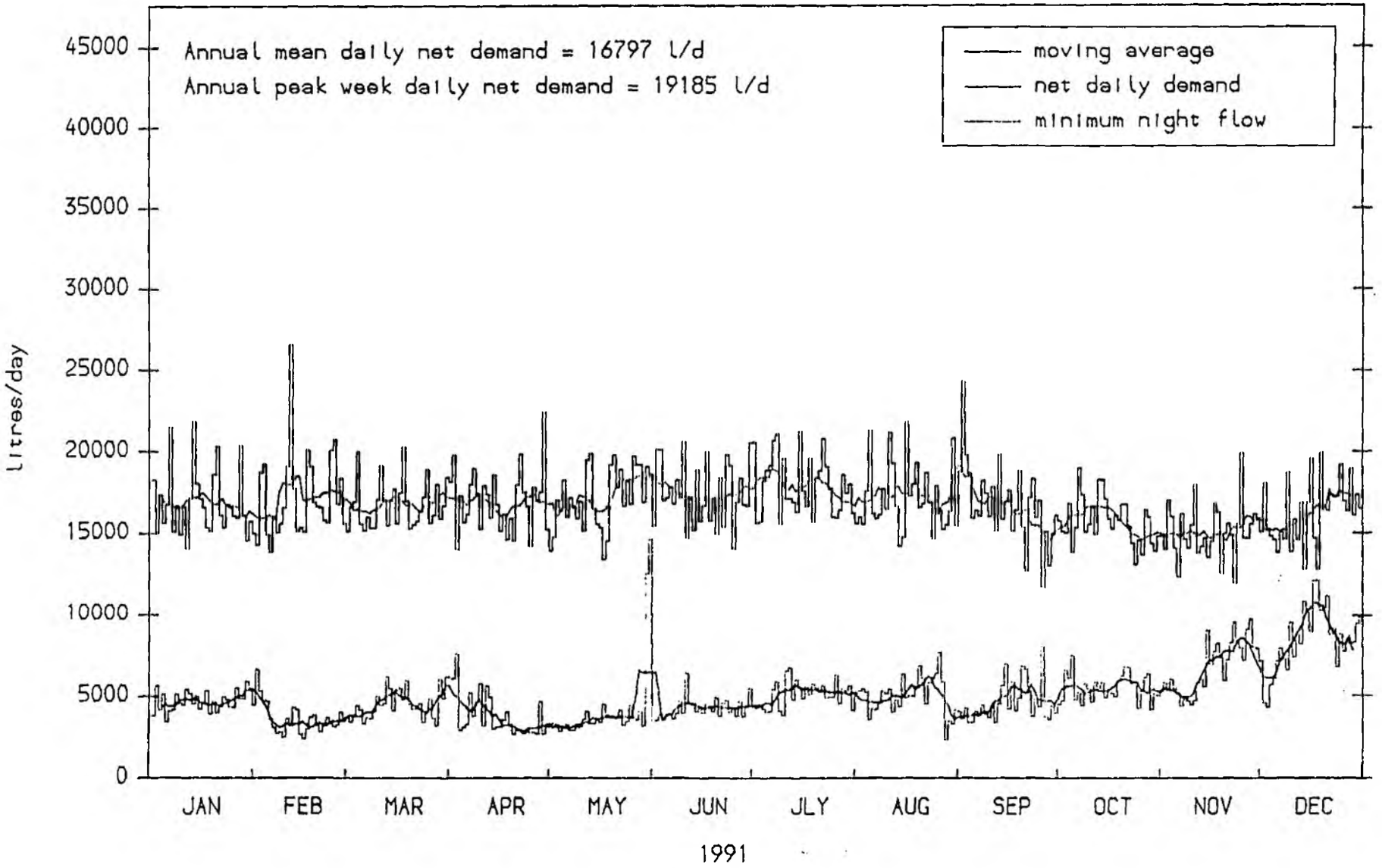
Northwood 034: water supply data for 1991 with 7 day moving average



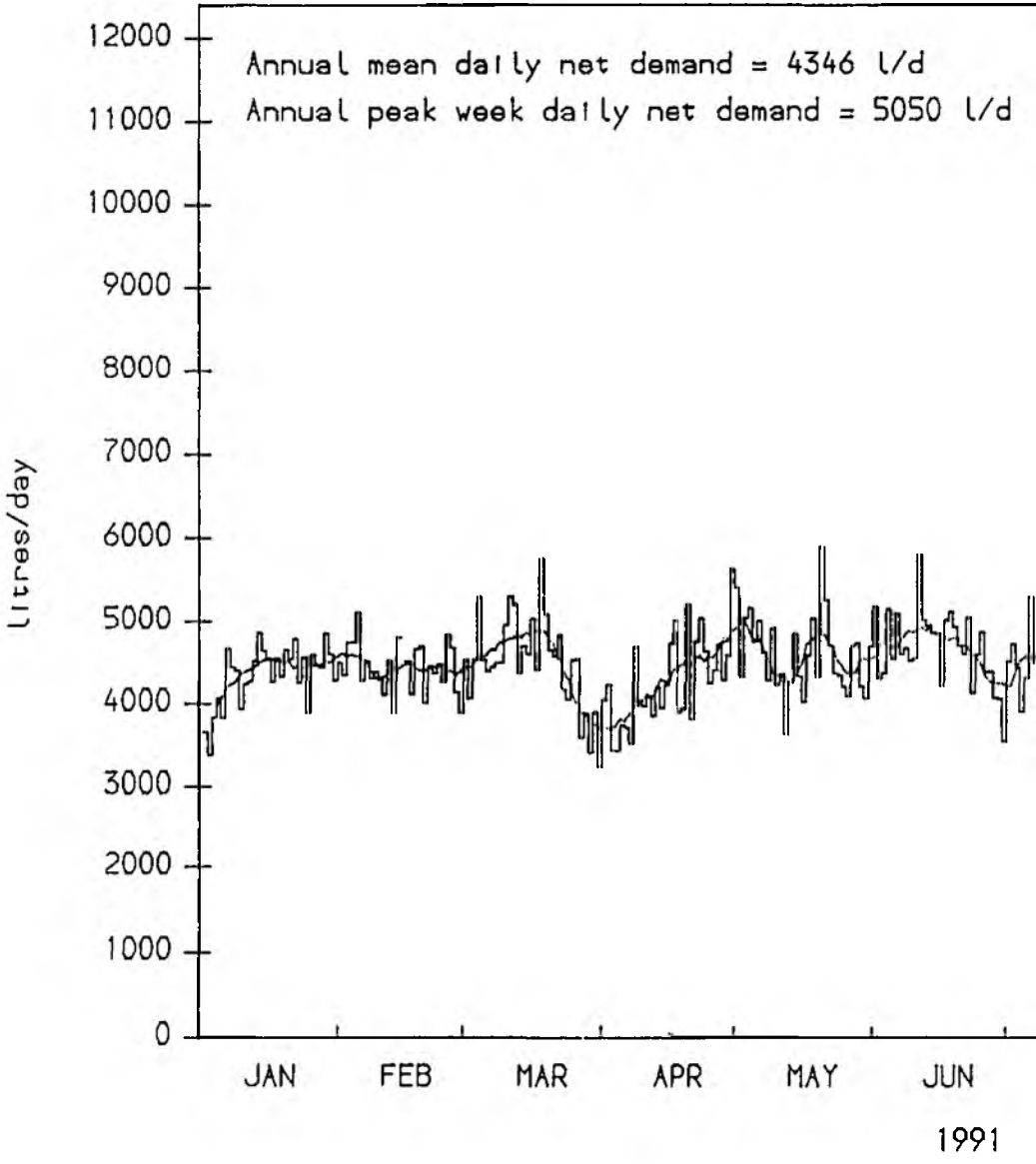
Michelle Gardens 035: water supply data for 1991 with 7 day moving average



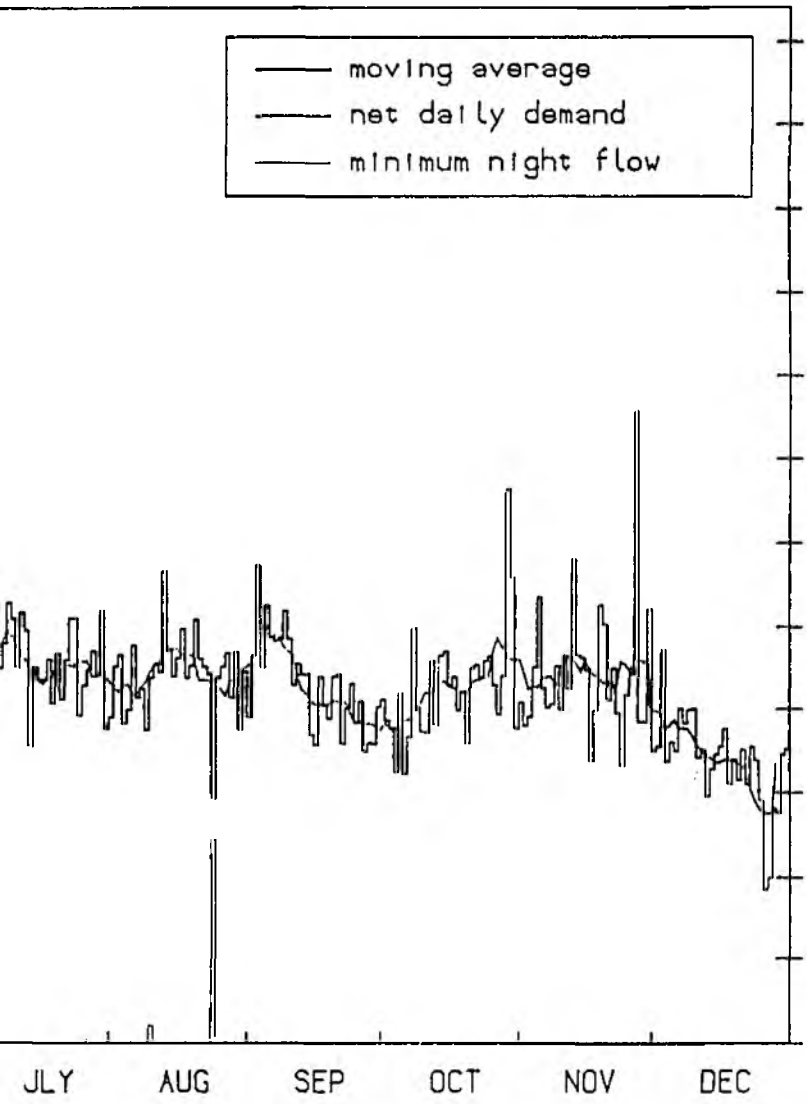
Broadley Avenue 036: water supply data for 1991 with 7 day moving average



Alexamdra Homes 037: water supply data for



1991 with 7 day moving average



APPENDIX B: MID KENT WATER COMPANY

CONTROL AREA CHECK LIST: MID KENT WATER COMPANY

AREA #	NAME	GRID REF	METER/LOGGER
C01	LANCTON OAST, ASHFORD	TR035417	Celia 50mm & 15mm
C02	YEOMAN GARDENS, ASHFORD	TR036420	Celia 50mm & 15mm
C03	ESSETFORD ROAD, ASHFORD	TR002412	Celia 50mm & 15mm
C04	FRANCIS ROAD, ASHFORD	TR007416	Kent Master 2000, 80mm
C05	AUSTIN ROAD, ASHFORD	TR005409	Kent Master 2000, 80mm
C06	OAKS PARK, CANTERBURY	TR126595	Celia 50mm & 15mm
C07	LONDON ROAD, CANTERBURY	TR141383	Kent Master 2000, 80mm
C08	ST PETERS, CANTERBURY	TR145579	Kent Master 2000, 80mm
C09	HOATH VILLAGE, CANTERBURY	TR797651	Kent Master 2000, 80mm 3000v, 50mm & 15mm
C10	HEAVER PLACE, CANTERBURY	TR152594	Celia 50mm & 15mm
C11	TADDINGTON WOOD, MAIDSTONE	TQ753626	Kent Master 2000, 80mm
C12	KINGSWOOD, MAIDSTONE	TQ840510	Kent Master 2000,80mm
C13	GROVE GREEN, MAIDSTONE	TQ784561	Kent Master 3000v comb 50mm & 15mm
C14	FOLEY PARK, MAIDSTONE	TQ768568	Kent Master 3000v comb 50mm & 15mm
C15	ALBERT PARK, MAIDSTONE	TQ758567	Kent Mater 2000, 80mm
C16	POYNTELL ROAD, STAPLEHURST	TQ787437	Kent Master 3000v comb 50mm & 15mm

CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

ACORN population profiles and annual consumption in 1991

MID KENT WATER COMPANY CONTROL AREAS

	control area #	population in Acorn Group B	C	E	F	J	K	Total popn	PCC (l/c/d)	Meas Cons (l/d)
MKWC Lacton Oast, Ashford	c01					65		65	142.4	9254
Yeoman Gardens, Ashford	c02						141	141	93.4	13172
Essetford Road, Ashford	c03			208	193			401	108.2	43408
Francis Road, Ashford	c04		475		170			645	98.1	63289
Austin Road, Ashford	c05		8		564			572	125.7	71918
Oaks Park, Canterbury	c06					177		177	187.4	33175
London Road, Canterbury	c07			785				785	111.4	87446
St Peters, Canterbury	c08		334					334	150.6	50290
Hoath Village, C'bury	c09	321						321	167.3	53708
Hever Place, Canterbury	c10	52				61		113	148.5	16786
Taddington, Maidstone	c11	498	189					687	188.4	129398
Kingswood, Maidstone	c12	870	378					1248	120.8	150711
Grove Green, Maidstone	c13	176				52		228	169.8	38711
Foley Park, Maidstone	c14	250						250	139.7	34916
Albert park, Maidstone	c15		382			177		559	116.2	64953
Poyntell Road, Maidstone	c16	269	12					281	127.6	35849

CONTROL AREA CALCULATIONS: 1991 HOUSEHOLD BASED

ACORN household profiles

MID KENT WATER COMPANY CONTROL AREAS

	control area #	households in Acorn Group B	C	E	F	J	K	Total hh	PHC (l/hh/d)	Meas Cons (l/d)
MKWC Lacton Oast, Ashford	c01					19		19	487.1	9254
Yeoman Gardens, Ashford	c02						53	53	248.5	13172
Essetford Road, Ashford	c03			70	64			134	323.9	43408
Francis Road, Ashford	c04		182		69			251	252.1	63289
Austin Road, Ashford	c05		3		208			211	340.8	71918
Oaks Park, Canterbury	c06					61		61	543.9	33175
London Road, Canterbury	c07			261				261	335.0	87446
St Peters, Canterbury	c08		163					163	308.5	50290
Hoath Village, C'bury	c09	117						117	459.0	53708
Hever Place, Canterbury	c10	17				20		37	453.7	16786
Taddington, Maidstone	c11	163	61					224	577.7	129398
Kingswood, Maidstone	c12	290	126					416	362.3	150711
Grove Green, Maidstone	c13	68						68	569.3	38711
Foley Park, Maidstone	c14	83						83	420.7	34916
Albert park, Maidstone	c15		182			85		267	243.3	64953
Poyntell Road, Maidstone	c16	92	4					96	373.4	35849

1988 demand data

ACORN GROUP	PCC Ave	PCC Pop Variance	MKWC POPN %	REGION POPN %
B	140.6	524.6	22.8	17.1
C	140.4	332.5	20.1	21.4
E	127.6	325.7	13.4	12.4
F	128.6	98.8	4.4	6.1
J	158.2	439.5	19.2	20.1
K	180.3	595.5	6.3	12.1
% Population Accounted for			86.2	89.2
Average PCC			144.7	147.3
Variance			413.4	412.2
Standard Error			2.5	2.5
95% Lower Confidence Int			139.7	142.3
95% Upper Confidence Int			149.7	152.3

CONTROL AREA CALCULATIONS: 1989 POPULATION BASED

ACORN GROUP	PHC Ave	PHC Pop Variance	MKWC POPN %	REGION POPN %
B	152.7	1480.5	22.8	17.1
C	138.3	1032.2	20.1	21.4
E	128.5	465.1	13.4	12.4
F	133.7	924.8	4.4	6.1
J	149.3	126.8	19.2	20.1
K	173.7	1908.8	6.3	12.1
% Population Accounted for			86.2	89.2
Average PCC			145.4	146.6
Variance			919.5	946.9
Standard Error			3.9	3.9
95% Lower Confidence Int			137.6	138.8
95% Upper Confidence Int			153.1	154.5

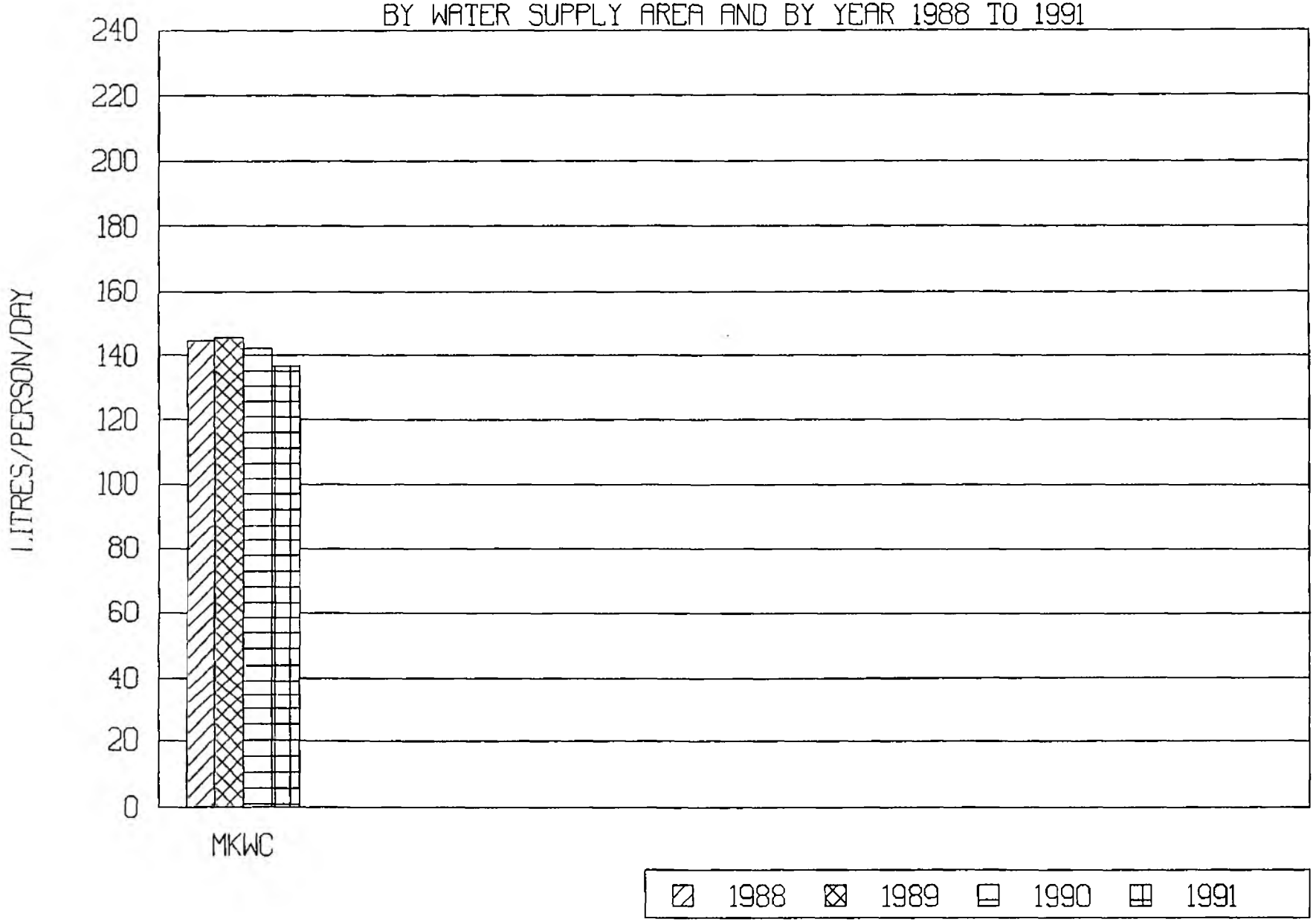
CONTROL AREA CALCULATIONS: 1990 POPULATION BASED

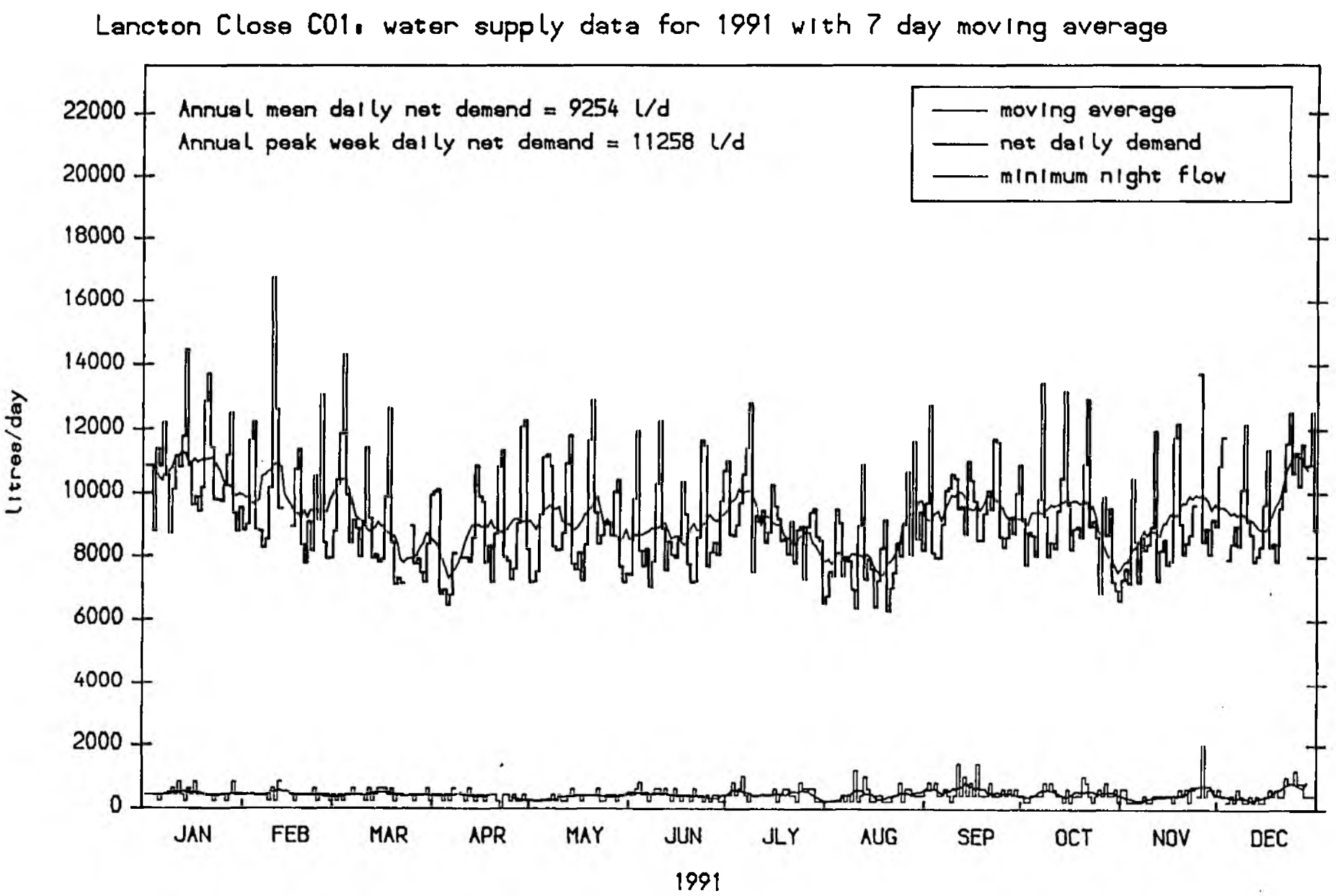
ACORN GROUP	PHC Ave	PHC Pop Variance	MKWC POPN %	REGION POPN %
B	147.5	1207.2	22.8	17.1
C	131.6	1014.0	20.1	21.4
E	127.0	646.4	13.4	12.4
F	130.0	1081.8	4.4	6.1
J	146.1	214.8	19.2	20.1
K	186.5	3133.5	6.3	12.1
% Population Accounted for			86.2	89.2
Average PCC			142.3	144.6
Variance			988.3	1112.0
Standard Error			4.0	4.3
95% Lower Confidence Int			134.2	136.1
95% Upper Confidence Int			150.3	153.2

CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

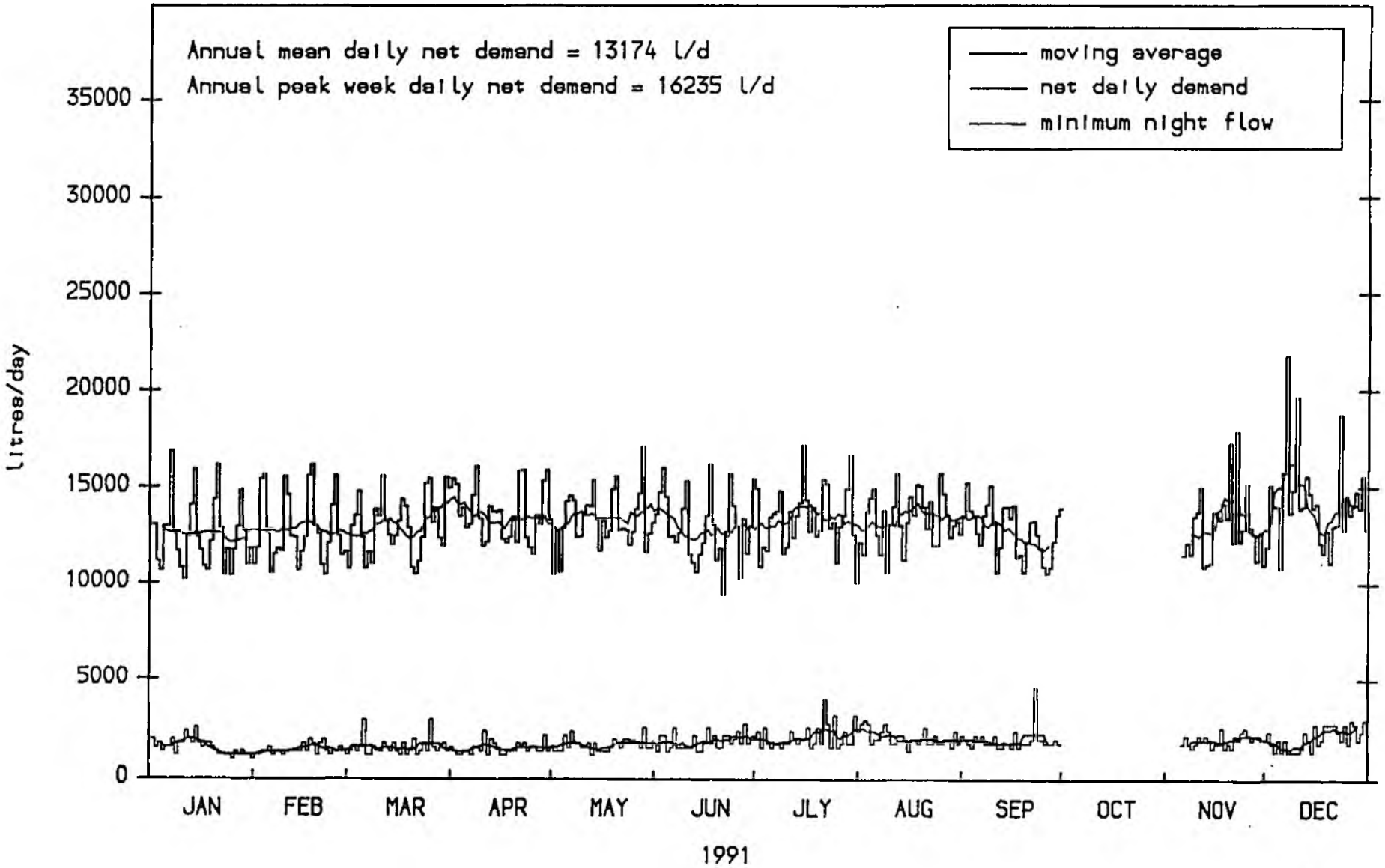
ACORN GROUP	PHC Ave	PHC Pop Variance	MKWC POPN %	REGION POPN %
B	143.7	808.6	22.8	17.1
C	126.3	523.6	20.1	21.4
E	126.4	450.0	13.4	12.4
F	116.6	163.2	4.4	6.1
J	139.4	157.3	19.2	20.1
K	175.1	2514.7	6.3	12.1
% Population Accounted for			86.2	89.2
Average PCC			136.9	138.6
Variance			633.1	730.9
Standard Error			3.2	3.4
95% Lower Confidence Int			130.6	131.8
95% Upper Confidence Int			143.3	145.4

CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
MID KENT WATER COMPANY
BY WATER SUPPLY AREA AND BY YEAR 1988 TO 1991

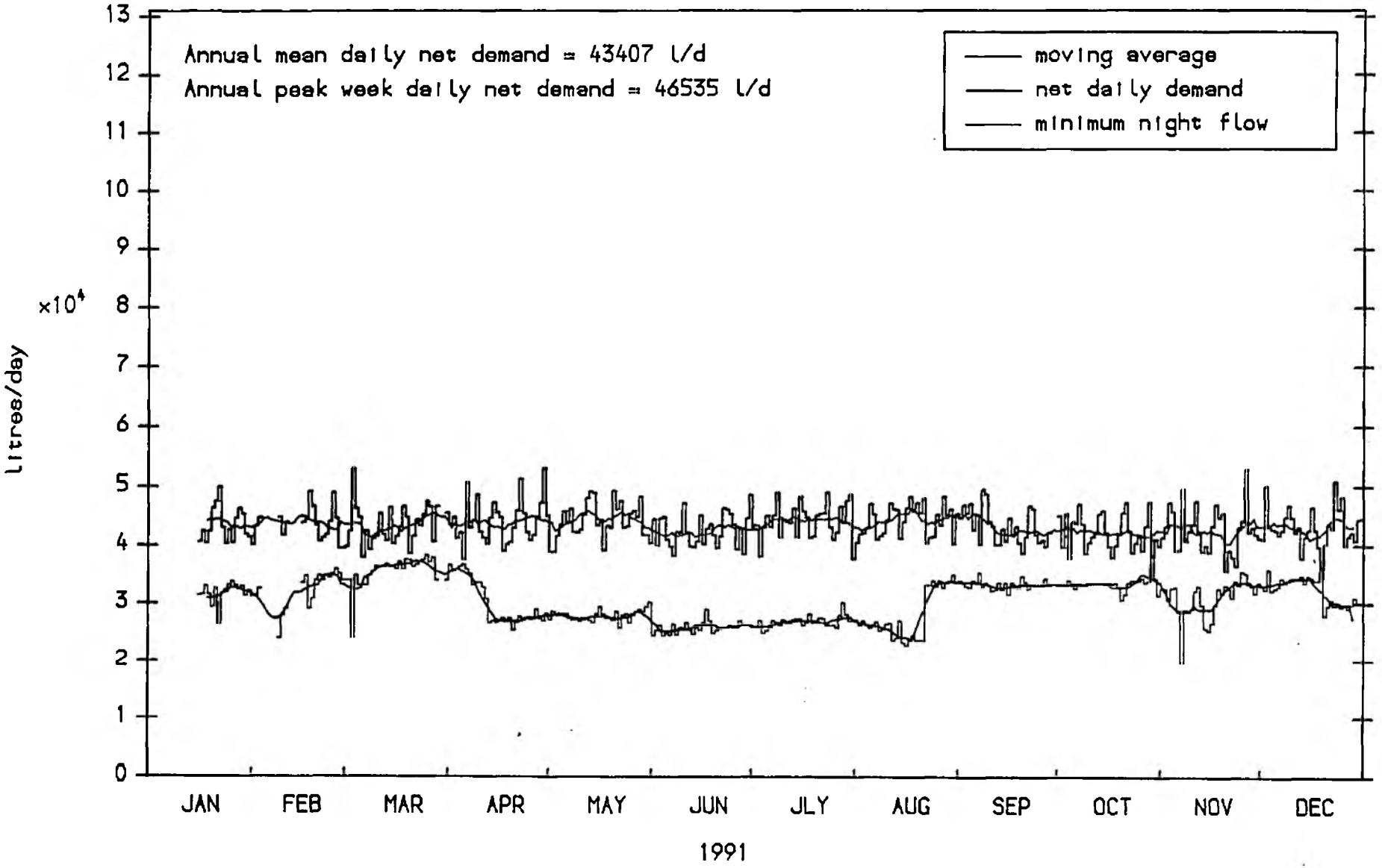



Lancton Close C01: water supply data for 1991 with 7 day moving average
Annual mean daily net demand = 9254 l/d
Annual peak week daily net demand = 11258 l/d
moving average
net daily demand
minimum night flow
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
litres/day
JAN
FEB
MAR
APR
MAY
JUN
JLY
AUG
SEP
OCT
NOV
DEC
1991

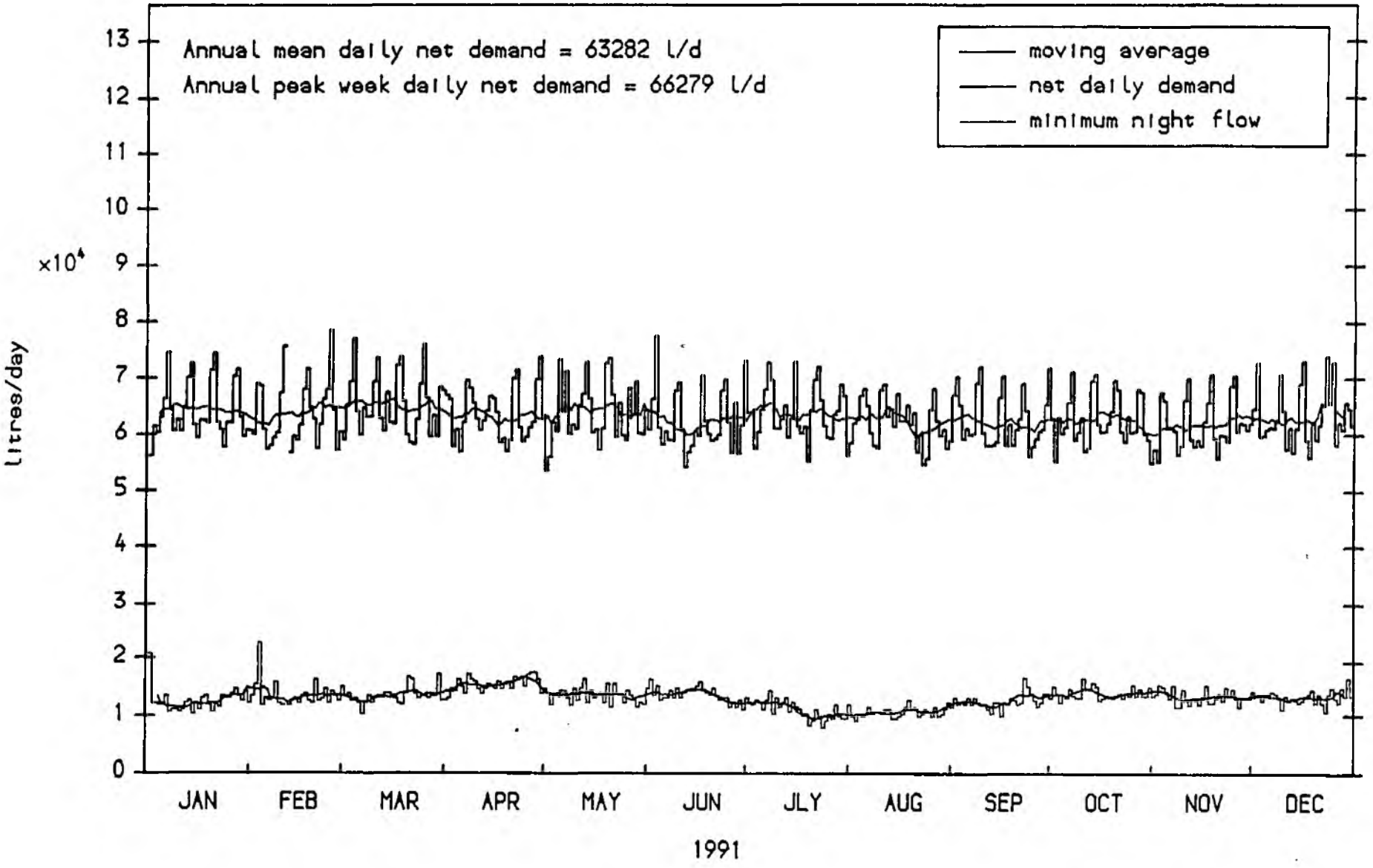
Yeoman Gardens CO2: water supply data for 1991 with 7 day moving average



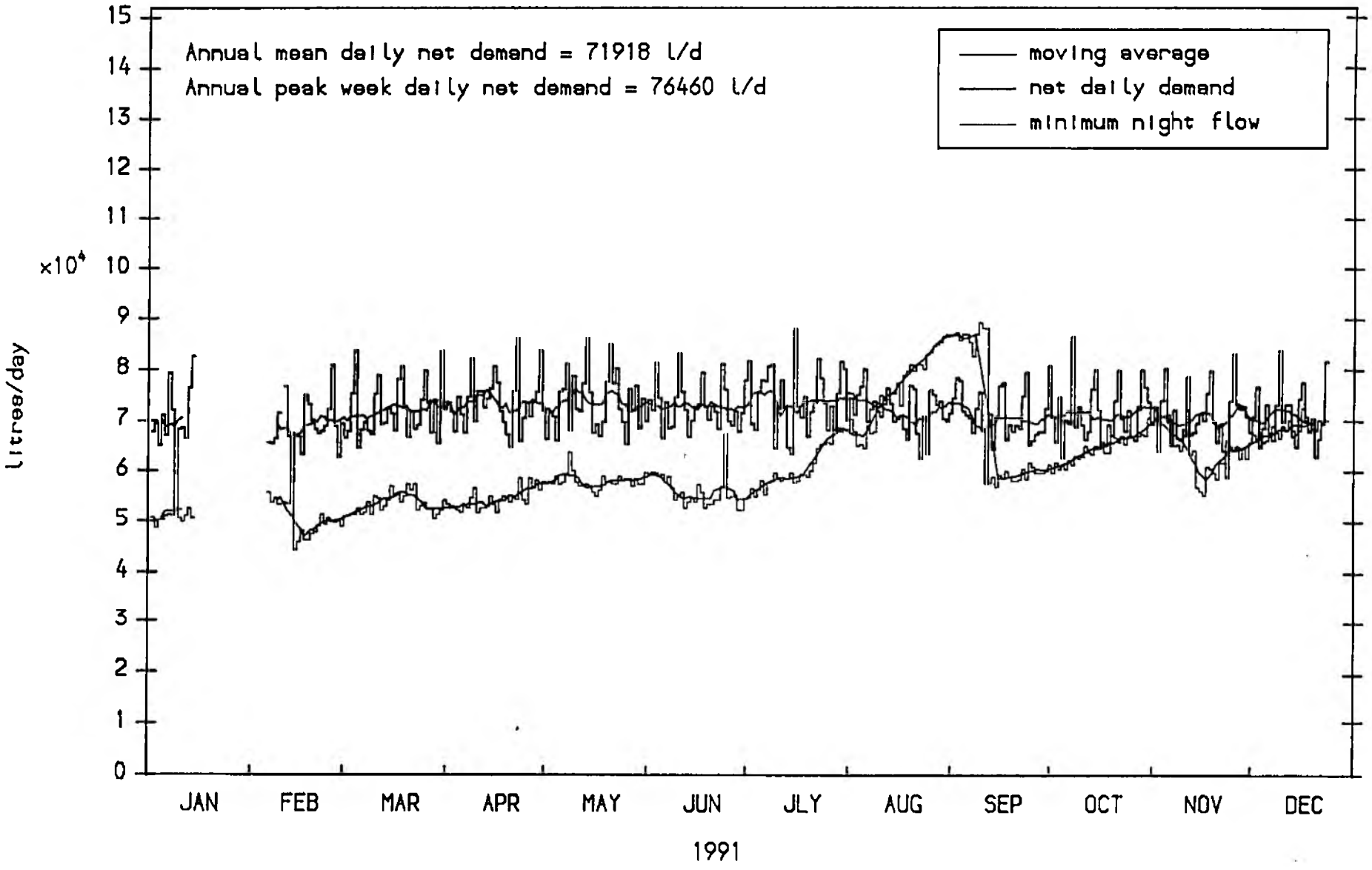
Essetford Road C03: water supply data for 1991 with 7 day moving average



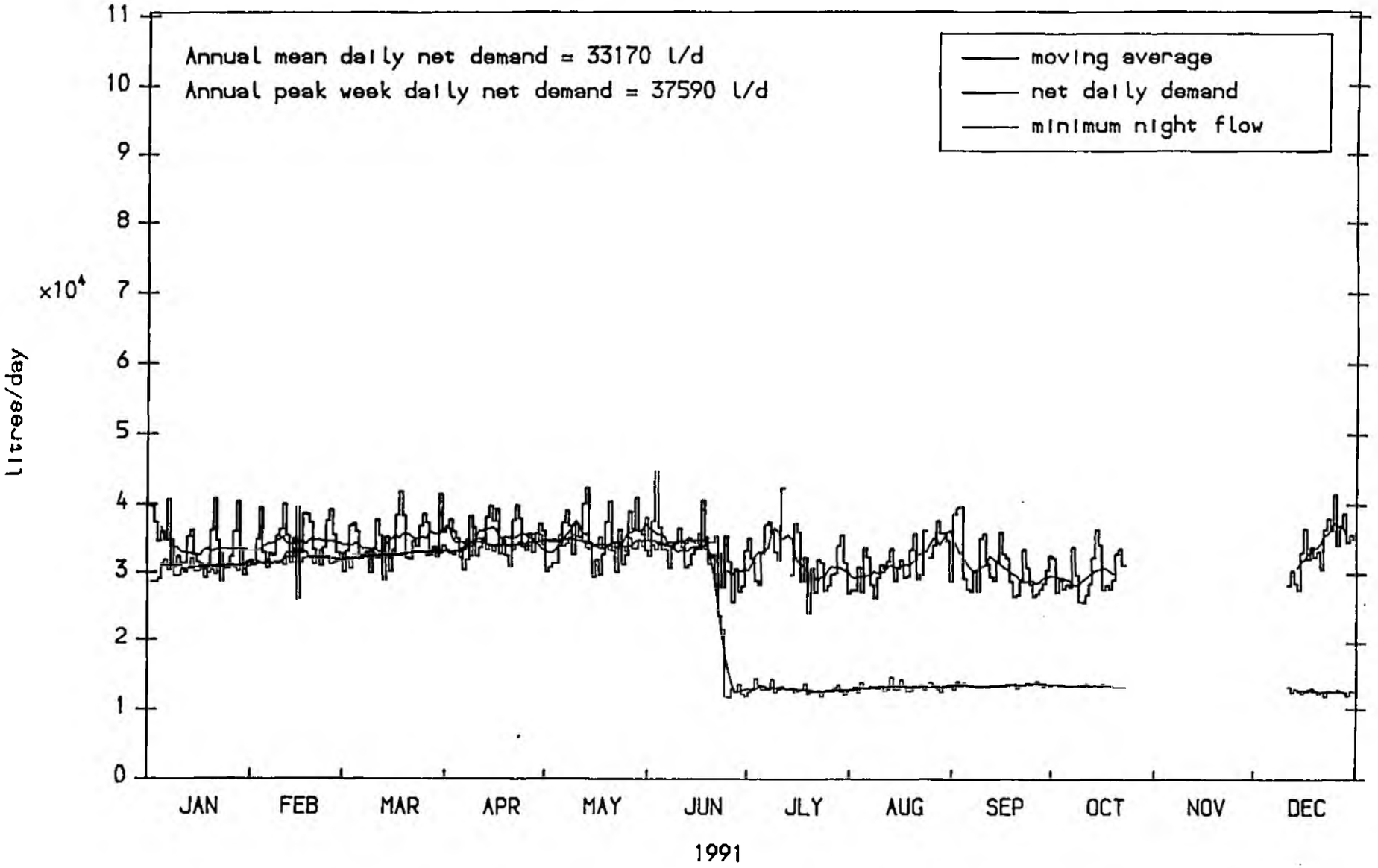
Francis Road C04: water supply data for 1991 with 7 day moving average

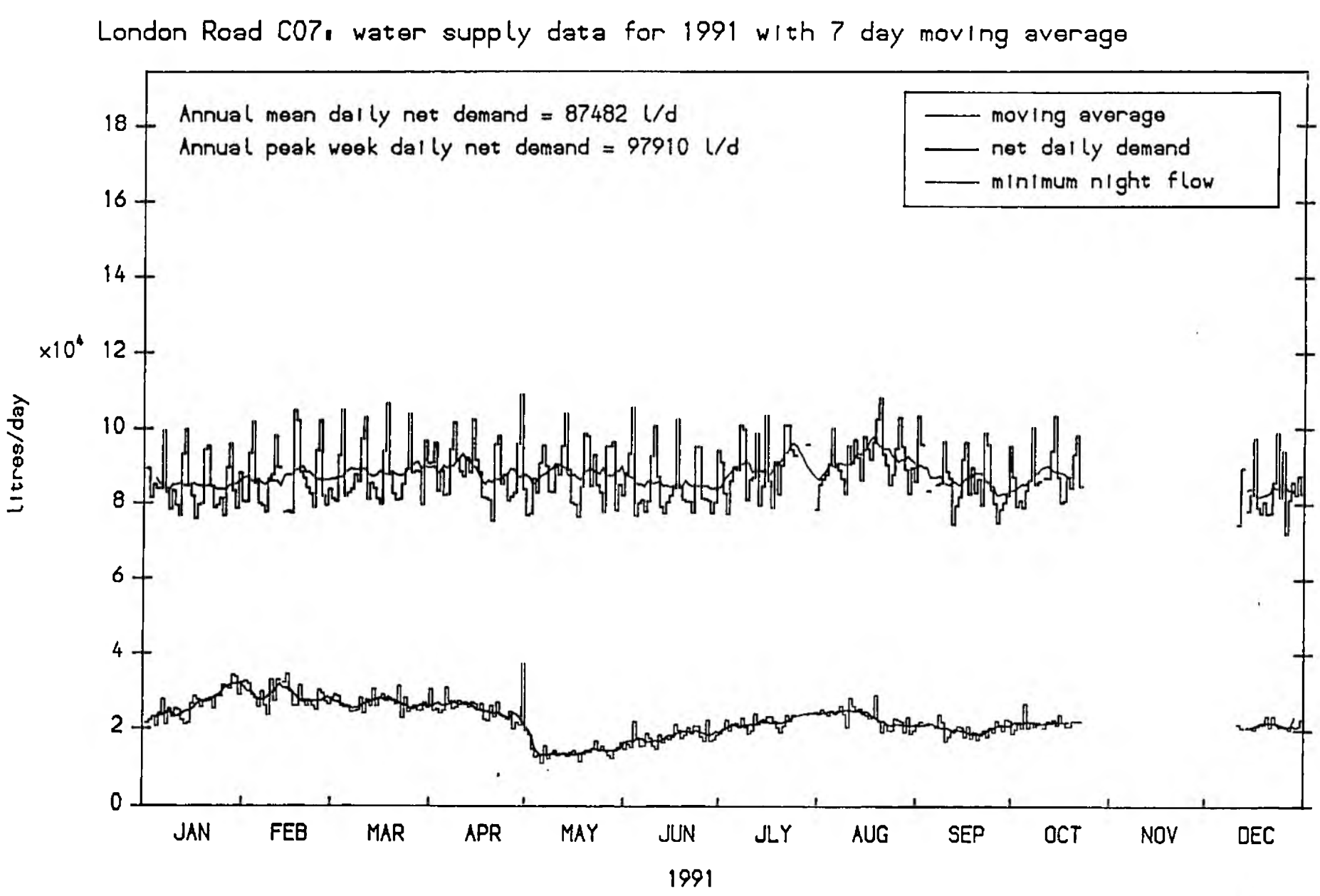


Austen Road C05: water supply data for 1991 with 7 day moving average

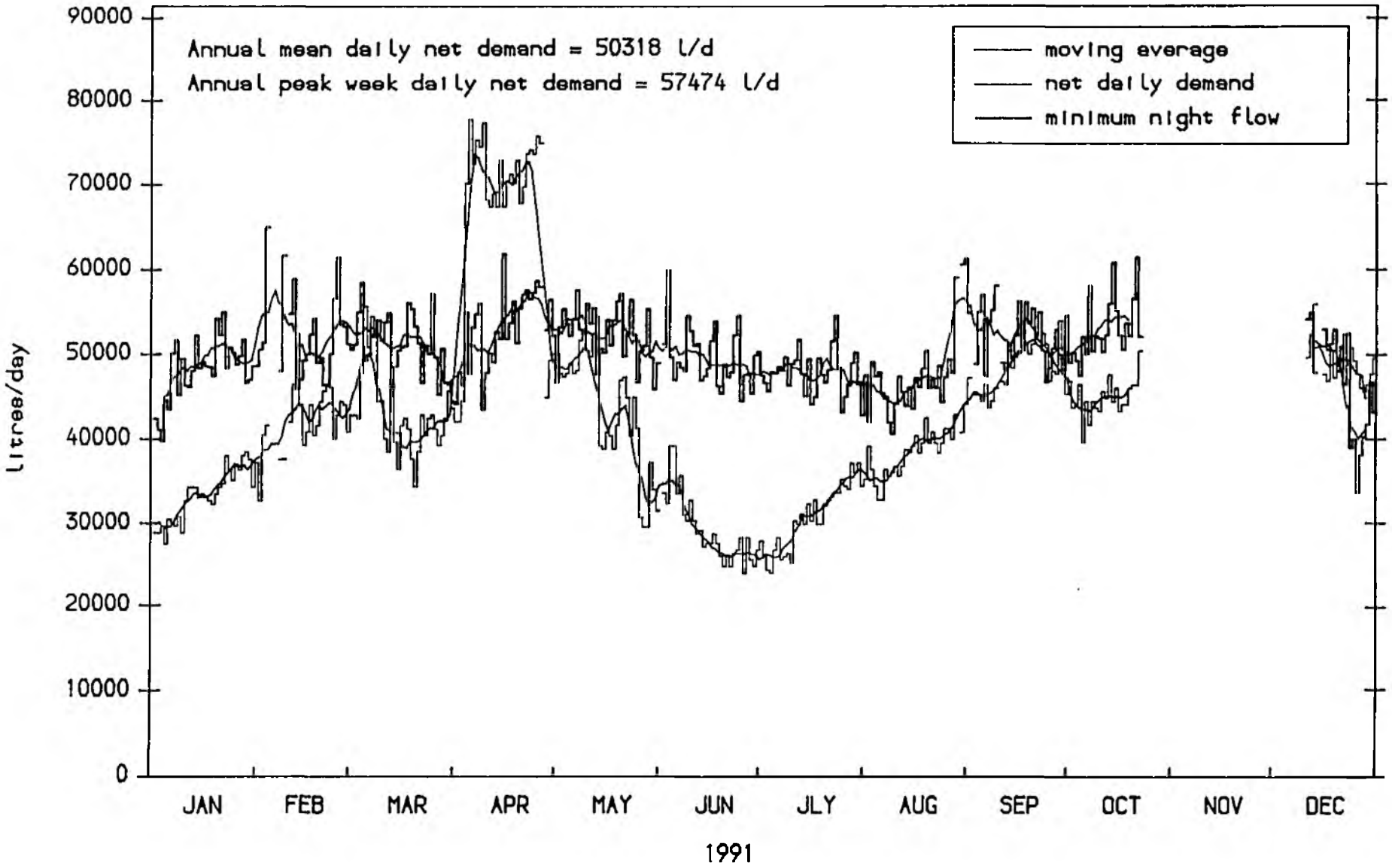


Oakes Park C06: water supply data for 1991 with 7 day moving average

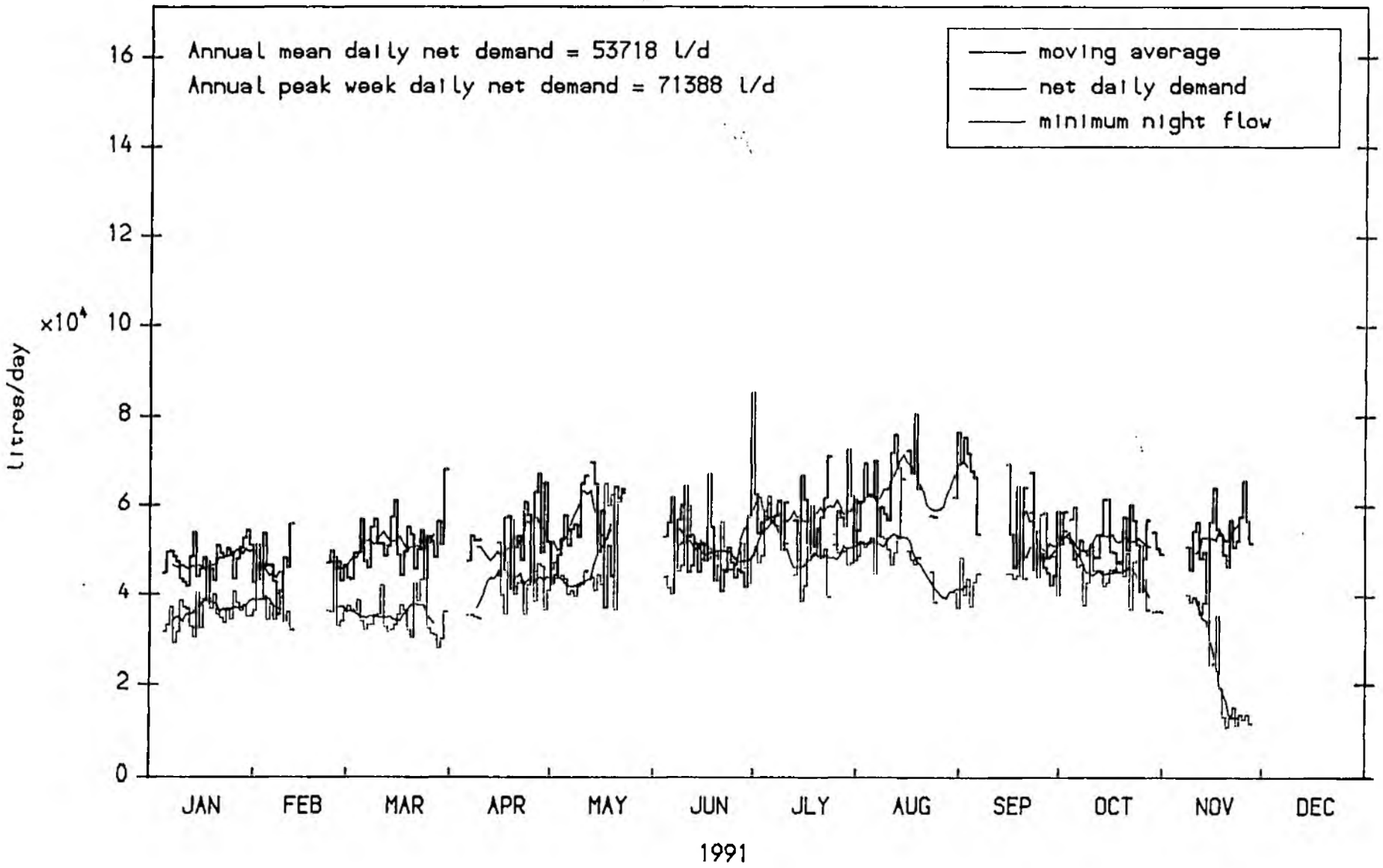



London Road C07: water supply data for 1991 with 7 day moving average
Annual mean daily net demand = 87482 l/d
Annual peak week daily net demand = 97910 l/d
moving average
net daily demand
minimum night flow
litres/day
x10⁴
18
16
14
12
10
8
6
4
2
0
JAN
FEB
MAR
APR
MAY
JUN
JLY
AUG
SEP
OCT
NOV
DEC
1991

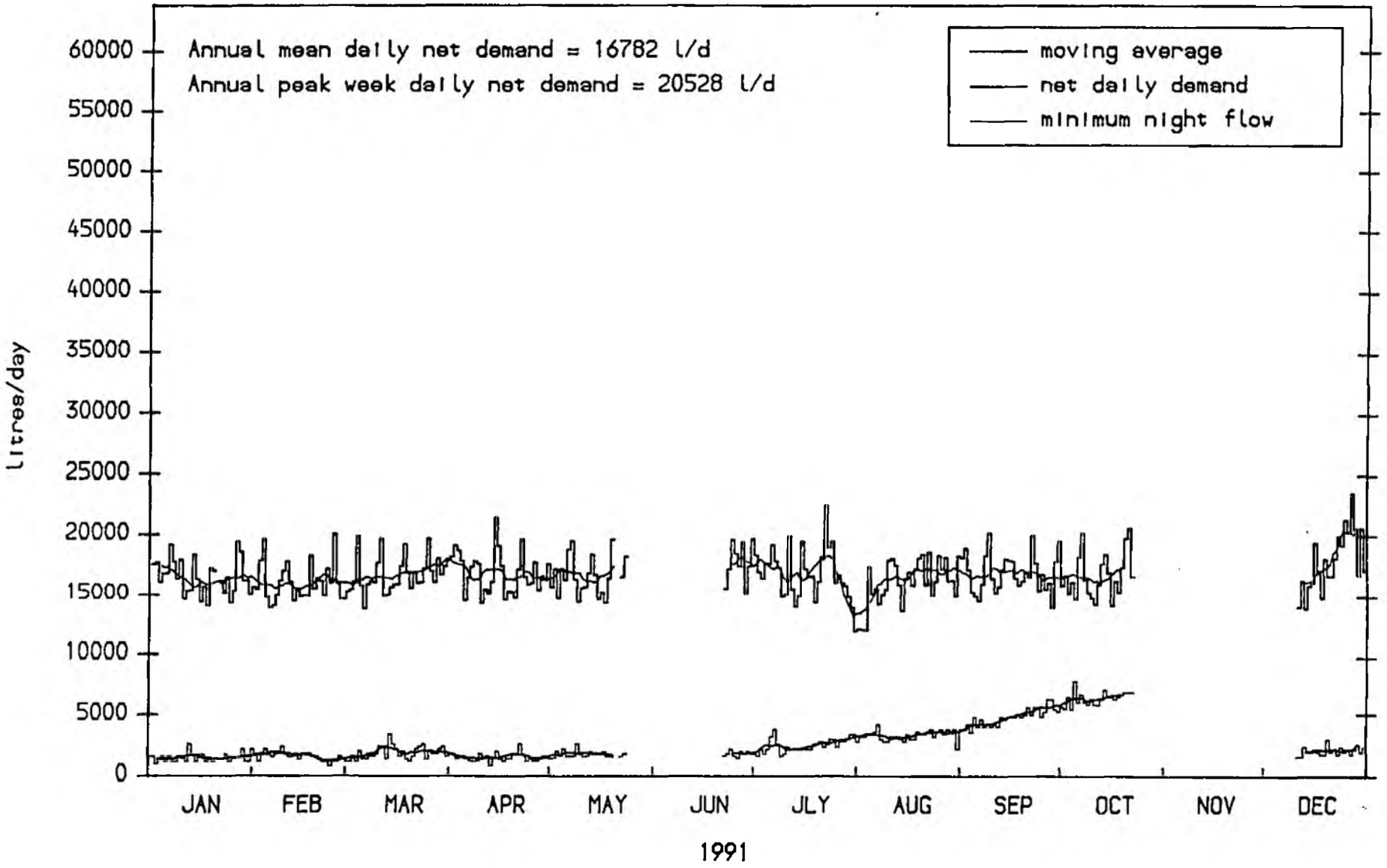
St Peters C08: water supply data for 1991 with 7 day moving average



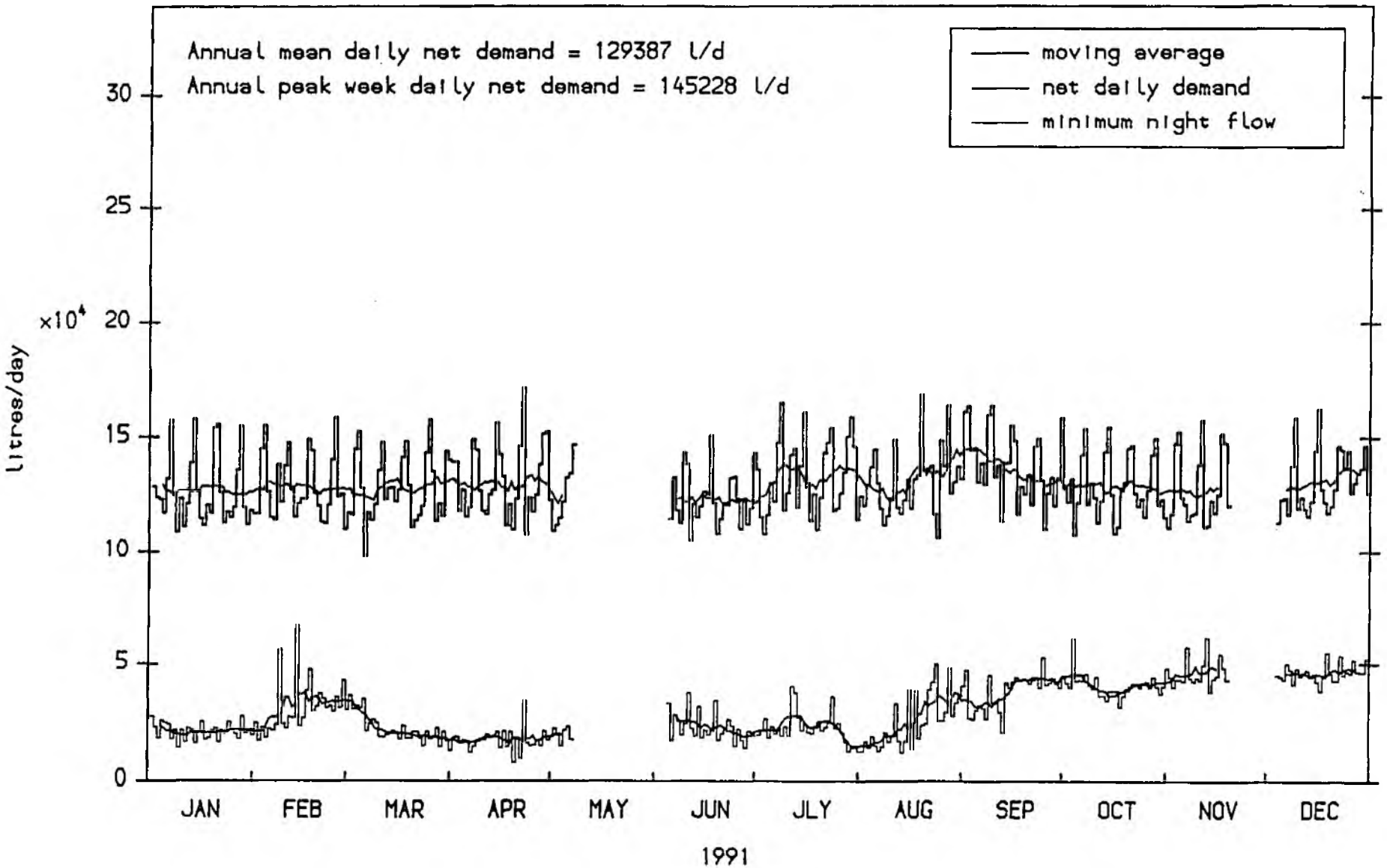
Hoath C09: water supply data for 1991 with 7 day moving average



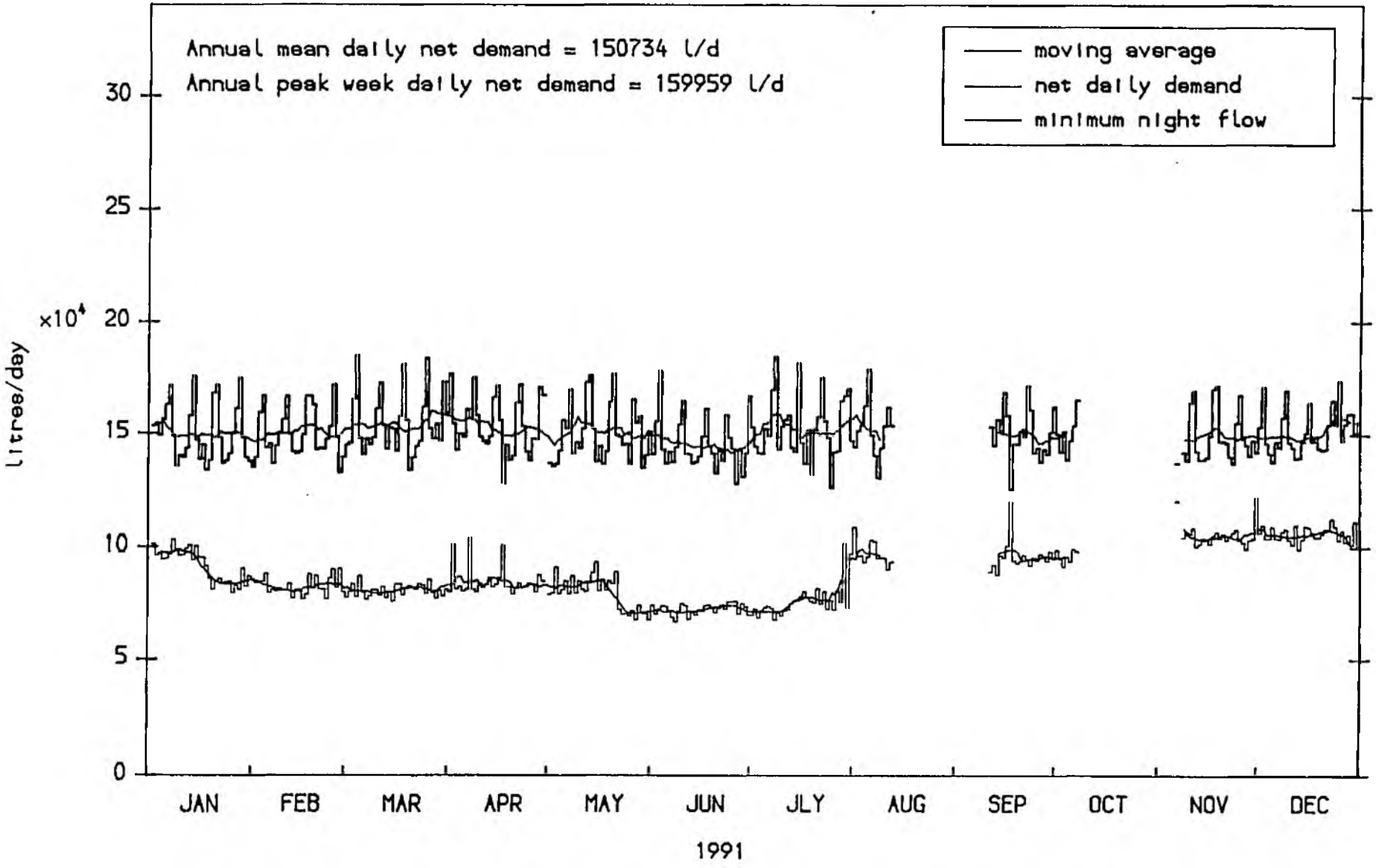
Heaver Place C10: water supply data for 1991 with 7 day moving average



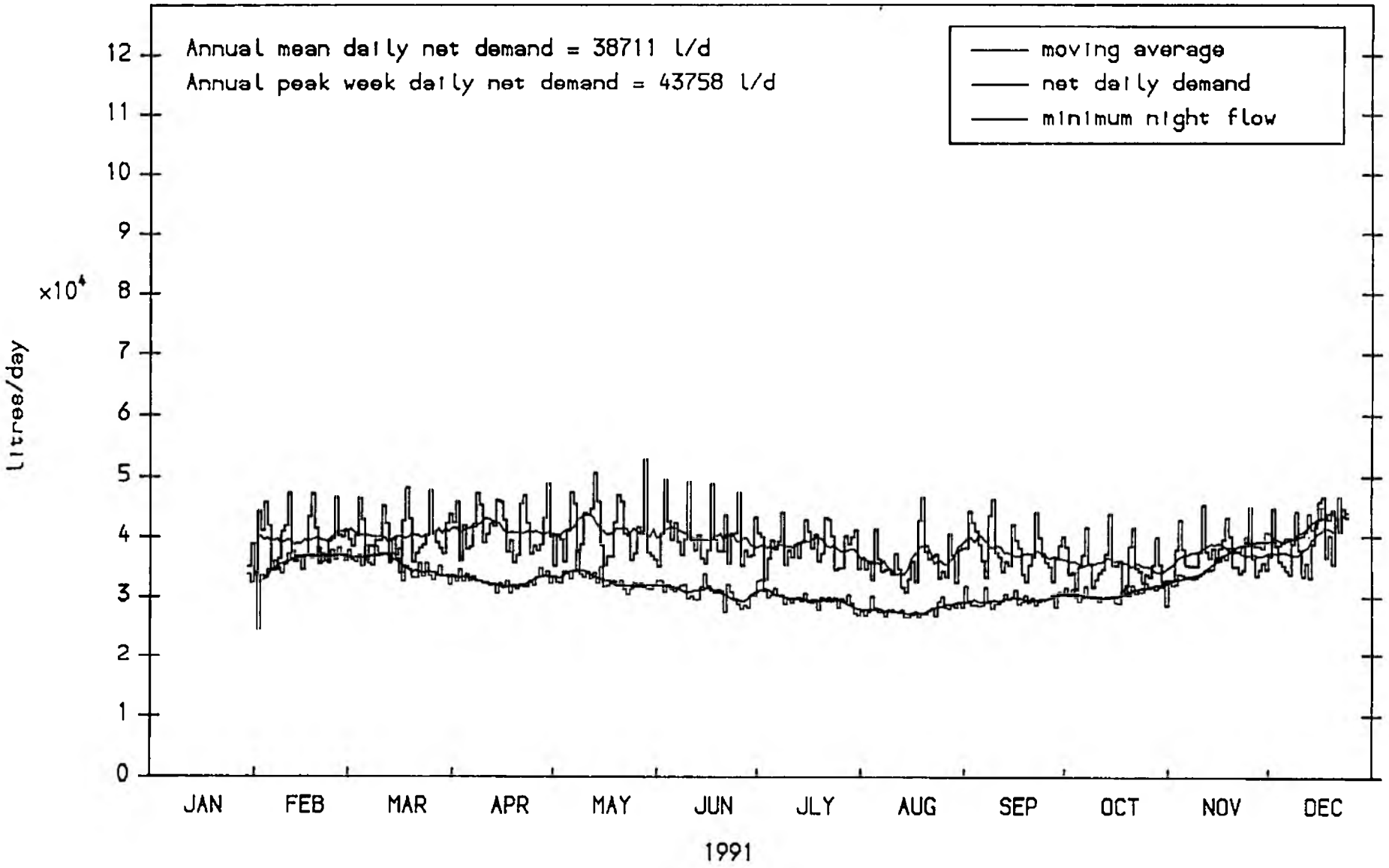
Taddington Wood C11: water supply data for 1991 with 7 day moving average



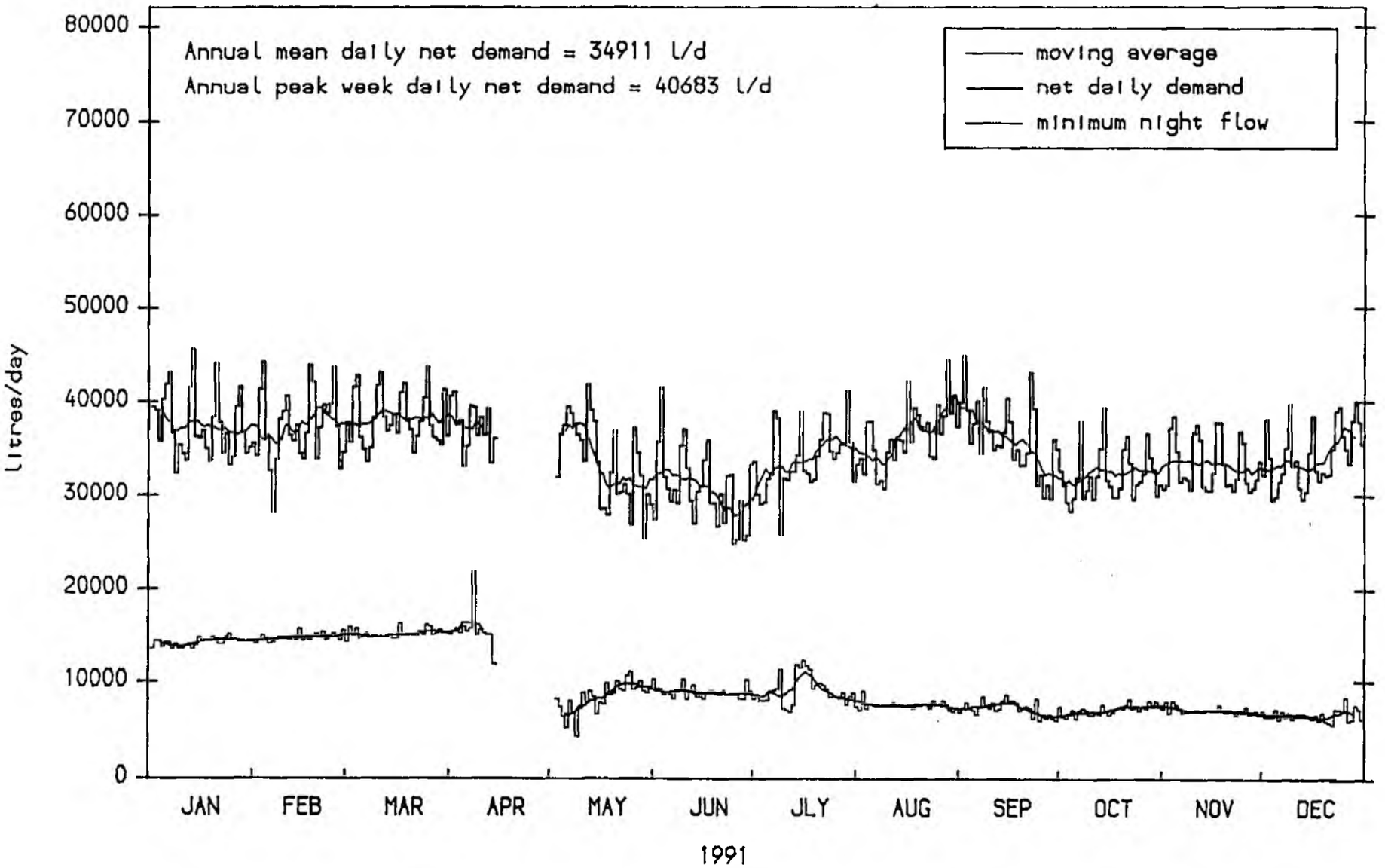
Kingswood C12: water supply data for 1991 with 7 day moving average



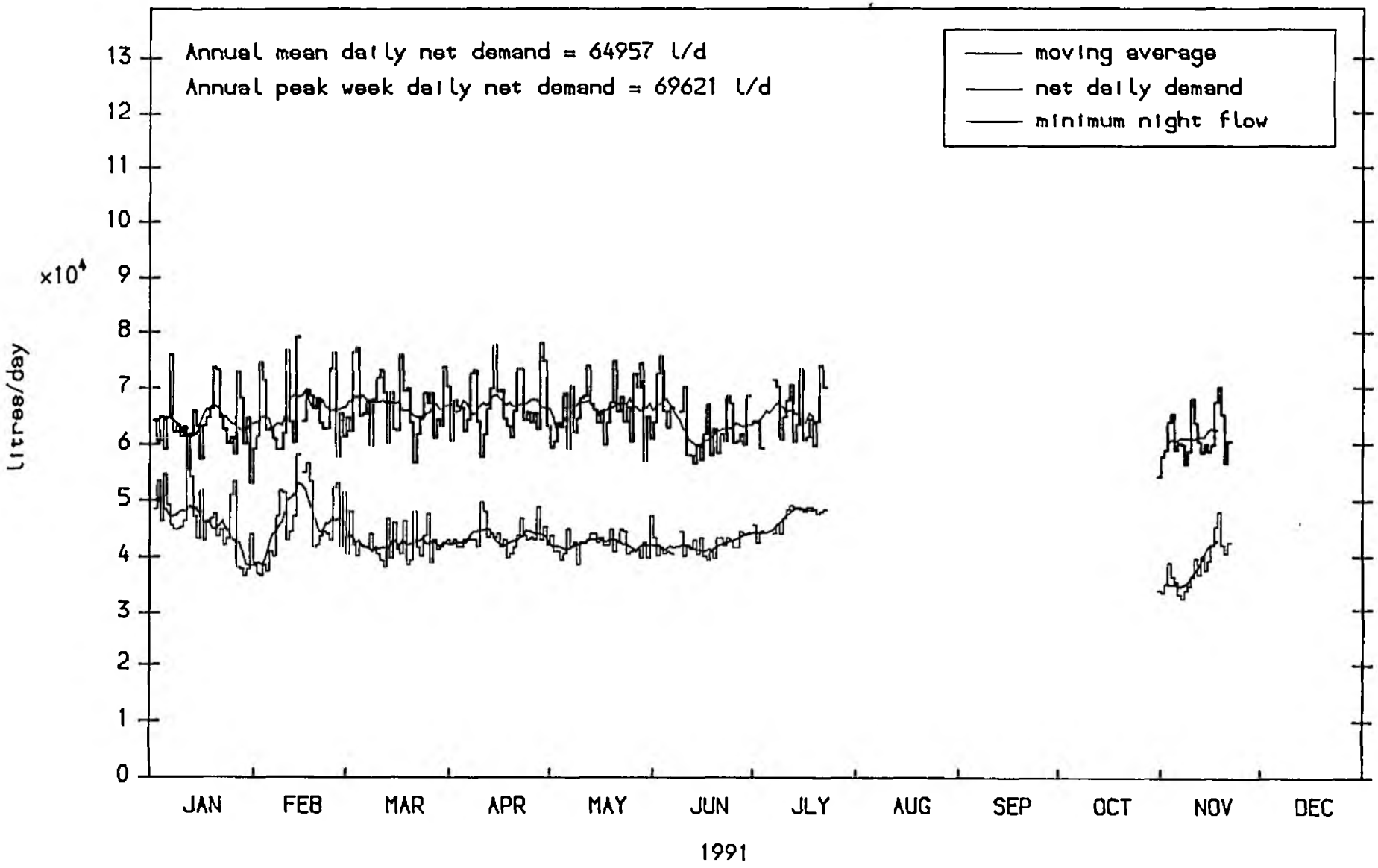
Grove Green C13: water supply data for 1991 with 7 day moving average



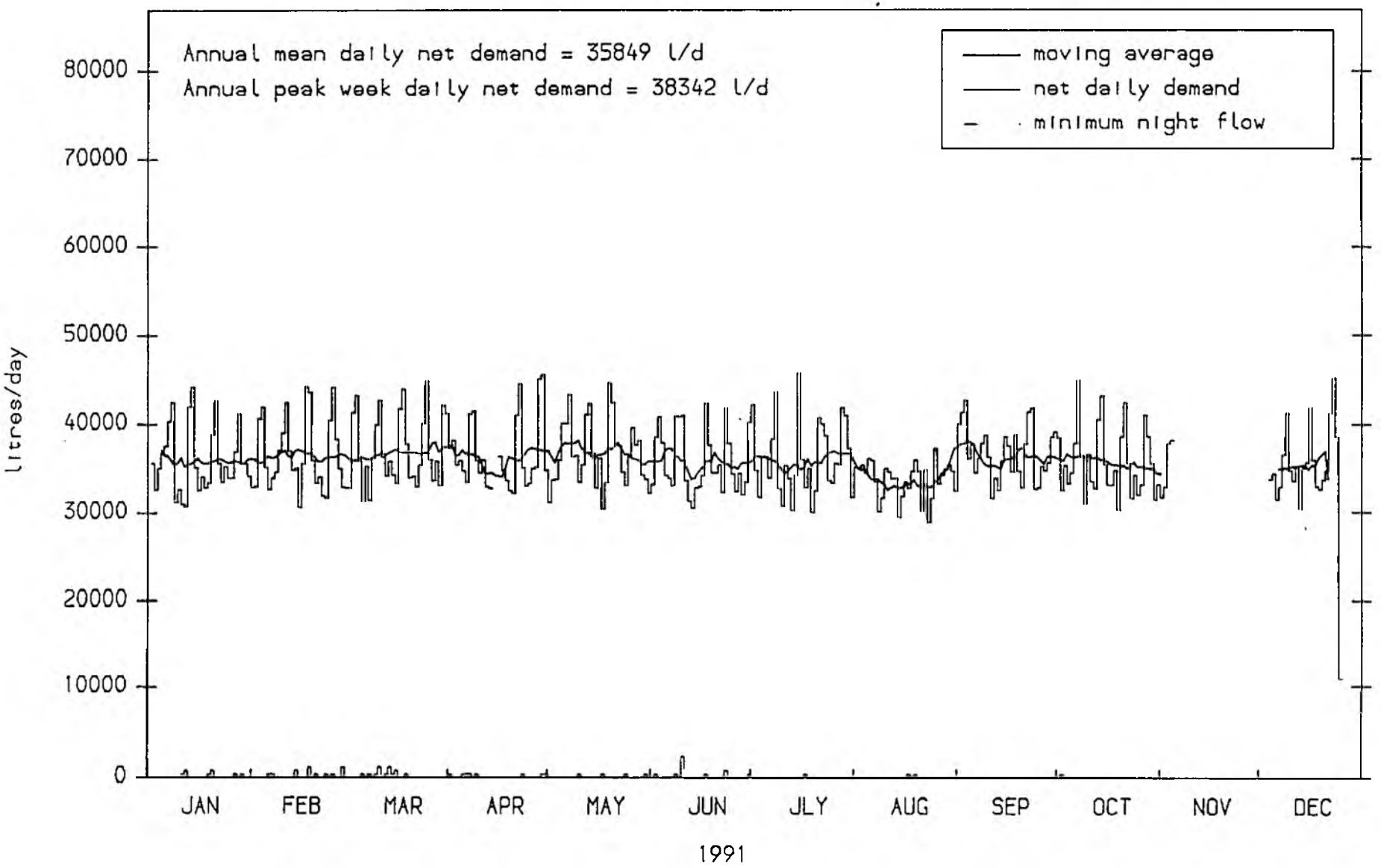
Foley Park C14: water supply data for 1991 with 7 day moving average



Albert Street C15: water supply data for 1991 with 7 day moving average



Poyntell Road C16: water supply data for 1991 with 7 day moving average



APPENDIX C: SOUTH EAST WATER

CONTROL AREA CHECK LIST: SOUTH EAST WATER

West Kent

AREA #	NAME	GRID REF	METER/LOGGER
C21	MARLBOROUGH CRESCENT, SEVENOAKS	TQ514553	
C22	SHIPBOURNE VILLAGE, TONBRIDGE	TQ605520	

Eastbourne

AREA #	NAME	GRID REF	METER/LOGGER
C31	1ST - 3RD AVENUE, BEXHILL	TQ758085	Kent Master 2000, 50mm
C32	GWYNETH GROVE, BEXHILL	TQ758091	Kent Master 2000, 80mm
C33	BODIAM VILLAGE, EASTBOURNE	TQ780261	Kent Master 2000, 80mm
C34	MARLEY GARDENS, BATTLE	TQ758159	Kent Master 2000, 80mm
C35	MARSDEN ROAD, EASTBOURNE	TQ631024	Kent Master 2000, 80mm
C36	EAST DEAN, EASTBOURNE	TV560983	Kent Helix 3000, 80mm & Kent Master 2000, 80mm
C37	ASHFORD ROAD, EASTBOURNE	TV613993	Kent Helix 3000, 80mm

Mid Sussex

AREA #	NAME	GRID REF	METER/LOGGER
C50	HAWTH HILL, SEAFORD	TV472998	Kent Master 2000, 80mm
C51	ALEXANDER ROAD, UCKFIELD	TQ476207	Kent Master 2000, 40mm
C52	FURNACE WOOD, FELBRIDGE	TQ351395	Kent Master 2000, 50mm
C53	NEVELL ROAD, UCKFIELD	TQ478224	Kent Master 2000, 100mm
C54	GRAVELYE LANE, HAYWARDS HEATH	TQ348245	Kent Master 2000, 80mm

CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

ACORN population profile and annual consumption in 1991

SOUTH EAST WATER CONTROL AREAS

	control area #	population in Acorn Group B	C	E	F	J	K	Total popn	PCC (l/c/d)	Meas Cons (l/d)
EWC 1st/3rd Avenue, Bexhill	c31			40		101	184	325	120.4	39134
Gyneth Grove, Bexhill	c32	520					5	525	119.8	62884
Bodaim Village	c33	136		76				212	169.1	35853
Marley Gardens	c34			622				622	107.1	66636
Marsden Road, Eastbourne	c35		66	923		7		996	107.8	107375
Eastdean, Eastbourne	c36						936	936	276.7	258983
Ashford Road, Eastbourne	c37		845		53		240	1138	130.4	148451
MSWC Hawth Hill, Seaford	c50						339	339	144.9	49109
Alexandra Road, Uckfield	c51	94	217					311	110.1	34230
Gravelye Lane, Haywards	c54				855			855	111.2	95104

CONTROL AREA CALCULATIONS: 1991 HOUSEHOLD BASED

ACORN household profiles

SOUTH EAST WATER CONTROL AREAS

	control area #	households in Acorn Group B	C	E	F	J	K	Total hh	PHC (l/hh/d)	Meas Cons (l/d)
EWC 1st/3rd Avenue, Bexhill	c31			17		43	79	139	281.5	39134
Gyneth Grove, Bexhill	c32	199					2	201	312.9	62884
Bodaim Village	c33	53		30				83	432.0	35853
Marley Gardens	c34			222				222	300.2	66636
Marsden Road, Eastbourne	c35		28	394		3		425	252.6	107375
Eastdean, Eastbourne	c36						456	456	567.9	258983
Ashford Road, Eastbourne	c37		395		25		112	532	279.0	148451
MSWC Hawth Hill, Seaford	c50						163	163	301.3	49109
Alexandra Road, Uckfield	c51	32	79					111	308.4	34230
Gravelye Lane, Haywards	c54				320			320	297.2	95104

1988 demand data

ACORN GROUP	PCC Ave	PCC Pop Variance	MSWC POPN %	EWC POPN %	WKWC POPN %	REGION POPN %
B	140.6	524.6	23.8	5.2	11.7	17.1
C	140.4	332.5	19.0	15.5	18.9	21.4
E	127.6	325.7	5.6	11.0	14.7	12.4
F	128.6	98.8	1.3	1.6	2.3	6.1
J	158.2	439.5	35.0	16.5	34.9	20.1
K	180.3	595.5	11.0	41.3	6.8	12.1
% Population Accounted for			95.7	91.1	89.3	89.2
Average PCC			150.6	160.0	148.0	147.3
Variance			446.0	477.1	412.4	412.2
Standard Error			2.6	2.7	2.5	2.5
95% Lower Confidence Int			145.4	154.6	143.0	142.3
95% Upper Confidence Int			155.8	165.3	153.0	152.3

CONTROL AREA CALCULATIONS: 1989 POPULATION BASED

ACORN GROUP	PEC Ave	PEC Pop Variance	MSWC POPN %	EWC POPN %	WKWC POPN %	REGION POPN %
B	152.7	1480.5	23.8	5.2	11.7	17.1
C	138.3	1032.2	19.0	15.5	18.9	21.4
E	128.5	465.1	5.6	11.0	14.7	12.4
F	133.7	924.8	1.3	1.6	2.3	6.1
J	149.3	126.8	35.0	16.5	34.9	20.1
K	173.7	1908.8	11.0	41.3	6.8	12.1
% Population Accounted for			95.7	91.1	89.3	89.2
Average PEC			149.3	155.9	145.4	146.6
Variance			878.7	1220.9	707.7	946.9
Standard Error			3.8	4.5	3.4	3.9
95% Lower Confidence Int			141.7	146.9	138.6	138.8
95% Upper Confidence Int			156.9	164.8	152.2	154.5

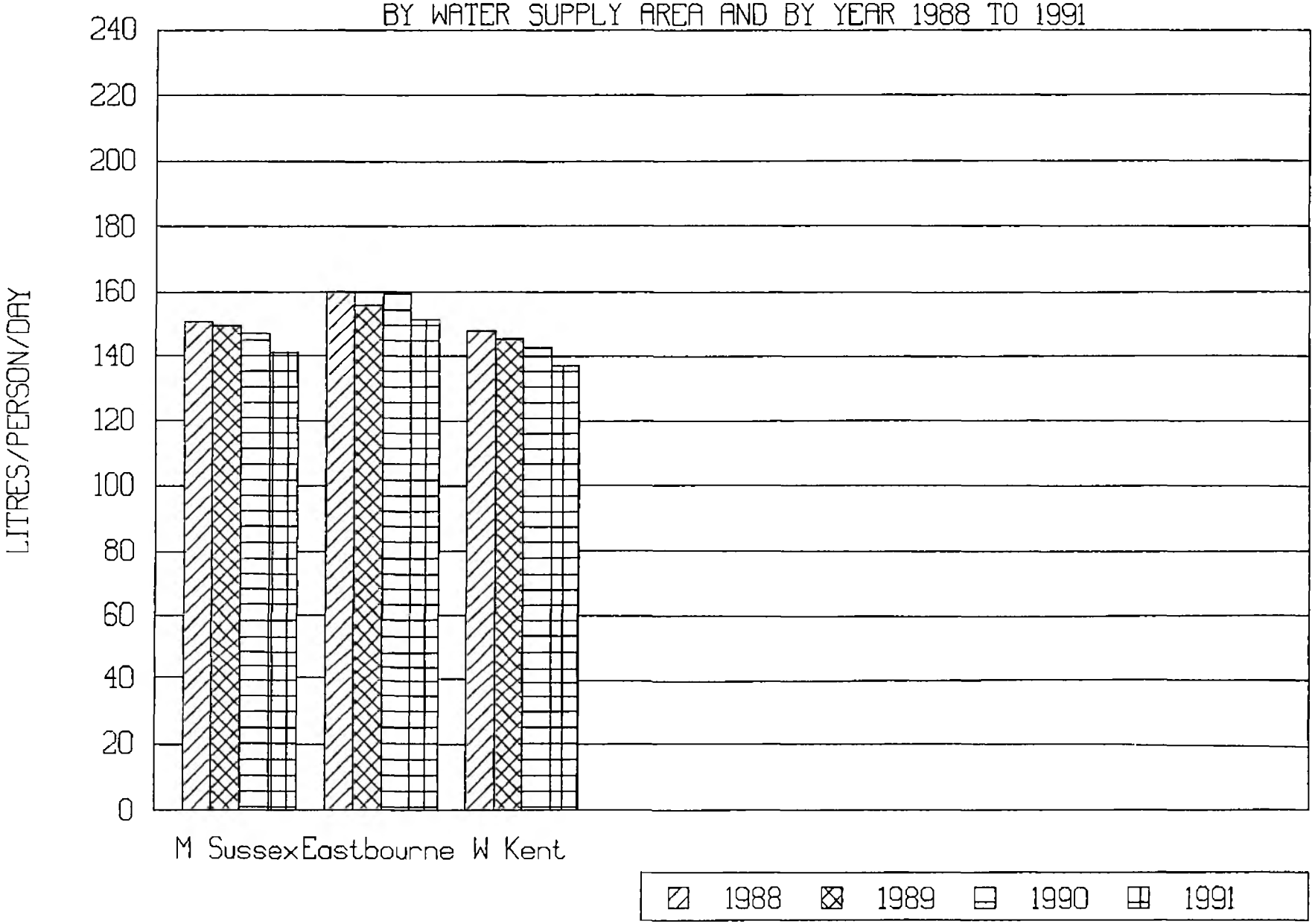
CONTROL AREA CALCULATIONS: 1990 POPULATION BASED

ACORN GROUP	PHC Ave	PHC Pop Variance	MSWC POPN %	EWC POPN %	WKWC POPN %	REGION POPN %
B	147.5	1207.2	23.8	5.2	11.7	17.1
C	131.6	1014.0	19.0	15.5	18.9	21.4
E	127.0	646.4	5.6	11.0	14.7	12.4
F	130.0	1081.8	1.3	1.6	2.3	6.1
J	146.1	214.8	35.0	16.5	34.9	20.1
K	186.5	3133.5	11.0	41.3	6.8	12.1
% Population Accounted for			95.7	91.1	89.3	89.2
Average PCC			146.9	159.4	142.7	144.6
Variance			992.8	1798.0	829.6	1112.0
Standard Error			4.0	5.4	3.7	4.3
95% Lower Confidence Int			138.8	148.6	135.4	136.1
95% Upper Confidence Int			155.0	170.3	150.1	153.2

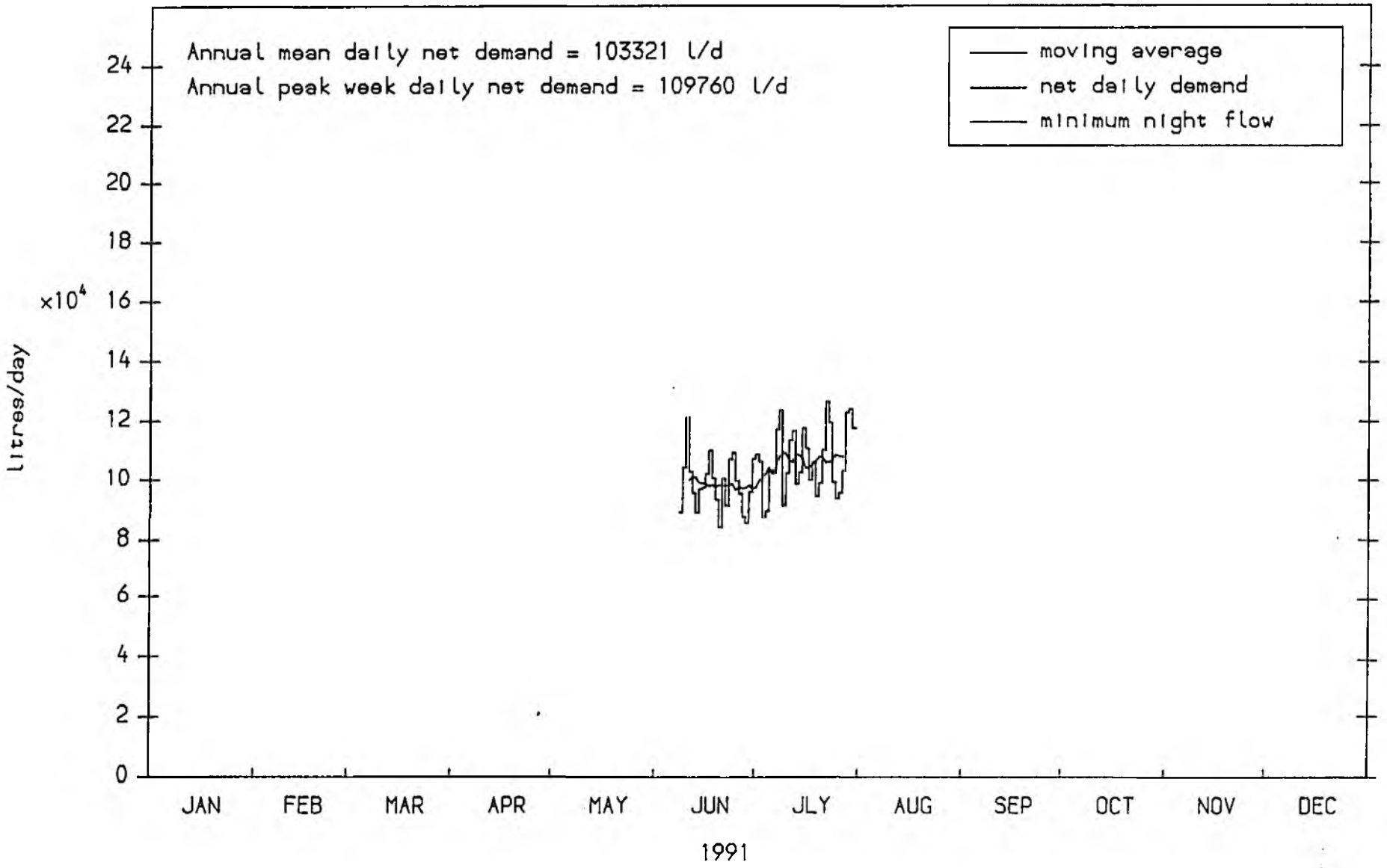
CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

ACORN GROUP	PHC Ave	PHC Pop Variance	MSWC POPN %	EWC POPN %	WKWC POPN %	REGION POPN %
B	143.7	808.6	23.8	5.2	11.7	17.1
C	126.3	523.6	19.0	15.5	18.9	21.4
E	126.4	450.0	5.6	11.0	14.7	12.4
F	116.6	163.2	1.3	1.6	2.3	6.1
J	139.4	157.3	35.0	16.5	34.9	20.1
K	175.1	2514.7	11.0	41.3	6.8	12.1
% Population Accounted for			95.7	91.1	89.3	89.2
Average PCC			148.9	151.6	137.2	138.6
Variance			688.2	1361.0	548.0	730.9
Standard Error			3.3	4.6	2.9	3.4
95% Lower Confidence Int			134.3	142.3	131.3	131.8
95% Upper Confidence Int			147.5	160.9	143.1	145.4

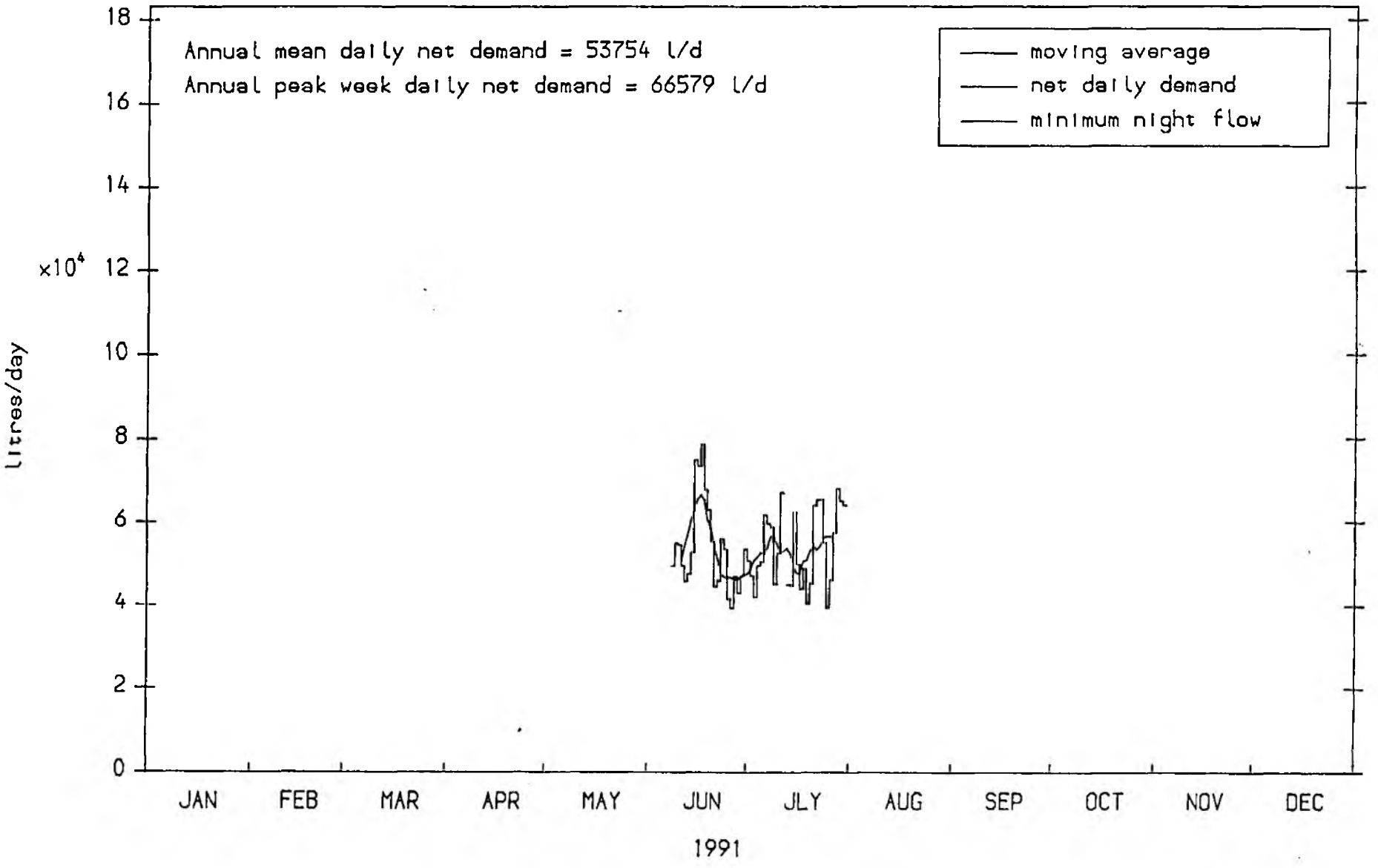
CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
SOUTH EAST WATER
BY WATER SUPPLY AREA AND BY YEAR 1988 TO 1991



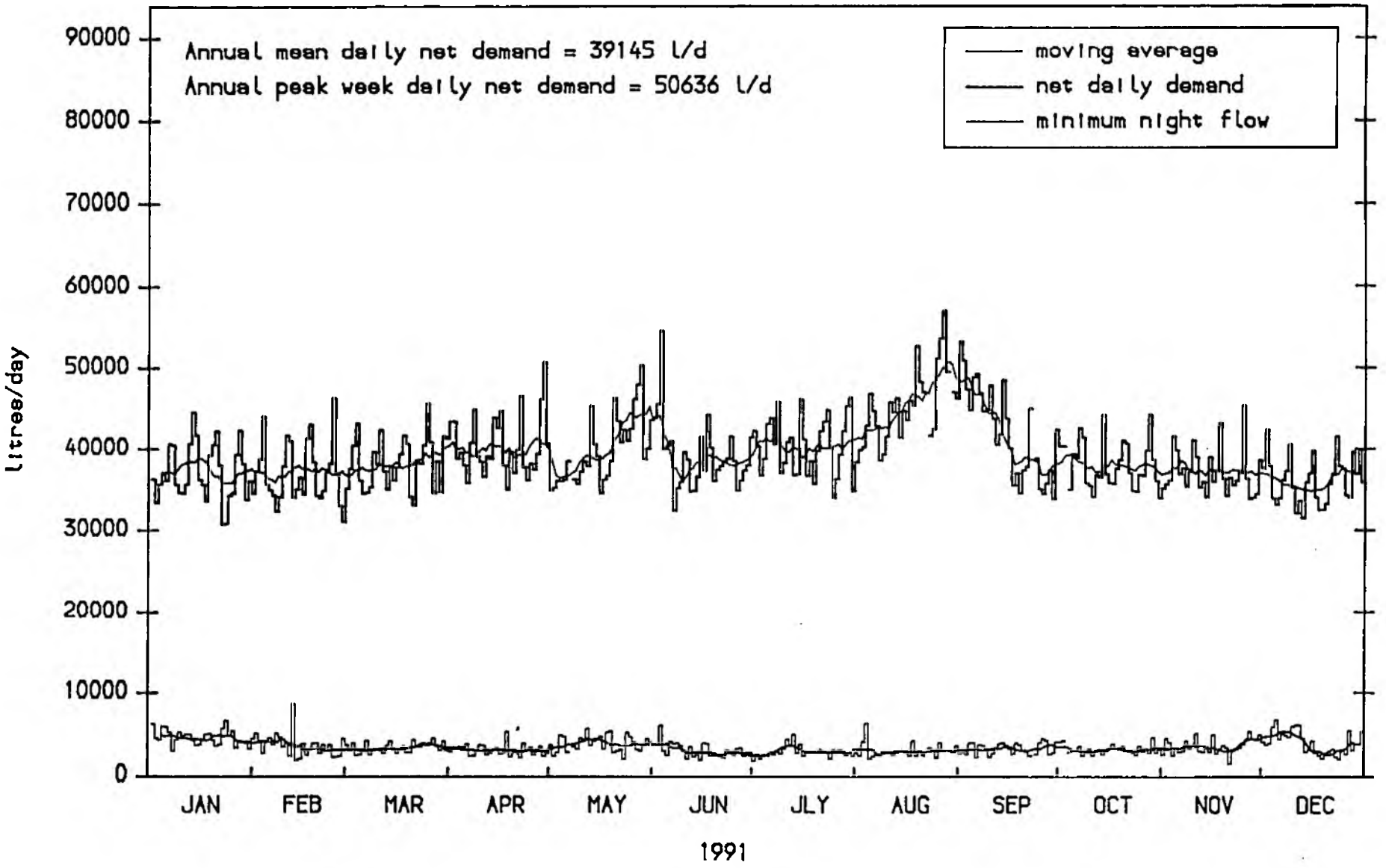
Marlborough Crescent C21: water supply data for 1991 with 7 day moving average



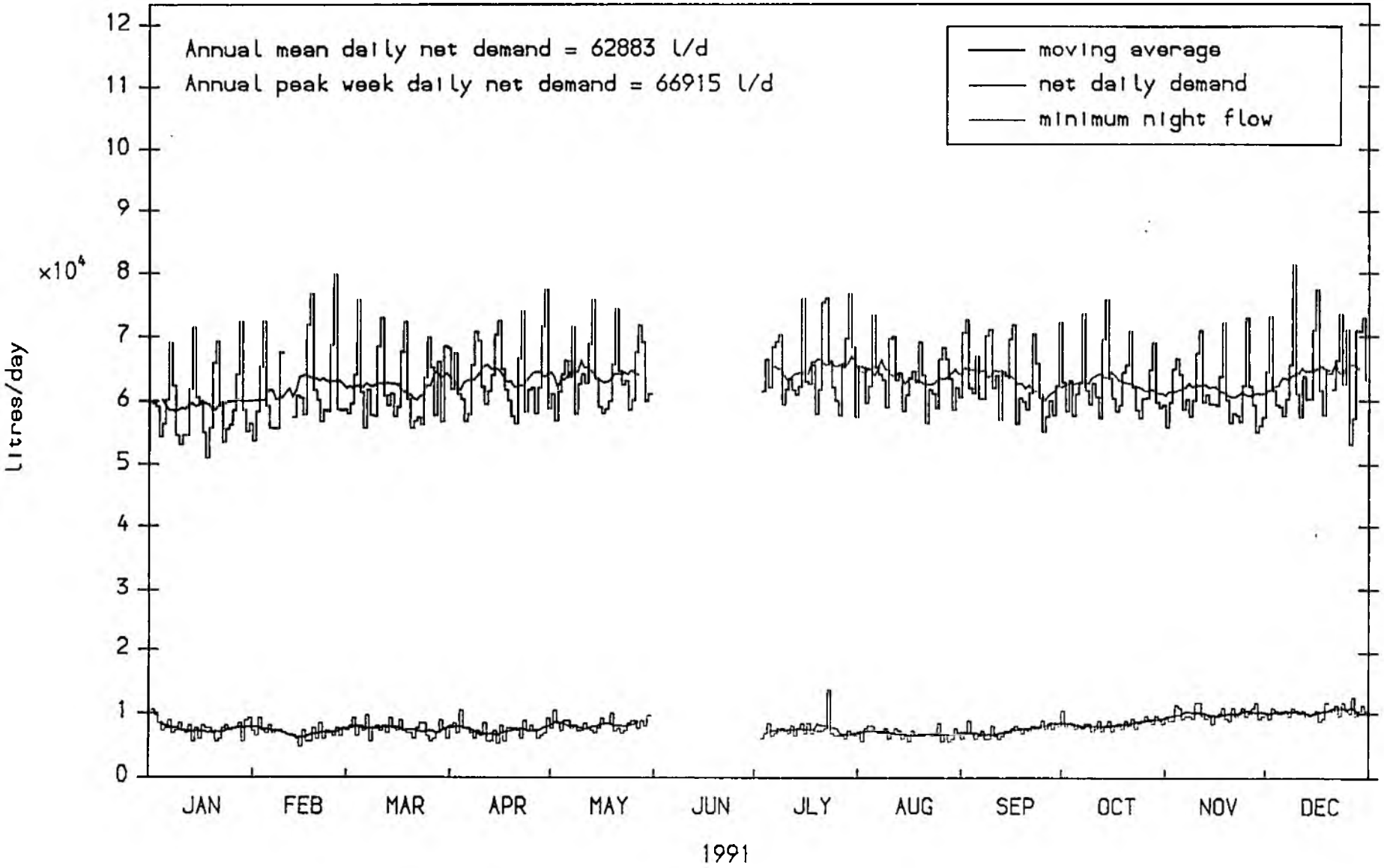
Shipbourne Village C22: water supply data for 1991 with 7 day moving average

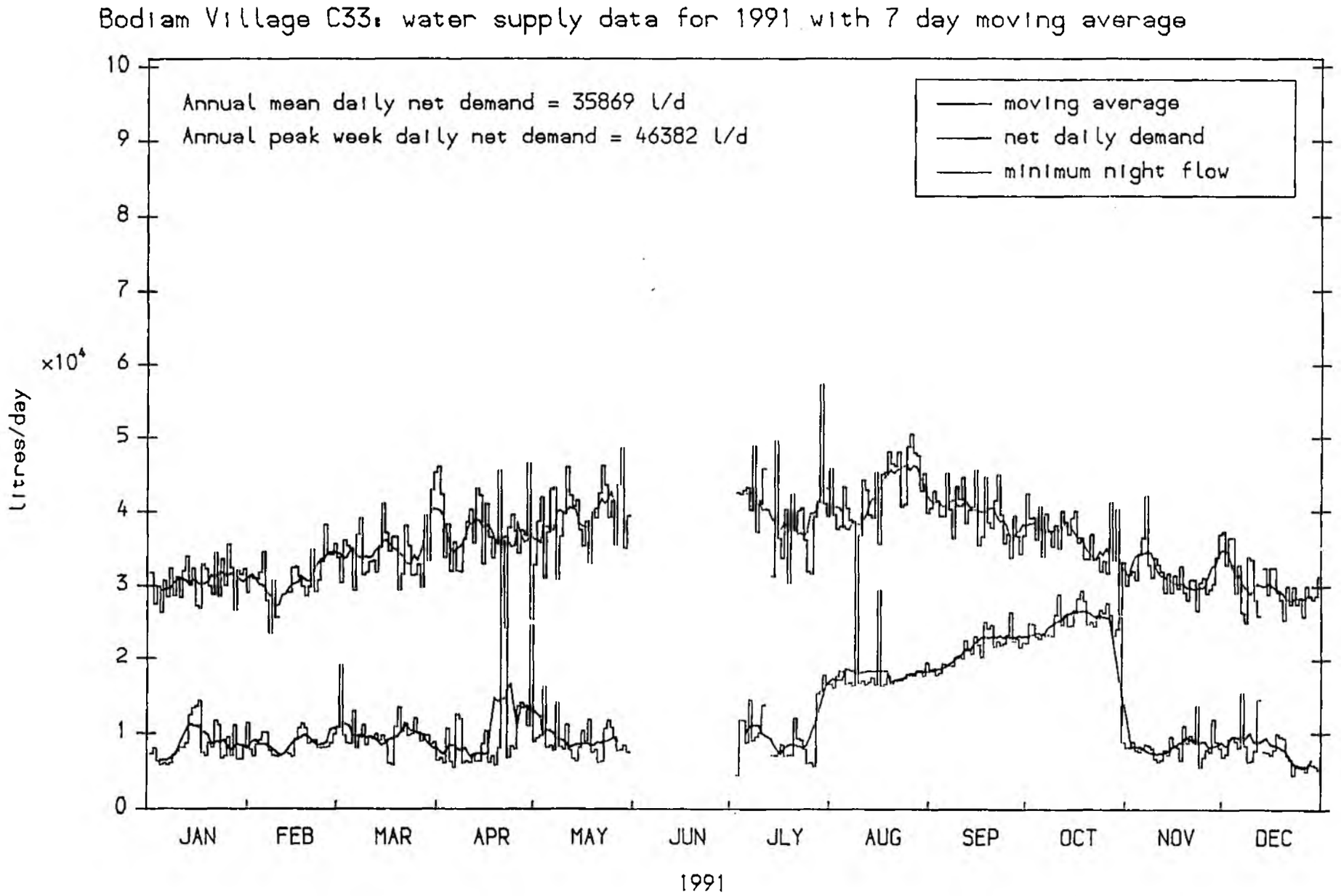


1st/3rd Avenue, Bexhill C31: water supply data for 1991 with 7 day moving average

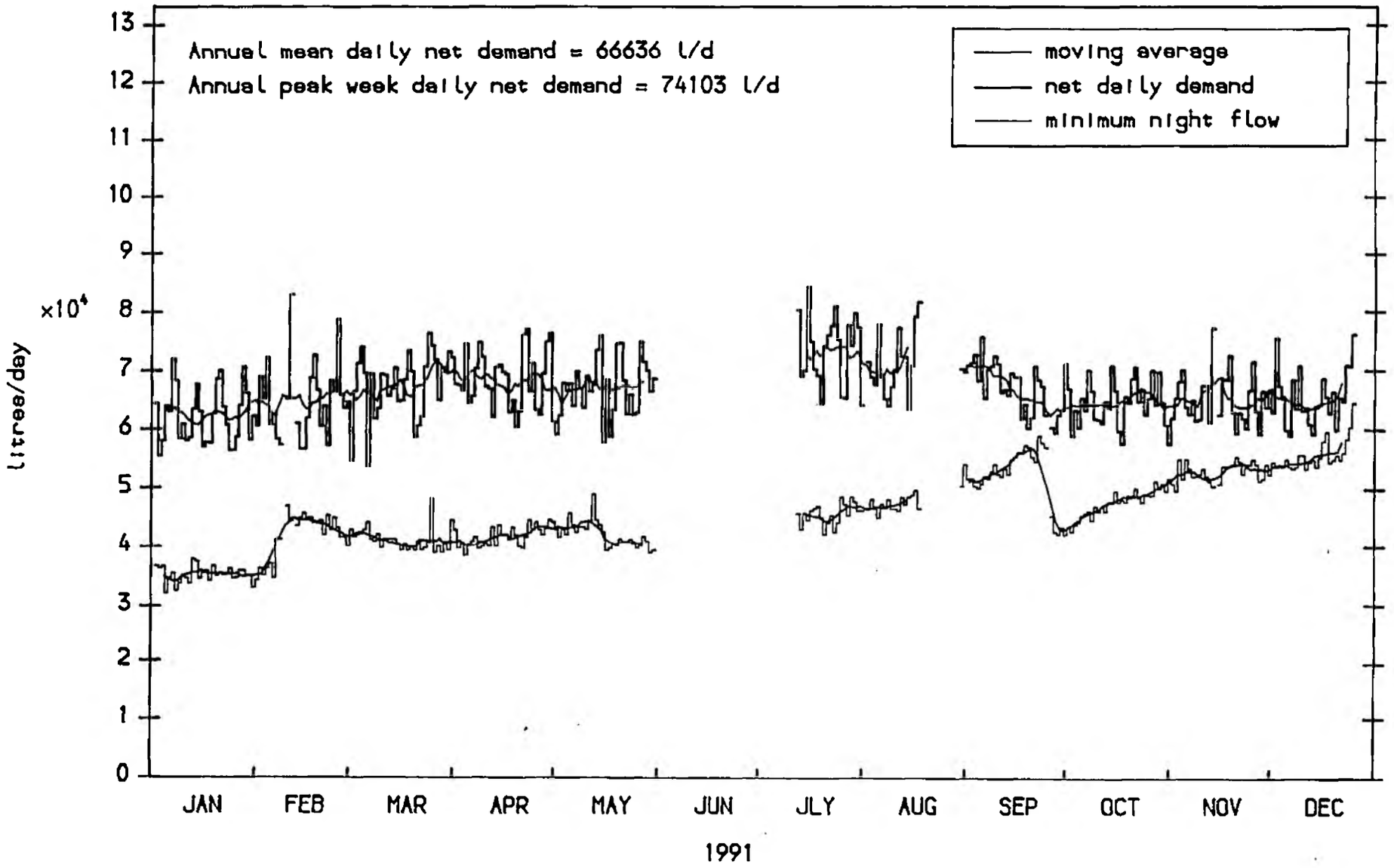


Gwyneth Road C32: water supply data for 1991 with 7 day moving average

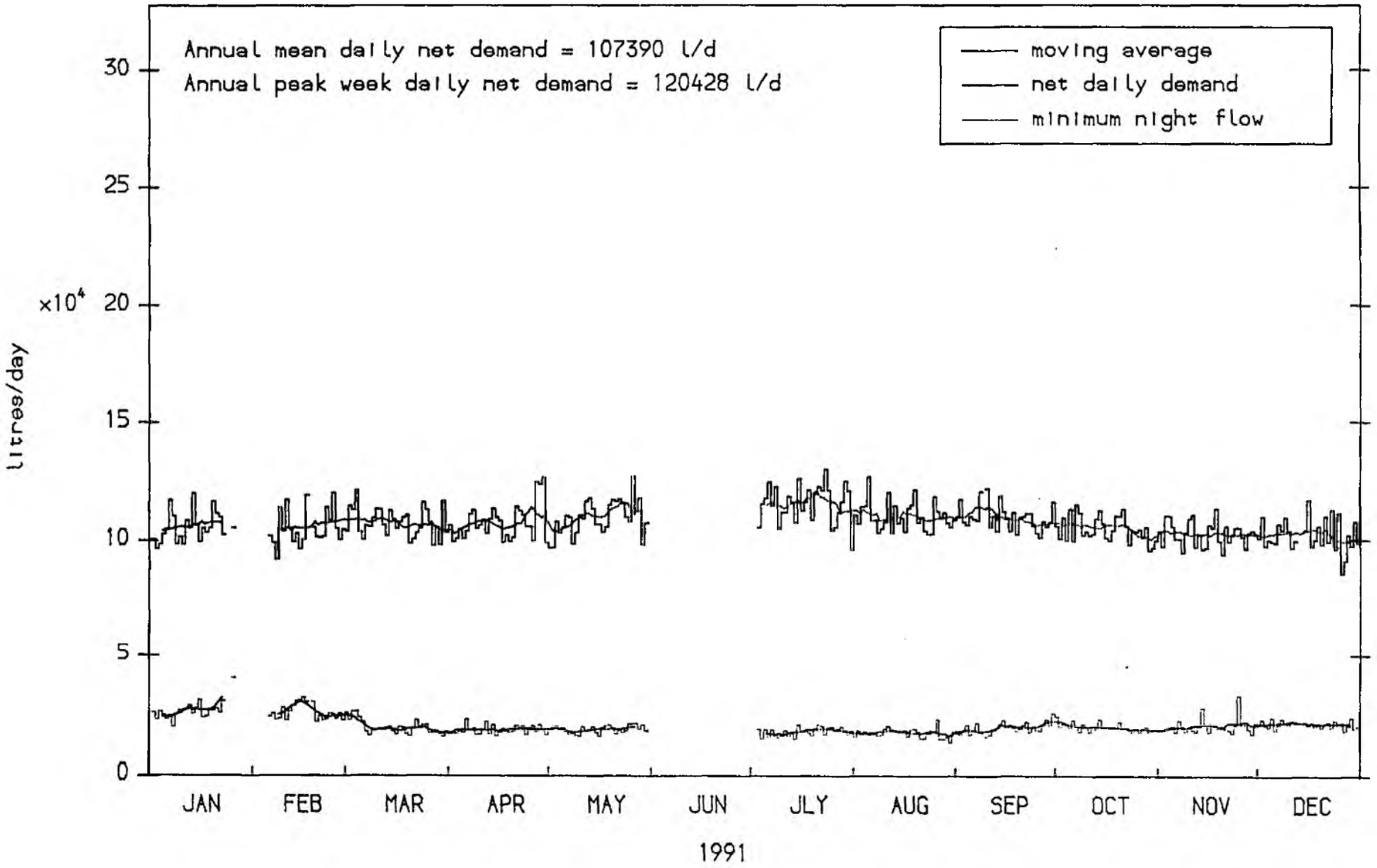



Bodiam Village C33: water supply data for 1991 with 7 day moving average
Annual mean daily net demand = 35869 l/d
Annual peak week daily net demand = 46382 l/d
moving average
net daily demand
minimum night flow
litres/day
x10⁴
10
9
8
7
6
5
4
3
2
1
0
JAN
FEB
MAR
APR
MAY
JUN
JLY
AUG
SEP
OCT
NOV
DEC
1991

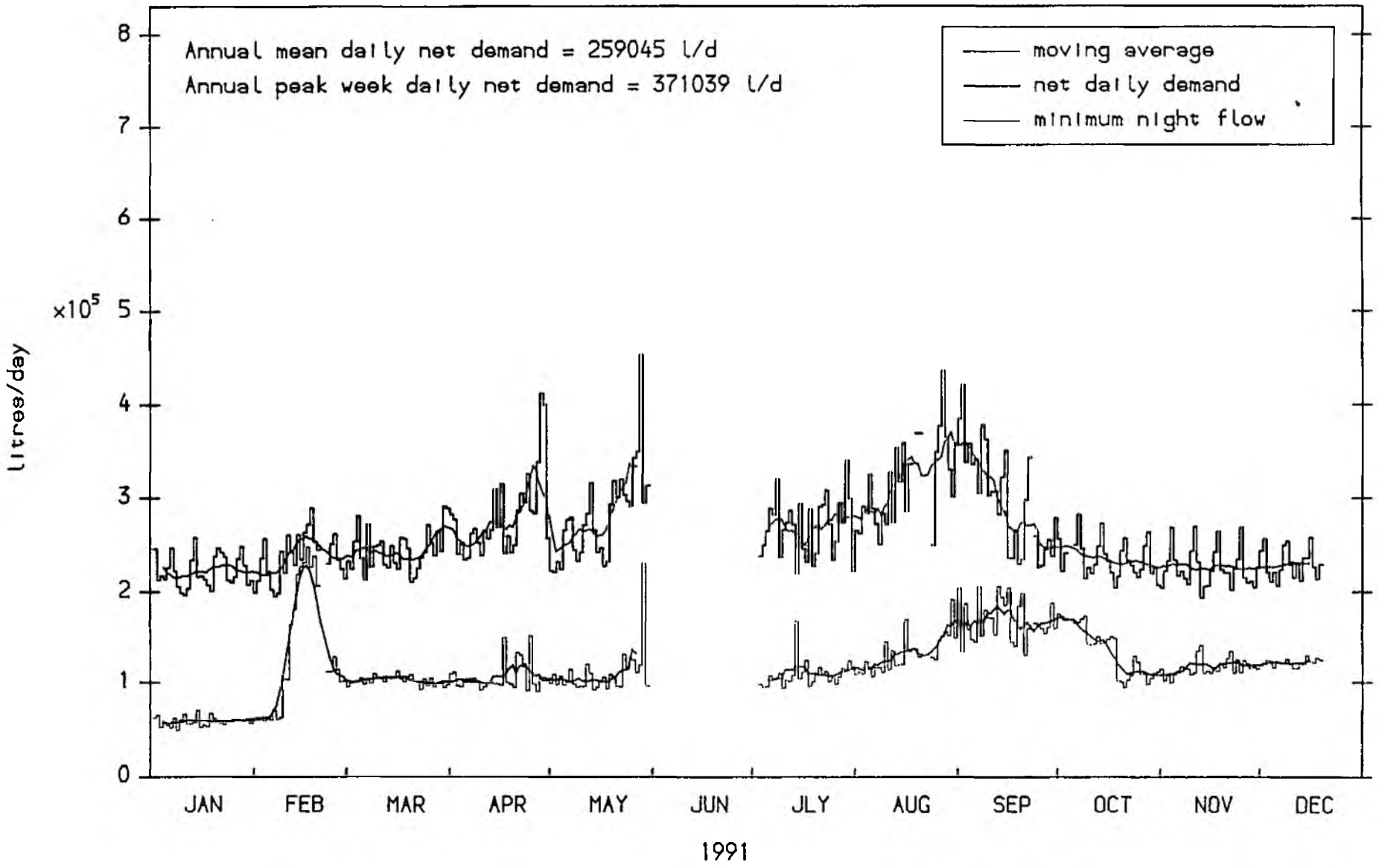
Marley Gardens, Battle C34: water supply data for 1991 with 7 day moving average



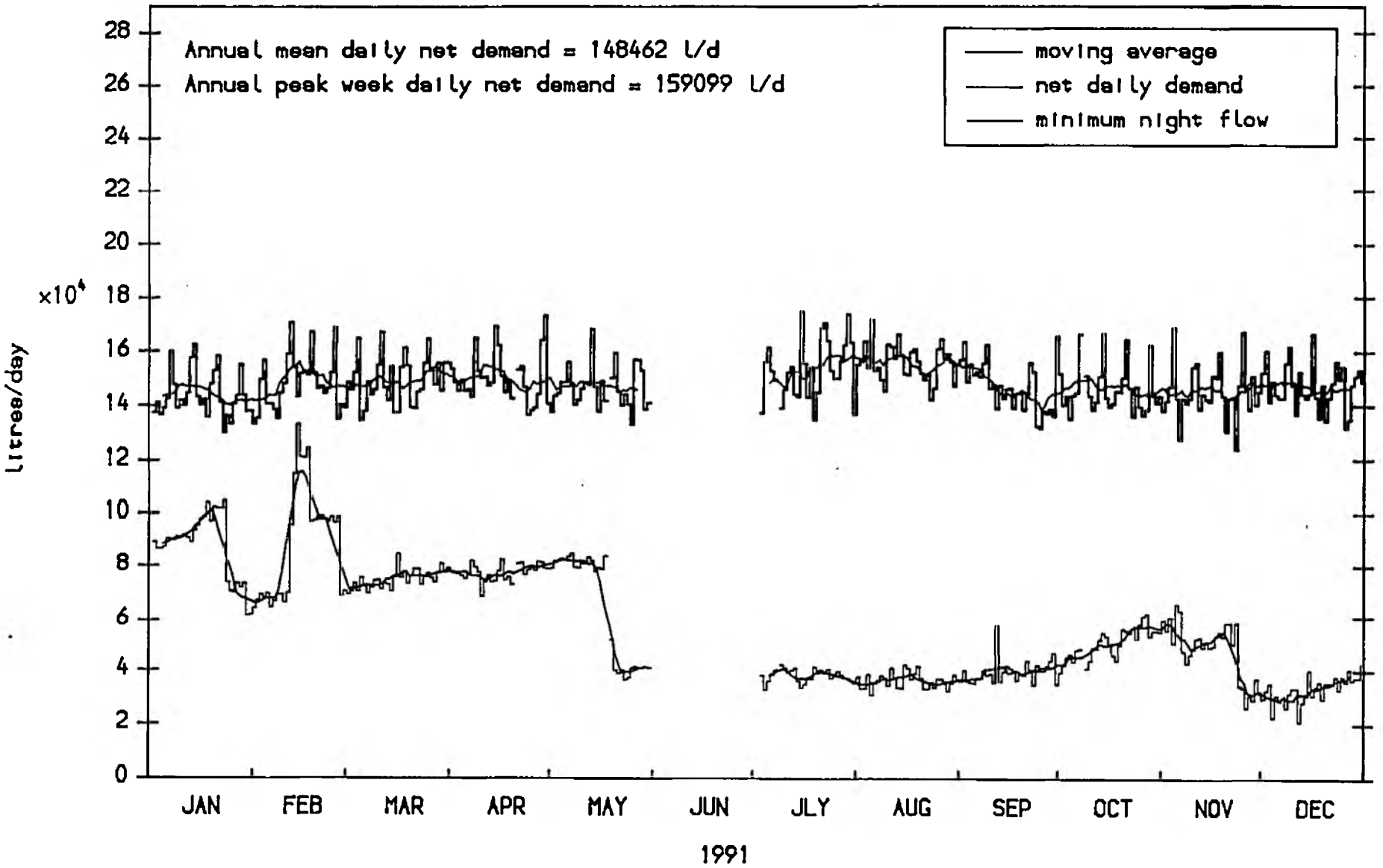
Marsden Road, Eastbourne C35: water supply data for 1991 with 7 day moving average



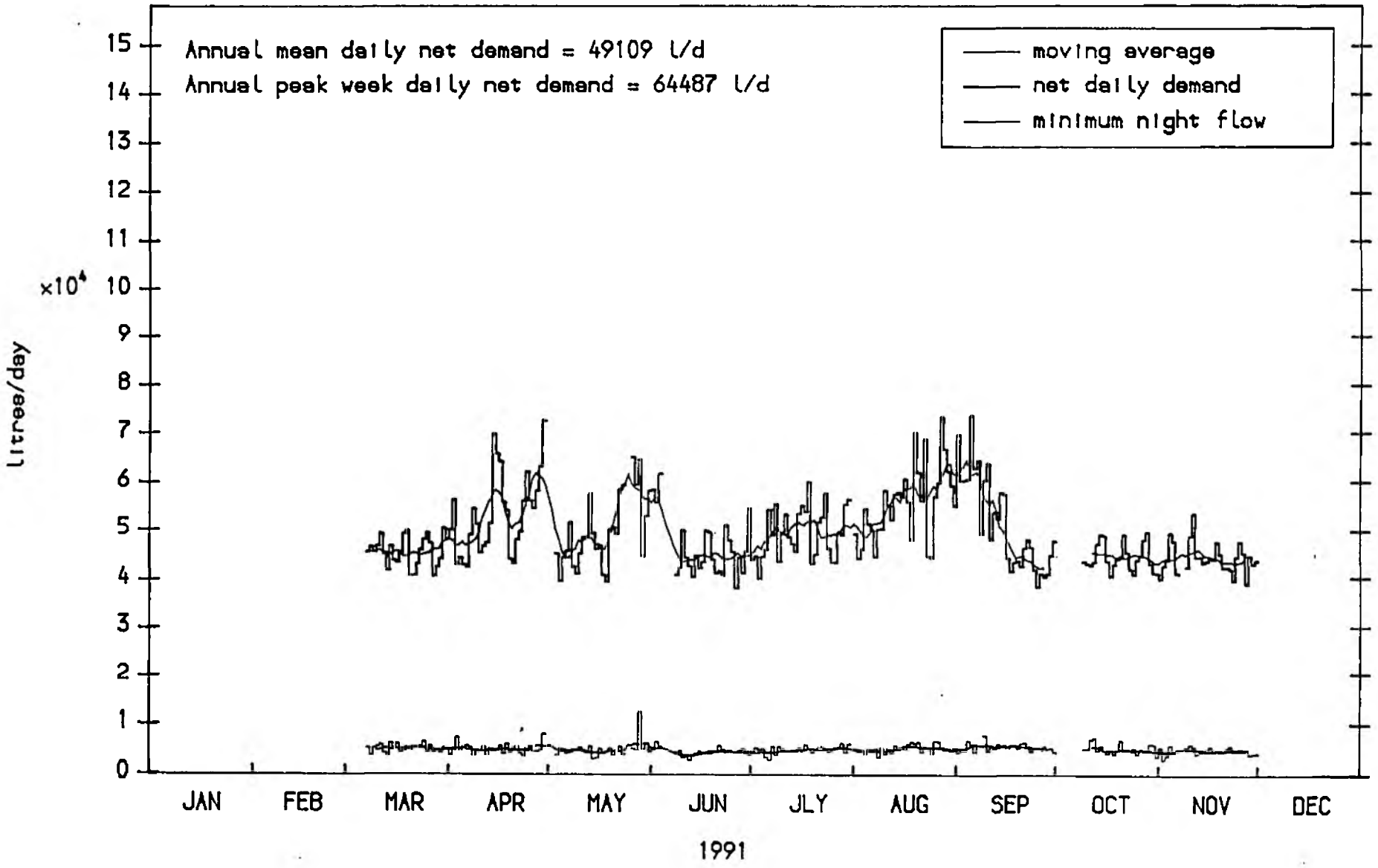
Eastdean, Eastbourne C36: water supply data for 1991 with 7 day moving average



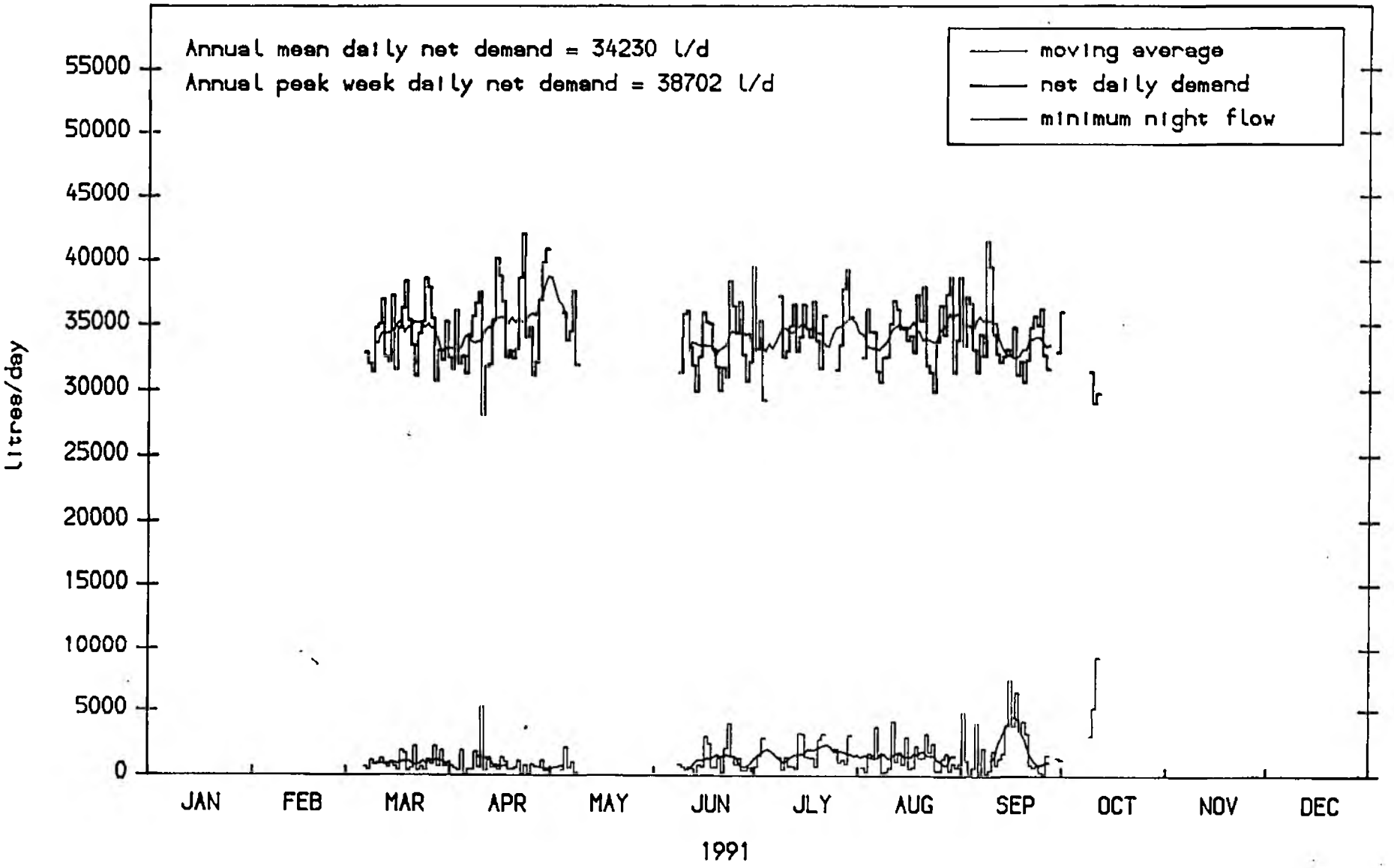
Ashford Road, Eastbourne C37: water supply data for 1991 with 7 day moving average



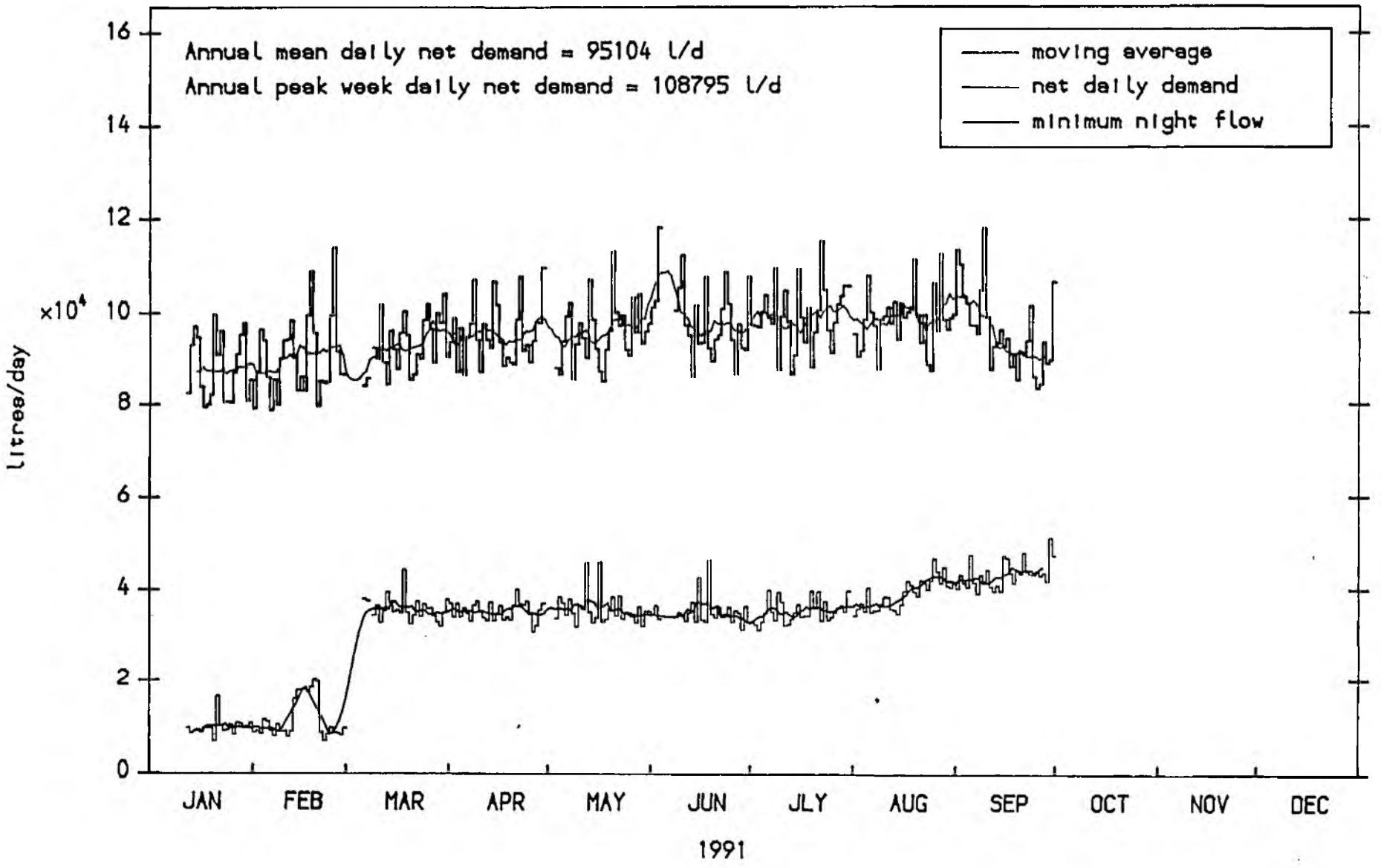
Hawth Hill, Seaford C50: water supply data for 1991 with 7 day moving average



Alexandra Road, Uckfield C51: water supply data for 1991 with 7 day moving average



Gravelye Lane, Haywards Heath C54: water supply data for 1991 with 7 day moving aver



APPENDIX D: FOLKESTONE AND DOVER WATER SERVICES

CONTROL AREA CHECK LIST: FOLKESTONE AND DOVER WATER SERVICES

AREA #	NAME	GRID REF	METER/LOGGER
C41	APPLEDORE CRESENT, FOLKESTONE	TR198373	Kent combination, 80mm
C42	ST MICHAELS STREET, FOLKESTONE	TR231363	Kent Master comb 3000v 50mm 2 X Celia 50mm 2X Celia 15mm
C43	MILLFIELD, HAWKINGE	TR225360	Kent Helix 3000v, comb
C44	OCTAVIAN DRIVE, LYMPNE	TR123351	Kent Helix 3000v, comb
C45	SENE PARK, HYTHE	TR169354	Celia 80mm & 20mm
C46	MARSHLANDS, DYMCHURCH	TR097290	Kent Master 3000v
C47	POPLAR LANE, LYDD	TR046213	Kent Master 3000v
C48	HOMEPINE, SANDGATE ROAD FOLKESTONE	TR223355	Kent Master 3000v
C49	WESTCLIFFE AREA, FOLKESTONE	TR213357	Kent master 3000v, 80mm & 2

CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

ACORN population profile and annual consumption in 1991

FOLKESTONE AND DOVER WATER SERVICES CONTROL AREAS

	control area #	population in Acorn Group B	C	E	F	J	K	Total popn	PCC (l/c/d)	Meas Cons (l/d)
FWC Appledene Cres, F'stone	c41	159						159	128.0	20355
St Michael St, F'stone	c42		193				37	230	117.1	26922
Millfield, Folkestone	c43			266				266	146.3	38928
Octanan Drive, Lympne	c44	162						162	175.3	28393
Sene Park, Hythe	c45						99	99	159.4	15779
Marshlands	c46		268					268	107.2	28719
Polar Lane, Lydd	c47	267						267	151.9	40557
Homepine, Folkstone	c48						160	160	111.7	17879
Westcliffe Area, F'stone	c49					290		290	127.8	37062

CONTROL AREA CALCULATIONS: 1991 HOUSEHOLD BASED

ACORN household profiles

FOLKESTONE AND DOVER WATER SERVICES CONTROL AREAS

	control area #	households in Acorn Group B	C	E	F	J	K	Total hh	PHC (l/hh/d)	Meas Cons (l/d)
FWC Appledene Cres, F'stone	c41	60						60	339.3	20355
St Michael St, F'stone	c42		81				16	97	277.5	26922
Millfield, Folkestone	c43			86				86	452.7	38928
Octanan Drive, Lympne	c44	59						59	481.2	28393
Sene Park, Hythe	c45						40	40	394.5	15779
Marshlands	c46		113					113	254.2	28719
Polar Lane, Lydd	c47	105						105	386.3	40557
Homepine, Folkstone	c48						138	138	129.6	17879
Westcliffe Area, F'stone	c49					101		101	367.0	37062

1988 demand data
Water Company Areas, PCC's from total data set

ACORN GROUP	PCC Ave	PCC Pop Variance	FWC POPN %	REGION POPN %
B	140.6	524.6	11.0	17.1
C	140.4	332.5	32.2	21.4
E	127.6	325.7	9.0	12.4
F	128.6	98.8	6.5	6.1
J	158.2	439.5	17.0	20.1
K	180.3	595.5	12.3	12.1
% Population Accounted for			88.0	89.2
Average PCC			147.2	147.3
Variance			396.0	412.2
Standard Error			2.4	2.5
95% Lower Confidence Int			142.3	142.3
95% Upper Confidence Int			152.1	152.3

CONTROL AREA CALCULATIONS: 1989 POPULATION BASED

Water Company Areas, PCC's from total data set

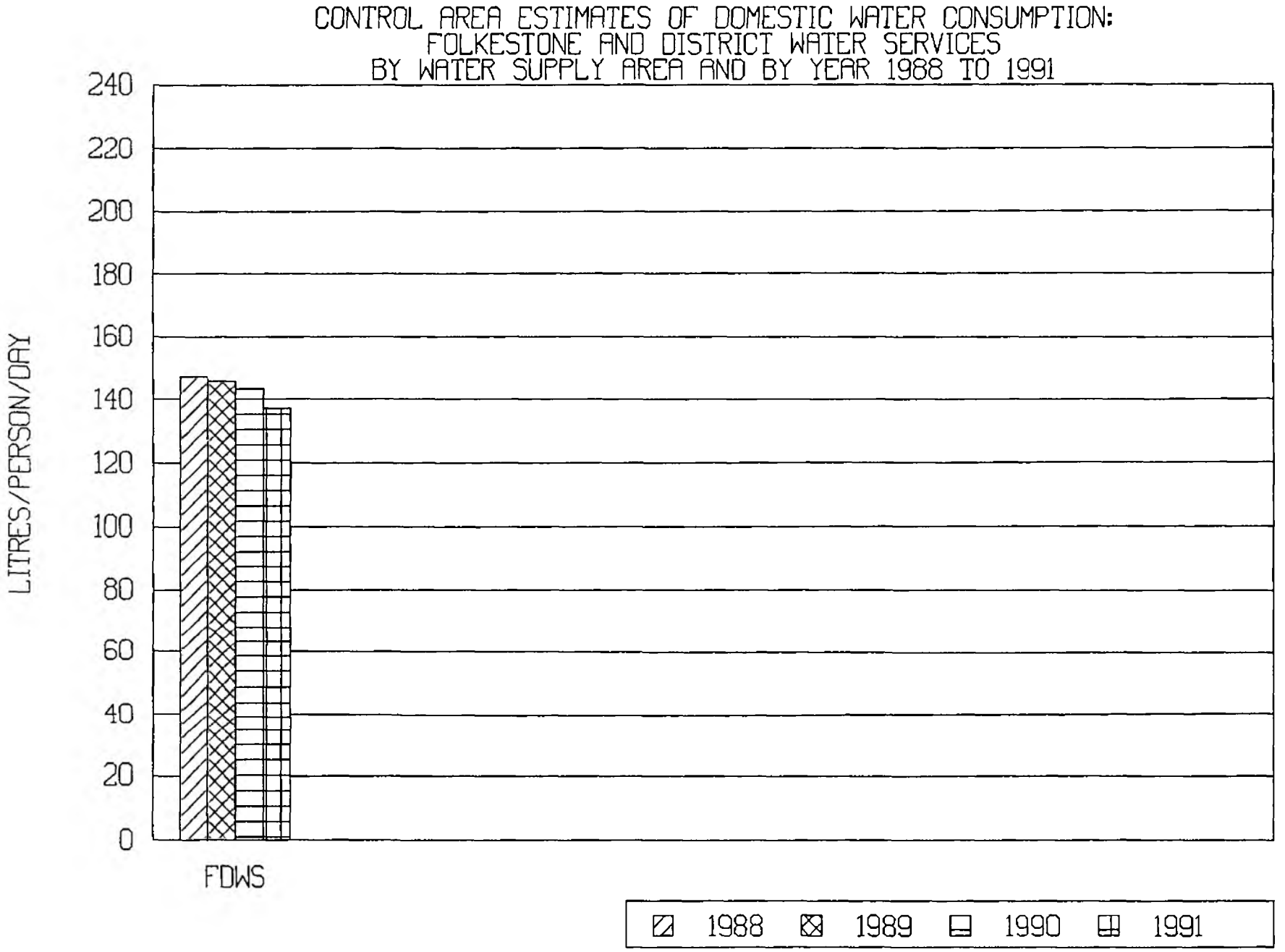
ACORN GROUP	PHC Ave	PHC Pop Variance	FWC POPN %	REGION POPN %
B	152.7	1480.5	11.0	17.1
C	138.3	1032.2	32.2	21.4
E	128.5	465.1	9.0	12.4
F	133.7	924.8	6.5	6.1
J	149.3	126.8	17.0	20.1
K	173.7	1908.8	12.3	12.1
% Population Accounted for			88.0	89.2
Average PCC			145.8	146.6
Variance			969.9	946.9
Standard Error			4.0	3.9
95% Lower Confidence Int			137.8	138.8
95% Upper Confidence Int			153.8	154.5

CONTROL AREA CALCULATIONS: 1990 POPULATION BASED

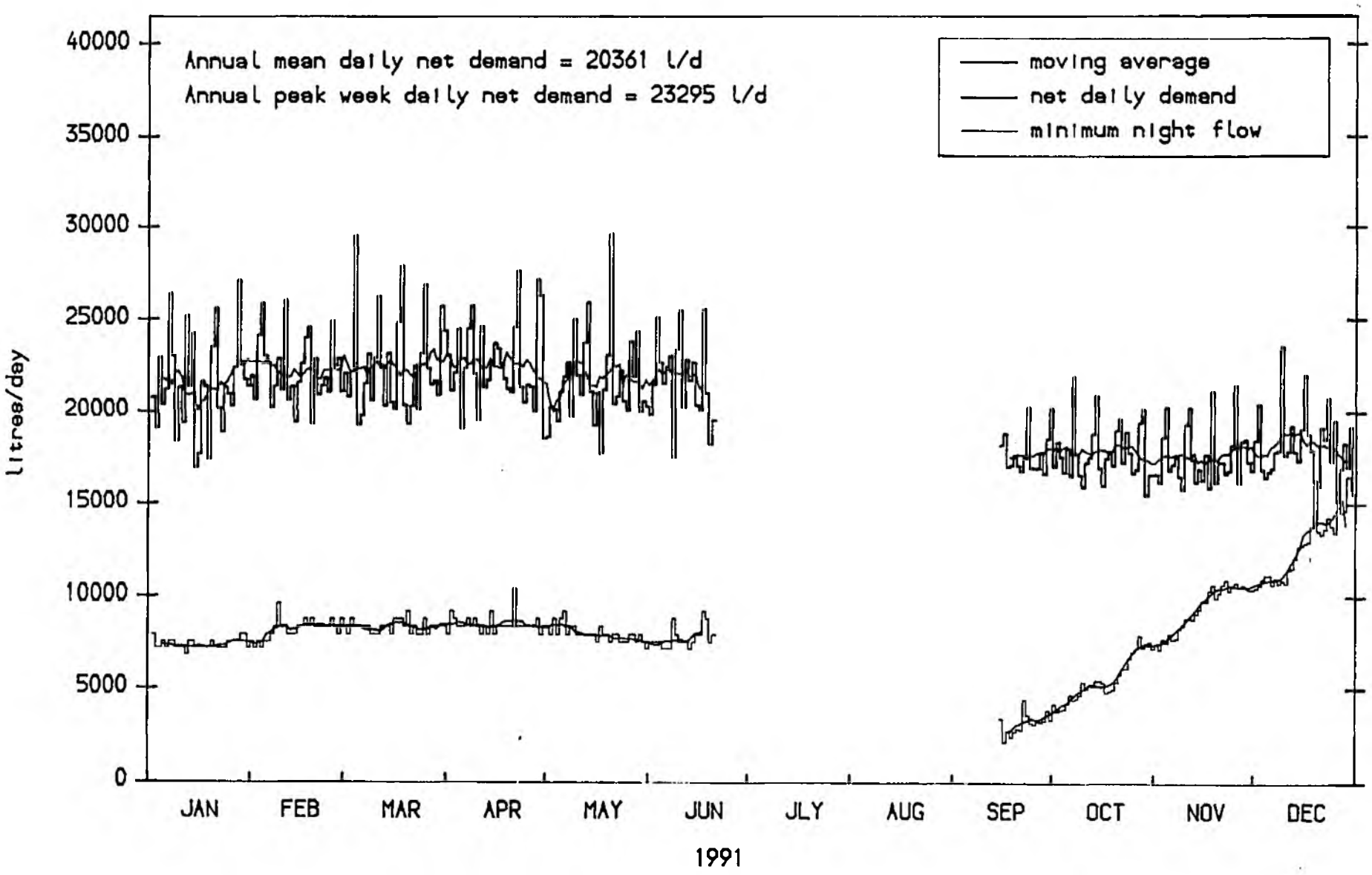
ACORN GROUP	PHC Ave	PHC Pop Variance	FWC POPN %		REGION POPN %
B	147.5	1207.2	11.0		17.1
C	131.6	1014.0	32.2		21.4
E	127.0	646.4	9.0		12.4
F	130.0	1081.8	6.5		6.1
J	146.1	214.8	17.0		20.1
K	186.5	3133.5	12.3		12.1
% Population Accounted for			88.0		89.2
Average PCC			143.5		144.6
Variance			1147.4		1112.0
Standard Error			4.3		4.3
95% Lower Confidence Int			134.8		136.1
95% Upper Confidence Int			152.1		153.2

CONTROL AREA CALCULATIONS: 1991 POPULATION BASED

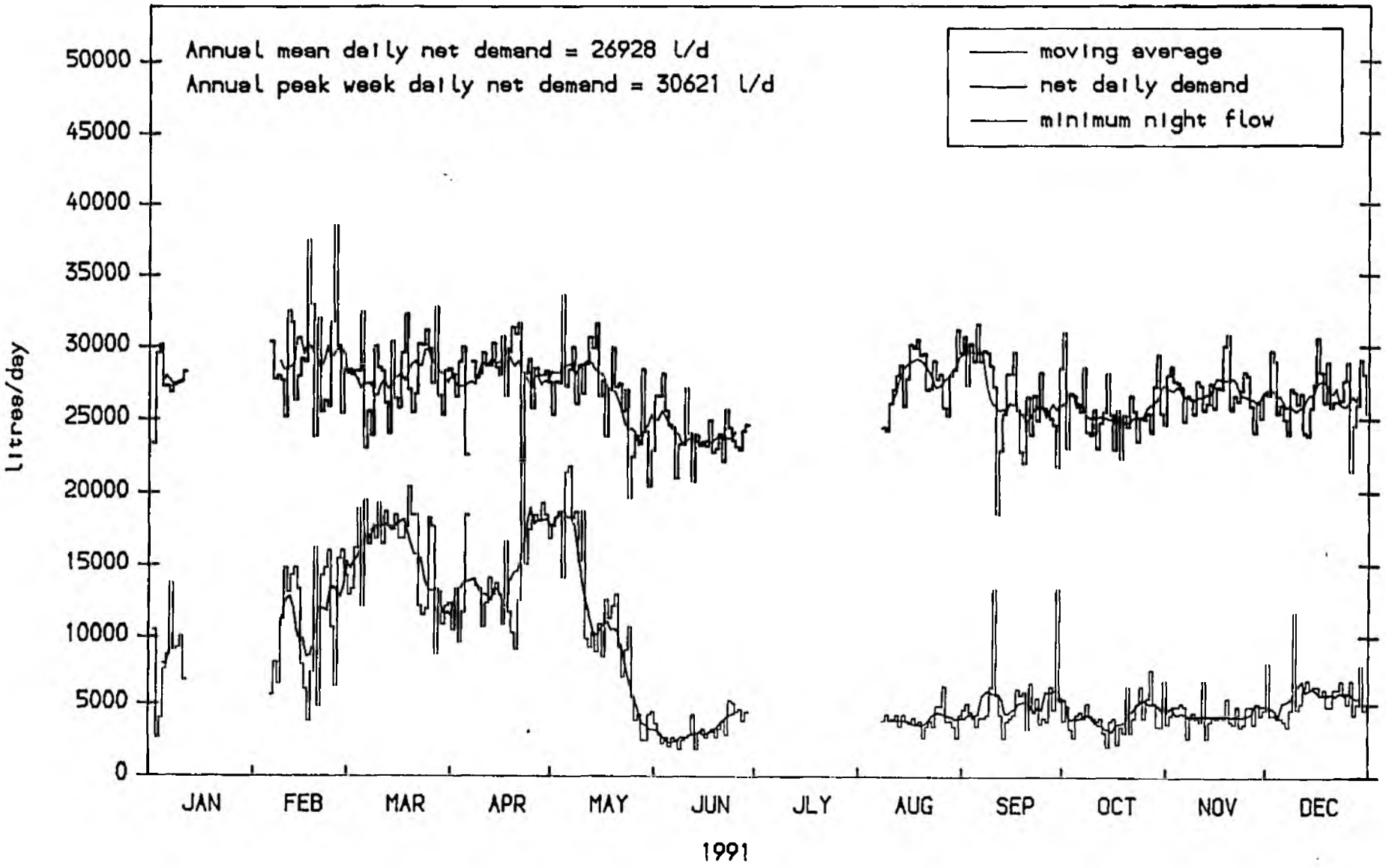
ACORN GROUP	PHC Ave	PHC Pop Variance	FWC POPN %		REGION POPN %
B	143.7	808.6	11.0		17.1
C	126.3	523.6	32.2		21.4
E	126.4	450.0	9.0		12.4
F	116.6	163.2	6.5		6.1
J	139.4	157.3	17.0		20.1
K	175.1	2514.7	12.3		12.1
% Population Accounted for			88.0		89.2
Average PCC			137.1		138.6
Variance			732.6		730.9
Standard Error			3.4		3.4
95% Lower Confidence Int			130.3		131.8
95% Upper Confidence Int			144.0		145.4


CONTROL AREA ESTIMATES OF DOMESTIC WATER CONSUMPTION:
FOLKESTONE AND DISTRICT WATER SERVICES
BY WATER SUPPLY AREA AND BY YEAR 1988 TO 1991
LITRES/PERSON/DAY
240
220
200
180
160
140
120
100
80
60
40
20
0
FDWS
1988
1989
1990
1991

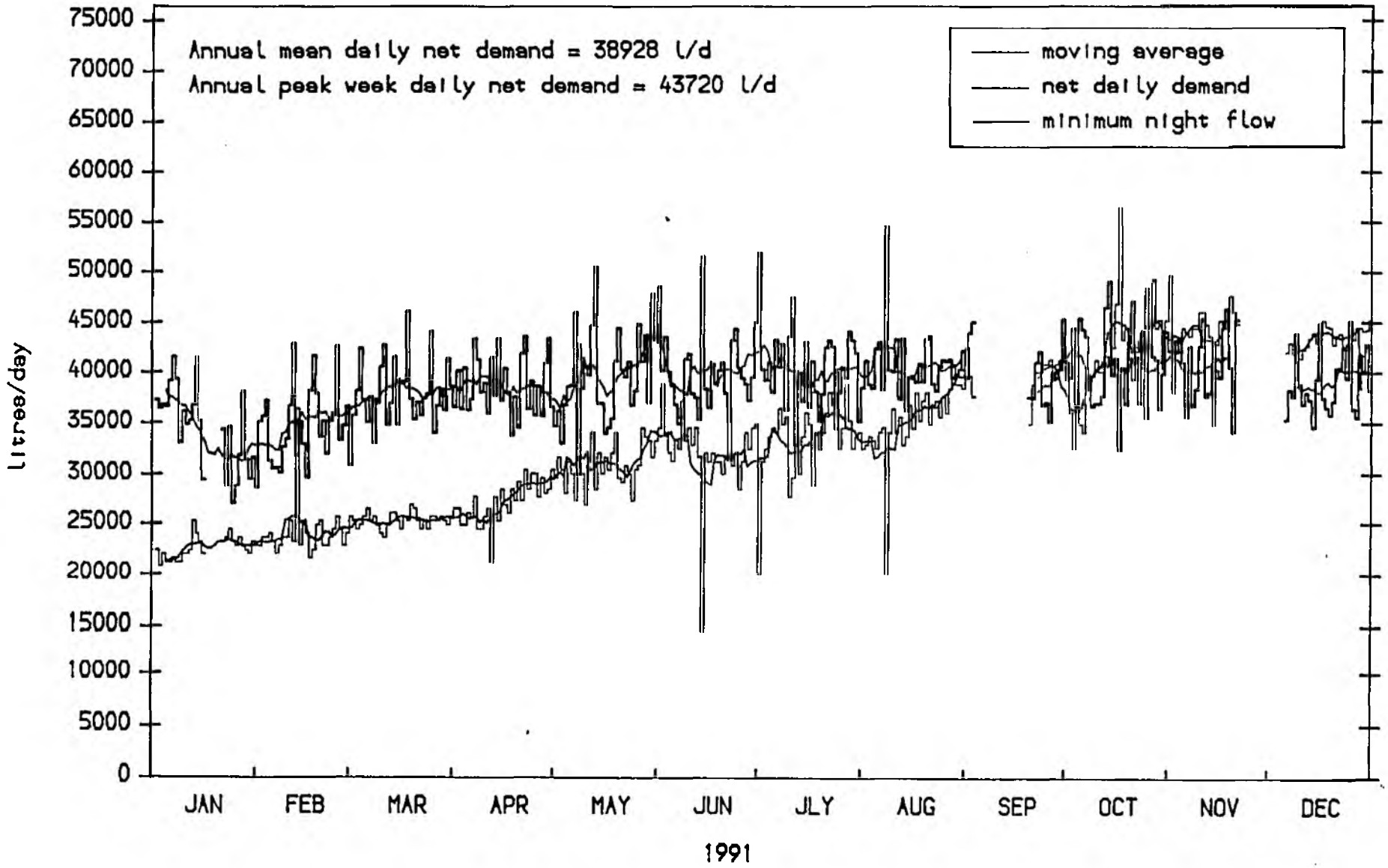
Appledore Crescent, Folkestone C41: water supply data for 1991 with 7 day moving ave



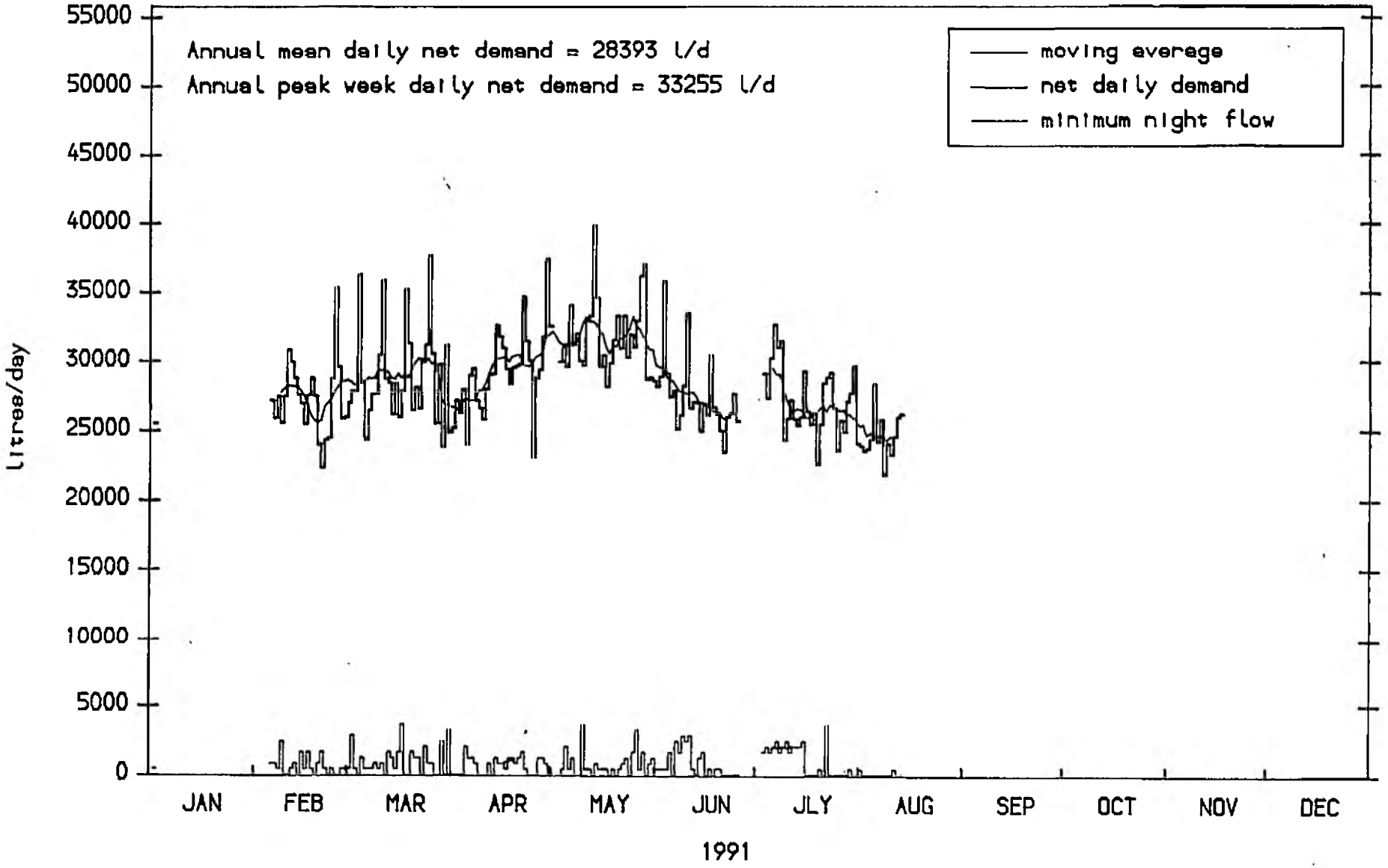
St Michaels Street, Folkestone C42: water supply data for 1991 with 7 day moving ave



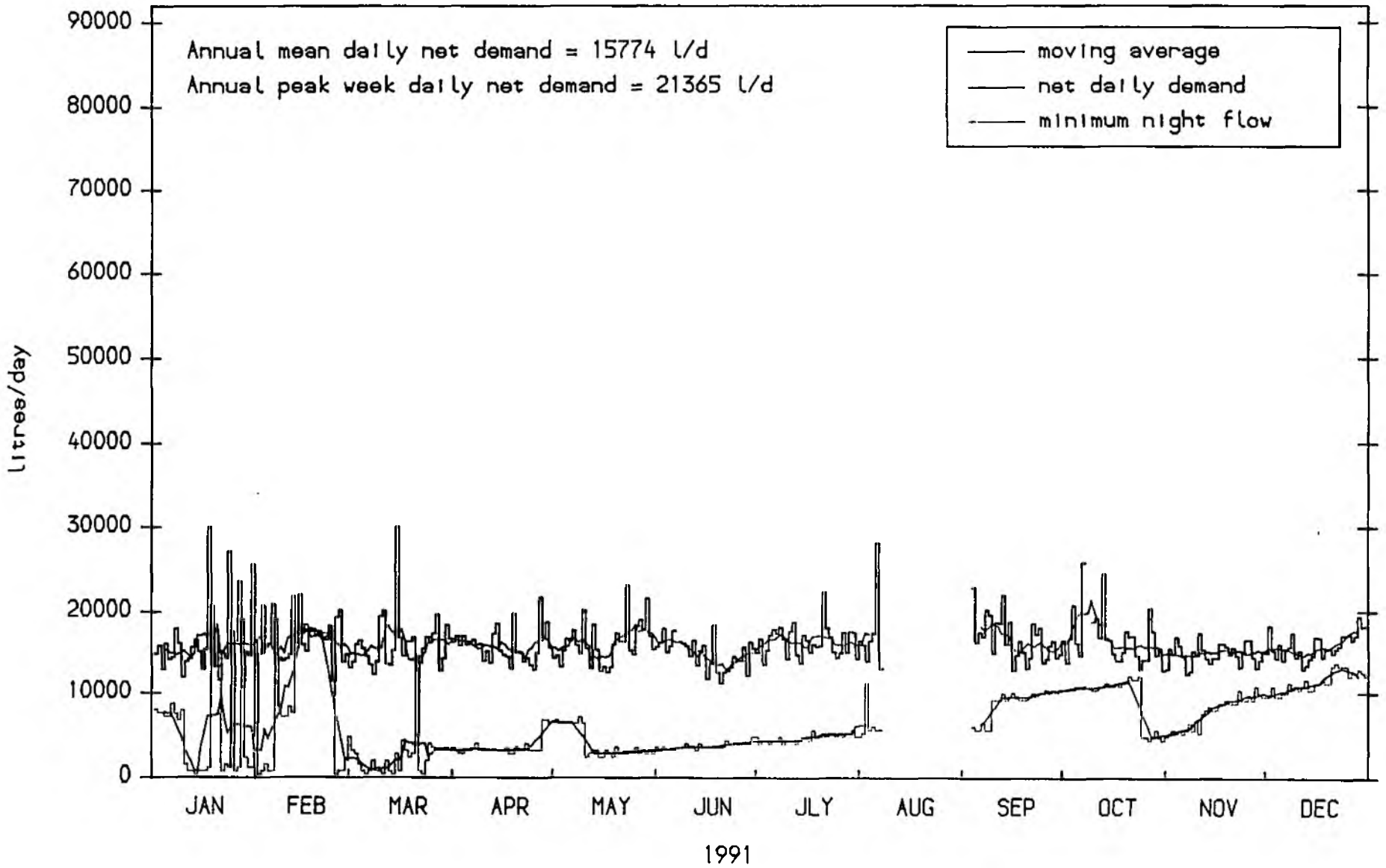
Millfield , Folkestone C43: water supply data for 1991 with 7 day moving average



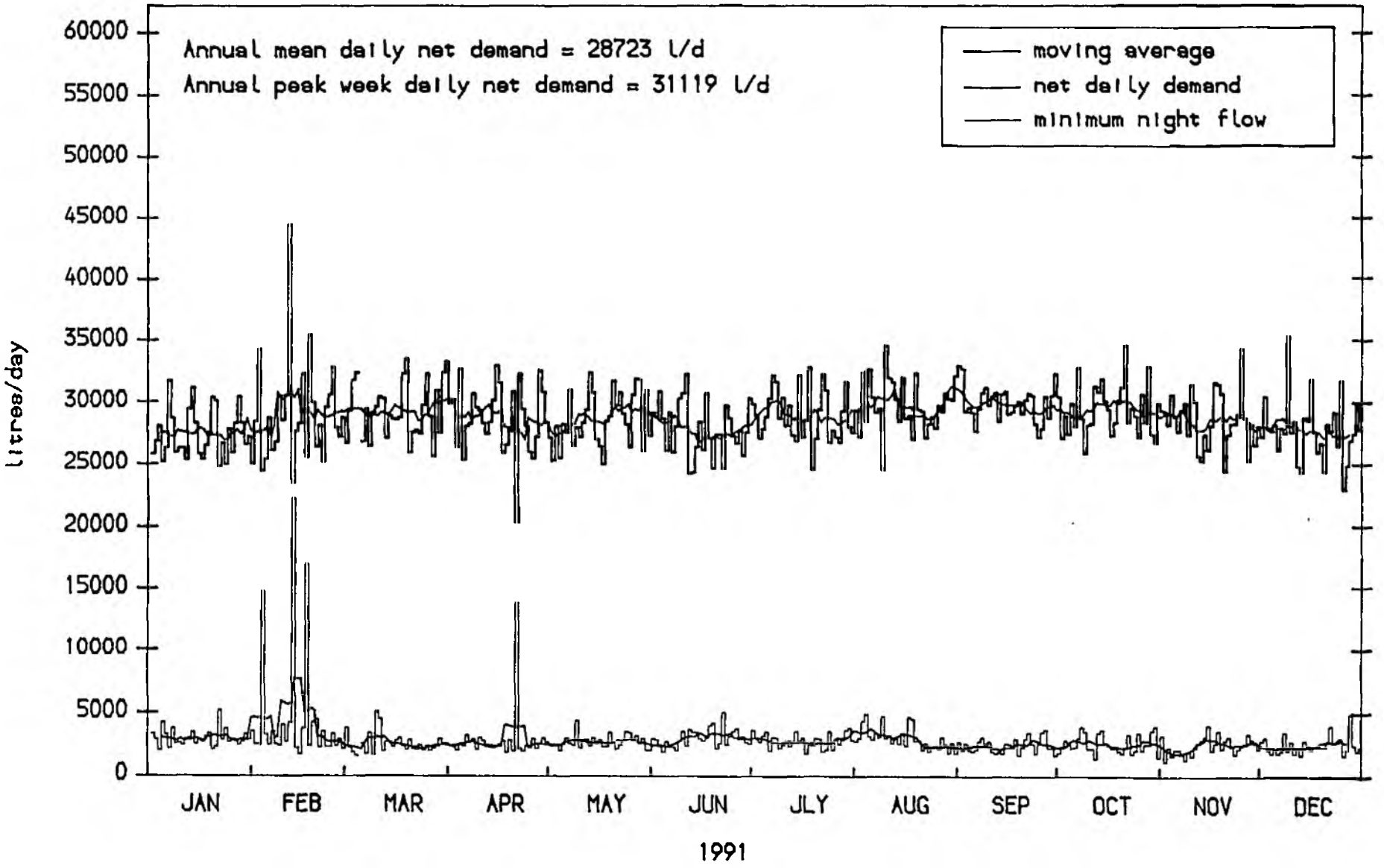
Octavian Drive, Lympne C44: water supply data for 1991 with 7 day moving average



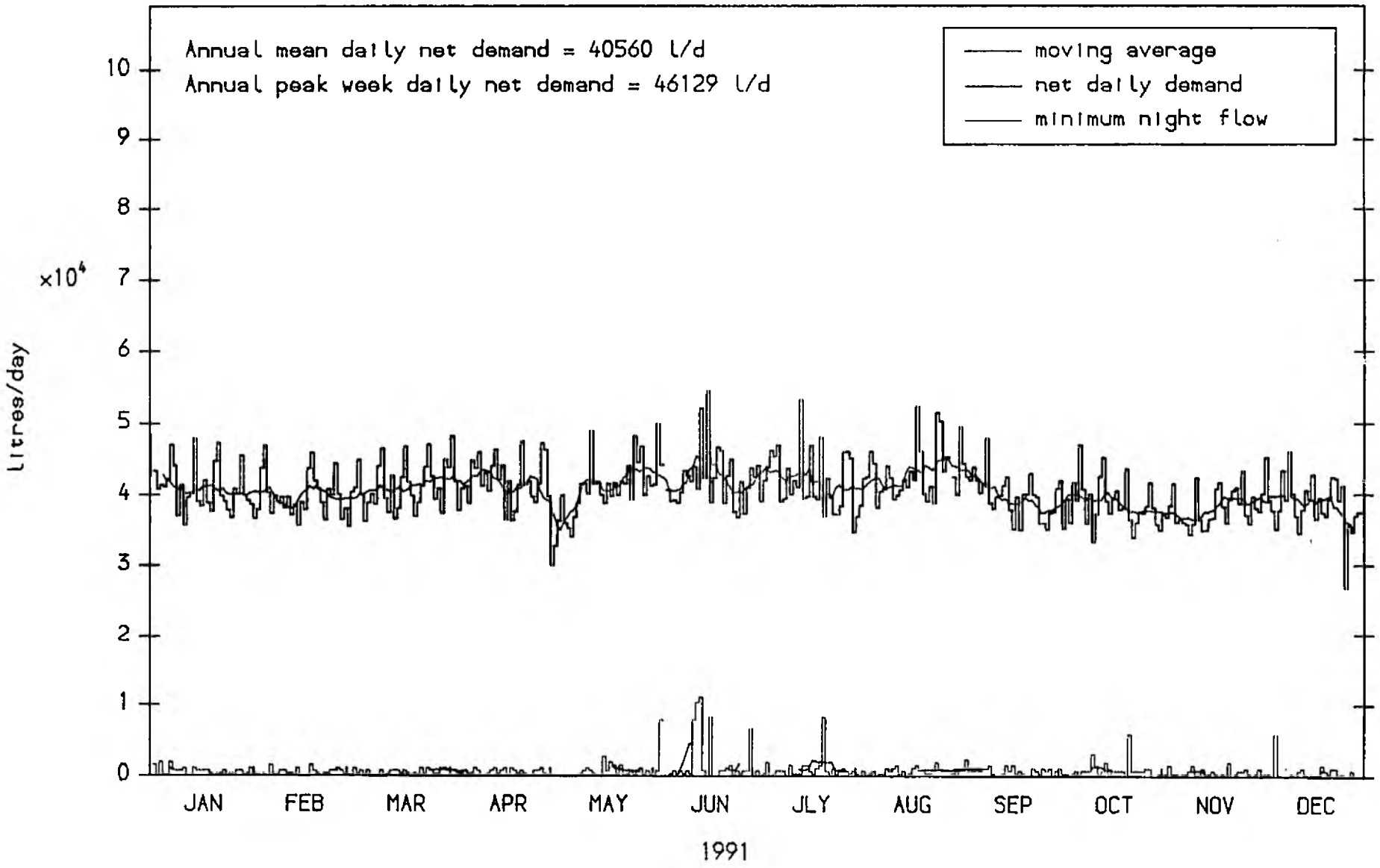
Sene Park, Hythe, Folkestone C45: water supply data for 1991 with 7 day moving aver



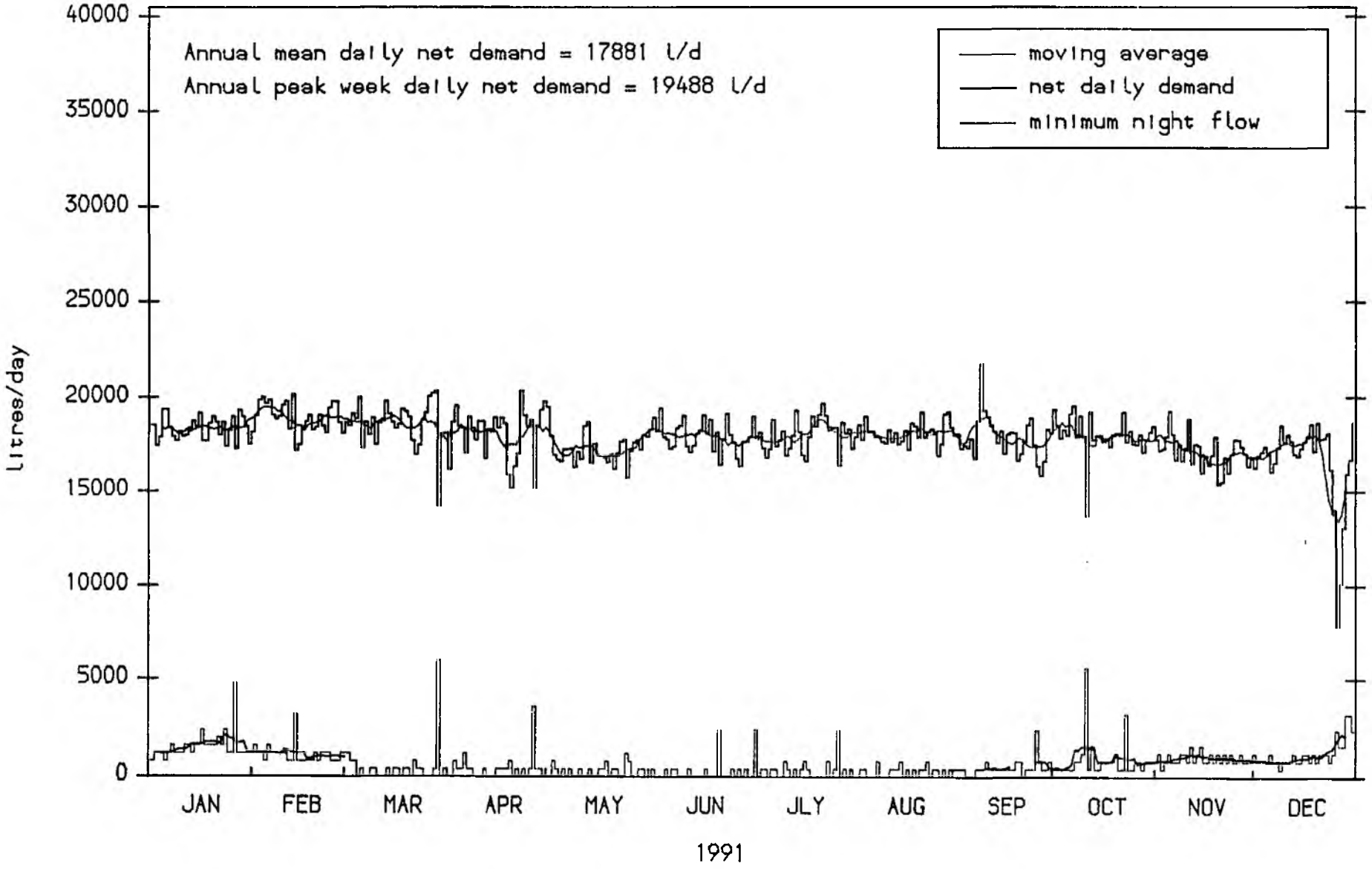
Marshlands, Folkestone C46: water supply data for 1991 with 7 day moving average



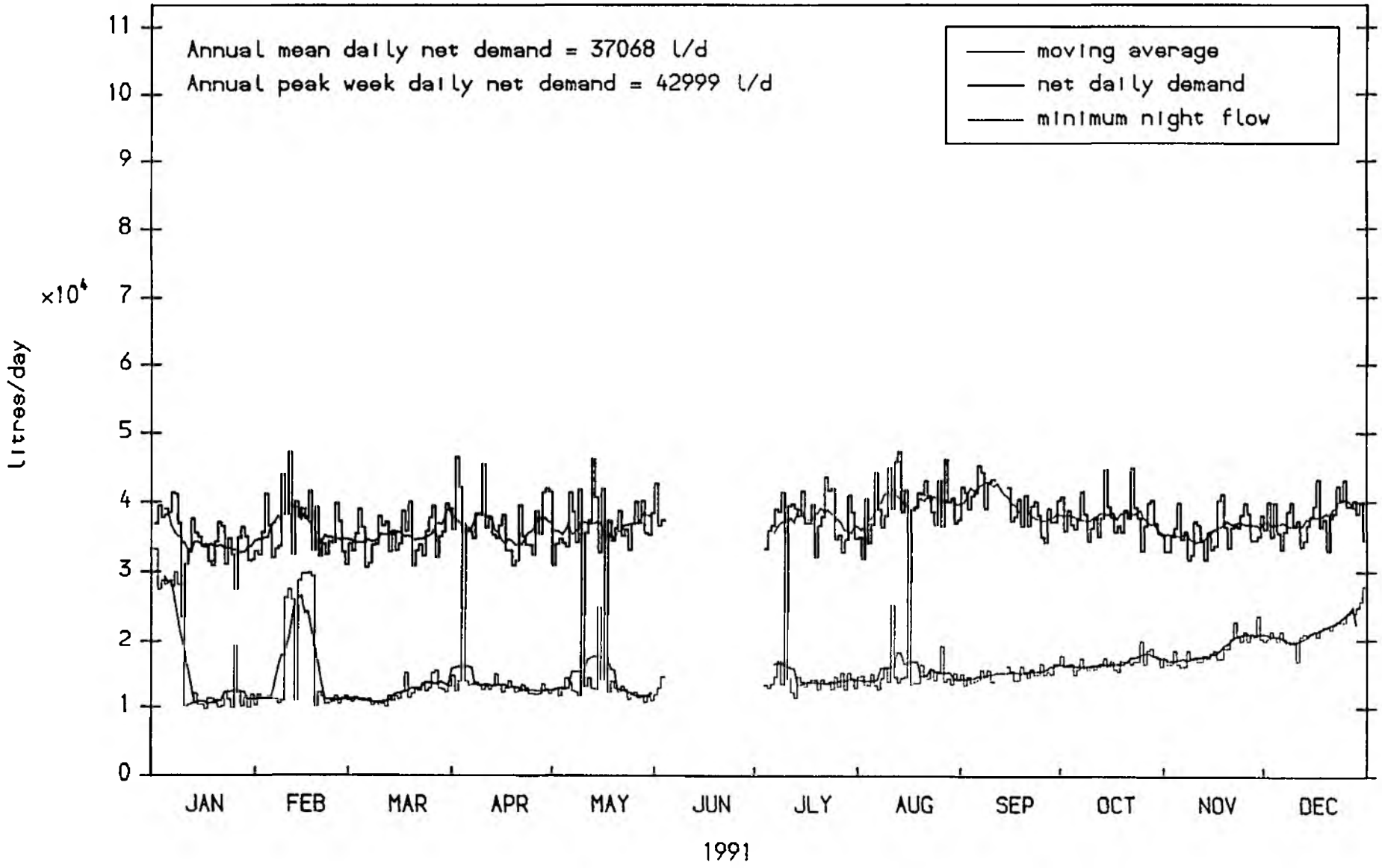
Polar Lane, Follkestone C47: water supply data for 1991 with 7 day moving average



Homepine, Folkestone C48: water supply data for 1991 with 7 day moving average



Westcliffe, Folkestone C49: water supply data for 1991 with 7 day moving average



APPENDIX E: EXCERPT FROM FORMER SOUTHERN WATER AUTHORITY WATER SUPPLY MANUAL

PJS/AC
23 September 1992

TITLE: REPLACEMENT

CHAPTER	SECTION	SHEET NUMBER	DATE ISSUED	DATE REVISED
6	7	1 of 1		

Age

A primary device shall be replaced when it has attained a maximum of 30 years in service unless it can be demonstrated that the device is fully operational and of adequate accuracy and that there is not a more economic method of making the measurement within that accuracy taking the full cost of replacement into account.

Secondary instrumentation shall be replaced after a maximum of 15 years of service.

Corroding/Eroding Nature of Water

Where calibration demonstrates that the performance of a meter has changed significantly, the cause of this shall be sought. It is possible that on a differential pressure device the cause may be some change in the internal geometry of the meter due to erosion or corrosion in which case the damage should be assessed and the meter changed if necessary.

Ranging

A measuring system shall be replaced when the range of flow to be measured has changed from the original value to the point where it no longer remains within the system's normal operating range taking the required accuracy into account. See Appendix 6/3/1 for details of suitable flow ranges.

TITLE: CHOICE OF FLOWMETER

CHAPTER	SECTION	SHEET NUMBER	DATE ISSUED	DATE REVISED
6	3	1 of 4		

Introduction

Flowmeters are influenced to a varying extent by the velocity profile of the flow in the pipeline immediately upstream of the meter. In general, the profile must be symmetrical and have no swirl content to have no significant effect on the performance of the meter. Profile asymmetry and swirl are caused by various types of upstream disturbances including the following:

Asymmetry
- partially open valve
- single bend
- protruding gasket
- flat taper

Swirl
- two bends in different planes
- partially open valve and a bend in different planes
- taper and bend or partially open valve

Appendix 6/3/1 summarises various aspects applicable to each type of meter in the initial list and further details on those aspects are given below. Study of these may not result in any one meter type being uniquely applicable to a particular measuring situation and if all technical applications are met, the choice will rely on cost. Meter types which are clearly unsuitable shall be identified and avoided. Care must be taken that all aspects are considered since a meter type's distinct advantage in one aspect can be completely offset in another.

Flowrange

Differential pressure flowmeters are limited to a 3 or 4:1 flow range mainly because of the square law relationship between flow and differential pressure. Under the foregoing conditions the secondary instrumentation is required to handle a differential pressure range of up to 16:1. The area ratio of the primary device and range of the secondary device must be properly selected for the flow limits so that adequate pressure signals are both generated and can be accurately measured. BS1042: Section 1.1 (ref 1) gives information for venturi meters and nozzles whilst manufacturers' literature should be consulted for low loss device information.

Helix meters can handle continuous flow over ranges up to 30:1 dependent upon the size of the meter. Manufacturers of electromagnetic and ultrasonic meters quote flow ranges of 10:1 but at the bottom end of this range, the meters' characteristics may be going non-linear with consequent loss of accuracy and it is therefore safer to restrict the flowrange to around 8:1. Some electromagnetic meters can be multi-ranged. Helix, electromagnetic and ultrasonic meters can deal with much lower flowrates than differential pressure flowmeters.

Care must be taken to ensure that the total range of flowrates to be measured falls within the working range of the selected flowmeter. For example, a flow range of 2-6 Ml/day is 3:1 and would appear to be suitable for a differential pressure device, but if that device is sized for 5-15 Ml/day which is also 3:1 then increased uncertainty of measurement will apply to flowrates between 2 and 5 Ml/day because the meter has been oversized. Conversely, undersizing of meters is equally to be avoided since prolonged running at flowrates above the designed maximum is also to be avoided it will result in increased head loss, cavitation, premature wear or permanent damage to the flowmeter dependent on the meter type.

Appendix 6/3/2 and 6/3/3 summarises the above flowranges and identifies the type of meter that would be suitable for working within that range.

Accuracy

A suitable requirement for uncertainty of water quantity measurement is plus or minus 2 per cent of the indicated value over the flowrange normally in use. This is in agreement with the value quoted in BS5728: Part 1 (ref 2) for cold water flowmeters at flowrates above a certain minimum; that minimum value varying according to the class of flowmeter.

Any of the foregoing flowmeters are capable of measuring within the above limits of uncertainty provided the meters are properly selected, reliably calibrated and properly installed and maintained.

Meter Selection

When selecting an installation position for a flowmeter, the following shall be applied as a minimum unless site conditions make the recommendations impracticable in which case expert advice shall be sought.

Classical venturi tube flowmeters

Appendix 6/3/4 shows the minimum straight lengths required between various fittings located upstream of the meter and the meter itself. All straight lengths are expressed in multiples of the pipe diameter and they shall be measured from the plane of the upstream pressure tapping of the meter.

Fittings or other disturbances situated at least four throat diameters downstream of the throat plane do not affect the accuracy of the measurement.

For further information, see BS 1042: Section 1.1 (ref 1).

Venturi nozzle flowmeters

Appendix 6/3/5 shows the minimum straight lengths required between various fittings located upstream of the meter and the meter itself. It also gives recommendations for the downstream straight pipe length. All straight lengths are expressed in multiples of the pipe diameter and they shall be measured from the upstream face of the nozzle.

Telemetry

The remote indicating device presently available for the Helix meter is not considered suitable for telemetry purposes because of the relatively low resolution of the signal. Any of the other meter types will be capable of interfacing to a telemetry system when equipped with the appropriate secondary instrumentation.

Output Signals

The Authority's standard of 4-20mA shall be adopted for all outputs.

Pumped or Gravity Supply

Head loss should be taken into account when selecting any flowmeter but it is certainly of high importance where costly energy can be saved as a result of proper selection. Appendix 6/3/6 shows the permanent head loss as a percentage of differential for various types of differential pressure flowmeters. The large range of different losses can be clearly seen. Non-intrusive flowmeters such as electromagnetic or ultrasonic will not cause any more head loss than a piece of plain pipe of the same internal diameter and length.

On gravity fed systems the allowable head loss should be calculated and the suitable flowmeters (on this aspect) selected accordingly. A policy of minimum head loss compatible with purchase costs should apply for systems where the supply is pumped. Flowmeter types having low loss characteristics are therefore highly preferable in the pumped supply case.

For further information, see BS 1042: Section 1.1 (ref 1)

Low loss differential pressure flowmeters

These devices have not been the subject of standardisation and manufacturers' literature shall be consulted for the appropriate recommendations. Those recommendations should be taken as minimum requirements. The manufacturer must be consulted in cases which are not covered in the literature.

A differential pressure flowmeter does not require an external power supply to generate the differential signal but the secondary instrumentation (pressure transmitter) does and that instrumentation has to be positioned close to the flowmeter. Typically, a 24V dc supply with current of up to 100mA is required. Power may also be required for local heating to provide ambient temperature stability for the transmitter.

Electromagnetic flowmeters

Recommendations for installation configuration are given in BS 5792 (ref 3). These entail a straight pipe length of at least 10 pipe diameters between an upstream disturbance causing asymmetrical velocity profile and the plane of the meter electrodes. Downstream disturbances are not regarded as being significant but it would be prudent to allow at least 5 pipe diameters of straight pipe. Swirling flow should be avoided where possible.

Electromagnetic flowmeters require 110 or 240V mains supply with power consumption of 10-30 Watt dependent on meter head size.

Ultrasonic flowmeters

Standards have not yet been established for ultrasonic meters. Manufacturers' literature should be consulted for suitable installation details. In the case of single path time-of-flight meters, the recommended upstream length of straight pipe should be regarded very much as a minimum since tests have proved manufacturers to be over-optimistic in their specifications.

Ultrasonic flowmeters require 220V ac or 24V dc supply with power consumptions of less than 10VA and 4 Watt respectively.

Helix meters

Manufacturer's literature does not specify particular lengths of straight pipe either upstream or downstream. They type of meter is known, however, to be affected by flow profile disturbances and a suitable specification would be 10 diameters straight upstream pipe with 5 diameters straight downstream. Swirling flow should be avoided.

A Helix meter will supply a local measurement of flow without any external power supply but if remote reading is required then mains supply is required at the main amplifier which can be positioned up to 1 mile from the meter. This supply would be 110 or 240V ac with power consumption of 7.5VA.

NRA

National Rivers Authority

Southern Region

Regional Office
Guildbourne House Chatsworth Road
Worthing West Sussex BN11 1LD
(0903) 820692