Evaporation Memorandum No 39

Class A pan evaporation measurements in Great Britain

B G Wales-Smith

Summary

The trial of the Class A pan in Great Britain is briefly described, the participating stations are mapped in a way which summarises the types of data recorded at each of them and the recent preparation of a catalogue of these data held by the Meteorological Office is reported. Accounts of studies, found by the writer, are listed. Recent analyses involving inter-station Class A pan evaporation comparisons and comparisons of Class A pan evaporation with British Standard Tank and Penman potential evaporation are described. Plans to process the data and a tried method of using them are mentioned.

1. Introduction

Specifications of equipment, installation and observational practice for Class A evaporation pan and associated, auxiliary measurements are given by the United States Weather Bureau (1955). Following the recommendations of the World Meteorological Organisation for the International Geophysical Year, the Meteorological Office installed Class A pans at Kew, Eskdalemuir and Lerwick Observatories and both sought and received the enthusiastic cooperation of a small group of scientific and professional bodies to entend the network of Class A evaporation stations. Monthly data sheets, mostly containing daily observations, were collected and archived at the Meteorological Office headquarters; their contents have recently been catalogued by the writer. Figure 1 shows the network of stations and gives a condensed version of the catalogue.

The measurements consist of some or all of the following:

(i) 24-hour water level change converted to evaporative loss by allowing for rainfall, if any,

(ii) 24-hour maximum and minimum temperatures taken from specially shielded thermometers floating in the surface layer of the water,

(iii) 24-hour totals of run-of-wind (miles or Kilometres per day) from a cup counter anemometer mounted with cup centres 6 inches (approx 15cm) above pan rim level,

(iv) 24-hour maximum and minimum temperatures in a standard thermometer screen and

(v) 24-hour run-of-wind at 2 metres above ground.

The measurements began at various dates in and after 1957 and are still being made at a few stations. The Meteorological Office completed its own observations with the Class A pan in 1967 and no longer collected these data from cooperating stations.

2. Studies of Class A Pan evaporation Data

This paper is not a review of the literature. Readers with a general interest in the subject are advised to consult (or may already if be aware of) CIMO Working Group (1966) and also Hounam (1971) and (1973); these three references are, themselves, sources of additional references. Analyses and studies of British data have been made by Law (1966) for Slaidburn, by Hamilton (1965) for Lerwick, by Lapworth (1965) for Kempton Park and by Holland (1966), (1967) for a number of stations.

3. Recent Analyses

3.1 2-Station Comparisons

In Figures 2 to 5 monthly totals of class A pan evaporation are compared at pairs of stations; some comments about these graphs follow:-

Figure 2 (Rothamsted and Fulbourn). The correlation is good, with Fulbourn evaporation $\geqslant$ that at Rothamsted in 20 months out of 21. This is reasonable, other things being equal, since the two places are only 60 km apart with Fulbourn about 100 m lower than Rothamsted.

Figure 3 (Kempton Park and Kew). The correlation is good. Although the stations are close together and almost the same height above sea level Kempton Park totals mostly exceed those attained at Kew. For the period April to September Holland (1967) obtained Class A pan to British Standard Tank factors of 1.3 at Kew (from 5 years of data) and 1.5 at Kempton Park (from 4 years of data). Lapworth (1965) reported that the B S Tanks at the 2 stations agreed to within 5% in annual totals over 7 years but that the Class A pan evaporation at Kempton exceeded that at Kew by an average of 6in (152 mm) per year. This discrepancy has not been explained so far as the writer is aware. Tank Colour differences can explain such discrepancies and Wales-Smith (1973) demonstrated the substantial increase in evaporation resulting from changing evaporation tank colour from white-to-black. The Kew tank (painted white) agreed well with that at Kempton Park and the two class A pans were not painted so although the effects of white-to-black change on evaporation have been quantified by experiment it seems most unlikely that they can be invoked to explain this particular discrepancy. It may well have been due to installation and exposure and perhaps to observational procedures as well.

Figure 4 (Farmoor and Wallingford). The monthly totals agree very well. The two stations are less that 30 km apart and with 15 m of one another in relation to sea level.

Figure 5 (Revesby and Cawood). The values are quite well correlated but Cawoods's values were almost always the higher. Cawood is some 70km north of Revesby (which might suggest lower evaporation) but 32 m closer to sea level (suggesting higher evaporation). Cawood is much further inland than Revesby and hence somewhat less affected by moist, onshore flow, and likely to have higher evaporation totals as a result. There may also have been significant differences in exposure etc.

3.2 Comparisons with British Tank data

Holland (1967) gives Pan-to-tank coefficients for the period April to September for 8 stations which give averages from 1.2 to 1.5 and an average (May to September) value of 1.1 for a high ground location in Wales. These values are based on comparisons of from 2 to 5 years in length.

Table 1 shows monthly coefficients for an unpainted Class A pan and a white painted British Standard tank at Kew from 1958 to 1967. The data used to obtain these values are plotted as a scatter diagram in Figure 6(a) a regression line inserted by eye gives $E_{AP} = 1.33\ E_{BTW}$. The coefficients are plotted, month-by-month in Figure 6(b); they are generally low in summer and high in winter. Holland found that the April values were higher, on average, than those of May to September with a minimum just after mid-summer.

3.3 Comparison with Penman potential evaporation

The 96 monthly totals of Class A pan evaporation at Kew are plotted against Penman potential evaporation (Penman (1948)) (using albedo 0.25, to represent vegetation, and wind speeds measured at 2 metres) in Figure 7. The points are not well fitted by a straight line through the origin. The failure to fit such a straight line to the points is explained by the tabulated values in Table 2 and by the plot of monthly coefficients in Figure 8. The seasonal pattern is much stronger than that shown in Figure 6(b) with very large winter values. Wales-Smith (1975) obtained similar curves relating black evaporation (buried) tank and irrigated lysimeter evaporation to Penman potential evaporation. The seasonal discrepancies between evaporimeter measurements and calculated estimates of evaporation are believed to be due to

(a) under-weighting the aerodynamic term and over-weighting the radiation balance term in Penman's formula demonstrated by Thom and Oliver (1977),

(b) the ~~under~~ over-estimation of ~~winter~~ summer and transitional season net radiation by Penman's formula - examples of which are given by Wales-Smith ~~(1976) and~~ and Bader (1978) and

(c) the effects of seasonal soil heat flux on evaporation suggested by Wales-Smith (1975).

4. Preservation of relevant documents

The official files relating to trials of the Class A pan have come up for survey (on a time basis) and all documents judged to be of future value have been preserved in the archives of the Meteorological Office, Met O 8.

5. Further exploitation of archival Class pan data.

As soon as staff availability permits the Class A pan evaporation and auxiliary data will be punched and checked for internal consistency.

(a) to ensure that calculations are correct,

(b) to ensure that values of variables are correctly dated (ie rainfall, evaporation, wind-run and maximum temperatures "thrown back" to the day before readings were actually taken). The body of data will then be readily available for analyses and other uses.

Kohler et al (1955) present a detailed technique for the estimation of shallow reservoir evaporation using Calss A pan and auxiliary data. Their formula and specifications of terms are given in Hounam (1973) pp 40-41.

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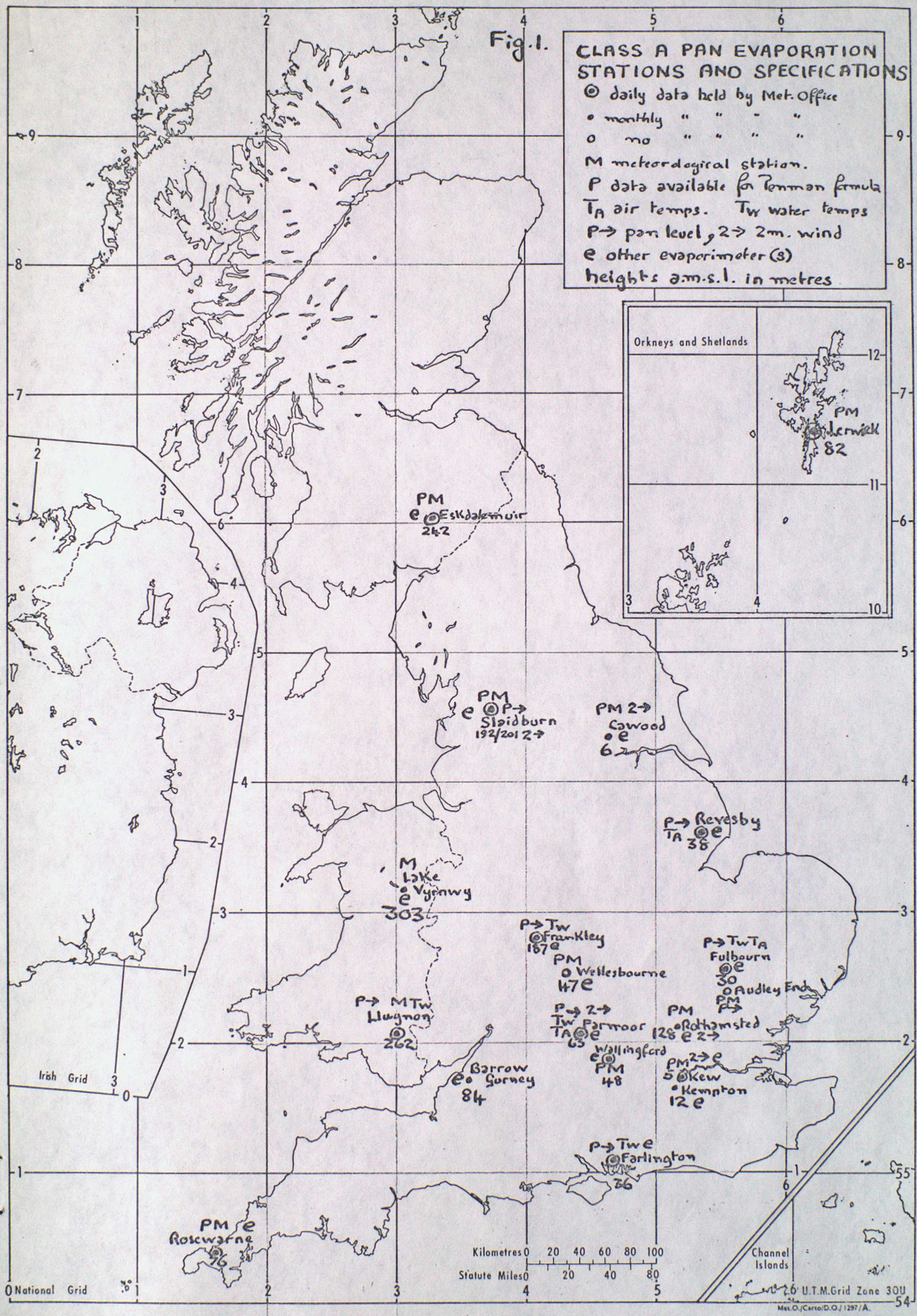
Fig. 1.
CLASS A PAN EVAPORATION STATIONS AND SPECIFICATIONS
⊙ daily data held by Met. Office
• monthly " " " "
o no " " " "
M meteorological station.
P data available for Penman formula
T_A air temps. T_W water temps
P→ pan level, 2→ 2m. wind
e other evaporimeter (s)
heights a.m.s.l. in metres
Orkneys and Shetlands
PM Lerwick 82
PM e Eskdalemuir 242
PM e P→ Slaidburn 192/201 2→
PM 2→ Cawood e 6
P→ T_A Reversby e 38
M Lake Vyrnwy e 303
P→ T_W Frankley 187 e
PM o Wellesbourne 47 e
P→ T_W T_A Fulbourn e 30
o Audley End PM P→
P→ M T_W Llugnon 262
P→ 2→ T_W Parwoor T_A e 63
PM Rothamsted 128 e 2→
e Wallingford PM 48
PM 2→ e 5 Kew
Kempton 12 e
e Barrow Gurney 84
P→ T_W e Farlington 36
PM e Rosewarne 76
Irish Grid
National Grid
Kilometres 0 20 40 60 80 100
Statute Miles 0 20 40 80
Channel Islands
U.T.M. Grid Zone 30U
Met.O./Carto/D.O./1297/A.

CLASS A PAN MARCH 1961 TO DEC 1962. (EXCLUDING FEB 1962). ROTHAMPSTEAD / FULBOURN.

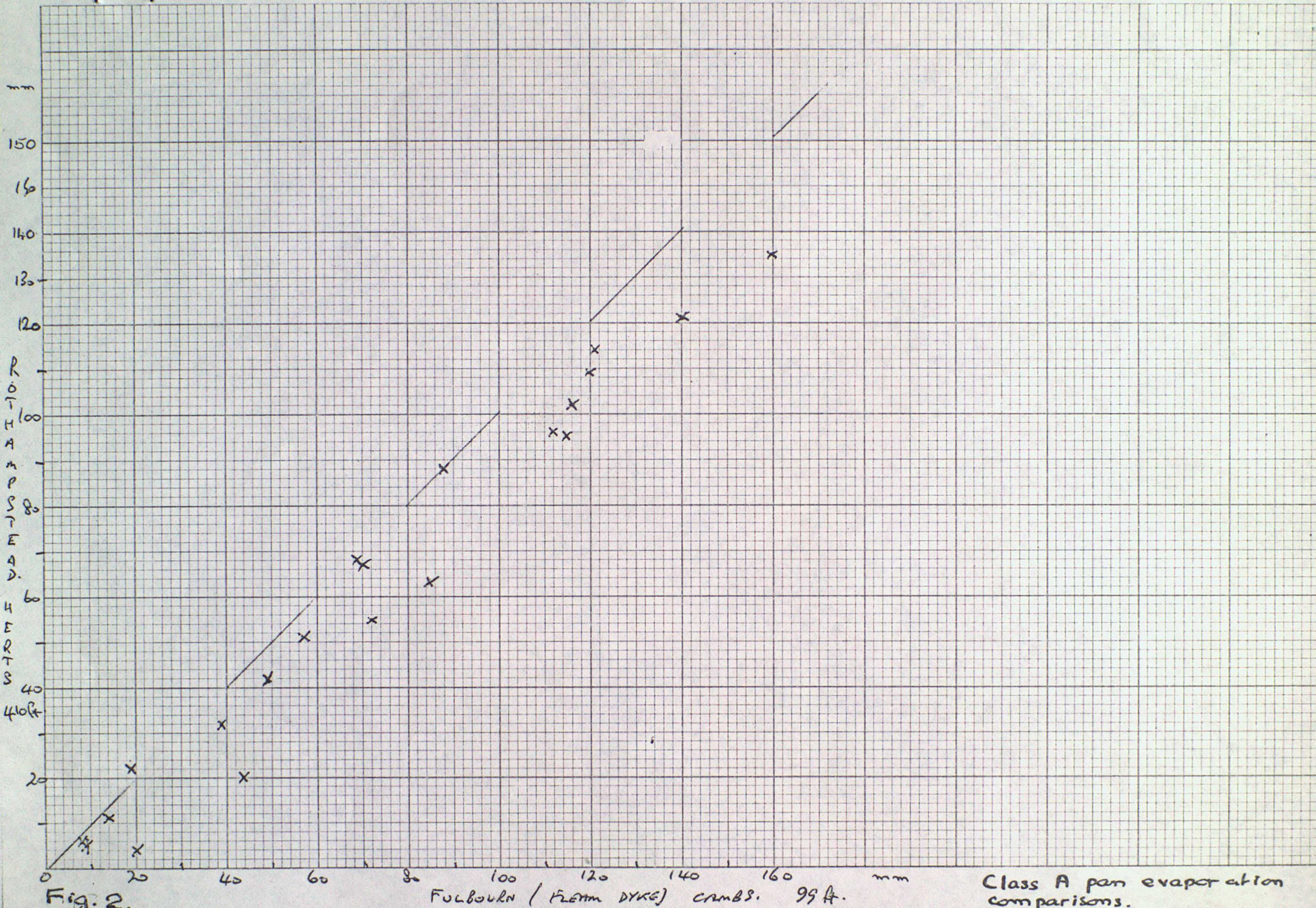

Fig. 2.

Class A pan evaporation comparisons.

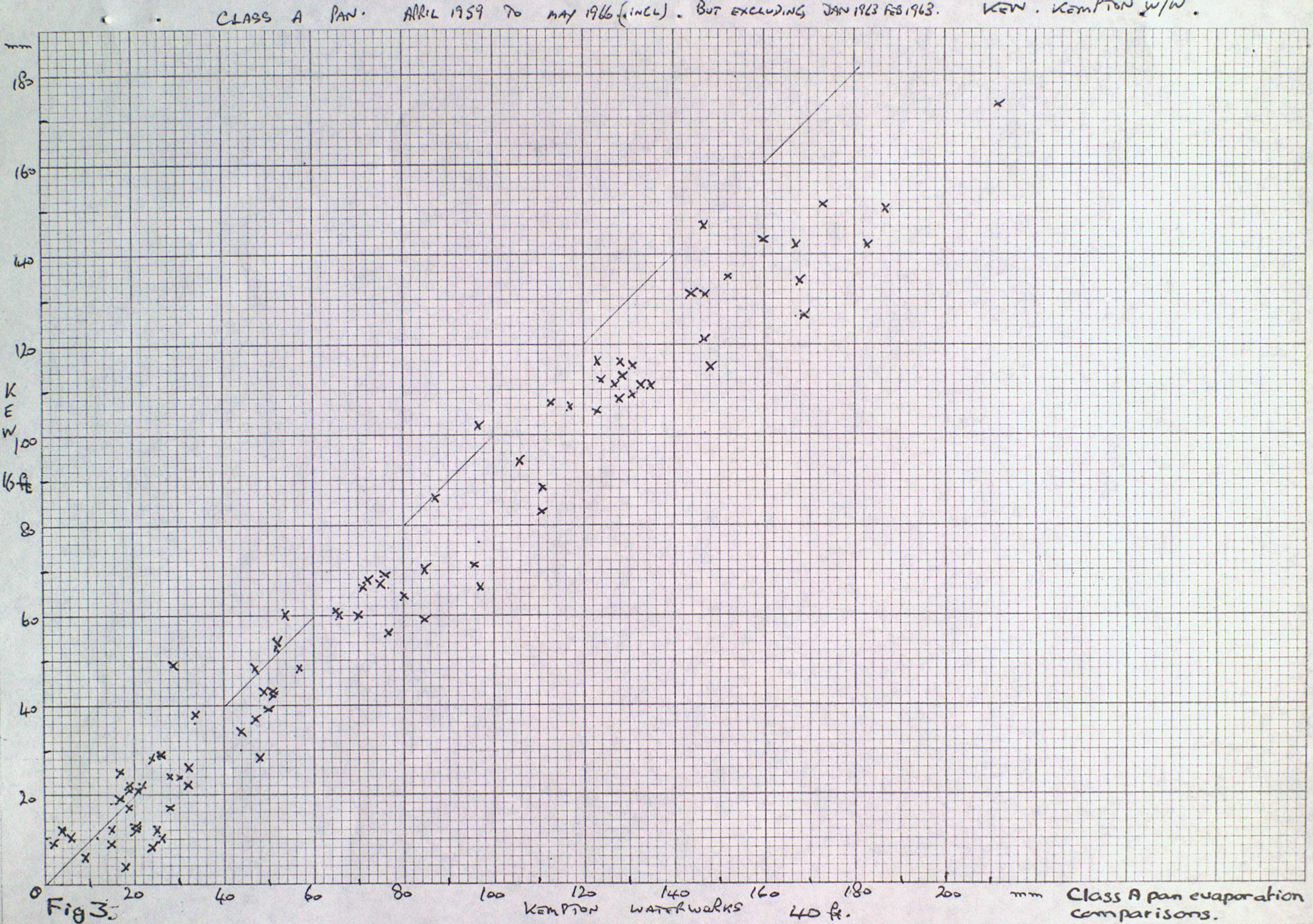

Fig 3.

Class A pan evaporation comparisons.

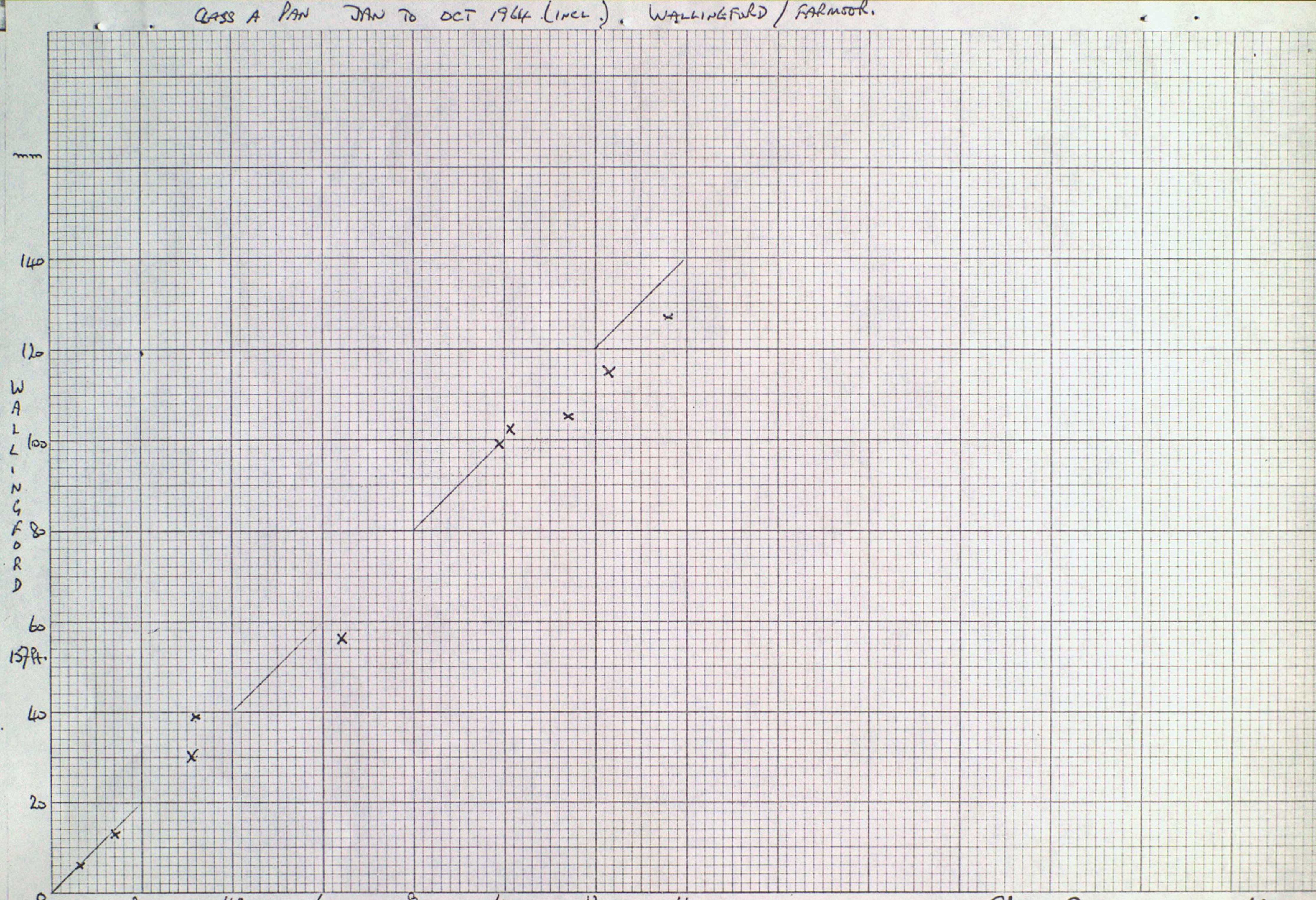

Fig. 4. Class A pan evaporation comparisons.

CLASS A PAN CAWOOD REVESBY. ASSOCIATED 1959 - 1963. MAINLY SUMMER MONTHS.

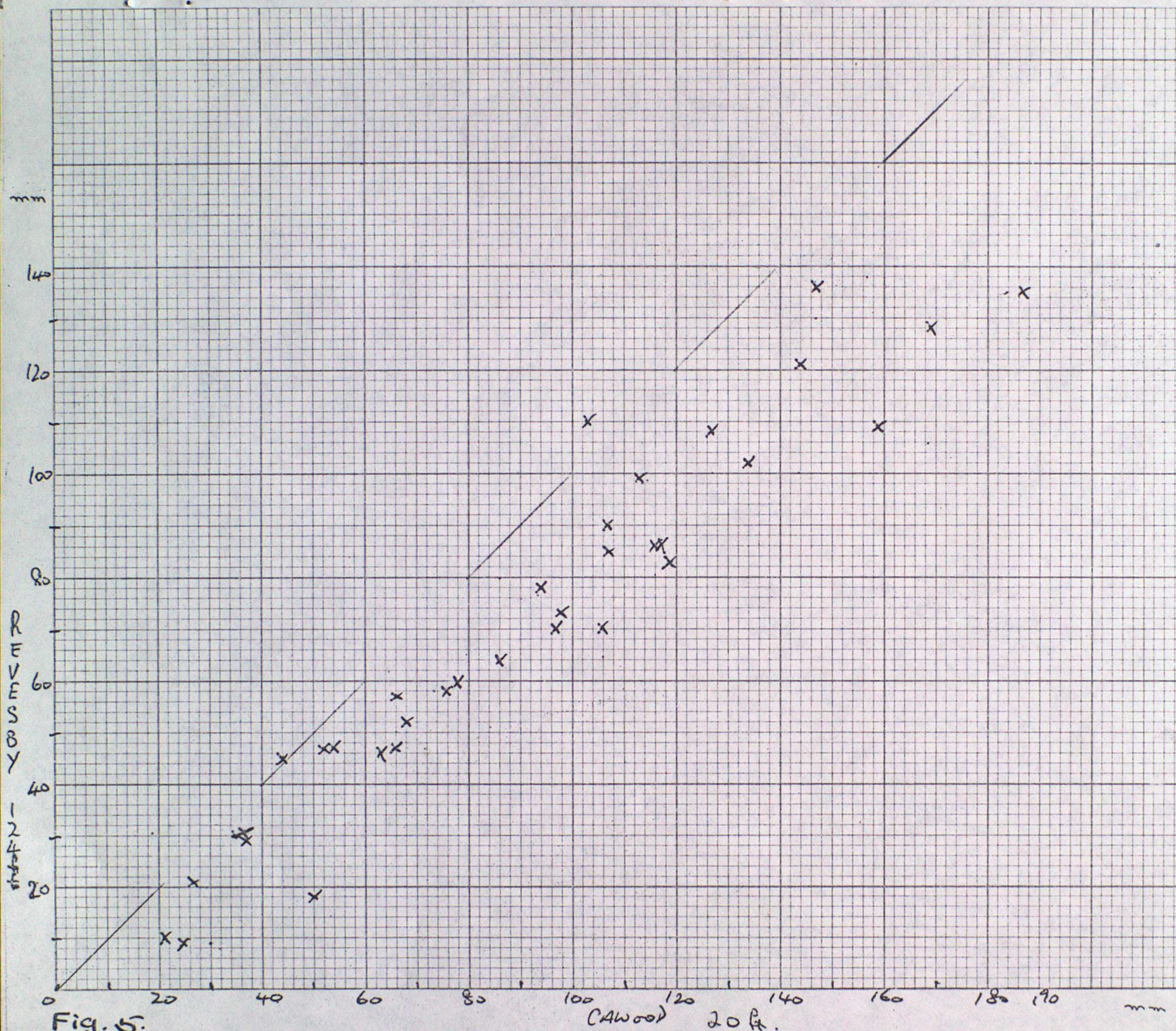

Fig. 5. Class A pan evaporation comparisons.

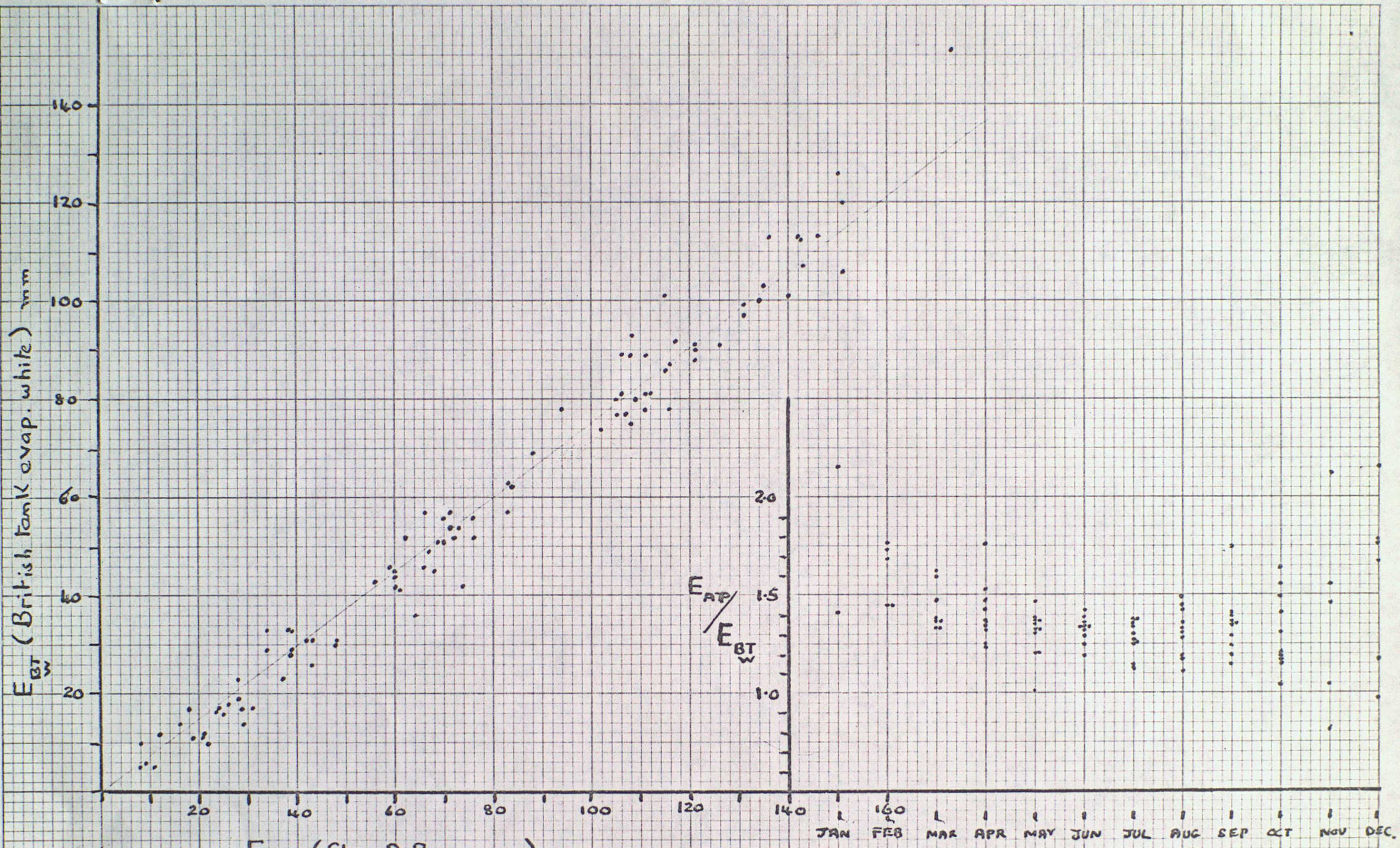

Fig. 6(a) {pan tank evaporation comparisons at Kew 1958-1967 ~ monthly totals

Fig 6 (b) monthly pan-to-tank coefficients at Kew 1958-1967

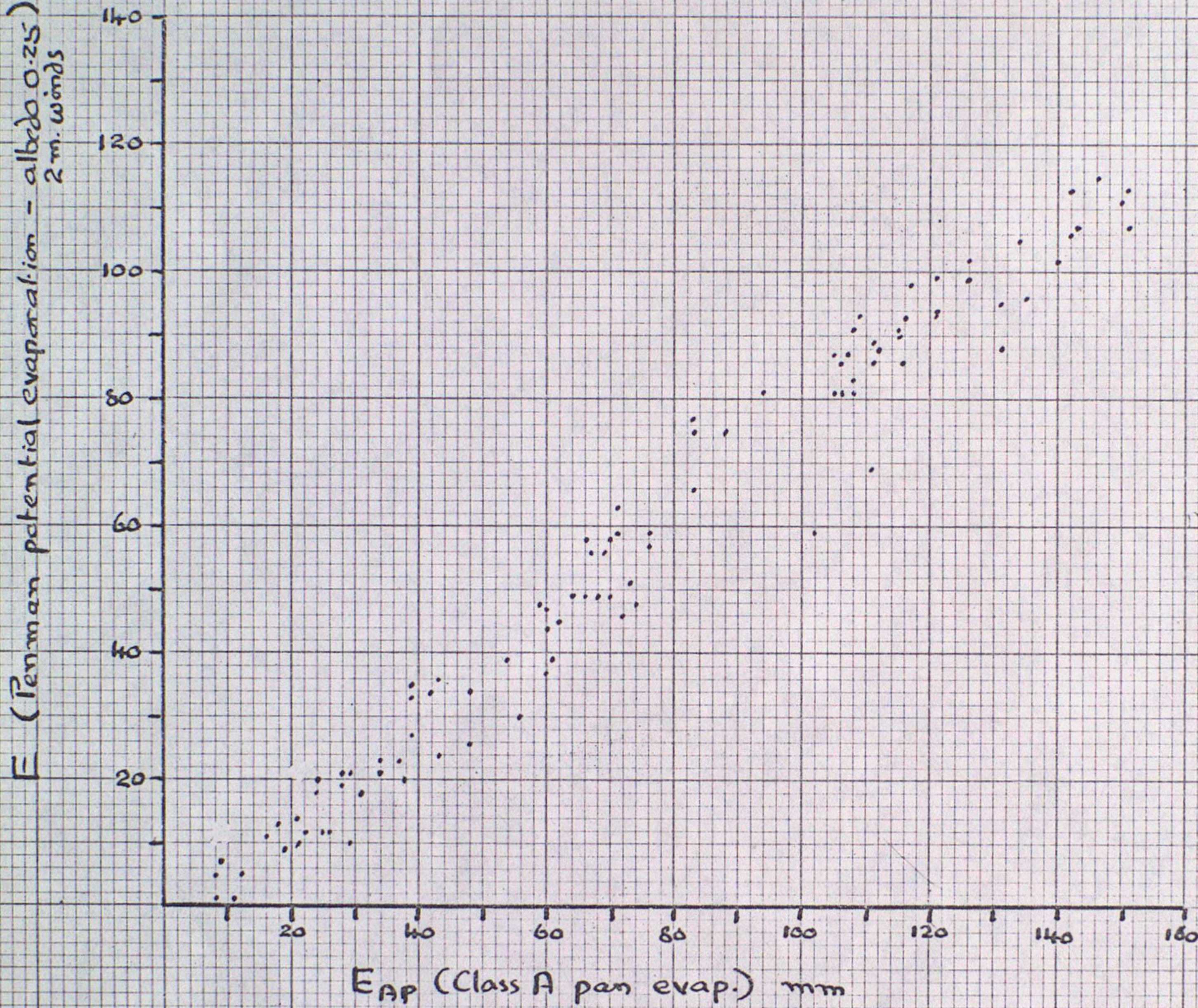

Fig. 7. Pan vs Penman evaporation comparisons at Kew 1958-1967 – monthly totals.

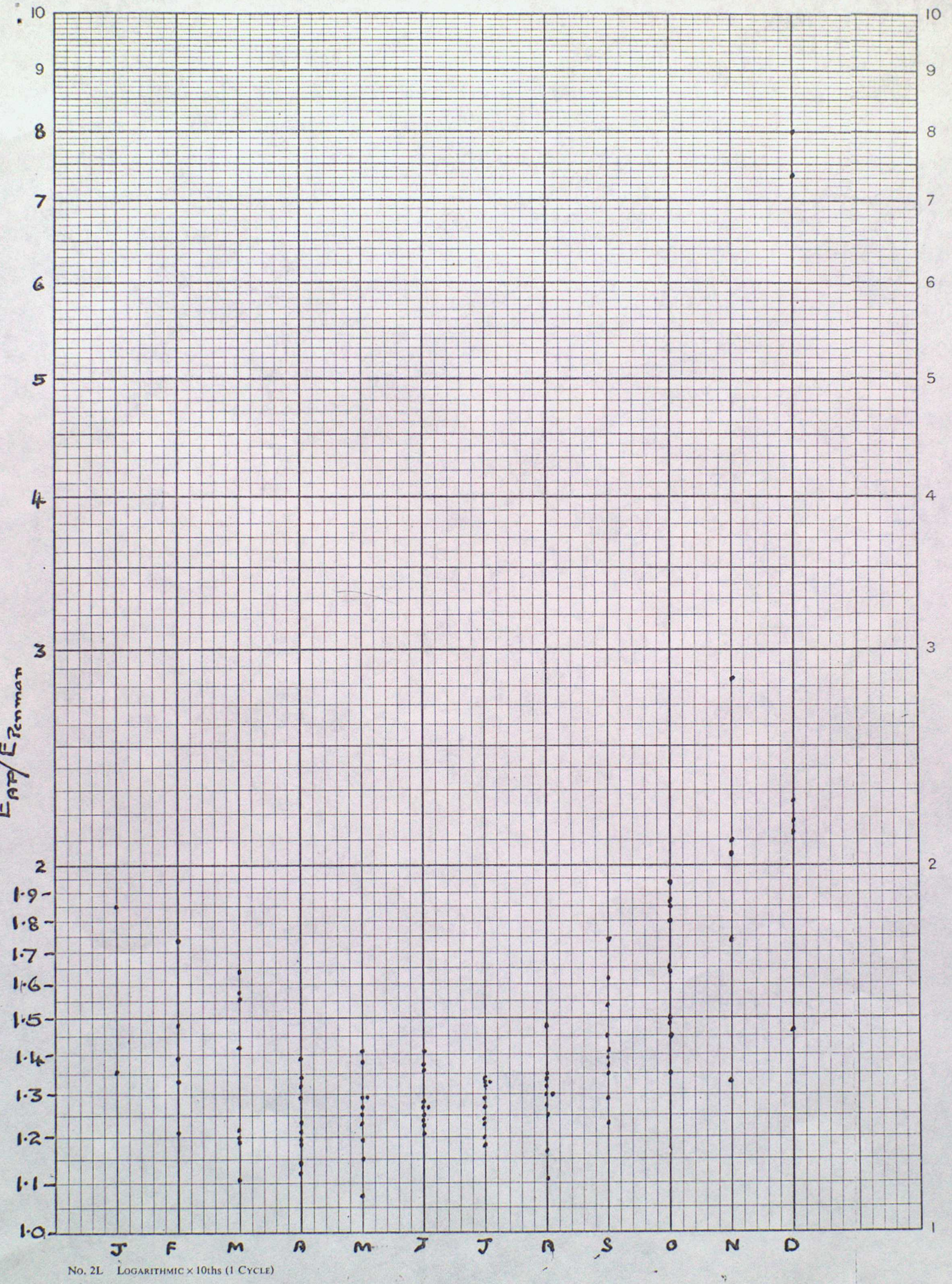

Fig. 8 Monthly ratio E_{AP}/E_{Penman} Kew 1958-1967

Table 1. Ratio E_{AP}/E_{BT_W} Pan to tank coefficient.

YEAR	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	Means
January ...	–	–	–	–	–	–	1·41	2·16	–	–	
February ...	–	–	–	1·45	–	–	1·69	1·73	1·45	1·77	
March ...	–	1·34	1·34	1·37	–	1·63	1·37	1·60	1·48	1·39	
April ...	1·32	1·47	1·24	1·53	1·25	1·37	1·36	1·43	1·77	1·35	
May ...	1·21	1·33	1·37	1·31	1·21	1·39	1·35	1·37	1·47	1·32	
June ...	1·36	1·25	1·29	1·42	1·19	1·34	1·34	1·34	1·39	1·33	
July ...	1·38	1·15	1·36	1·25	1·14	1·27	1·34	1·30	1·38	1·26	
August ...	1·45	1·11	1·33	1·49	1·17	1·28	1·36	1·31	1·43	1·19	
September	1·39	1·24	1·29	1·75	1·15	1·41	1·37	1·35	1·36	1·19	
October ...	1·15	1·31	1·49	1·56	1·04	1·64	1·17	1·41	1·21	1·19	
November	–	–	–	1·46	–	2·12	1·56	–	1·04	·81	
December	1·67	1·17	–	–	–	·97	1·78	–	1·77	2·16	

Table 2 Ratio E_{AP}/E_{Penman} Pan to Penman coefficient.

YEAR	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	Means
January ...	–	–	–	–	–	–	1·36	1·85	–	–	
February ...	–	–	–	1·33	–	–	1·48	1·39	1·21	1·74	
March ...	–	1·19	1·11	1·64	–	1·20	1·22	1·42	1·56	1·57	
April ...	1·19	1·29	1·12	1·39	1·18	1·21	1·23	1·14	1·32	1·34	
May ...	1·19	1·38	1·29	1·41	1·15	1·23	1·29	1·27	1·25	1·07	
June ...	1·21	1·25	1·27	1·41	1·36	1·28	1·27	1·24	1·37	1·23	
July ...	1·24	1·32	1·18	1·34	1·27	1·20	1·33	1·23	1·29	1·33	
August ...	1·25	1·27	1·11	1·35	1·30	1·17	1·48	1·30	1·34	1·32	
September	1·41	1·62	1·23	1·54	1·35	1·29	1·74	1·37	1·45	1·39	
October ...	1·65	1·85	1·35	1·87	1·50	1·64	1·94	1·80	1·49	1·45	
November	–	–	–	2·10	–	2·84	2·05	–	1·33	1·74	
December	8·00	1·47	–	–	–	2·26	2·13	–	2·17	7·33	