Evaporation Memorandum No 32 by B G Wales-Smith

THE IMPORTANCE OF ALBEDO IN THE PENMAN POTENTIAL EVAPORATION FORMULA

1. Introduction In using the above formula derived by Penman (1948) whether explicitly or implicitly, the Meteorological Office has normally taken the albedo $^{(r)}$ as 0.25 for green vegetation. In the new Meteorological Office model for agricultural and hydrological water balance (MAHWAB(x)) the albedo of an area is associated with the land use and this, in turn, has some seasonal variation.

2. Variation of estimated (Penman) potential evaporation (pe) with albedo

Monthly totals of pe were calculated for Kew Observatory for the period January 1971 to April 1976 for r = 0.05, 0.15 and 0.25. The results are shown in Figs 1 and 2 where pe values for r = 0.05 and 0.15 (E_{05} and E_{15}) are each compared with the corresponding pe values for r = 0.25 (E_{25}). Two empirical equations relating the E-values are given in the figures. E_r/E_{25} is plotted against r for r = 0.25, 0.15 and 0.05 in Fig 3. Approximate values of $E_r/E25$ can be read from thestraight line for all r between .25 and .05. This result is obtained because Penman's E is dominated by the incoming radiation term.

3. Consequences of using an albedo lower than 0.25

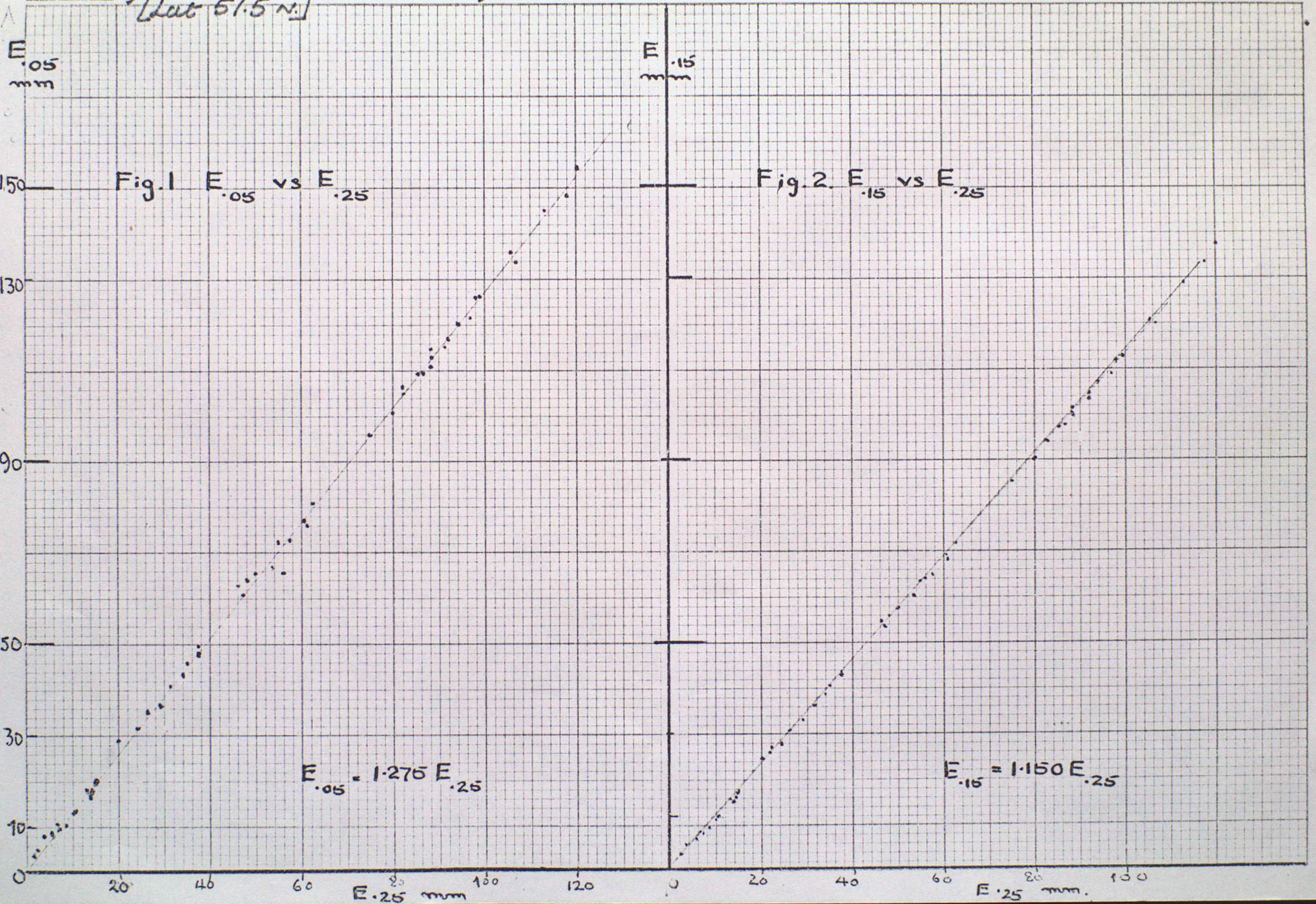
The albedo is the percentage of incoming radiation reflected to space as short wave radiation. The lower the albedo the greater the energy available to cause evaporation. The Meteorological Office operational soil moisture deficit (smd) model (in use in 1976) obtains Penman pe in a manner which implicity takes albedo as 0.25. MAHWAB (x) associates albedo with land use. A 40x40 Km MAHWAB (x) square made up of 10% broad leaved and 10% coniferous woodlands, 3% impermeable surfaces, 2% water, 5% heather and or 2% rock, 10% fruit and vegetables, 20% rough grazing, 20% permanent grass, 8% temporary grass and 10% cereals would, in June , be allocated an average albedo 0.18. This means that taking the albedo as .25 would result in a 7% under-estimate of energy available for evaporation and (Fig 3) in a pe value some 9% low.

Real (as opposed to potential) evaporation is limited by the water available. Fig 4 compares potential and real on actual smd using Penman's root constant model (Penman (1949)) and SMEM (x) (the experimental soil moisture extraction model used in MAHWAB (x)). In SMEM (x) there is a limit of smd for a given rooting depth and Penman's model is normally subjected to an upper limit in practice. Use of, say 1.09E instead of E would result in any given value of smd being attained more quickly but would not affect the maximum value attained. The correct estimation of pe is of great importance in the development of smd with time; it is also important in terms of losses from reservoirs etc.

Penman, H L (1948) Natural evaporation from open water, bare soil and grass. Proc Roy Soc 1948, Ser A, 193, 120-145.

Penman, H L (1949) The dependence of transpiration on weather and soil conditions J Soil Sci 1949, 1, 74-89.

MONTHLY P. E. (mm) at KEW, JAN. 1971 to APRIL 1976. [Lat 51.5 N.]



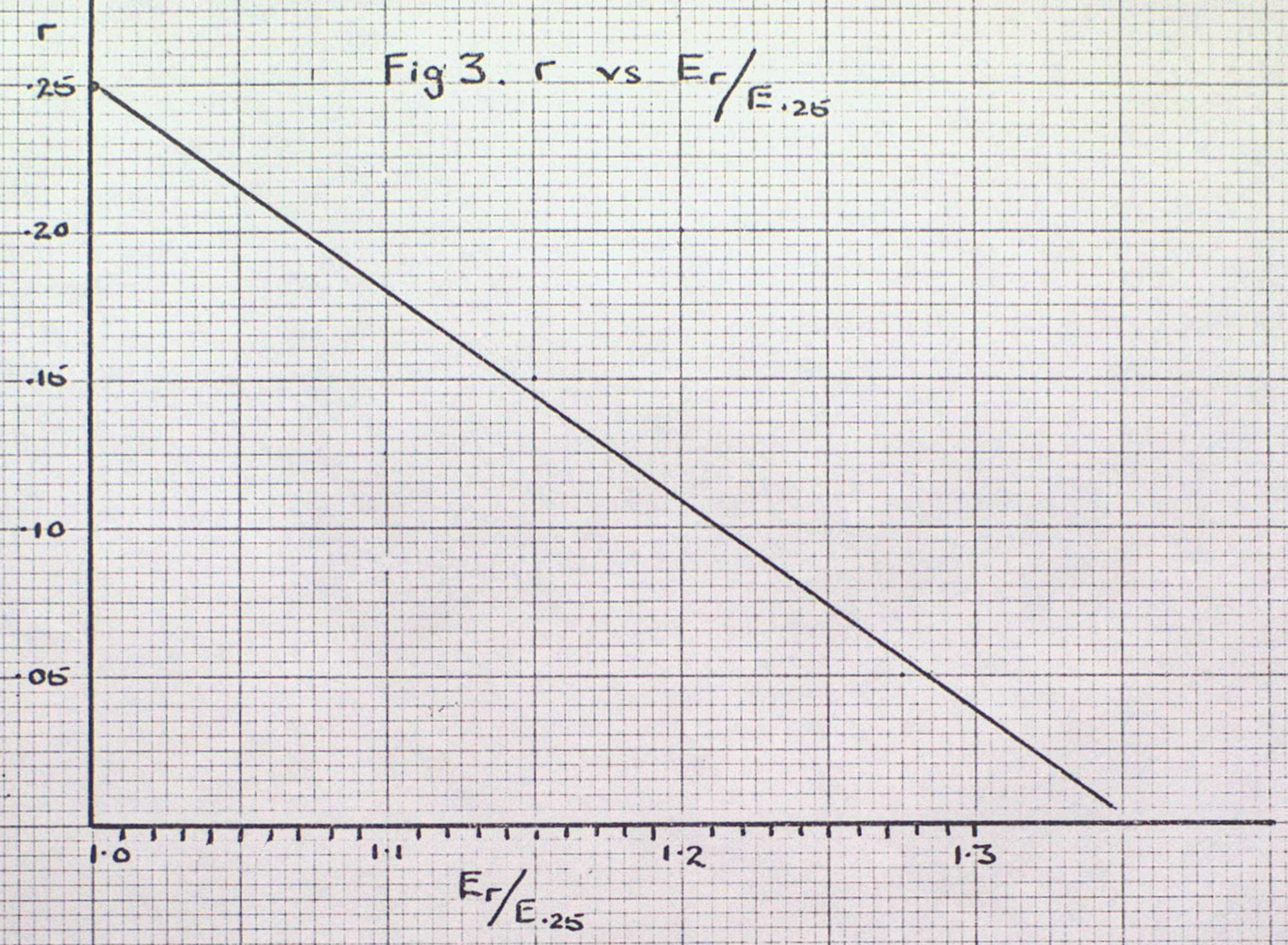
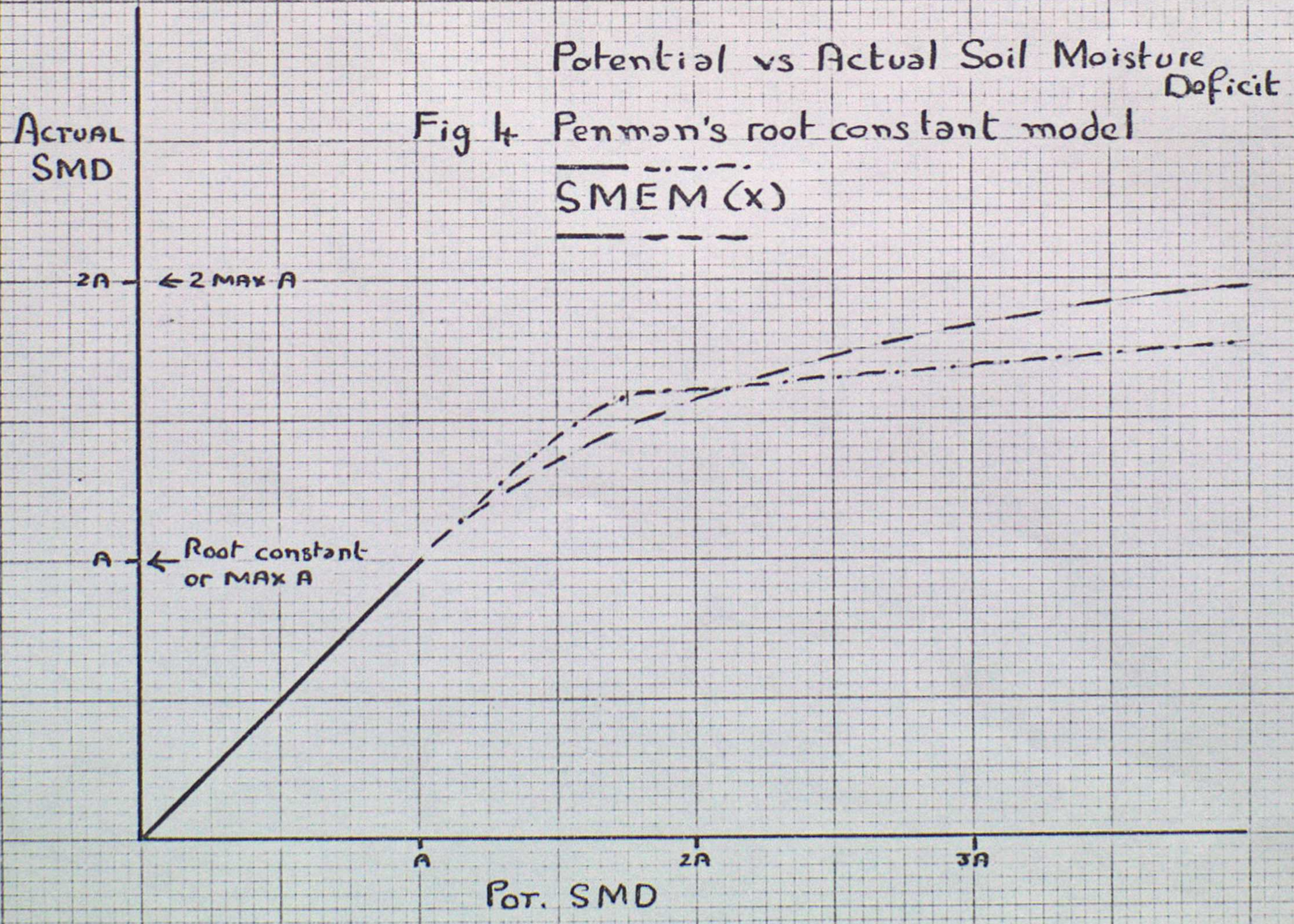


Fig 3. r vs Er/E.25
r
·25
·20
·15
·10
·05
1·0
1·1
1·2
1·3
Er/E.25


Potential vs Actual Soil Moisture Deficit
Fig 4 Penman's root constant model
SMEM (x)
ACTUAL SMD
2A
← 2 MAX A
A
← Root constant or MAX A
A
2A
3A
POT. SMD