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Job No.			
Sheet no.	1		
Date	24/09/10		
Project	By: IJ	Checked	Approved
Title: Evapotranspiration calculations			

Design data:-

Location = BRACKNELL
National Grid = SU8769
Latitude (φ)= 51º 21' 16.36"
Elevation = 30 m
Month = September
Day = 22
Maximum temp. = 17.0ºC
Minimum air temp. = 12.00ºC
Mean air temp = 14.50ºC
Wind speed (2m) = 2.30 m/s
Sunshine hours = 6
Albedo (α)= 0.23

Calculated data:-

Constants:

Specific heat (C_p) of air	= 1.005kJ/kg/ºK
Latent heat of vapourisation (λ)	= 2.450MJ/kg
Day of year (J)	= 265

Air values:

Atmospheric pressure (P) at 30 m	= 100.9 kPa
Air density (ρ) for 30 metres at 14.5ºC	= 1.216kg/m³

Vapour pressures:

Saturation Vapour pressure (e_s) at 14.5ºC	= 1.651 kPa/ºC
Calculated actual vapour pressure (e_a)	= 1.40 kPa
Calculated actual vapour pressure ($e^o[T_{max}]$)	= 1.94 kPa
Calculated actual vapour pressure ($e^o[T_{min}]$)	= 1.40 kPa
Mean calculated actual vapour pressure (e_{s_mean})	= 1.670 kPa/ºC
Slope of vapour pressure curve (Δ) at 14.5ºC	= 0.11 kPa
Psychrometric constant (γ) for 30 metres	= 0.067

Sun values:

Solar declination (δ)	= -0.012 rads
Sun hour angle (ω)	= 1.555 rads
Daylight hours	= 11.882 hours

Radiation values

Extraterrestrial radiation (R_a)	= 22.791MJ/m²/day
Shortwave radiation (R_{so})	= 17.23MJ/m²/day
Calculated Solar radiation (R_s)	= 14.33MJ/m²/day
Net shortwave radiation (R_{ns})	= 11.03MJ/m²/day
Net longwave radiation (R_{nl})	= 4.52MJ/m²/day
Net radiation (R_n)	= 6.51MJ/m²/day
Equivalent evaporation	= 2.66mm/day
Outgoing radiation (R_o)	= 8.44MJ/m²/day

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Calculation of ET_o (FAO Penman-Monteith / ASCE) :-

$$ET_{ref} = \frac{0.408\Delta(R_n - G) + \gamma(C_n/T+273)\,U_2(e_s - e_a)}{\Delta + \gamma(1 + C_d\,U_2)}$$

where :-

ET_{ref} = reference evapotranspiration in mm/day.

Δ = Slope of vapour pressure curve at 14.5ºC

R_n = Net radiation

G = Soil heat flux density.....ignored in this calculation

γ = Psychrometric constant for 30 metres

T = mean daily air temperature at 2m

U_2 = wind speed at 2 metres

e_s = saturation vapour pressure

e_a = actual vapour pressure

C_n = numerator constant ..... 900 for short grasses (<= 0.12m)

C_d = denominator constant ..... 0.34 for short grasses (<= 0.12m)

substituting :-

$$ET_{ref} = \frac{0.408 \times 0.11\,(6.51 - 0) + (0.067 \times \{900/[14.50 + 273]\} \times 2.30(\,1.67 - 1.40)}{0.11 + 0.067 \times (\,1 + [0.34 \times 2.30])}$$

giving :-

ET_{ref} = 1.82 mm/day (1.82 l/m²/day)

NOTES :-

1) The mean air temperature is average of maximum and minimum daily values.
2) The actual vapour pressure assumes dewpoint temperature is the same as the minimum temperature.
3) If no measured sunlight value is entered, the working value is assumed to be 50% of daylight hours.
4) The numerator constant is a function of the time-step, and aerodynamic resistance.
5) The denominator constant is a function of the time-step, bulk surface resistance, and aerodynamic resistance.

For further information, refer to the ASCE or FAO documents.