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Groundwater Extraction and The Water Balance

By

George H. Hargreaves[1]

ABSTRACT

Groundwater extraction and net use are related to groundwater depletion and the water balance. Potential evapotranspiration, actual crop or vegetative evapotranspiration, dependability of precipitation, moisture deficits and a moisture availability index are defined.

A method is presented for estimating potential evapotranspiration and crop evapotranspiration from a minimum of climatic data. For arid areas the only weather measurement required is temperature. Crop factors are presented for a wide variety of crops. A water balance study for an essentially closed basin in Nicaragua is described and used to illustrate the relationships proposed.

The economics of using groundwater extraction to prevent or alleviate drainage problems is discussed. Irrigation requirements are related to the economics of pumping water for irrigation.

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INTRODUCTION

A portion of the groundwater extracted from the area of withdrawal will be returned to the ground-water aquifer if the area of withdrawal corresponds to the area of water use. If net use of groundwater exceeds recharge there will be a lowering of the water table. It is frequently desirable to know in a general way what changes can be expected by various rates of use. A better understanding can be had of these changes providing evapotranspirational uses by crops and native vegetation can be estimated. Since in many areas only a minimum of data are available the procedure for estimation should be as simple as is practicable.

It sometimes becomes desirable that irrigation by groundwater extraction be combined with irrigation from rivers or reservoir storage in order to prevent or alleviate drainage problems. A better knowledge of net water use provides a criteria for planning and for the estimating of the amount of pumping required.

A knowledge of irrigation requirements is a necessary part of the economic analysis in feasibility studies for irrigation development whether from groundwater or surface supplies. This paper provides the basic procedures for accurately estimating net water requirements.

DEFINITION OF TERMS

Actual Evapotranspiration, ETA, or crop evapotranspiration is the water used by crops or vegetation including evaporation from moist soils and vegetation. It depends principally upon climate, rate and stage of crop growth and soil moisture availability.

Potential Evapotranspiration, ETP, is the amount of water transpired from an actively growing short green plant cover (usually grass) with a continuously adequate moisture supply. It includes evaporation from plants and from the soil surface. For this study values used are based upon short rye grass grown under conditions of low advection, deep rooted grasses at Coshocton, Ohio and grass mixtures having similar water requirements. It is dependent upon climate and can be estimated from climatic parameters.

<u>Dependable Precipitation</u>, PD, is the precipitation at a specified probability of occurrence based upon a gamma distribution analysis. For irrigation development a seventy-five percent probability, or the rainfall that can be anticipated to be equalled or exceeded three years out of four based upon the available rainfall records, has been selected as a reasonable probability level for most agricultural conditions.

<u>Moisture Deficit</u>, ETDF, is the difference between potential evapotranspiration and the dependable precipitation. It is an index of irrigation needs and requirements.

<u>Moisture Availability Index</u>, MAI, is the ratio of dependable precipitation to the estimated potential evapotranspiration. For many crops, under uniform soil fertility and other conditions, production increases as a straight line function of MAI between values of MAI of 0.34 and 0.70 to 0.85. MAI is therefore proposed as a convenient index of moisture adequacy or deficiency from precipitation.

ESTIMATING POTENTIAL EVAPOTRANSPIRATION

The California State Department of Water Resources (2)[2] measured Class A pan evaporation from pans located in irrigated grass surrounds and grass and pasture evapotranspiration in various locations representing four distinct climatic zones. Grass and pasture evapotranspiration averaged about 0.80 times pan evaporation. This relationship was particularly well demonstrated by the data from the coastal fogbelt area. Based upon this study it is believed that for fairly large irrigated areas potential evapotranspiration, ETP, can be approximated from the equation

$$ETP = 0.80 \times EVPM \qquad (1)$$

in which EVPM is the measured Class A pan evaporation from a pan located in a fairly large irrigated area. This relationship is also probably satisfactory for locations having fairly low sensible heat transfer as is the case for high humidities with low wind velocities. For highly advective conditions (hot dry windy weather), particularly with bare soil surrounds, the ratio of

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[2] Numerals in parentheses refer to corresponding items in the Appendix-References.

grass evapotranspiration from lysimeters to pan evaporation may be as low as 0.55 and possibly lower.

Blaney-Criddle, Thornthwaite and Hargreaves (5) have related potential evapotranspiration to day length and climatic factors. A methodology proposed by Christiansen (3) and since used and modified by various graduate students and technicians uses extraterrestrial radiation expressed as units of evaporation and coeffficients for the various weather elements. An equation for potential evapotranspiration, ETP, can be written that combines these concepts with an addition of a correction for latitude (sun angle). A monthly potential evapotranspiration factor, MF, is multiplied by temperature in degrees Fahrenheit, TMF, and relative humidity correction, CH, in order to obtain estimated values of ETP. The equation can be written

$$ETP = MF \times TMF \times CH \quad (2)$$

in which

$$MF = C \times R \times DL/12 \times CLA$$

where

C = a constant depending upon the units of ETP

R = extraterrestrial radiation expressed as equivalent evaporation by dividing the radiation (calories per square centimeter per day) by the heat of vaporization at the mean temperature in degrees centigrade, TM, and converting to appropriate units, usually inches or mm per month.

DL = Day length in hours (sunrise to sunset)

$CLA = 0.17 \times (70 - ABLA)^{1/2}$ (2a)
with a maximum value of 1.00

ABLA = absolute value of the latitude in degrees

$CH = 0.166 \times (100 - HM)^{1/2}$ (2b)
with a maximum value of 1.00

HM = mean monthly 24-hour relative humidity in percent.

In arid climates (mean 24-hour relative humidity of 64 percent or less) the correction for humidity, CH, becomes 1.00 and can be omitted from equation 2. Values of MF depend only on latitude and can be published for all latitudes. The calculation of potential evapotranspiration for arid areas is therefore accomplished by multiplying a tabular value times mean temperature in degrees Fahrenheit. Values of MF, the monthly evapotranspiration factor, are given in inches per month and mm per month in Appendix III, Tables A1 and A2. Computer equations for calculating monthly values, MF, of the potential evapotranspiration factor and daily values, DF, are also presented in Appendix III.

In order to demonstrate the validity of equation 2 a comparison was made between ETP and measured grass evapotranspiration, ETL, at various locations. These comparisons are shown for four locations, varying from latitude 56 degrees north to 38 degrees south, together with the climatic data in Appendix III.

CROP EVAPOTRANSPIRATION

A good summary of crop coefficients to be used with Class A pan evaporation from well standardized conditions is given by Middleton, Pruitt, Crandall and Jensen (7). The coefficients apply to full crop cover conditions and have been converted so as to apply to potential evapotranspiration, ETP. Crop evapotranspiration or actual evapotranspiration, ETA, is obtained from the equation

$$ETA = K \times ETP \qquad (3)$$

in which K is a crop coefficient. Crop coefficients based upon those given by Middleton, et al. (7) are given in Table 1.

Table 1. Average Crop Coefficients to be Used for Full Crop Cover

Crop	K		K
Apples, Delicious	1.31	Potatoes, White Rose (early)	1.21
Alfalfa, Ranger (arid)	1.19	Potatoes, Neted Gem (late)	1.16
Beans, Red Mexican	1.11	Sorghum, NK 140	1.09
Soybeans	1.11	Sorghum d.d. yellow Sooner	0.96
Clover, Ladino	1.13	Wheat, Marfed (spring)	1.15
Corn (field)	1.15	Wheat, Omar (winter)	1.13
Pear, Dark Perfection	0.96	Grapes, Concord (no cover)	0.86
Peaches, Elberta (no cover)	1.25	Alfalfa, DuPuits (humid)	1.16
Peaches, Elberta (alfalfa cover)	1.00	Rasberries, Payallup	1.24
Sugar Beets	1.13	Strawberries, Northeast	0.48

All available sources of crop evapotranspiration data were used to provide a general summary of crop coefficients for both full crop cover conditions and for the growing season average. These coefficients are from the data available principally from agricultural experiment stations and various publications and are presented in Table 2.

Although timing of water availability has an important influence on crop growth and yields there is a general relationship between moisture adequacy and production. Scott (8) demonstrates essentially no change in production per unit of water applied between 45 and 75 percent of ETA. The moisture adequacy yield curve became approximately a straight line relationship within that range and yields per unit of water applied fell off with increasing adequacy up to 100 percent of the value ETP x K. The relationship beyond full adequacy is not given.

Various other crops demonstrate similar production functions with a maximum value of water in the production function occuring at about 70 to 85 percent of fully adequate application.

A WATER BALANCE STUDY

A water balance and irrigation requirements study was made in 1971 by the UNDP Groundwater Investigations in Nicaragua of the Chinandega-Leon drainage area. The area investigated is nearly a closed basin comprising 136,400 hectares. A land use inventory of all crops and vegetation groupings was available. Precipitation was measured at 23 locations. Groundwater outflow was estimated from water levels and well tests along the zone of outflow which is a very limited area.

Potential evapotranspiration was calculated from the weather data using monthly means. The crop coefficients used for full crop cover or full vegetative cover and full moisture availability are given in Table 3.

The crop coefficients were reduced during periods of less than full crop cover and during periods of less than full moisture availability. Dates of drying of vegetation were used to determine periods of moisture shortage.

Table 2. Crop Coefficients, K (for use with potential evapotranspiration ETP)

Crop	Average K for Full Crop Cover	Average Seasonal K
Field and oil crops including beans, castor beans, corn, cotton, flax, peanuts, potatoes, safflower, soybeans, sorghum, sugar beets, tomatoes, and wheat	1.15	.90
Fruits, nuts and grapes		
Citrus fruits (oranges, lemons and grapefruit)	.75	.75
Deciduous fruits (peaches, plums and walnuts)	.90	.70
Deciduous fruits with cover crop	1.25	1.00
Grapes	.75	.60
Hay, forage and cover crops		
Alfalfa	1.35	1.00
Short grass	1.00	1.00
Clover pasture	1.15	
Green Manure	1.10	.95
Sugar cane	1.25	1.00
Summer vegetables	1.15	.85

Table 3. Crop Coefficients for Full Cover and Full Moisture Adequacy - Chinandega-Leon Area, Nicaragua

Crop or Vegetation	Crop Coefficient	Crop or Vegetation	Crop Coefficient
Sugar Cane	1.25	Cotton	1.15
Bananas	1.15	Improved Pasture	1.25
Irrigated Pasture	1.25	Native Grass	1.15
Vegetables	1.15	Forest	1.35
Grain	1.15		

The study included irrigation requirements and an estimate of the probable changes in water levels for various areas under irrigation. A summary was made for the area giving mean precipitation, vegetative consumptive use, changes in ground water storage, surface water outflow, unaccountable irrigation losses and ground water outflow. An estimate was made relative to the area that can be economically irrigated without adversely affecting the water balance.

EXTRACTING GROUNDWATER FOR DRAINAGE

A knowledge of crop evapotranspiration provides a useful criteria for evaluating the possibilities of controlling drainage problems or preventing a rise in water table elevations from creating drainage problems.

Pumping of groundwater has been planned as part of numerous surface irrigation projects. The irrigation planning and design for much of the east side in the Central Valley of California was based upon the assumption that 35 percent of the water used would be pumped from groundwater. This was to minimize future drainage problems.

The Modesto and Turlock irrigation districts in California formerly operated systems of open drains. They now use a system of wells to provide drainage as well as irrigation water result-in substantial profits from the irrigation water pumped. In the Salt River Valley of Arizona pumping about one third of the irrigation supply from groundwater solved the drainage problem.

Unfortunately not all drainage problems can be solved in this manner. Successful extraction of groundwater for drainage requires satisfactory water quality, a favorable salt balance and suitable aquifer conditions.

ECONOMIC CONSIDERATIONS

A fairly precise estimate of irrigation requirements is necessary in order to determine the desirable size of pump and motor and to make an economic analysis including capital and operating costs. Methods of preparing engineering costs estimates are given in various hand books. Less information, however, is available on the economics of under irrigating or over irrigating various crops.

Scott (8) made a study of the value of water used in producing sugar cane. If a factor is used to indicate available water used divided by the potential use by the cane expressed as a percentage, then the relationship of production to the percentage factor can be summarized as follows:

Percentage Factor (Use x 100/Max ETA)	Tons of Cane Per Inch of Water Used
45-75 percent	0.84
80-90 percent	0.81
95 percent	0.77
100 percent	0.74

The concept of a percentage factor is similar to the moisture availability index previously defined. Mirnizami, as cited by Hargreaves (4), related yields of dry farmed wheat to moisture levels. Regression equations were developed relating yield to MAI and to ETDF. Correlation coefficients for the unfertilized trials were in the range of 0.93 to 0.97. Although straight line relationships were demonstrated, the range in MAI was about 0.33 to 0.84. Production per unit of available moisture can be expected to fall off significantly with increasing moisture availability.

An attempt was made to obtain moisture availability and yield data from as many representative locations as possible. Scott (8) used lysimeter evapotranspiration for determining potential water use by sugar cane. Three locations were compared. Beckett and Huberty (1) presented yield data for alfalfa at Davis and Delhi in California as a function of irrigation water applied. Stewart and Hagan (9) reported corn yields at Davis as a function of season total water supply. Where necessary the moisture available from irrigation was corrected by adding moisture available from rainfall.

If Y is expressed as a ratio of actual yield to the maximum yield under the prevailing fertility level, cultural practices and other conditions and X is the ratio of moisture available to the amount for which the yield is a maximum, then Y will vary from 0 to 1.0 and X from 0 to 1.0 or more. Based upon the data cited above a generalized production function equation can be written

$$Y = 0.8X + 1.3X^2 - 1.1X^3 \qquad (4)$$

Equation 4 results in a maximum increase in yield per increment increase in moisture at X = 0.394, Y = 0.450. The slope of the curve at this point is 1.31. The point where a unit increase in X produces a unit increase in Y (slope = 1.0) is X = 0.701, Y = 0.821. For values of X exceeding 1.02 Y decreases.

For sugar cane and alfalfa yield was maximum for a moisture adequacy or availbility approximately equal to the calculated values of ETP under the prevailing climatic conditions. Yield of corn was maximized at approximately 1.25 lysimeter evapotranspiration for corn (ETA) at the same location.

Although the slope of the production function may be influenced to some degree by fertility level, there was little scatter in the relationship found from the data cited above. It is therefore proposed that equation 4 is adequate for most economic models for the purpose of determining an "economic" optimum level of moisture adequacy. This economic optimization would require use of all operational costs and the product value per unit of Y. It is of interest however to note that in equation 4 seventy percent of optimum moisture produces 82 percent of optimum yield.

Water extracted from aquifers is frequently relatively expensive. As full adequacy (crop actual evapotranspiration) is approached the production per unit of water applied falls off. A careful evaluation of crop evapotranspiration requirement is therefore necessary in evaluating maximum returns per unit of investment in groundwater development.

CONCLUSION

Fairly precise estimates of irrigation requirements and net water use are required in the planning and evaluation of ground water developments for irrigation. The solution of drainage problems and estimation of possible future depletion is greatly facilitated through improved estimates of potential evapotranspiration. Methodology is presented for estimating potential evapotranspiration from a minimum of weather data for a wide range of climatic conditions. For most climates the only weather data required are mean temperature and mean humidity. For arid climates only temperature data are required.

Crop coefficients for use with potential evapotranspiration are based upon available sources from various parts of the world. The coefficients presented appear satisfactory for use in connection with prevailing cultural practices.

Under favorable conditions pumping from groundwater for irrigation provides an economically feasible method of furnishing drainage for gravity irrigation projects.

Since production per unit of water applied falls off above about 70 to 85 percent of full moisture adequacy, a good knowledge of crop water requirements is necessary for the economic evaluation of projects for the use of ground-water extraction for irrigation.

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APPENDIX II - NOTATION

Notations used in the text and in Appendix III are defined as follows:

ABLA = absolute value of the latitude in degrees
C = a constant in the evapotranspiration equation
CH = dimensionless coefficient for mean 24-hour relative humidity
CLA = dimensionless latitude correction
DEC = declination (angle of the sun)
DER = declination in radians
DETP = ETL - ETP
DF = daily evapotranspiration factor
DL = day length in hours (sunrise to sunset)
DM = number of days in the month
ETA = actual crop evapotranspiration
ETDF = moisture deficit or evapotranspiration deficit
ETIN = potential evapotranspiration in inches (monthly)
ETL = grass evapotranspiration in mm from lysimeter measurements
ETP = potential evapotranspiration in mm (monthly)
ETPD = potential evapotranspiration (daily values)
ES = mean monthly distance of the sun to the earth divided by the mean solar distance
EVPM = measured Class A pan evaporation
F = evapotranspiration factor in Tables A1 and A2 (MF)
FTMF = F x TMF or MF x TMF
HM = mean 24-hour relative humidity for the period
K = crop coefficient for estimating ETA
LD = degrees of latitude
LDM = minutes of latitude
MAI = moisture availability index (MAI = PD/ETP)
MF = monthly evapotranspiration factor
MO = month of the year
PD = dependable precipitation at 75 percent probability (that equalled or exceeded three years out of four)
R = extraterrestrial radiation expressed as equivalent evaporation

RET = ETL/ETP
RH = mean 24-hour relative humidity (HM)
RLD = extraterrestrial radiation in Langleys per day
RMD = R in mm per day at TM
RMM = R in mm per month at TM
TM = mean temperature in degrees centigrade
TMF = mean temperature in degrees Fahrenheit
X = ratio of moisture availability to the amount for which yield is a maximum
XLR = latitude in radians
Y - ratio of actual yield to maximum yield under prevailing conditions and practices.

APPENDIX III - COMPUTER EQUATIONS, ETP-ETL COMPARISONS AND ETP FACTORS

Computer Programs

Parts of computer programs are presented giving the data required and the equations for calculating day length, extra-terrestrial radiation and potential evapotranspiration. Equations are given for daily and monthly values. The symbols used are explained in Appendix II.

Computer Comparisons of ETP with ETL

Climatic data and comparisons of ETP with ETL are presented. Data used are from four locations where evapotranspiration measurements were available for all twelve months of the year. The locations are: Davis, California; Coshocton, Ohio; Copenhagen, Denmark and Aspendale, Australia. An explanation of the column headings is given in Appendix II.

Potential Evapotranspiration Factor, F, or MF

Tables A1 and A2 give values of a potential evapotranspiration factor in inches per month and in mm per month. This factor, F, is used to calculate ETP by multiplying F times TMF (mean temperature) and where appropriate, applying a correction for relative humidity. For arid climates (mean 24-hour relative humidity of 64 percent or less) a correction for relative humidity is not required.

```
 DATA USED FOR CALCULATION OF DAY LENGTH AND RADIATION
 -----------------------------------------------------
 DATA (DM(M), M=1,12)/31.,28.,31.,30.,31.,30.,31.,31.,30.,31.,30.,
131./
 DATA (DEC(M),M=1,12)/-20.949,-13.553,-2.683,9.207,18.606,23.016,21
$.196,13.523,2.289,-9.565,-18.854,-23.040/
 DATA (ES(M),M=1,12)/.97104,.98136,.99653,1.01313,1.02625,1.03241,1
$.02987,1.01916,1.00347,.98693,.97369,.96812/

 CALCULATION OF DAY LENGTH (DL) AND RADIATION (RMM)
 --------------------------------------------------
 XLR=(FLOAT(LD)+FLOAT(LDM)/60.)/57.2958
 DER=DEC(M)/57.2958
 Z=-TAN(XLR)*TAN(DER)
 IF(Z)7,8,7
7 OM=ATAN(SQRT(1.0-Z*Z)/ABS(Z))
 GO TO 9
8 OM=1.5708
9 DL=OM/0.1309
 IF(Z)12,13,13
12 DL=24.-DL
13 RLD=120.*(DL*SIN(XLR)*SIN(DER)+7.6394*COS(XLR)*COS(DER)*SIN(OM)/ES
 1(M))
 RMD=10.*RLD/(595.9-0.55*TM(M))
 RMM=RMD*DM(M)

 CALCULATION OF MONTHLY ETP
 --------------------------
 ABLA=ABS(FLOAT(LD)+FLOAT(LDM)/60.)
 CLA=.17*SQRT(70.-ABLA)
 IF(CLA.GT.1.00) CLA=1.00
 CH=.166*SQRT(100.-HM(M))
 IF(CH.GT. 1.00)CH=1.00
 MF=RMM*DL/12.*CLA*.000190
 TMF=32.+1.8*TM(M)
 ETP=MF*TMF*25.4*CH
```

CALCULATION OF DAILY ETP

```
  2 CONTINUE
    D=0.
    DO 90 M=1,12
    ND=DM(M)
    DO 80 K=1,ND
    NDA(K)=K
    D=D+1.
    Y=COS(0.0172142*(D+192.))
    DER=0.40876*Y
    DECL=57.2958*DER
    ES=1.00028+.03269*Y
    Z=-TAN(XLR)*TAN(DER)
    IF(Z)  44,43,42
 42 OM=ATAN(SQRT(1.0-Z*Z)/ABS(Z))
    DL=OM/0.1309
    GO TO 45
 43 OM=1.5708
    DL=12.
    GO TO 45
 44 OM=ATAN(SQRT(1.0-Z*Z)/ABS(Z))
    DL=24.-(OM/0.1309)
 45 CONTINUE
    RLD=120.*(DL*SIN(XLR)*SIN(DER)+7.639*COS(XLR)*COS(DER)*SIN(OM))/ES
    RMD=10.*RLD/(595.0-.55*TM)
    DF=RMD*DL/12.*CLA*.000190*25.4
    ETPD(K,M)=DF*TMF*CH
 80 CONTINUE
 90 CONTINUE
```

1960 DAVIS CALIFORNIA LAT 38 32 LONG 121 46 ELEV 18

MO	TM	TMF	RH	CH	RMM	MF	FTMF	ETL	ETP	ETIN	DETP	RET
1	7.4	45.	75.	.83	205.	.758	34.	29.	29.	1.14	0.	1.02
2	9.2	49.	64.	1.00	241.	.974	47.	63.	47.	2.48	16.	1.34
3	12.8	55.	68.	.94	356.	1.602	88.	87.	83.	3.43	4.	1.05
4	13.9	57.	66.	.97	432.	2.150	123.	120.	119.	4.72	1.	1.01
5	17.0	63.	65.	.98	510.	2.753	172.	158.	169.	6.22	-11.	.93
6	23.3	74.	57.	1.00	523.	2.934	217.	221.	217.	8.70	4.	1.02
7	24.5	76.	57.	1.00	530.	2.925	223.	214.	223.	8.43	-9.	.96
8	20.5	69.	60.	1.00	479.	2.473	170.	166.	170.	6.54	-4.	.97
9	20.4	69.	57.	1.00	385.	1.807	124.	132.	124.	5.20	8.	1.06
10	16.8	62.	54.	1.00	302.	1.272	79.	94.	79.	3.70	15.	1.19
11	10.9	52.	73.	.86	216.	.821	42.	39.	37.	1.54	2.	1.07
12	7.2	45.	77.	.80	188.	.674	30.	27.	24.	1.06	3.	1.12
AVE	15.3	60.	64.	.95	364.	1.762	113.	112.	110.	4.43	2.	1.06

15 YR AV COSHOCTON OHIO LAT 40 22 LONG 81 48 ELEV 360

MO	TM	TMF	RH	CH	RMM	MF	FTMF	ETL	ETP	ETIN	DETP	RET
1	-2.8	27.	75.	.83	189.	.666	18.	17.	15.	.67	2.	1.14
2	-1.6	29.	72.	.88	227.	.881	26.	27.	23.	1.06	4.	1.20
3	2.6	37.	71.	.89	343.	1.491	55.	42.	49.	1.65	-7.	.86
4	9.6	49.	68.	.94	424.	2.059	101.	80.	95.	3.15	-15.	.84
5	16.0	61.	71.	.89	508.	2.687	163.	153.	146.	6.02	7.	1.05
6	20.0	68.	75.	.83	522.	2.877	196.	170.	162.	6.69	8.	1.05
7	22.6	73.	73.	.86	528.	2.864	208.	173.	180.	6.81	-7.	.96
8	22.0	72.	74.	.85	475.	2.399	172.	149.	145.	5.87	4.	1.02
9	18.2	65.	74.	.85	375.	1.713	111.	103.	94.	4.06	9.	1.10
10	12.1	54.	71.	.89	288.	1.170	63.	65.	56.	2.56	9.	1.16
11	4.5	40.	74.	.85	201.	.730	29.	25.	25.	.98	0.	1.01
12	-1.8	29.	79.	.76	172.	.587	17.	16.	13.	.63	3.	1.25
AVE	10.1	50.	73.	.86	354.	1.677	97.	85.	84.	3.35	1.	1.05

1971 COPENHAGEN DENMARK LAT 55 41 LONG 12 33 ELEV 10

MO	TM	TMF	RH	CH	RMM	MF	FTMF	ETL	ETP	ETIN	DETP	RET
1	-.3	31.	91.	.50	73.	.140	4.	4.	2.	.16	2.	1.82
2	1.5	35.	83.	.68	122.	.293	10.	9.	7.	.35	2.	1.29
3	.2	32.	82.	.70	241.	.716	23.	12.	16.	.47	-4.	.74
4	5.8	42.	72.	.88	357.	1.278	54.	34.	48.	1.34	-14.	.71
5	11.5	53.	70.	.91	477.	1.965	104.	86.	94.	3.39	-8.	.91
6	13.5	56.	77.	.80	512.	2.268	128.	77.	102.	3.03	-25.	.76
7	16.5	62.	79.	.76	509.	2.187	135.	102.	103.	4.02	-1.	.99
8	16.5	62.	77.	.80	421.	1.606	99.	92.	79.	3.62	13.	1.17
9	12.0	54.	79.	.76	287.	.923	49.	43.	38.	1.69	5.	1.14
10	9.4	49.	78.	.78	174.	.455	22.	28.	17.	1.10	11.	1.62
11	4.5	40.	82.	.70	87.	.180	7.	9.	5.	.35	4.	1.77
12	5.1	41.	83.	.68	57.	.101	4.	8.	3.	.31	5.	2.80
AVE	8.0	46.	79.	.75	276.	1.009	53.	42.	43.	1.65	-1.	1.31

1961 ASPENDALE AUSTRALIA LAT -38 0 LONG 145 0 ELEV 20

MO	TM	TMF	RH	CH	RMM	MF	FTMF	ETL	ETP	ETIN	DETP	RET
1	23.8	75.	57.	1.00	560.	3.101	232.	254.	232.	10.00	22.	1.09
2	22.3	72.	52.	1.00	451.	2.346	169.	183.	169.	7.20	14.	1.08
3	19.6	67.	66.	.97	406.	1.928	130.	132.	126.	5.20	6.	1.05
4	17.8	64.	70.	.91	291.	1.243	80.	76.	72.	2.99	4.	1.05
5	13.1	56.	80.	.74	218.	.842	47.	40.	35.	1.57	5.	1.15
6	12.0	54.	80.	.74	175.	.638	34.	29.	25.	1.14	4.	1.14
7	10.1	50.	80.	.74	196.	.731	37.	28.	27.	1.10	1.	1.03
8	11.2	52.	83.	.68	262.	1.069	56.	38.	38.	1.50	-0.	1.00
9	13.8	57.	69.	.92	349.	1.587	90.	77.	83.	3.03	-6.	.92
10	17.2	63.	62.	1.00	464.	2.333	147.	134.	147.	5.28	-13.	.91
11	18.7	66.	59.	1.00	523.	2.846	187.	173.	187.	6.81	-14.	.93
12	19.7	67.	58.	1.00	574.	3.238	218.	190.	218.	7.48	-28.	.87
AVE	16.6	62.	68.	.89	372.	1.825	119.	113.	113.	4.44	-1.	1.02

TABLE A1. POTENTIAL EVAPOTRANSPIRATION FACTOR F FOR ETP IN INCHES/MO

NORTH LAT	JAN	FEB	MAR	APR	MONTH MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
60	.002	.007	.021	.041	.067	.080	.076	.053	.028	.012	.004	.001
59	.003	.008	.022	.043	.070	.082	.078	.055	.030	.013	.004	.002
58	.004	.009	.024	.046	.072	.085	.081	.058	.032	.015	.005	.002
57	.004	.010	.026	.048	.075	.087	.083	.060	.034	.016	.006	.003
56	.005	.011	.028	.050	.077	.089	.086	.063	.036	.018	.007	.004
55	.006	.013	.030	.053	.080	.091	.088	.065	.038	.019	.008	.005
54	.007	.014	.032	.055	.082	.093	.090	.067	.040	.021	.009	.005
53	.008	.015	.034	.057	.084	.095	.092	.070	.042	.022	.010	.006
52	.009	.017	.036	.059	.086	.097	.094	.072	.044	.024	.011	.007
51	.011	.018	.038	.061	.088	.099	.096	.074	.046	.026	.013	.008
50	.012	.019	.040	.063	.090	.100	.098	.076	.048	.028	.014	.010
49	.013	.021	.042	.065	.092	.102	.100	.078	.050	.029	.015	.011
48	.014	.022	.044	.067	.094	.103	.101	.080	.052	.031	.017	.012
47	.016	.024	.046	.069	.096	.105	.103	.082	.054	.033	.018	.013
46	.017	.026	.048	.071	.097	.106	.105	.084	.056	.035	.020	.015
45	.019	.027	.050	.073	.099	.108	.106	.086	.058	.037	.021	.016
44	.021	.029	.052	.075	.101	.109	.108	.088	.060	.039	.023	.018
43	.022	.031	.054	.077	.102	.110	.109	.090	.062	.041	.025	.019
42	.024	.032	.056	.079	.104	.111	.110	.091	.064	.043	.026	.021
41	.026	.034	.058	.081	.105	.113	.112	.093	.066	.045	.028	.022
40	.027	.036	.060	.083	.107	.114	.113	.095	.068	.047	.030	.024
39	.029	.038	.063	.084	.108	.115	.114	.097	.070	.049	.032	.026
38	.031	.040	.065	.086	.109	.116	.115	.098	.072	.051	.034	.028
37	.033	.042	.067	.088	.111	.117	.116	.100	.074	.053	.036	.030
36	.035	.044	.069	.089	.112	.117	.117	.101	.076	.056	.038	.032
35	.037	.045	.070	.091	.112	.118	.118	.102	.077	.057	.039	.033
34	.039	.046	.071	.091	.112	.117	.117	.102	.078	.059	.041	.035
33	.040	.048	.073	.091	.111	.116	.116	.102	.079	.060	.042	.037
32	.042	.049	.074	.091	.111	.115	.116	.102	.080	.061	.044	.038
31	.043	.050	.074	.092	.110	.114	.115	.102	.080	.063	.045	.040
30	.045	.052	.075	.092	.110	.113	.114	.102	.081	.064	.047	.041
29	.046	.053	.076	.092	.109	.112	.113	.102	.082	.065	.048	.043
28	.048	.054	.077	.092	.109	.111	.112	.102	.082	.066	.050	.044
27	.049	.055	.078	.093	.108	.110	.112	.102	.083	.067	.051	.046
26	.051	.056	.079	.093	.108	.109	.111	.101	.083	.069	.052	.048
25	.052	.058	.080	.093	.107	.108	.110	.101	.084	.070	.054	.049
24	.054	.059	.081	.093	.106	.107	.109	.101	.084	.071	.055	.051
23	.056	.060	.081	.093	.106	.106	.108	.101	.085	.072	.057	.052
22	.057	.061	.082	.093	.105	.105	.107	.100	.085	.073	.058	.054
21	.059	.062	.083	.093	.104	.104	.106	.100	.086	.074	.060	.056
20	.060	.063	.084	.093	.104	.103	.105	.100	.086	.075	.061	.057
19	.062	.065	.084	.093	.103	.102	.105	.099	.087	.076	.062	.059
18	.063	.066	.085	.093	.102	.101	.104	.099	.087	.078	.064	.060
17	.065	.067	.086	.093	.101	.100	.103	.099	.087	.079	.065	.062
16	.066	.068	.086	.093	.101	.099	.102	.098	.088	.080	.067	.063
15	.068	.069	.087	.092	.100	.098	.101	.098	.088	.080	.068	.065
14	.069	.070	.087	.092	.099	.097	.100	.097	.088	.081	.069	.067
13	.071	.071	.088	.092	.098	.096	.099	.097	.088	.082	.071	.068
12	.072	.072	.089	.092	.097	.094	.097	.096	.089	.083	.072	.070
11	.074	.073	.089	.092	.096	.093	.096	.096	.089	.084	.073	.071
10	.075	.074	.089	.091	.095	.092	.095	.095	.089	.085	.075	.073
9	.076	.075	.090	.091	.094	.091	.094	.094	.089	.086	.076	.074
8	.078	.076	.090	.091	.094	.090	.093	.094	.089	.087	.077	.076
7	.079	.077	.091	.090	.093	.088	.092	.093	.089	.087	.078	.077
6	.081	.078	.091	.090	.092	.087	.091	.093	.089	.088	.080	.079
5	.082	.079	.091	.089	.091	.086	.090	.092	.089	.089	.081	.080
4	.083	.079	.092	.089	.090	.085	.088	.091	.089	.090	.082	.082
3	.085	.080	.092	.089	.088	.084	.087	.090	.089	.090	.083	.083
2	.086	.081	.092	.088	.087	.082	.086	.090	.089	.091	.085	.085
1	.087	.082	.092	.088	.086	.081	.085	.089	.089	.092	.086	.086
0	.089	.083	.093	.087	.085	.080	.084	.088	.089	.092	.087	.088

TABLE A1. POTENTIAL EVAPOTRANSPIRATION FACTOR F FOR ETP IN INCHES PER MONTH

SOUTH LAT	MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
-1	.090	.083	.093	.086	.084	.078	.082	.087	.089	.093	.088	.089
-2	.091	.084	.093	.086	.083	.077	.081	.086	.089	.093	.089	.091
-3	.093	.085	.093	.085	.082	.076	.080	.086	.088	.094	.090	.092
-4	.094	.085	.093	.085	.081	.074	.078	.085	.088	.094	.091	.093
-5	.095	.086	.093	.084	.080	.073	.077	.084	.088	.095	.092	.095
-6	.096	.087	.093	.083	.078	.072	.076	.083	.088	.095	.093	.096
-7	.098	.087	.093	.083	.077	.070	.075	.082	.087	.096	.094	.097
-8	.099	.088	.093	.082	.076	.069	.073	.081	.087	.096	.095	.099
-9	.100	.089	.093	.081	.075	.068	.072	.080	.087	.097	.096	.100
-10	.101	.089	.093	.080	.073	.066	.070	.079	.086	.097	.097	.101
-11	.102	.090	.093	.080	.072	.065	.069	.078	.086	.097	.098	.103
-12	.103	.090	.093	.079	.071	.063	.068	.077	.085	.098	.099	.104
-13	.104	.091	.092	.078	.070	.062	.066	.076	.085	.098	.100	.105
-14	.106	.091	.092	.077	.068	.060	.065	.075	.084	.098	.101	.107
-15	.107	.092	.092	.076	.067	.059	.063	.073	.084	.098	.102	.108
-16	.108	.092	.092	.075	.066	.058	.062	.072	.083	.098	.103	.109
-17	.109	.092	.091	.074	.064	.056	.061	.071	.083	.099	.104	.110
-18	.110	.093	.091	.073	.063	.055	.059	.070	.082	.099	.104	.111
-19	.111	.093	.091	.073	.062	.053	.058	.069	.082	.099	.105	.113
-20	.112	.094	.090	.072	.060	.052	.056	.068	.081	.099	.106	.114
-21	.113	.094	.090	.071	.059	.050	.055	.066	.080	.099	.107	.115
-22	.114	.094	.089	.070	.057	.049	.053	.065	.080	.099	.107	.116
-23	.114	.094	.089	.069	.056	.048	.052	.064	.079	.099	.108	.117
-24	.115	.095	.088	.067	.055	.046	.051	.063	.078	.099	.109	.118
-25	.116	.095	.088	.066	.053	.045	.049	.062	.077	.099	.109	.119
-26	.117	.095	.087	.065	.052	.043	.048	.060	.077	.099	.110	.120
-27	.118	.095	.087	.064	.050	.042	.046	.059	.076	.099	.111	.121
-28	.119	.095	.086	.063	.049	.040	.045	.058	.075	.099	.111	.123
-29	.120	.096	.086	.062	.048	.039	.043	.056	.074	.098	.112	.124
-30	.120	.096	.085	.061	.046	.037	.042	.055	.073	.098	.113	.125
-31	.121	.096	.084	.060	.045	.036	.040	.054	.072	.098	.113	.126
-32	.122	.096	.084	.058	.043	.035	.039	.052	.071	.098	.114	.127
-33	.123	.096	.083	.057	.042	.033	.037	.051	.070	.097	.114	.128
-34	.124	.096	.082	.056	.040	.032	.036	.050	.069	.097	.115	.129
-35	.124	.096	.081	.055	.039	.030	.034	.048	.068	.097	.115	.130
-36	.124	.095	.080	.053	.037	.029	.033	.046	.067	.096	.115	.129
-37	.123	.094	.078	.051	.035	.027	.031	.044	.065	.094	.113	.129
-38	.122	.092	.076	.049	.033	.025	.029	.042	.063	.092	.112	.128
-39	.120	.091	.074	.047	.031	.024	.027	.040	.061	.090	.111	.126
-40	.119	.089	.072	.045	.030	.022	.026	.038	.059	.088	.109	.125
-41	.118	.087	.070	.043	.028	.020	.024	.037	.057	.086	.108	.124
-42	.116	.086	.068	.041	.026	.019	.022	.035	.055	.085	.107	.123
-43	.115	.084	.066	.039	.024	.017	.021	.033	.053	.083	.105	.122
-44	.113	.082	.064	.037	.023	.016	.019	.031	.051	.081	.103	.120
-45	.112	.081	.062	.036	.021	.015	.018	.029	.049	.079	.102	.119
-46	.110	.079	.059	.034	.020	.013	.016	.027	.047	.076	.100	.117
-47	.108	.077	.057	.032	.018	.012	.015	.026	.045	.074	.098	.116
-48	.107	.075	.055	.030	.017	.011	.013	.024	.043	.072	.096	.114
-49	.105	.073	.053	.028	.015	.010	.012	.022	.041	.070	.095	.112
-50	.103	.071	.051	.027	.014	.009	.011	.021	.039	.068	.093	.111
-51	.101	.069	.049	.025	.013	.008	.010	.019	.037	.066	.091	.109
-52	.099	.067	.047	.023	.011	.007	.009	.018	.035	.064	.089	.107
-53	.097	.065	.045	.022	.010	.006	.008	.016	.033	.061	.086	.105
-54	.095	.063	.042	.020	.009	.005	.007	.015	.031	.059	.084	.103
-55	.092	.061	.040	.019	.008	.004	.006	.013	.030	.057	.082	.101
-56	.090	.059	.038	.017	.007	.003	.005	.012	.028	.054	.080	.098
-57	.087	.057	.036	.016	.006	.003	.004	.011	.026	.052	.077	.096
-58	.085	.054	.034	.014	.005	.002	.003	.010	.024	.049	.075	.093
-59	.082	.052	.032	.013	.004	.002	.003	.009	.022	.047	.072	.091
-60	.079	.049	.030	.011	.004	.001	.002	.007	.020	.044	.069	.088

TABLE A2. POTENTIAL EVAPOTRANSPIRATION FACTOR F FOR ETP IN MM PER MONTH

NORTH LAT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
60	.061	.177	.525	1.039	1.700	2.026	1.920	1.334	.705	.299	.089	.037
59	.077	.203	.571	1.101	1.770	2.091	1.989	1.402	.757	.334	.108	.049
58	.095	.230	.618	1.161	1.837	2.152	2.054	1.467	.809	.370	.128	.063
57	.114	.258	.666	1.219	1.901	2.210	2.117	1.531	.861	.408	.151	.079
56	.135	.288	.714	1.277	1.962	2.265	2.176	1.592	.913	.447	.174	.097
55	.159	.319	.762	1.334	2.021	2.317	2.233	1.652	.965	.487	.200	.116
54	.183	.352	.811	1.390	2.078	2.367	2.287	1.711	1.017	.528	.227	.138
53	.210	.385	.861	1.445	2.133	2.415	2.340	1.768	1.069	.570	.256	.161
52	.238	.420	.911	1.499	2.186	2.461	2.390	1.824	1.121	.614	.286	.186
51	.268	.456	.961	1.552	2.238	2.506	2.439	1.879	1.172	.658	.318	.213
50	.300	.493	1.012	1.605	2.288	2.548	2.485	1.932	1.224	.703	.351	.242
49	.333	.531	1.063	1.657	2.336	2.589	2.531	1.985	1.276	.749	.386	.272
48	.367	.570	1.115	1.709	2.383	2.628	2.577	2.036	1.327	.796	.422	.304
47	.404	.610	1.167	1.760	2.429	2.665	2.616	2.086	1.379	.844	.460	.337
46	.441	.651	1.219	1.810	2.473	2.702	2.656	2.136	1.430	.892	.499	.372
45	.481	.693	1.271	1.859	2.515	2.736	2.695	2.184	1.481	.942	.539	.409
44	.521	.736	1.324	1.908	2.557	2.769	2.733	2.231	1.532	.992	.580	.447
43	.563	.780	1.376	1.956	2.597	2.801	2.769	2.277	1.583	1.042	.623	.487
42	.607	.824	1.429	2.003	2.636	2.831	2.804	2.323	1.633	1.094	.667	.528
41	.651	.869	1.482	2.050	2.674	2.860	2.837	2.367	1.684	1.145	.712	.571
40	.697	.915	1.535	2.096	2.710	2.887	2.869	2.410	1.734	1.198	.758	.615
39	.744	.962	1.588	2.141	2.745	2.913	2.899	2.452	1.783	1.251	.805	.660
38	.793	1.009	1.641	2.186	2.779	2.938	2.928	2.493	1.833	1.304	.854	.707
37	.843	1.057	1.694	2.229	2.811	2.961	2.956	2.533	1.882	1.358	.903	.755
36	.893	1.106	1.746	2.272	2.842	2.983	2.983	2.572	1.930	1.412	.953	.805
35	.940	1.148	1.789	2.301	2.856	2.987	2.991	2.596	1.967	1.458	.999	.851
34	.979	1.181	1.816	2.309	2.844	2.964	2.972	2.595	1.987	1.491	1.036	.889
33	1.018	1.214	1.842	2.317	2.832	2.941	2.953	2.595	2.006	1.524	1.073	.929
32	1.057	1.246	1.867	2.324	2.819	2.918	2.934	2.594	2.024	1.557	1.110	.968
31	1.096	1.278	1.892	2.330	2.806	2.895	2.915	2.592	2.041	1.589	1.147	1.008
30	1.135	1.310	1.916	2.336	2.793	2.871	2.895	2.589	2.058	1.621	1.184	1.048
29	1.174	1.341	1.940	2.341	2.779	2.847	2.875	2.586	2.074	1.653	1.222	1.088
28	1.214	1.372	1.963	2.346	2.764	2.823	2.855	2.583	2.090	1.684	1.259	1.128
27	1.253	1.403	1.986	2.350	2.750	2.799	2.834	2.579	2.105	1.714	1.296	1.168
26	1.292	1.434	2.008	2.353	2.734	2.775	2.813	2.574	2.119	1.745	1.332	1.208
25	1.332	1.465	2.029	2.356	2.719	2.750	2.792	2.569	2.133	1.774	1.369	1.249
24	1.371	1.495	2.050	2.358	2.702	2.725	2.770	2.563	2.146	1.804	1.406	1.289
23	1.410	1.525	2.070	2.359	2.686	2.699	2.747	2.556	2.159	1.832	1.442	1.330
22	1.449	1.554	2.089	2.360	2.669	2.674	2.725	2.549	2.171	1.861	1.478	1.370
21	1.488	1.583	2.108	2.360	2.651	2.648	2.702	2.541	2.182	1.888	1.514	1.411
20	1.527	1.612	2.126	2.359	2.633	2.621	2.678	2.533	2.192	1.916	1.550	1.451
19	1.565	1.640	2.144	2.358	2.614	2.594	2.655	2.524	2.202	1.942	1.586	1.491
18	1.604	1.668	2.161	2.356	2.595	2.567	2.630	2.514	2.211	1.969	1.621	1.532
17	1.642	1.696	2.177	2.353	2.575	2.540	2.606	2.504	2.720	1.994	1.657	1.572
16	1.680	1.723	2.193	2.350	2.555	2.512	2.581	2.493	2.227	2.020	1.691	1.612
15	1.718	1.750	2.208	2.346	2.534	2.484	2.555	2.482	2.235	2.044	1.726	1.652
14	1.756	1.776	2.222	2.342	2.513	2.456	2.529	2.470	2.241	2.068	1.760	1.692
13	1.794	1.802	2.236	2.337	2.491	2.427	2.503	2.457	2.247	2.092	1.795	1.732
12	1.831	1.828	2.249	2.331	2.469	2.398	2.476	2.444	2.252	2.115	1.828	1.771
11	1.868	1.853	2.261	2.324	2.447	2.369	2.449	2.430	2.256	2.137	1.862	1.811
10	1.905	1.878	2.273	2.317	2.423	2.339	2.421	2.415	2.260	2.159	1.895	1.850
9	1.941	1.902	2.284	2.310	2.400	2.309	2.393	2.400	2.263	2.180	1.928	1.889
8	1.977	1.926	2.294	2.301	2.376	2.278	2.365	2.384	2.265	2.201	1.960	1.928
7	2.013	1.949	2.303	2.292	2.351	2.247	2.336	2.368	2.267	2.221	1.992	1.966
6	2.049	1.972	2.312	2.282	2.326	2.216	2.306	2.351	2.268	2.240	2.024	2.004
5	2.084	1.994	2.320	2.272	2.300	2.185	2.277	2.333	2.268	2.259	2.055	2.043
4	2.119	2.016	2.328	2.261	2.274	2.153	2.247	2.315	2.268	2.277	2.086	2.080
3	2.154	2.037	2.334	2.250	2.248	2.121	2.216	2.297	2.267	2.294	2.116	2.118
2	2.188	2.058	2.340	2.237	2.221	2.089	2.185	2.277	2.265	2.311	2.147	2.155
1	2.222	2.078	2.346	2.224	2.193	2.056	2.154	2.257	2.263	2.327	2.176	2.192
0	2.255	2.098	2.350	2.211	2.165	2.023	2.123	2.237	2.260	2.343	2.205	2.229

TABLE A2. POTENTIAL EVAPOTRANSPIRATION FACTOR F FOR ETP IN MM PER MONTH

SOUTH LAT	JAN	FEB	MAR	APR	MONTH MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
-1	2.288	2.117	2.354	2.197	2.137	1.990	2.091	2.216	2.256	2.358	2.234	2.265
-2	2.321	2.136	2.357	2.182	2.108	1.956	2.059	2.194	2.251	2.372	2.263	2.301
-3	2.353	2.154	2.360	2.167	2.079	1.922	2.026	2.172	2.246	2.386	2.290	2.337
-4	2.385	2.172	2.362	2.151	2.050	1.888	1.993	2.150	2.240	2.398	2.318	2.372
-5	2.416	2.189	2.363	2.134	2.020	1.854	1.960	2.126	2.234	2.411	2.345	2.407
-6	2.447	2.205	2.363	2.117	1.989	1.820	1.926	2.103	2.226	2.422	2.371	2.442
-7	2.478	2.221	2.363	2.099	1.959	1.785	1.893	2.078	2.218	2.433	2.397	2.476
-8	2.508	2.237	2.362	2.081	1.927	1.750	1.858	2.054	2.210	2.443	2.423	2.510
-9	2.538	2.251	2.360	2.062	1.896	1.715	1.824	2.028	2.201	2.453	2.448	2.544
-10	2.567	2.266	2.357	2.043	1.864	1.679	1.789	2.003	2.191	2.462	2.473	2.577
-11	2.596	2.279	2.354	2.023	1.832	1.644	1.754	1.976	2.180	2.470	2.497	2.610
-12	2.625	2.292	2.350	2.002	1.799	1.608	1.719	1.950	2.169	2.477	2.520	2.643
-13	2.652	2.305	2.345	1.981	1.767	1.572	1.684	1.922	2.157	2.484	2.543	2.675
-14	2.680	2.317	2.340	1.959	1.733	1.536	1.648	1.895	2.144	2.490	2.566	2.706
-15	2.707	2.328	2.334	1.937	1.700	1.500	1.612	1.867	2.131	2.496	2.588	2.738
-16	2.734	2.339	2.327	1.914	1.666	1.464	1.576	1.838	2.117	2.500	2.610	2.769
-17	2.760	2.349	2.319	1.891	1.632	1.427	1.540	1.809	2.103	2.504	2.631	2.799
-18	2.785	2.359	2.311	1.867	1.598	1.391	1.504	1.780	2.088	2.508	2.651	2.830
-19	2.811	2.368	2.302	1.843	1.564	1.354	1.467	1.750	2.072	2.510	2.671	2.859
-20	2.835	2.377	2.293	1.818	1.529	1.318	1.431	1.719	2.056	2.512	2.691	2.889
-21	2.860	2.385	2.282	1.792	1.494	1.281	1.394	1.689	2.039	2.514	2.710	2.918
-22	2.883	2.392	2.272	1.767	1.459	1.244	1.357	1.658	2.021	2.514	2.728	2.947
-23	2.907	2.399	2.260	1.740	1.423	1.208	1.320	1.626	2.003	2.514	2.747	2.975
-24	2.930	2.405	2.248	1.713	1.388	1.171	1.283	1.595	1.984	2.513	2.764	3.003
-25	2.952	2.411	2.234	1.686	1.352	1.134	1.246	1.563	1.965	2.512	2.781	3.031
-26	2.975	2.416	2.221	1.659	1.316	1.097	1.209	1.530	1.945	2.510	2.798	3.058
-27	2.996	2.420	2.206	1.630	1.280	1.061	1.172	1.497	1.924	2.507	2.814	3.085
-28	3.018	2.424	2.191	1.602	1.244	1.024	1.134	1.464	1.903	2.503	2.830	3.112
-29	3.039	2.427	2.176	1.573	1.208	.988	1.097	1.431	1.881	2.499	2.845	3.139
-30	3.059	2.430	2.159	1.544	1.172	.952	1.060	1.397	1.859	2.494	2.859	3.165
-31	3.079	2.432	2.142	1.514	1.135	.916	1.023	1.364	1.836	2.489	2.874	3.191
-32	3.099	2.434	2.125	1.484	1.099	.880	.986	1.329	1.812	2.483	2.888	3.217
-33	3.119	2.435	2.106	1.453	1.063	.844	.949	1.295	1.788	2.476	2.901	3.242
-34	3.138	2.436	2.087	1.422	1.026	.808	.912	1.261	1.764	2.469	2.914	3.268
-35	3.157	2.436	2.068	1.391	.990	.773	.876	1.226	1.739	2.460	2.927	3.293
-36	3.148	2.415	2.030	1.348	.945	.731	.832	1.180	1.698	2.430	2.914	3.289
-37	3.120	2.378	1.980	1.297	.896	.686	.784	1.129	1.647	2.385	2.882	3.265
-38	3.090	2.340	1.929	1.246	.847	.643	.738	1.077	1.597	2.339	2.850	3.239
-39	3.058	2.302	1.878	1.196	.800	.600	.692	1.027	1.546	2.293	2.816	3.212
-40	3.025	2.262	1.826	1.146	.753	.559	.648	.977	1.495	2.245	2.780	3.183
-41	2.991	2.222	1.774	1.096	.708	.519	.605	.928	1.444	2.197	2.744	3.153
-42	2.955	2.180	1.722	1.047	.664	.480	.563	.880	1.393	2.147	2.706	3.122
-43	2.918	2.138	1.669	.999	.620	.443	.522	.832	1.343	2.097	2.666	3.088
-44	2.879	2.095	1.617	.951	.578	.407	.483	.786	1.292	2.047	2.626	3.053
-45	2.839	2.050	1.564	.904	.537	.372	.445	.740	1.241	1.995	2.584	3.017
-46	2.797	2.005	1.510	.857	.498	.339	.408	.696	1.191	1.943	2.540	2.979
-47	2.754	1.959	1.457	.811	.459	.307	.373	.652	1.141	1.890	2.496	2.939
-48	2.709	1.912	1.403	.766	.422	.276	.339	.609	1.091	1.836	2.450	2.898
-49	2.663	1.864	1.350	.721	.387	.247	.307	.567	1.041	1.781	2.402	2.855
-50	2.615	1.814	1.296	.677	.352	.220	.276	.527	.992	1.726	2.353	2.810
-51	2.565	1.764	1.242	.634	.319	.194	.246	.487	.943	1.670	2.302	2.763
-52	2.513	1.713	1.188	.592	.288	.170	.218	.449	.894	1.613	2.250	2.715
-53	2.459	1.661	1.133	.551	.258	.147	.192	.412	.845	1.556	2.196	2.664
-54	2.403	1.607	1.079	.511	.229	.126	.168	.376	.797	1.497	2.140	2.611
-55	2.345	1.552	1.025	.471	.202	.106	.144	.341	.750	1.438	2.082	2.556
-56	2.285	1.496	.970	.433	.176	.088	.123	.308	.703	1.377	2.022	2.498
-57	2.221	1.438	.916	.396	.153	.072	.103	.276	.656	1.316	1.959	2.437
-58	2.155	1.378	.861	.360	.130	.057	.085	.246	.610	1.253	1.894	2.374
-59	2.085	1.317	.806	.325	.110	.045	.069	.217	.564	1.189	1.826	2.307
-60	2.012	1.253	.751	.291	.091	.033	.055	.189	.519	1.124	1.755	2.236