NEW ZEALAND AGRICULTURAL ENGINEERING INSTITUTE

SCIENTIA ET INDUSTRIA CUM PROBITATE

WIND EROSIVENESS SUMMARIES FOR NEW ZEALAND SITES

PROJECT REPORT P/15

WIND EROSIVENESS SUMMARIES FOR NEW ZEALAND SITES

D. J. PAINTER

PROJECT REPORT P/15

June 1977

NEW ZEALAND AGRICULTURAL ENGINEERING INSTITUTE
LINCOLN COLLEGE, CANTERBURY,
NEW ZEALAND

CONTENTS

SUMMARY

Monthly, seasonal and annual values of wind erosiveness, prevailing wind-erosiveness direction and preponderance are given for the 21 New Zealand sites from which suitable hourly wind speed and direction data were available. The values are generally high (by comparison with U.S.A. values) and show considerable variation between sites and according to the time of year.

1. INTRODUCTION - THE WIND EROSION PROBLEM

Wind erosion control is particularly important in arable farming areas. It can be achieved by sheltering the soil in various ways, and by ensuring that the susceptibility of the soil to being eroded is low. This can be done by the proper choice of cultivation and management practices.

The ability of the wind to erode soil varies from place to place and is generally greater at some times of the year than at others. This 'ability' can be deduced from wind records. Where these records include wind direction, the importance of the various wind directions to potential wind erosion can also be deduced.

2. WIND EROSIVENESS AND WIND EROSION CONTROL

Wind erosion hazard depends upon the actual, rather than potential, amounts of soil transported. The factors in wind erosion hazard are:

(a) how erosive the winds are

(b) the area of cultivated or exposed soil

(c) how dry and erodible this soil is

(d) how serious the consequences of wind erosion would be.

Better estimates of wind erosion hazard than are available at present could benefit:

(a) land use planning

(b) shelter design

(c) criteria for allocating subsidies for soil conservation measures

(d) choice of cultivation techniques

(e) choice of when to cultivate.

Until objective values of wind erosion hazard become available, the wind erosiveness values given in this report can be used, along with estimates of the other factors affecting the hazard. These wind erosiveness values define the contribution <u>of the wind</u> to wind erosion hazard (Painter, 1977). The definitions of wind erosiveness (WE), prevailing wind erosiveness direction (PWED) and preponderance (PREP) are based on practices developed in the U.S.A. (Skidmore and Woodruff, 1968). Values for the 21 New Zealand sites having suitable wind records are given in the appendix. Provision of these values is the main purpose of this report.

3. METHOD OF CALCULATION

3.1 WIND EROSIVENESS

The wind erosiveness (WE) has been estimated from wind records using the following equation:

$$WE = \Sigma f \overline{u}^3 \quad \text{for } \overline{u} \geq u_t \quad (\text{units } m^3/s^3)$$

f are frequencies of occurrence of windspeeds ($\overline{u}$) in speed and direction class intervals; they are normalised so that $\Sigma f = 1$. u_t is a threshold speed, below which soil movement would not occur.

Windspeeds either measured at, or corrected to, 10 m height above ground have been used. A value of 9.8 m/s at this height was chosen for u_t (Painter, 1977).

3.2 PREVAILING WIND-EROSIVENESS DIRECTION AND PREPONDERANCE

Because windspeeds above a threshold speed are cubed in the wind erosiveness computations, the prevailing wind-erosiveness direction (PWED) is different (in general) from the prevailing wind direction. The prevailing wind-erosiveness direction is obtained by calculating the ratio of all wind erosiveness components parallel to a certain direction, to those at right angles to that direction.

When all compass directions have been examined, that which gives the maximum value of the calculated ratio is the prevailing wind-erosiveness direction. It is the direction in which the greatest potential for transporting soil occurs and is thus the direction at right angles to which shelter for wind erosion control purposes should ideally be aligned. For many purposes, the PWED can be given as an alignment, for example, N - S, as control measures designed to combat northerly winds will also be effective against southerlies.

The maximum value of the calculated ratio is referred to as the *preponderance* (Skidmore and Woodruff, 1968). This expression indicates by how much wind erosiveness in the prevailing wind erosiveness direction is greater than that in other directions. Preponderance is unity when there is no prevailing wind erosiveness direction, and shelter aligned in any direction would then be equally effective. Values typical of New Zealand sites are one to four, although much higher values occur (see Appendix).

4. DISCUSSION

4.1 ACCURACY OF THE ESTIMATES

The 21 sites listed in the appendix have been chosen because:

(a) wind data is (or was) recorded at each of them for each hour of the day,

(b) at least four years (and up to 13 years) of data is available as a frequency distribution,

(c) the anemographs are mounted at or near 10 m height,

(d) the locations are not obviously unsuitable (for example, by being in city surroundings or on top of an isolated hill).

At each site the variation of wind erosiveness throughout the year should accurately represent the potential ability of the wind to transport dry, erodible soil. The prevailing wind erosiveness direction and preponderance should likewise be accurate for the particular site. How well these values represent the locality near to the anemograph site can only be determined by a careful consideration of topography, obstructions and surface roughness effects.

Comparisons between sites will be influenced by the extent to which corrections for height reflect true speed differences in different weather conditions. Results might also differ if different periods of record are considered, as the two sets of results for Christchurch Airport show. Although no numerical estimates of accuracy can be given, it is unlikely that such sources of error would change the order in which the sites would be ranked on wind erosiveness values.

4.2 WIND EROSIVENESS ESTIMATES AT OTHER SITES

An approximate method for estimating wind erosiveness from mean speeds equivalent to monthly wind run has been given in Painter (1977). The relationship fits East Coast, South Island sites well, and is as good a fit as can be obtained to the other sites in the appendix. It is:

$$WE = 0.54\ \bar{u}_6^{3.9}$$

where $\bar{u}_6$ is the mean speed equivalent to the monthly wind run, measured at 6 m height above ground. More than 60 additional sites at which wind erosiveness can be estimated are made available in this way. Comparisons between sites using this method would be unreliable, but it should allow wind erosiveness variation throughout the year at a particular site to be predicted.

A rule-of-thumb to compare wind erosiveness for different months of the year, at a site where there is a record of at least four years of daily wind run measured at 6 m height above ground, is to take half the fourth power of the monthly equivalent speed measured in metres per second.

4.3 COMPARISON WITH UNITED STATES OF AMERICA RESULTS

Although the wind erosiveness, prevailing wind erosiveness direction and preponderance values given here and in Painter (1977) can be used in the same way as Skidmore and Woodruff's (1968) 'relative magnitude of wind erosion forces, prevailing wind erosion direction and preponderance' values, the numerical values may not be directly compared. Not only are the present units m^3s^{-3} (compared to $miles^3hour^{-3}$), but different values of threshold speed appropriate to the actual anemograph heights above ground have been used in this study. When the New Zealand data was processed in the way adopted by Skidmore and Woodruff, many of the wind erosiveness values lay between 100 and 300, compared to between ten and 100 for the U.S.A. monthly values (S.I. units).

Wind erosiveness values are high *compared to U.S.A. values (even from the 'dust-bowl' areas), but the wind erosion hazard is* lower *, mainly because very dry conditions are less frequent.* For such reasons wind erosiveness is not on its own as direct an indicator of wind erosion hazard as the corresponding 'relative magnitude of wind erosion forces' has been taken to be. The values of the wind erosiveness must be considered along with the likelihood of dry soil surfaces occurring at the particular time of year, the areas of soil cultivated (or otherwise exposed) in the locality, the particle size range (structure) of the soil and the consequences of wind erosion occurring, to arrive at a reasonable estimate of the wind erosion hazard.

5. REFERENCES

ANON. (1971) 'Wind erosion control', Soil and Water 8 (1 & 2) : 23 - 27.

PAINTER, D. J. (1976) 'What cost wind blown soil?', New Zealand Farmer 97 (23) : 47 - 48.

PAINTER, D. J. (1977) 'Wind erosiveness in New Zealand', (in press).

SKIDMORE, E.L. and WOODRUFF, N.P. (1968) 'Wind erosion forces in the United States and their use in predicting soil loss', USDA ARS Agriculture Handbook No 346, 42 pages.

APPENDIX

TABLE 1

Monthly, seasonal and annual values of wind erosiveness (WE), prevailing wind erosion direction (PWED), preponderance (PREP) and mean wind speed ($\bar{u}$) computed from hourly records for 21 New Zealand stations. (*One direction is given for brevity; it implies the alignment including the direction 180 degrees from it i.e. E implies the E-W alignment, SE implies the SE-NW alignment, etc)*

The following information is in each title line:
STATION NAME: N.Z. METEOROLOGICAL SERVICE IDENTIFICATION : PERIOD OF SURFACE WIND FREQUENCY DISTRIBUTION :
STATION HEIGHT ABOVE SEA LEVEL : INSTRUMENT HEIGHT ABOVE GROUND : (NOTE CONCERNING HEIGHT CORRECTION IF NEEDED)

UNITS: Wind erosiveness in m^3s^{-3}; mean wind speed in m/s.

TIWAI POINT: 168533 : 2/71-3/75 : 4 m ASL : 14 m HI : WE' and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	507	411	372	495	641	388	129	90	482	842	624	369	429	500	200	651	471	417	444
PWED*	ESE	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
PREP	2.4	2.3	3.9	3.1	3.1	2.0	2.1	2.7	2.3	3.4	4.2	3.1	2.4	3.3	2.1	3.3	2.7	2.7	2.7
$\bar{u}$	6.3	5.5	5.6	5.3	6.4	5.3	3.5	3.4	6.3	7.4	6.3	5.5	5.7	5.8	4.0	6.7	5.8	5.3	5.6

INVERCARGILL A: 168433 : 1/60-12/72 : 0.3 m ASL : 9.1 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	283	266	244	272	192	223	47	120	219	409	367	289	280	236	129	332	300	187	244
PWED*	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
PREP	4.5	4.2	3.6	3.9	3.5	3.0	2.6	3.3	2.1	3.1	3.3	3.2	3.9	3.7	3.0	2.8	3.2	3.5	3.3
$\bar{u}$	5.3	4.8	4.7	4.6	4.0	4.2	3.2	3.6	4.8	6.1	5.8	5.2	5.1	4.4	3.7	5.6	5.2	4.1	4.7

DUNEDIN A : 150921 : 1/63-12/72 : 1.3 m ASL : 10.0 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	67	51	73	102	75	94	25	80	95	138	108	82	67	83	66	114	114	52	83
PWED*	ENE	ENE	ENE	ENE	ENE	ENE	E	ENE	E	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE
PREP	3.5	4.4	2.6	2.8	3.2	4.9	2.6	2.3	1.4	1.9	3.2	3.9	3.8	2.9	3.2	2.0	3.2	2.0	2.7
$\bar{u}$	3.5	3.0	3.2	3.2	3.1	3.0	2.3	3.0	3.6	4.1	3.8	3.6	3.8	3.2	2.8	4.4	3.9	2.7	3.3

TIMARU A : H41323 : 1/58-12/62 : 22.8 m ASL : 10.0 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	12	8	3	6	4	3	2	1	4	11	13	14	12	4	2	9	9	4	7
PWED*	E	ESE	N	ESE	N	ENE	NNE	NNE	N	N	N	N	N	N	NNE	N	N	N	N
PREP	2.1	1.3	8.7	2.9	4.9	1.7	7.4	15.7	3.1	1.8	3.2	4.1	1.4	1.7	3.1	2.4	1.3	3.1	1.6
$\bar{u}$	2.5	2.0	1.7	1.8	1.6	1.4	1.3	1.6	2.0	2.4	2.8	2.7	2.4	1.7	1.4	2.4	2.5	2.4	2.0

CHRISTCHURCH A: H32451: 1/60-12/72 : 30.1 m ASL : 14.0 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	76	55	65	71	45	30	33	36	75	88	89	77	70	60	33	84	88	34	62
PWED*	E	ENE	NNE	ENE	NE	NE	NE	NE	N	SE	SE	E	E	NE	NE	SE	ENE	NE	ENE
PREP	1.2	1.2	1.2	1.6	1.9	2.0	2.2	1.8	1.1	1.5	1.5	1.1	1.2	1.4	2.0	1.3	1.0	1.2	1.0
$\bar{u}$	4.5	4.3	3.9	3.5	3.2	2.7	3.1	3.2	4.0	4.1	4.4	4.5	4.4	3.5	3.0	4.2	4.3	3.2	3.8

CHRISTCHURCH A: H32451 : 1/60-12/68 : 30.1 m ASL : 14.0 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	85	60	58	83	30	26	32	37	60	84	106	77	81	62	33	90			66
PWED*	E	E	NNE	ENE	NNE	NE	NE	NE	NE	SE	SE	ENE	E	NE	NE	SE			ENE
PREP	1.3	1.1	1.5	2.0	1.7	1.7	2.3	2.1	1.3	1.4	1.5	1.4	1.2	1.5	2.0	1.2			1.1
$\bar{u}$	4.6	4.2	3.8	3.4	3.1	2.7	3.1	3.2	3.8	4.1	4.4	4.5	4.4	3.4	3.0	4.1			3.7

KAIKOURA : G23471 : 1/64-12/72 : 99.1 m ASL : 6.7 m HI : WE and $\bar{u}$ corrected to 10 m : U_t also adjusted

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	238	260	256	307	371	314	225	323	359	326	266	270	242	311	287	316	312	263	291
PWED*	NE	NNE	NNE	NNE	NE	NE	NE	NE	NE	NE	NE	NE	NNE	NNE	NE	NE	NE	NE	NNE
PREP	4.2	3.4	2.7	2.9	4.2	3.8	3.6	3.7	3.5	2.3	2.3	3.1	3.7	3.3	3.7	2.6	3.2	3.2	4.5
$\bar{u}$	4.5	4.2	3.9	4.2	4.2	4.2	3.8	4.2	4.4	4.5	4.6	4.4	4.4	4.1	4.0	4.5	4.6	4.2	4.3

HOKITIKA : F20793 : 1/65-12/72 : 38.6 m ASL : 10.0 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	18	13	24	43	26	28	22	57	67	71	52	43	25	31	36	64	36	43	39
PWED*	ENE	ENE	ENE	ENE	ENE	E	NE	NNE	NNE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE
PREP	1.8	3.4	2.9	2.1	2.9	1.6	1.4	1.5	1.7	1.6	1.9	1.8	2.0	2.4	1.3	1.6	1.7	1.7	1.7
$\bar{u}$	3.1	2.7	2.7	2.9	2.5	2.6	2.5	3.0	3.4	3.7	3.5	3.1	3.0	2.7	2.7	3.5	3.3	2.6	3.0

WOODBOURNE A : G13581 : 1/46-12/50 : 26.4 m ASL : 28.3 m HI : WE and $\bar{u}$ corrected to 10 m : U_t also adjusted

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	61	56	49	18	24	19	18	30	52	61	35	60	59	30	22	50	67	14	40
PWED*	E	ESE	E	E	SSE	ESE	ESE	E	E	E	E	E	E	ESE	E	E	E	E	E
PREP	3.5	1.4	1.3	2.4	3.0	2.5	2.7	3.7	2.2	2.4	1.4	2.4	2.2	1.4	2.7	2.0	1.9	2.2	2.0
$\bar{u}$	3.6	3.8	3.2	2.8	2.6	2.7	2.8	3.2	3.5	3.8	3.4	3.8	3.7	2.8	2.9	3.6	4.0	2.5	3.3

NELSON A : G13222 : 1/62-12/72 : 1.5 m ASL : 14.3 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	82	56	54	66	44	26	20	50	77	104	117	104	81	55	32	100	85	49	67
PWED*	NNE	NNE	NE	NE	NE	NE	NE	NE	NNE	NNE	NNE	NNE	NNE	NE	NE	NNE	NNE	NNE	NNE
PREP	2.4	2.5	2.6	4.3	3.3	3.3	3.5	3.7	3.2	2.5	2.7	2.7	2.5	3.3	3.5	2.7	2.8	2.6	2.7
$\bar{u}$	3.8	3.5	3.1	2.9	2.3	1.9	1.8	2.5	3.3	3.8	4.1	4.0	3.8	2.8	2.1	3.8	3.7	2.4	3.1

WELLINGTON A : E14387 : 1/60-12/72 : 6.1 m ASL : 14.3 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	585	474	499	498	565	585	574	642	693	689	775	565	544	521	600	719	662	524	596
PWED*	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
PREP	5.7	5.6	4.8	4.6	4.3	4.6	4.8	4.9	4.7	5.2	5.3	5.4	5.6	4.5	4.7	5.0	5.0	4.8	4.9
$\bar{u}$	7.3	6.9	6.7	6.5	6.6	6.7	6.5	7.0	7.3	7.7	8.0	7.4	7.2	6.6	6.7	7.7	7.5	6.5	7.0

PARAPARAUMU A : E04991 : 2/62-12/72 : 11.5 m ASL : 12.8 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	57	51	34	81	85	100	75	85	116	115	111	75	61	81	87	114	102	69	82
PWED*	SE	SSE	N	SSE	NNE	N	NNE	NNE	N	SE	SE	SSE	SE	SSE	NNE	SE	SSE	SE	SSE
PREP	2.2	1.8	1.4	1.3	1.7	1.3	1.7	1.6	1.6	1.8	2.3	1.6	1.8	1.4	1.5	1.8	1.5	1.4	1.4
$\bar{u}$	3.8	3.5	3.3	3.5	3.6	3.8	3.6	4.1	4.5	4.6	4.4	3.8	3.7	3.5	3.8	4.5	4.4	3.4	3.9

LEVIN RESEARCH CENTRE : E05622 : 4/68-9/73 : 45.6 m ASL : 13.1 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	0	0.3	2	6	9	8	6	10	11	25	11	6	2	6	8	13	10	5	8
PWED*	N	ESE	E	E	E	E	E	E	E	E	E	ESE	ESE	E	E	E	E	E	E
PREP	0.0	-	8.4	2.9	3.2	4.0	8.6	9.3	5.6	9.8	5.7	8.1	-	3.3	6.6	4.1	3.8	5.1	3.7
$\bar{u}$	2.1	1.9	1.9	2.3	2.2	2.3	2.1	2.2	2.7	3.3	2.3	2.1	2.0	2.1	2.2	2.8	2.7	1.9	2.3

OHAKEA : E05231 : 1/60-12/72 : 47.1 m ASL : 17.0 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	166	131	102	149	75	118	57	100	132	173	225	160	153	108	92	177	197	68	132
PWED*	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE
PREP	4.9	5.7	5.2	5.2	2.7	2.9	2.9	2.4	3.7	4.5	5.5	5.1	5.2	4.4	2.7	4.6	4.3	4.1	4.2
$\bar{u}$	4.8	4.5	4.2	4.4	4.0	4.3	3.9	4.2	4.6	4.8	5.1	4.6	4.6	4.2	4.1	4.9	5.2	3.8	4.5

GISBORNE A : D87692 : 2/62-12/72 : 4.0 m ASL : 18.2 m HI : WE and $\bar{u}$ corrected to 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	55	57	31	42	62	60	66	67	92	103	108	64	59	45	65	101	97	38	67
PWED*	SE	SSE	SSE	SSE	N	N	N	SSE	SSE	SE	SE	SSE	SSE	SSE	N	SE	SSE	SSE	SSE
PREP	3.3	2.5	3.1	1.6	1.9	1.7	2.3	1.6	1.8	2.6	2.8	2.6	2.7	1.8	1.8	2.3	2.1	2.0	2.1
$\bar{u}$	3.8	3.7	3.5	3.5	3.7	4.0	3.9	4.2	4.4	4.5	4.5	3.9	3.8	3.5	4.0	4.5	4.6	3.3	4.0

WAIOURU : E95464 : 12/69-9/74 : 831.0 m ASL : 10.0 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	3	14	7	20	22	19	37	76	50	34	28	26	14	16	47	38	34	23	28
PWED*	NE	NNE	NNE	NNE	NNE	N	N	N	N	N	N	N	E	NNE	NNE	N	N	N	N
PREP	1.3	6.0	2.0	1.4	2.8	4.2	2.7	4.6	2.1	1.2	2.0	1.8	1.1	1.9	3.9	1.7	1.8	2.3	2.0
$\bar{u}$	3.3	3.6	3.4	4.1	3.8	3.6	3.9	3.9	4.3	4.5	4.0	3.7	3.5	3.7	3.8	4.5	4.4	3.3	3.8

NEW PLYMOUTH A : C94011 : 6/68-12/72 : 27.4 m ASL : 10.0 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	88	164	114	165	224	242	142	235	266	465	168	142	131	168	206	260	228	161	195
PWED*	SSE	SSE	SSE	E	E	E	ENE	NNE	ENE	ENE	E	E	SSE	E	E	ENE	E	E	E
PREP	1.2	2.6	1.4	1.6	1.3	1.5	1.2	1.2	1.4	2.0	1.3	1.2	1.4	1.3	1.1	1.5	1.2	1.2	1.2
$\bar{u}$	4.6	5.2	4.8	5.3	5.3	5.6	5.2	5.6	6.0	6.6	5.1	4.9	4.9	5.1	5.5	5.9	5.8	5.0	5.4

AUCKLAND A : C74082 : 1/66-12/72 : 7.6 m ASL ; 10.0 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	139	141	125	202	192	153	137	194	240	277	219	193	161	174	165	246	246	175	230
PWED*	NE	NNE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PREP	3.2	2.4	3.7	3.2	2.9	2.0	2.3	2.3	2.7	2.9	2.6	3.4	3.0	3.1	2.2	2.7	2.6	2.3	2.5
$\bar{u}$	5.4	5.0	4.7	5.3	4.7	4.5	4.3	5.0	5.6	6.0	5.6	5.7	5.4	4.9	4.6	5.7	5.6	4.7	5.2

ROTORUA A : B86131 : 4/64-12/72 : 285.8 m ASL : 10.0 HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	11	41	18	30	36	26	27	34	40	50	41	22	24	28	29	43	39	23	43
PWED*	N	SSE	ESE	ENE	NE	SE	N	N	ENE	ENE	E	E	SSE	ENE	SSE	ENE	ENE	SSE	ENE
PREP	1.1	2.9	1.4	1.6	1.1	1.4	1.6	1.4	1.8	1.7	1.4	1.1	1.6	1.2	1.3	1.6	1.1	1.0	1.6
$\bar{u}$	3.5	3.5	3.1	3.3	3.1	2.9	3.0	3.4	3.8	4.0	4.0	3.7	3.6	3.2	3.1	3.9	4.0	2.9	3.4

WHENUAPAI : A64761 : 1/66-12/72 : 25.8 m ASL : 10.6 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	58	46	37	54	53	48	61	78	97	83	69	54	47	48	65	82	98	38	60
PWED*	ENE	ENE	ENE	ENE	ENE	E	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE
PREP	1.7	2.2	3.3	2.7	2.4	1.8	2.6	2.1	2.0	2.5	2.0	2.1	1.9	2.7	1.9	2.2	2.3	2.1	2.2
$\bar{u}$	3.6	3.5	3.3	3.3	3.1	3.4	3.4	3.6	4.1	3.9	4.0	3.9	3.7	3.2	3.5	4.0	4.5	2.7	3.6

WHANGAREI A : A54733 : 8/58-7/63 : 36.5 m ASL : 10.6 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	0	7	12	12	13	9	16	7	14	17	10	0	2	12	11	10	9	9	9
PWED*	N	NE	E	E	ENE	ESE	E	E	E	ENE	NE	N	NE	E	E	ENE	E	ENE	E
PREP	0.0	5.6	3.3	1.3	2.0	2.1	2.7	3.8	3.4	2.2	11.4	0.0	5.6	1.9	2.4	2.4	2.4	1.9	2.0
$\bar{u}$	2.7	2.6	2.5	2.5	2.6	2.9	3.1	2.9	3.2	3.3	2.7	2.6	2.6	2.5	3.0	3.1	3.3	1.3	2.8

KAITAIA A : A53021 : 2/62-12/72 : 109.9 m ASL : 10.0 m HI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aut	Win	Spr	Day	Night	Annual
WE	55	76	52	127	70	83	101	118	84	75	101	47	59	66	114	86	107	42	97
PWED*	E	ENE	ENE	ENE	ENE	ENE	ENE	NE	NE	ENE	E	ENE	ENE	ENE	ENE	NE	ENE	NE	ENE
PREP	1.6	1.6	1.6	2.6	1.3	2.0	2.1	1.9	1.7	2.2	1.1	1.9	1.5	1.9	1.8	1.9	1.9	1.8	2.6
$\bar{u}$	4.3	4.6	4.4	4.6	4.3	4.7	4.8	4.8	4.9	4.6	4.7	4.5	4.5	4.4	4.8	4.8	5.4	3.8	4.6

OTHER N.Z.A.E.I. PROJECT REPORTS

P/1 The Effect of Fire on Standard 8 S.W.G. and High Tensile 12 S.W.G. Plain Fencing Wire: G.M. Garden (August 1967).

P/2 The Hydraulic Performance of Trough Valves: T.D. Heiler (July 1968) (2nd Edition May 1971) (out of print).

P/3 Procedures for testing trench laid plastic drain pipes up to 4" diameter: T.D. Heiler (July 1968) (out of print).

P/4 A Provisional Test Procedure for Crawler Tractor Safety Frames: E.M. Watson and G.M. Garden (July 1971).

P/5 Procedure for testing Broadcast-type Distributors used for the application of granular insecticide: J.E. Hager and K.R. Humphries (August 1969) (out of print).

P/6 Procedures for testing Boardcast-type Fertiliser Distributors: K.R. Humphries (February 1971).

P/7 Tractor Safety Frame Noise Levels: G.M. Garden with Medical Assessment by J.F. Copplestone (March 1971).

P/8 The Spinning Disc Distributor Part 1: G.R. Davies (February 1972) (out of print).

P/9 The Spinning Disc Distributor Part 2: G.R. Davies (February 1973) (out of print).

P/10 Flow Characteristics of Plastic Drainage Pipe available in New Zealand: M.S. Humphris and G.J. Harrington (June 1973).

P/11 The Flow Characteristics of some Pressure Reducing Valves: G.J. Harrington (October 1975).

P/12 Liquid Manure Pumps: Procedure for Clean Water Hydraulic Testing: A.J. Dakers (July 1976).

P/13 Contouring by Computer from Stadia Field Data: G.J. Harrington (May 1976).

P/14 Report on the Bruff TG1 Trenchless Drainlayer: V.J. Bidwell (October 1976).