MONITORING SOIL SALINITY USING ELECTROMAGNETIC CONDUCTIVITY MEASUREMENTS AND GEOSTATISTICAL PROCESSING

- a case study in Taveta, Kenya -

W.A. van Dooremolen

February 1992

Consultancy for:
Kenya Soil Survey, National Agricultural Research Laboratories, P.O. Box 14733, Nairobi, Kenya.
DLO The Winand Staring Centre for Intergrated Land, Soil and Water Research, P.O. Box 125, 6700 AC Wageningen, The Netherlands.

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SUMMARY

An electromagnetic device (EM 38) was used to measure apparent electrical conductivity (ECa) in a study area of 55 ha near Taveta (South-eastern Kenya). At 905 points, located in a 25*25 meter grid, apparent electrical conductivity was determined. In addition, $EC_{1:2.5}$ for the 0-30 cm layer was measured at 70 points within this grid at mutual distances of 100 meter. Clay content and gravimetric moisture contents were also determined for these points to see how these variables contributed to variations in the inductive electromagnetic conductivity measurements. To study the suitability of ECa measurements for salinity mapping purposes, a set of 29 random data points was selected in which EC and ECa readings were collected. Logtransformed $EC_{1:2.5}$ and Eca data, which show a normal distribution, were used for statistical manipulation. Using geostatistical interpolation methods, lnEC was estimated in these random points and compared to the real values to indicate the accuracy of several interpolation methods.

Both $EC_{1:2.5}$ and ECa displayed a high variability within the grid distances for both variables. This resulted in high nugget effects in the semivariograms. As a consequence, using ECa as a covariable in the cokriging procedure did not add significantly to the accuracy of estimations within the random testpoints, compared to ordinary kriging of lnEC.

Inverted salinity profiles make up the largest part of the area, due to high evapotranspiration and lack of irrigation since 1989 when the main irrigation channel was destroyed. Differences in profile and composition of the soils are reflected in the four soil units that were distinguished by Kanake (1982). Salinity profile and soil type proved to be of importance when correlating electromagnetic ECa measurements with $EC_{1:2.5}$ measurements. Multiple regression, stratified on soil type and type of salinity profile, revealed that moisture content and clay content contributed significantly to explaining EC.

ACKNOWLEDGEMENTS

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1 INTRODUCTION

Operation and maintenance of viable irrigation schemes and the efficient use of water requires up-to-date information on soil salinity. Monitoring soil salinity is complicated because of its high variability. Intensive soil sampling is usually required to account for spatial variability, whereas maps on current soil salinity become obsolete rather rapidly because of temporal variability (Rhoades & Corwin, 1984). The electrical conductivity of the saturated paste extract (ECe) has been widely used to characterize the salinity tolerance of crops. Because the determination of ECe is rather time consuming, however, only a limited number of soil samples are usually analyzed. Therefore reliable and fast procedures for producing soil salinity maps on a regular basis could improve the effective use of irrigation water, preventing soil degradation and sustaining crop production.
Recently, rapid field methods of measuring rootzone soil conductivity, utilizing electromagnetic induction, have been developed. Corwin and Rhoades (1981,1982,1984) demonstrated that soil salinity in the field can be assessed using the electromagnetic induction method, which has been used in geophysical explorations for mineral bodies and groundwater reservoirs for a long time. Measuring apparent electric conductivity (ECa) by means of inductive electromagnetic readings and processing data by means of geostatistical interpolation techniques seem promising as tools in monitoring soil salinity. This study deals with the practical applicability of these methods for producing accurate salinity maps.
In the present study, ECa and EC were measured at 905 and 70 locations on a regular grid at mutual distances of 25 and 100 meter respectively. A total of 29 random points was sampled to serve as testpoints. Kriging and cokriging were performed on the testpoints and predicted values of logtransformed EC were compared to actual values. Measured ECa values were used as covariables in the cokriging procedure.

2 STUDY AREA

2.1 Location and extent

The area was extensively described by Kanake (1982) and Berger and Kalders (1983). The Kimorigo irrigation scheme is located in Taveta Division of the Taita-Taveta District, at latitude 3°27'S and longitude 37°41.6'E, and at 730 m above mean sea level. The study area (55 ha of the Kimorigo scheme) lies roughly between irrigation channels c6 - c13 (Figure 1).

The Kimorigo scheme receives water from the Lumi river which is led to the scheme by a 2 km long channel. Dykes were constructed to prevent the cultivated plots from inundation during periods of flooding, generally occurring from April to June. In 1961 many of the irrigation works were destroyed as a result of flooding, leaving channels silted and no longer operational. Because the influence of floods was underestimated, faults in dykes are now a common feature. Due to bad constructing, water could not be discharged adequately by the drainage channels during periods of intensive rains. In 1989, farmers decided to break down the main irrigation channel at a intersection with the main drainage channel, to prevent flooding of the village. Repairs have not been conducted since. Starts have been made improving the drainage by digging new drainage channels but these have not been finished yet due to lack of funding. Since then farmers have dug small channels to use water from drainage channels for irrigation purposes. The main part of the scheme, however, has been abandonned. Within the study area about 30 % of the area is still being cultivated, cotton being the main crop. The remaining part is partially covered with bush and used for cattle grazing.

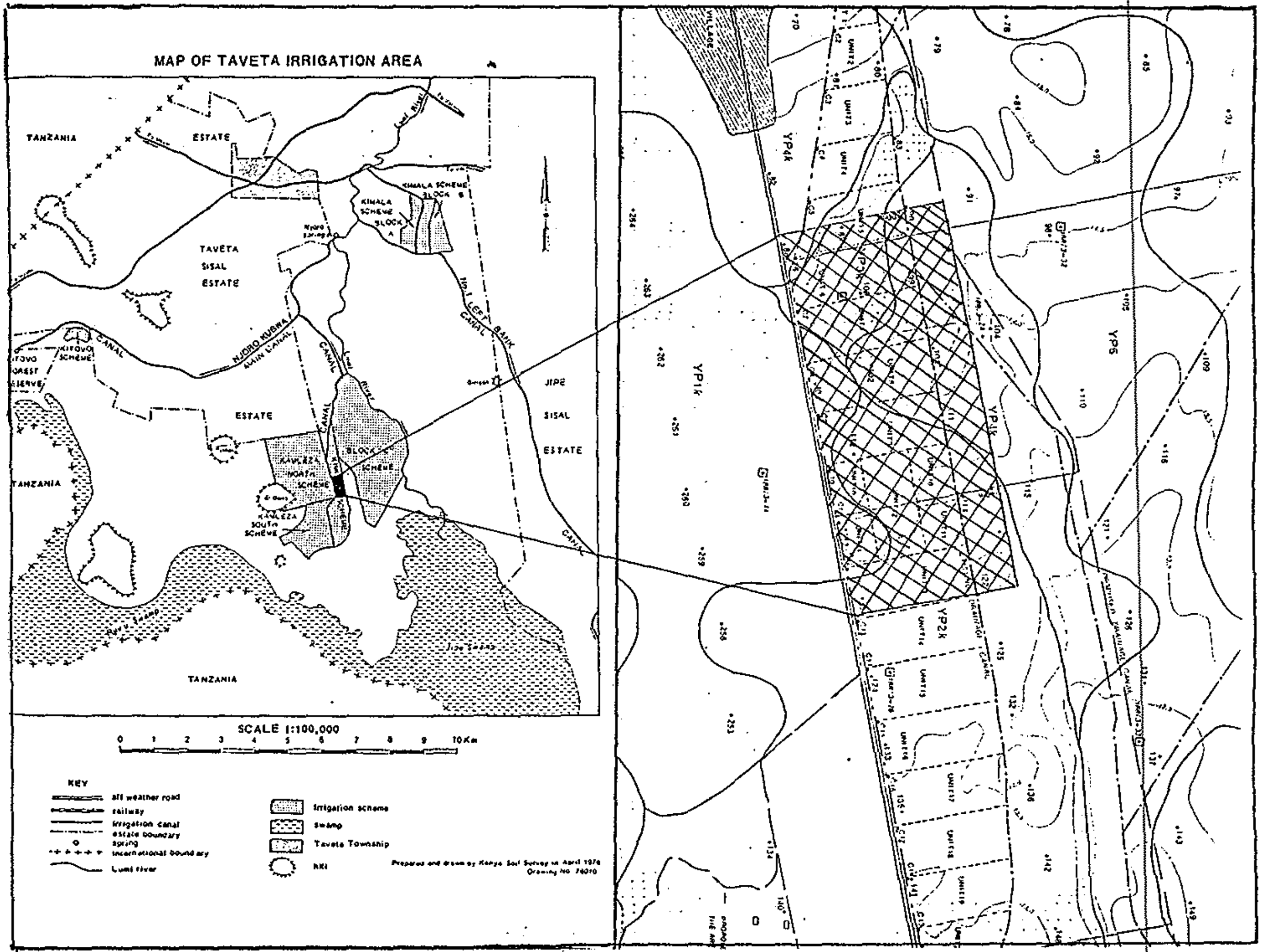


Figure 1. Location of study area.

2.2 Climate

The survey area belongs to the tropical semi-arid climate. Mean annual rainfall is 596 mm with a long rainy season between March and May and the short rains in November to December (Table 1). The calculated total potential evaporation (Eo) per year is 2146 mm and the ratio of rainfall to potential evaporation (r/Eo) is 28 %.
The mean annual temperature is 26 C, with the lowest mean in July-August (21 C), and the highest in December-January (28 C; Kanake, 1982).

Table 1. Rainfall data for Taveta, DO's office (Kanake, 1982).

Month	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	34	42	103	143	73	11	7	7	7	20	91	58

2.3 Geology and Physiography

The study area is located on an old alluvial plain formed by the Jipe swamp and the Lumi river. In a wider sense, it is viewed as part of the piedmont plain connecting the Pare mountains in the south with the Kilimanjaro volcanic pile to the north. The Pare mountains consist of metamorphic pre-cambrian rocks and the Kilimanjaro of volcanic rocks; the study area is made up of tuffaceous grits of Pleistocene to recent age (Kanake, 1982).
The area has a flat to very gently undulating topography and slopes gently to the marshes surrounding lake Jipe.

2.4 Description of soils

The soils of the study area are developed on Quaternary calcareous tuffaceous grits of Pleistocene or more recent date (Bear, 1955).
Two main soil types are distinguished within the study area i.e. (i) mollic Andosols (YP1,YP2 and YP3) which are generally well drained, moderately deep to deep clay soils, over a hard petrocalcic layer at 70 - 180 cm, these soils are non to slightly saline, and (ii) mollic Gleysols (YP4), imperfectly to poorly drained, moderately deep to deep clay soils, over a hard petrocalcic layer at 80 - 170 cm, they are moderately to strongly saline.

2.5 Salinity

Salinization hazard is a common problem of irrigated land in the semi-arid and arid regions. Within the Kimorigo scheme the cause of salinity has been attributed to poor drainage due to the presence of an impervious calcareous layer at a depth of 0.9 - 2.0 m (van Alphen et al., 1979; Kanake, 1982; Otieno, 1989). On the impervious layer a perched groundwater table

occurs which fluctuates through the seasons, ranging from 0.2 m in places during the wet season to 1.7 m during the dry season. The ground water quality is very poor with EC levels greater than 8 mS/cm (Otieno, 1989). First, the salts in the groundwater accumulate in the deeper soil layers during the dry season and second, the rising groundwater, coupled with high evapotranspiration transports the salts from deeper soil layers to the surface.
The spatial distribution of salinity depends on several parameters including hydrological conditions, soil characteristics and management which usually vary from place to place in the field resulting in a distinct spatial variability of salinity. The soil properties (hydraulic conductivity, soil water content, etc.) may vary in an irregular fashion in the horizontal plane, which may be much too complex to be described by analytical functions (Russo,1984). Knowledge of the nature of spatial variability is important for salinity management. Geostatistical methods can be used for describing the concentration distribution in the field. Besides, spatial distribution of salinity changes in time, due to variations in climate, irrigation and drainage. The impact of such changes varies from place to place and requires frequent monitoring in order to properly manage the land and control salinization.

3 METHODS AND MATERIALS

3.1 Inductive electromagnetic measurements

To sustain irrigated agriculture, periodic information on soil salinity is required. This knowledge is needed to assess the salt balance and water use efficiency. As more farmers tend to use the same amount of scarce irrigation water, leaching will decrease and salinization hazard will increase calling for a efficient distribution and use of the water.
Inventories on salt-affected soils are scarce in most tropical countries, nor are there monitoring programs to document the salinity status of soils and waters and assess the adequacy of irrigation and drainage systems. In order to establish long term monitoring programs, the need for simple and practical methods for measuring soil salinity is obvious.
Soil salinity can also be measured using electromagnetic induction. For ECa measurements the electromagnetic device EM38 was used. The instrument was primarily developed to determine relationships between apparent electrical conductivity (ECa) and salinity (Rhoades and Corwin, 1981). It has a transmitter coil and a receiver coil. An alternating current (13.2 KHz) in the transmitter coil induces a primary magnetic field, inducing current flows for the conducting components in the soil. In turn, these currents induce a secondary magnetic field (Figure 2). The instrument is designed such that the electrical conductivity is a linear function of the ratio of the secondary field to the primary field which is directly recorded. Thus, no electrodes need to be inserted into the surface and measurements can be taken at each spot at any time.

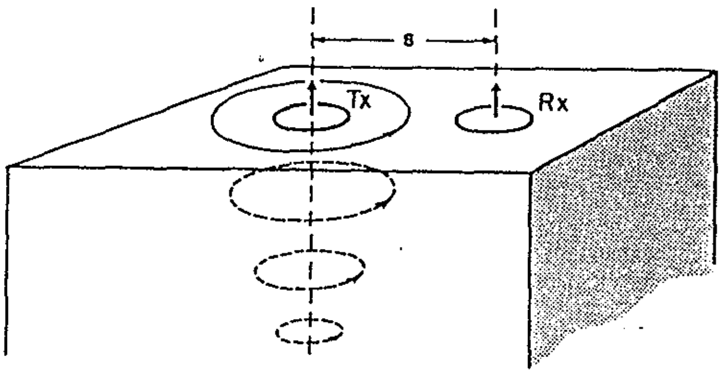


Figure 2. Induced current flow (homogeneous halfspace).(Tx = Transmitter coil, Rx = Receiver coil and s = intercoil spacing).

The EM38 measures the apparent electrical conductivity of the soil, which reflects the cumulative relative contribution of bulk soil conductivity of various layers above some depth. This depth depends on the distance between the coils. For the EM38 instrument this distance is fixed at 1 meter. McNeill (1980) showed that the apparent conductivity of the soil measured by the instruments equals:

$$\sigma_a = 4(Hs/Hp)/2\pi f \mu_o s^2$$

were σ is the conductivity of the soil (mS/m), Hp and Hs are the intensities of the primary and secondary magnetic fields at the receiver coil (ampere-turns/m), f is the frequency of the current (Hz), is the magnetic permeability of free space (i.e. air) in henrys/m, and s is the intercoil spacing (m).
The relationship between depth and relative contributions of the different depth intervals to the overall EM reading depends upon the orientation of the transmittercoil with respect to the soil surface (Rhoades, 1984). Figure 3 shows the relative responses for the horizontal and vertical orientation.

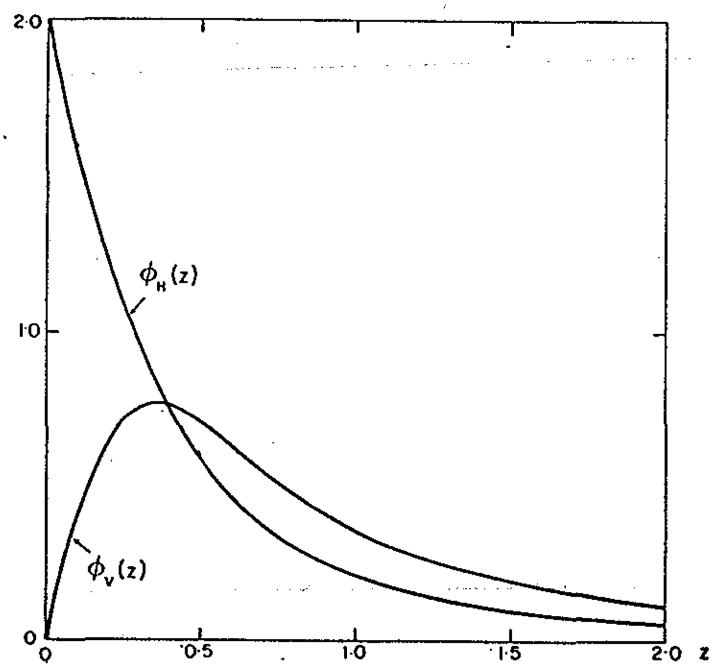


Figure 3. Comparison of relative responses for vertical and horizontal dipoles.

In vertical dipole mode, when the axes of the coils are orthogonal to the ground surface, the effective depth of penetration is around 1.5 meter. When operated on its side, called the horizontal dipole mode, the effective depth is about 0.75 meter. Comparison of the vertical and horizontal readings enables one to determine whether salinity increases or decreases with depth. The instrument has a range from 0 to 1000 mS/m in both dipole modes.

Practical techniques have been developed for determining the vertical ECa distribution from EM measurements. A series of equations has been derived which give the actual ECa, within a given soil depth interval from measurements of the apparent bulk soil conductivity made with the magnetic coils of the EM instrument when positioned both horizontally and vertically (Rhoades and Corwin, 1981;1982; 1989). In this way, bulk soil electrical conductivity of various soil layers can be determined rapidly and simply from two above-ground electromagnetic measurements.

Advantages of electromagnetic measurements (ECa) as compared to conventional EC measurements (EC) include that

(i) they are gathered rapidly and are directly collected in the field,

(ii) they do not alter the surface so one can measure at exactly the same spot more than once,

(iii) measurements in dry or stony soils are possible as there is no need for sampling or soil contact with electrodes, and

(iv) because of the large volume of soil that is subjected to the measurement, a reliable estimate of a weighted mean conductivity of the soil is obtained.

3.2 Statistical procedures

3.2.1 Sampling

Mixed soil samples of the upper 30 cm were taken in a 100*100 meter grid and for each sample electrical conductivity of 1:2.5 soil/water extract, gravimetric soil moisture and clay content were measured. Up to 70 samples were taken within the 55 ha study area.
Overlaying this main grid, a denser 25*25 meter grid was used for electromagnetic ECa measurements in both vertical and horizontal dipole positions using the EM38 apparatus, rendering a total of 905 observation points.
In addition, 29 random locations were taken as test points for which the mentioned characteristics were also determined. Sampling locations for both grids and random points are shown in Figure 4.
Relations between EM measurements and $ECe_{1:2.5}$, soil moisture and texture were studied by means of linear regression. To study spatial correlation, semivariograms and crossvariograms were made. They were used to interpolate to the 29 test points and to compare the accuracy of the predictions with the available ECe measurements in these points.

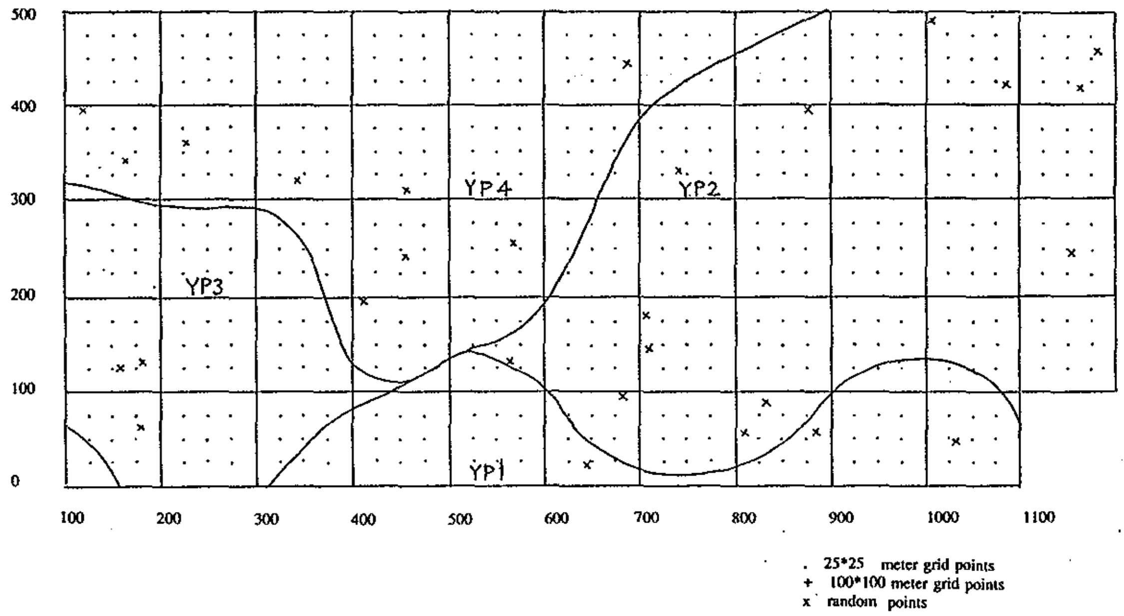


Figure 4. Locations of sampling points.

3.2.2 Multiple regression

Multiple regression was conducted to study the relation between electromagnetic readings, measured moisture and clay content and EC. In this way, regression models are obtained in which one response variable (y) is explained by several explanatory variables $(x_1,..x_n)$. LnEC was used as a response variable to stabilize the variance as it has more linear relations with the explanatory variables. Logtransformed EM readings and interactions with moisture and clay content were also added to the set of explanatory terms.
The EM38 measures the bulk soil conductivity. This figure is largely determined by EC, moisture content and clay content, which were all measured in the study area. To diminishe the possible interference of other conductive components, separate models were developed, stratified according to four soil units. An other factor of influence on EM measurements is the way EC levels are distributed with depth (salinity profile). In well drained soils, EC usually increases with depth. If drainage is imperfect and evaporation is high, salts tend to accumulate at the surface resulting in so-called inverted salinity profiles. EC measurements in profile pits showed that both types of salinity profiles occur within this study area. An EM38 measurement reflects the cumulative contribution to bulk soil conductivity of various layers above some depth. The relative response differs at different soil depth intervals as described in section 3.1. Salinity distribution with depth is thus of importance. Because the exact salinity profile at a certain location is not known it was derived from differences between EMh and EMv (Rhoades et al. 1989). Based on this, separate models were developed for homogeneous and inverted salinity profiles.
For each stratified subset, using one or more of the explanatory variables, the three best fits were calculated. The suitability of a model in a practical sense not only depends on the variance accounted for and the significance of the explanatory terms, but also on which terms are included in the model. Preferably only EM measurements were used since values were obtained in all 905 points at the 25*25 meter grid. Multiple regression equations were used to combine information from both EM-horizontal and EM-vertical readings to get a better correlation with lnEC in these points, as compared to the separate EM measurements. Regression models that include moisture and clay content could not be used for these points because they were only measured at the 100*100 meter grid.

3.2.3 Geostatistical interpolation

Spatial variability of the variables is described by semivariograms and cross-variograms. The semivariance is given by:

$$\gamma(h)=\sum_{i=1}^{N_h} [z(x_i) - z(x_{i+h})]^2 /2N_h$$

in which γ is the estimation for the semivariance for distance h and N_h the number of pairs of values $[z(x_i), z(x_{i+h}]$ separated by a vector h.
The semivariogram, besides providing information about anisotropies and correlation distances, can be used in the interpolation technique 'kriging', which takes account of the correlation between adjacent samples while estimating the interpolated value without bias and with minimum variance (Vauclin, 1983).
Kriging is a weighted moving average with an estimator of the form:

$$z(x_0) = \sum_{i=1}^{N} \lambda_i z(x_i),$$

where N is the number of observations $z(x_i)$ involved in the estimation of the unrecorded point x_0 and λ_i are the weights.
The weights are taken such that the estimator Z(x0) is unbiased and the variance is minimal. This yields the following kriging equation

$$\sum_{j=1}^{N} \lambda_j \gamma(x_i,x_j)+\mu=\gamma(x_i,x_0),\ i=1 \text{ to } N$$

under the restriction that

$$\sum_{j=1}^{N} \lambda_j = 1$$

When considering a second variable z_2 of which many measurements are available, we can estimate z_1, using the values of both z_1 and z_2 and the cross correlation between them, expressed as $\gamma_{12}(h)$. This crossvariance is given by:

$$\gamma_{12}(h) = \sum_{i=1}^{N_h} [(z_1(x_i) - z_1(x_{i+h})) (z_2(x_i) - (z_2(x_{i+h}))] /2N_h$$

The estimation can be done by the cokriging method in which the estimator has the form:

$$z_1(x_0) = \sum_{i=1}^{N_1} \lambda_{1i} z_1(x_{1i}) + \sum_{j=1}^{N_2} \lambda_{2j} z_2(x_{2j})$$

where λ_{1i} and λ_{2j} are the weights associated with z_1 and z_2, and N_1 and N_2 are the numbers of neighbours of z_1 and z_2 involved in the estimation of point x_0, respectively. (Vauclin et al., 1983).
The estimation will be unbiased if

$$\sum_{i=1}^{N_1} \lambda_{1i} =1 \quad and \quad \sum_{j=1}^{N_2} \lambda_{2j} = 0$$

Minimizing the variance yields the following cokriging equations:

$$\sum_{i=1}^{N_1} \lambda_{1i} \gamma_{11}(x_{1i},x_{1k}) + \sum_{j=1}^{N_2} \lambda_{2j} \gamma_{12}(x_{1k},x_{2j}) - \mu_1 = \gamma_{12}(x_0,x_{1k}),\ k=1 \ to \ N_1$$

and

$$\sum_{i=1}^{N_1} \lambda_{1i} \gamma_{12}(x_{2l},x_{1i}) + \sum_{j=1}^{N_2} \lambda_{2j} \gamma_{22}(x_{2j},x_{2l}) - \mu_2 = \gamma_{22}(x_0,x_{2l}),\ l = 1 \ to \ N_2$$

4 RESULTS

4.1 Descriptive statistics

$EC_{1:2.5}$, moisture content and clay content were measured on a rectangular 100*100 meter grid. Furthermore electromagnetic measurements were gathered on a 25*25 meter grid. The results of descriptive statistics on $EC_{1:2.5}$, electromagnetic measurements, moisture content (weight %) and clay content are shown in Table 2.

Table 2. Descriptive statistics for measurements in grid points.

variable	number of observ.	mean	median	standard deviation	variance	min.	max.
EC	70	247.6	208.4	228.4	51426.5	20	1115
EMh	905	321.4	316.0	148.2	21947.2	29	1000
EMv	905	285.7	260.0	145.1	21039.0	28	992
Moisture %	70	38.7	40.1	10.1	100.3	18	59
Clay %	67	60.0	60.0	6.8	45.2	38	76

As the frequency distribution of EC and EMh is close to lognormal, it is preferable to take the logarithm of the data before making the geostatistical estimation (Delhomme, 1974; Neuman, 1982). Figure 5 shows the distribution of EC and EM measurements before and after logtransformation. Descriptive statistics of logtransformed EC and EM measurements are shown in Table 3.

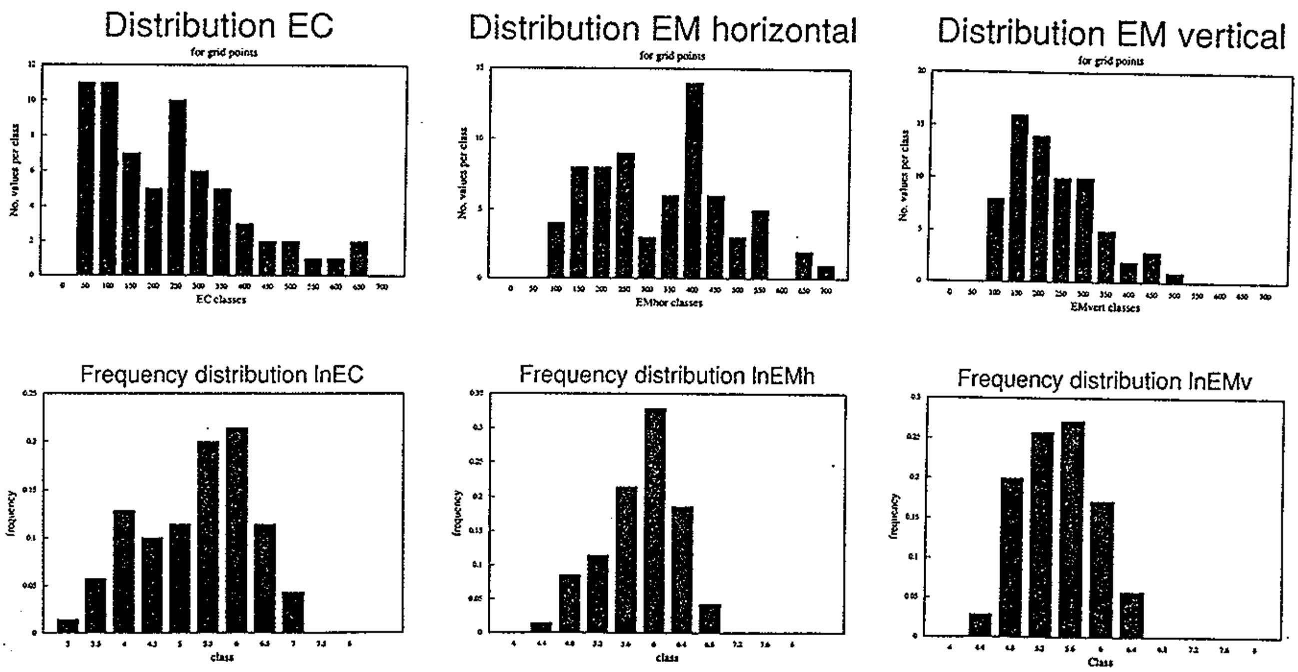


Figure 5. Frequency distribution of EC and EM measurements.

Table 3. Descriptive statistics for logtransformed measurements.

variable	number of observations	mean	median	standard deviation	variance	min.	max.
lnEC	70	5.1	5.3	1.00	0.99	3.0	7.0
lnEMh	905	5.6	5.8	0.52	0.27	3.4	6.9
lnEMv	905	5.5	5.6	0.53	0.29	3.4	6.9

The correlation matrix of the different variables is shown in Table 4.

Table 4. Correlation coefficients between the different variables.

	EC	lnEC	EMh	EMv	lnEMh	lnEMv	moist	clay
EC	1							
lnEC	0.876	1						
EMh	0.708	0.754	1					
EMv	0.053	0.025	0.091	1				
lnEMh	0.659	0.766	0.964	0.107	1			
lnEMv	0.088	0.046	0.082	0.970	0.087	1		
moist	0.116	0.263	0.023	-0.438	0.095	-0.439	1	
clay	-0.179	-0.241	-0.159	0.221	-0.163	0.222	0.012	1

Of interest are correlations between explanatory variables and response variables.
LnEC and lnEMh have the highest correlation coefficient (0.766). Their relation is linear, as can be seen in Figure 6.

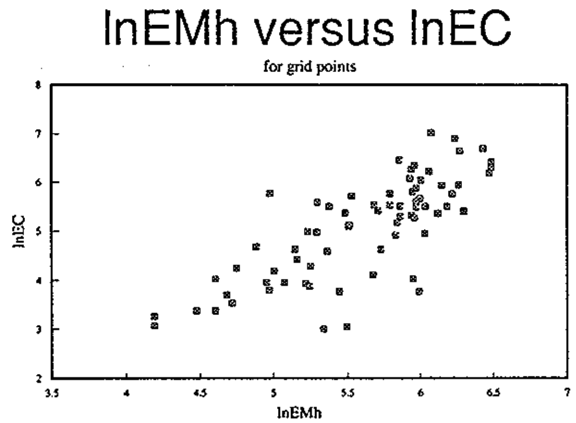


Figure 6. lnEC versus lnEMh.

4.2 Multiple regression

Multiple regression analysis was performed on EM measurements, gravimetric moisture content and clay content, in order to find a regression equation with lnEC as the dependent variable. Several models were employed to find an optimal relationship for calculating lnEC in the 25*25 meter grid. First we are mainly interested in a model that only has electromagnetic measurements as explanatory variables. Several models were tried, including both EM measurements and their interaction plus logtransformed values.
The interaction term between emh and emv is given by :
emhemv = emh * emv

Applying this procedure to the whole data set it was found that only lnEMh added significantly to the model.
The optimal regression equation yielded:

lnEC = -2.672 + 1.376 * lnEMh.

This model accounted for 55.5 % of the variance and had a variation of 0.43.

The EM38 measures the conductivity of an entire volume of soil. This means that other components, such as moisture and clay content, can have an impact on the measurements. Therefore these variables were added in the model, to explain lnEC. They proved to contribute significantly to the model.
The total set of explanatory terms thus becomes:

emh = horizontal EM reading,
emv = vertical EM reading,
emhemv = emh * emv,
lnemh = ln(emh),
lnemv = ln(emv),
lnemhemv = ln(emhemv),
moist = gravimetric moisture content,
tex = clay content (hydrometer content),
emhmoist = emh * moist,
emvmoist = emv * moist,
emhtex = emh * tex,

emvtex = emv * tex,
lnemhmoist = ln(emhmoist),
lnemvmoist = ln(emvmoist),
lnemhtex = ln(emhtex),
lnemvtex = ln(emvtex).

A model, accounting for 65.1 % of the variance can be found when moisture is included in the model :

lnEC = 3.351 + 0.004912 * emh - 0.00402 * emv + 0.0001352 * emvmoist

In this model moisture is included as an interaction term with emv. Emv also appears as a separate term. Adding also clay content to the model gives:

lnEC = 3.358 + 0.004789 * emh + 0.00012833 * emvmoist - 0.0000596*emvtex

accounting for 65.8 % of the variance.
Emv is now included as interaction term with moisture and clay content.

Separate models were fit for a series of subsets which were stratified based on soil type and salinity profile, as explained in section 3.2.2.
Stratification on salinity profile was based on the difference between EMh and EMv. If EMh > EMv, the salinity profile is considered inverted. If EMh < EMv, a normal salinity profile is expected (Rhoades et al. 1989). Figure 7 shows a contour map of the difference between EMh and EMv.

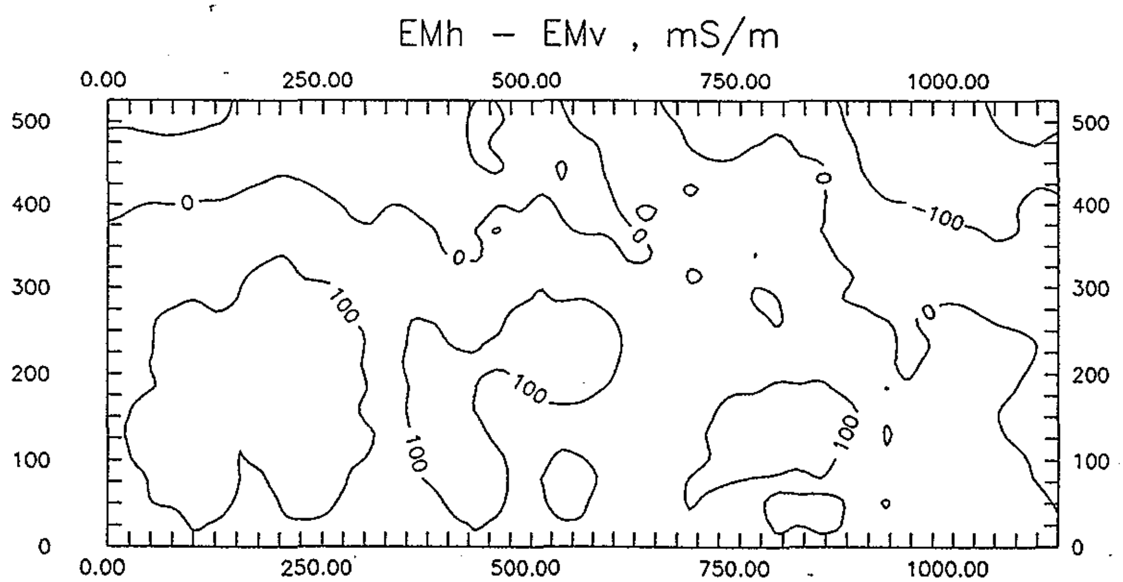


Figure 7. Contour map for difference between EMh and EMv.

First multiple regression equations were obtained for homogeneous salinity profiles. When using only inductive electromagnetic readings only 31.5 % of the variance of lnEC could be accounted for, giving:

2.205 + 0.02434 * emh - 0.0000389 * emhemv

However, when adding clay content and moisture content to the regression equations, the model could account for 80.3 % of the variation:

lnEC = 41.05 -6.2 * lnemv - 0.909 * moist + 0.0002494 * emhtex - 0.02182 * lnemhtex + 0.1756 * lnemvmoist

When adding more terms to the regression equation the model could be improved. However, since only a few points with a normal salinity distribution are available, too few degrees of freedom would be left for an accurate model.

For inverted profiles the model yielded:

lnEC = -4.32 + 1.664 * lnEMh

which accounted for 62.1 % of the variance.

Other soil characteristics like porosity, bulk density, etc., can have an influence on EM readings. Therefore stratification was performed based on 4 soil types in the area as described by Kanake (1982). Descriptions of the 4 soil types YP1, YP2, YP3 and YP4 are given in Appendix 1.
Soil types YP1 and YP3 have to few measuring locations to perform regression analysis.They are therefore united in one stratum.

Multiple regression was applied in which all terms plus interactions were used. This resulted in the regression equations given below.

- soil unit YP2.

Without moisture or clay content 57.3 % of the variance was accounted for yielding:

lnEC = -2.92 + 1.418 * lnemh

Including moisture gives:

lnEC = 15.66 + 0.00001826*emhemv - 2.495 * lnemv + 0.0001769 * emvmoist

which accounted for 70.1 % of the variance. Adding clay content hardly improved the model.

-soil units YP1 and YP3.

Without moisture or clay content up to 58.6 % of the variance was accounted for, giving:

lnEC = 13.8 + 0.0417 * emv + 5.36 * lnemh - 4.24 * lnemhemv

Including clay gave a slight improvement:

lnEC = 25.4 - 4.47 * lnemv - 0.1823 * tex + 0.000748 * emvtex + 0.01891 * lnemhtex

which accounted for 62.8 % of the variance. Adding moisture to the equations yields models with many variables and only slight improvements.

-soil unit YP4.

Without moisture or clay content, 68.3 % of the variance was accounted for, using the model

lnEC = 3.336 + 0.00538 * emh.

A significant improvement was found when adding clay content to the model, i.e.

lnEC = -10.45 + 1.62 * lnemhemv - 0.0001578 * emvtex

accounting for 84.8 % of the variance.

Up to 93.2 % of the variance was accounted for when moisture was added to the equation giving:

lnEC = -9.86 + 1.538 * lnemhemv + 0.0001002 * emvmoist - 0.0001908 * emvtex.

These models can be used to calculate lnEC for the 25*25 meter grid. However, only EM measurements are available in these points. If optimal regression equations are to be used, moisture and clay content will also have to be measured for the 25*25 meter grid. Furthermore, the way moisture and texture contribute to the bulk soil conductivity, as measured with the EM38, differs with soil type, resulting in regression models with different explanatory terms.

4.3 Interpolation

Interpolations were carried out on the 29 testpoints using kriging and cokriging. Real lnEC values were compared to the interpolated ones to study accuracy of the predictions. For the cokriging procedure a covariable is added. This covariable which is spatially correlated to the response variable (lnEC) is available for the 25*25 meter grid, providing more information on shorter distances which can result in better interpolations.
As one of the purposes of the study is to see whether easily obtainable EM measurement can be used to produce accurate salinity maps, lnEMh, which has the best correlation with lnEC, was used as a covariable to predict lnEC in the random testpoints.

For the structural analysis the semivariograms and cross-variograms were calculated and experimental variograms computed. The experimental variograms, when fitted with theoretical models, are shown in Figure 8. For lnEMh an exponential model was found while for lnEC and the crossvariogram, linear models were fitted. All models have a pronounced nugget effect. The following equations apply to the variograms:

$$\gamma_1 = 0.60018 + 0.000889*h$$

$$\gamma_2 = 0.15424 + 0.11805*(1.5*(h/173.11) - 0.5*(h/173.11))$$

$$\gamma_{12} = 0.23966 + 0.000358*h$$

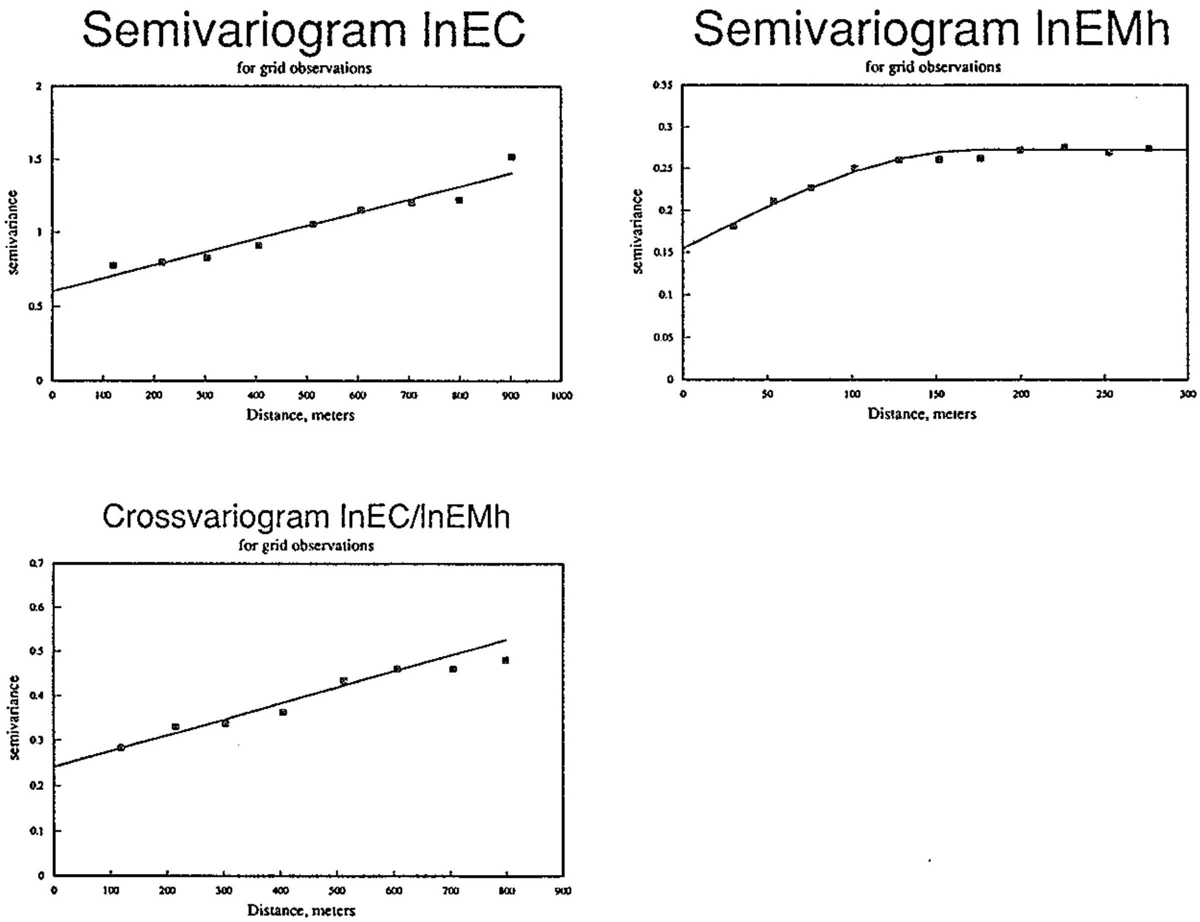


Figure 8. variograms based on grid points.

Using these variograms lnEC was estimated for 29 random testpoints. Predicted values were compared with known lnEC values to test the accuracy of the predictions. It was found that kriging or cokriging did not differ much in their estimations. Mean Root Squared Prediction Error for kriging and cokriging is 0.708 and 0.702 respectivelly.
A plausible reason for this lack of difference between the two methods lies in the fact that the semivariograms and cross variograms show high nuggets compared to sill and slopes of the variograms. Weights assigned to the covariables must add up to 0 in order to get unbiased predictions. Because of the high nugget/sill ratio, weights will not differ too much and will be close to zero. Hence the contribution of covariables around the prediction point will be minimal.

The nugget effect is built up by short range variability, variability due to measurement and operator errors and the variability within the sample (Hoogerwerf et al.,1991). Assuming the errors to be independent yields:

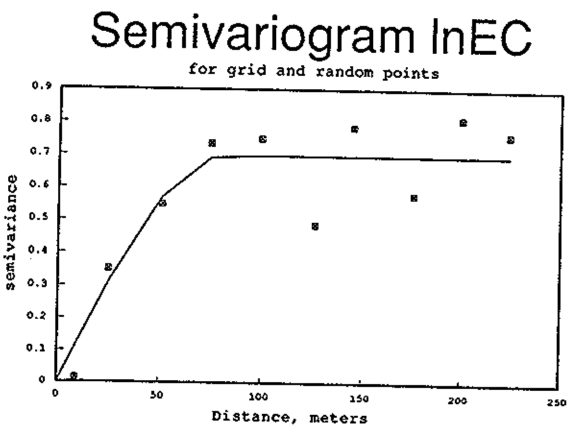
$$\sigma^2_{nugget} = \sigma^2_{Measurement} + \sigma^2_{Operator} + \sigma^2_{Shortdistance} + \sigma^2_{support}$$

To study the contribution of short distance variability new variograms were computed, including measured values for the 29 random testpoints, to get semivariances within the minimum grid distances. It was found that in all cases the nugget effect was strongly reduced when using information of semivariance at shorter distances as shown in Figure 9. The new variogram models are:

$\gamma 1$ = 0.697*(1.5*(h/81.6) - 0.5*(h/81.6)^3)

$\gamma 2$ = 0.285*(1-exp(-h/181)

$\gamma 12$ = 0.0468 + 0.222*(1-exp(-h/36.7)



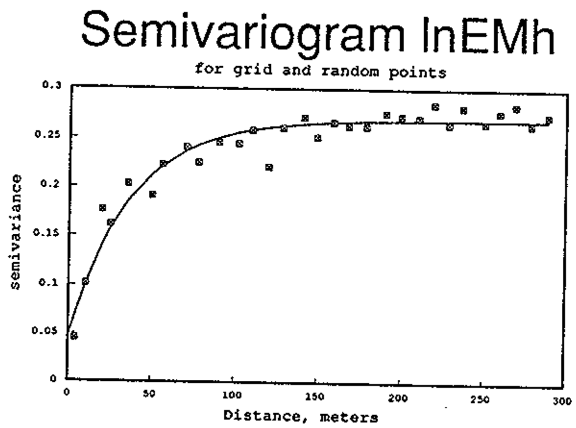


Figure 9. Variograms based on grid and random points.

These variograms indicate that much of the nugget effect can be attributed to short distance variability.

Instead of using individual EM measurements as covariables, a combination of them could be used. Regression equations , based on the 100*100 meter grid points, can serve to transform EM measurements into a new variable. It was shown that in some cases moisture and/or clay content attributed significantly to the regression model when explaining lnEC. These two variables, however, are only present within the 100*100 meter grid.

5 CONCLUSIONS AND RECOMMENDATIONS

Good correlations were found between inductive electromagnetic measurements (EM) and $EC_{1:2.5}$.Using multiple regression, lnEC was explained by EM measurements but also by moisture content and clay content, properties that contributed significantly to the model. A higher percentage of the variance could be accounted for when regression was conducted on stratified data, based on soil units.
Semivariograms of EM measurements and EC showed a clear spatial structure. It demonstrates the usefulness of geostatistical interpolation methods. Information on short distance variability, i.e. distances smaller than the grid densities, proved to be of importance when establishing variograms.

Within the study area it was concluded that for practical monitoring purposes, EM measurements alone are not suited for accurate salinity mapping. In combination with moisture and clay content however, most of the variation of lnEC could be accounted for. A rapid, non destructive method of measuring moisture content would be required for monitoring purposes.
Better regression models were found when the area was stratified into soil units. A detailed soil survey, preceeding the monitoring program, is therefore recommended.
Since it is not clear in which way moisture and clay content contribute to the EM measurements, further research is relevant to see if standard calibration curves can be established and whether such equations can be applied in a practical way.
Geostatistical interpolation can be used for mapping salinity. Within this study area,EC and EM measurements displayed a strong spatial dependance over short distances. When defining monitoring salinity development, information on short distance variability should be taken into account by adding random points or clusters to the overall sampling and monotoring programme.

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Appendix 1.

Profile descriptions of soil units within the study area as described by Kanake (1992).

Mapping Unit YP1
Profile no. 188/3-43 (Kenya Soil Survey)

Geology	: volcanic (calcareous tuffaceous grits)
Physiography	: piedmont plain
Relief, macro	: level to very gently undulating
Relief meso/micro	: nil
Slope at site/position	: 0-2 % /plain
Vegetation/Landuse	: irrigated bananas, pawpaw and vegetables
Erosion water/wind	: nil
Surface stoniness	: nil
Rock outcrops	: nil
Flooding	: nil
Effective soil depth	: deep, 110 cm
Ground water depth	: below 110 cm (dry season)
Drainage class	: well drained

Ap	0-18 cm	dark reddish brown (5YR 3/3) clay, weak, fine, crumby structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many, fine to medium pores; many fine, common medium, roots; clear and wavy transition to:
Bu1	18-42 cm	reddish brown (5YR 4/4) clay; weak, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many fine, common fine to medium pores; common, medium roots; gradual and smooth transition to:
Bu2	42-83 cm	dark red (5YR 3/6) clay; weak, very fine and fine,

		subangular blocky structure; friable when moist, sticky and plastic when wet; few, thin, clay skins; many very fine and fine medium pores; common fine roots; diffuse and smooth transition to:
Bu3	83-110 cm	reddish brown (5YR 4/4) clay; weak, very fine and fine, subangular blocky structure; friable when moist, sticky and plastic when wet; many fine and very fine, common medium, pores; common fine roots.
R	>110 cm	hard layer of petrocalcic material ("caliche")

Mapping unit YP2
Profile No. 188/3-26 (Kenya Soil Survey)

Geology	:	volcanic (calcareous tuffaceous grits)
Physiography	:	piedmont plain
Relief, macro	:	level to very gently undulating
Relief, meso/micro	:	nil
Slope at site/position	:	0-1 %, plain
Vegetation/landuse	:	stargrass/cotton growing and some mango and coconut trees
Erosion - water/wind	:	nil
Surface stoniness	:	nil
Rock outcrops	:	nil
Flooding	:	nil
Effective soil depth	:	deep, 140 cm
Groundwater depth	:	below 140 cm (rain season)

Drainage class	:	well drained
Ap	0-20 cm	dark brown (10YR 3/3) clay; fine, crumby structure; soft when dry, friable when moist; sticky and plastic when wet; many very fine and fine pores; many fine and medium roots; clear and wavy transition to:
BA	20-50 cm	dark yellowish brown (10YR 4/4) clay; weak, medium to coarse, prismatic structure; hard when dry, friable when moist, sticky and plastic when wet; common, fine and medium pores; common, fine and medium roots; gradual and wavy transition to:
Bu1	50-88 cm	dark brown (10YR 3/3) clay; moderate, medium to coarse, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common, fine and medium pores; few fine roots; gradual and smooth transition to:
Bu2	89-104 cm	dark brown (10YR 3/3) clay; moderate, fine to medium, angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few, thin clay skins; common, fine and medium pores; few, fine roots; gradual and smooth transition to:
BC	105-140 cm	dark yellowish brown (10YR 4/4) clay; moderate, fine to medium, angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common fine and medium pores; few, very fine roots;
R	>140 cm	hard layer to petrocalcic material ("caliche").

Mapping Unit YP3
Profile no. 188/3-28 (Kenya Soil Survey)

Geology	: volcanic (calcareous tuffaceous grits)
Physiography	: piedmont plain
Relief, macro	: level to very gently undulating
Slope at site/position	: 0-1 % /plain
Vegetation/Landuse	: cotton growing
Erosion water/wind	: nil
Rock outcrops	: nil
Flooding	: nil
Effective soil depth	: deep, 140 cm
Groundwater depth	: below 140 cm (rain season)
Drainage class	: well drained

Ap	0-20 cm	dark brown (7.5YR 3/2) clay; weak, fine, crumby structure; soft when dry, very friable when moist, sticky and plastic when wet; many, very fine pores; many fine and medium roots; gradual and smooth transition to :
AB	20-40 cm	dark yellowish brown (10YR 3/4) clay; moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common, very fine and fine pores; many, fine and medium roots; clear and wavy transition to :
Bu1	40-67 cm	dark brown (10YR 3/3) clay; strong, fine to medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common, very fine and fine pores; many, fine and medium roots; diffuse and smooth

		transition to :
Bu2	67-99 cm	dark brown (10YR 3/3) clay; moderate, fine to medium, angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; common, very fine and fine pores; common, fine and medium roots; clear and wavy transition to :
BC	99-140 cm	dark yellowish brown (10YR 3/6) clay; moderate to strong, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many, very fine pores; few, fine, dead roots.

Mapping unit YP4

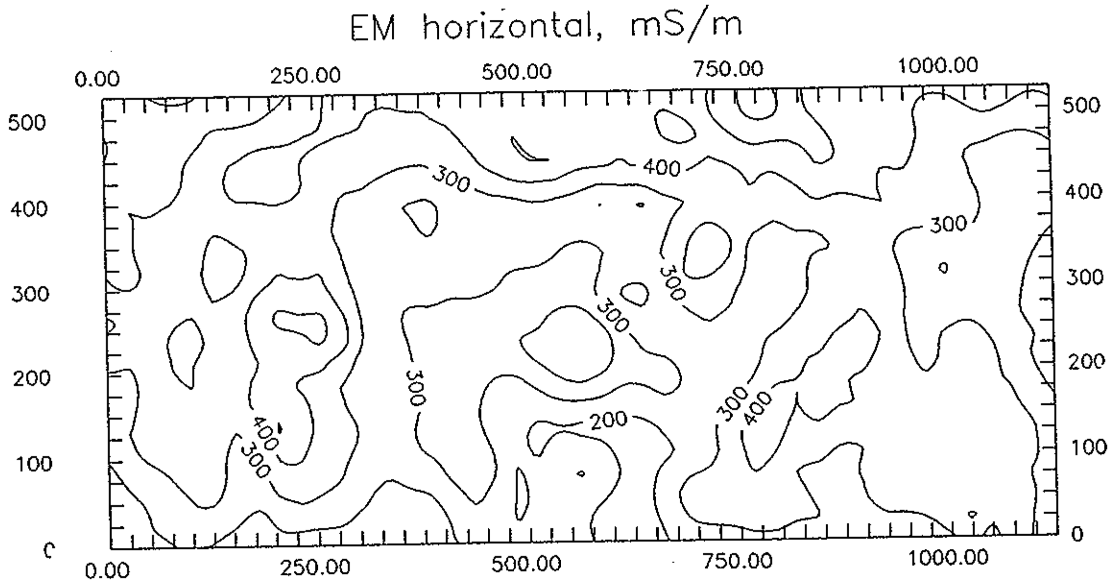
Profile pit : 188/3-24 (Kenya Soil Survey)

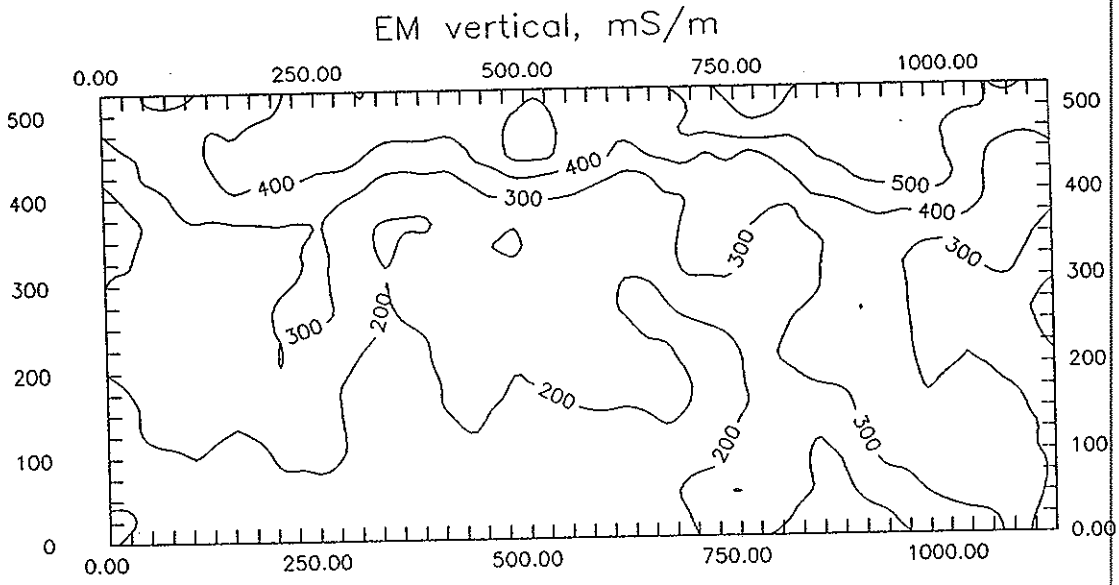
Geology	:	volcanic (calcareous tuffaceous grits)
Physiography	:	piedmont plain
Relief, macro	:	level to very gently undulating
Slope at site/position	:	0-2 %, plain
Vegetation/Land use	:	bushed grassland/ grazing, with some cotton is
planted in places		
Erosion, water/wind	:	nil
Rock outcrops	:	nil
Flooding	:	nil
Effective soil depth	:	very deep, 150 cm

Groundwater depth	:	2.5 m, rain season
Drainage class	:	imperfectly drained

Ah	0-30 cm	very dark greyish brown (10YR 3/2) clay; weak, fine and medium crumby structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many, very fine and fine pores; fine and medium roots; gradual and wavy transition to:
AB	30-60 cm	very dark grey (10YR 3/1) clay; moderate, fine to medium, angular blocky structure; hard when dry, very friable when moist, sticky and plastic when wet; common calcium carbonate mycelia; common very fine and fine pores; many, fine and medium roots; gradual and wavy transition to:
Bu1	60-100 cm	dark greyish brown (10YR 4/2) clay; moderate, very coarse prismatic structure, breaking down to moderate, medium, angular blocky; hard when dry, very friable when moist, sticky and plastic when wet; common calcium carbonate mycelia; common, moderately thick clay skins; common very fine and fine pores; common fine roots; clear and wavy transition to:
Bu2	100-120 cm	very dark greyish brown (10YR 8/2) clay; weak, medium to coarse, angular blocky structure; hard when dry, very friable when moist, sticky and plastic when wet; common, moderately thick clay skins; few, very fine and fine pores; few, fine roots.

Appendix 2


EM horizontal, mS/m
0.00
250.00
500.00
750.00
1000.00
500
400
300
200
100
0
300
400
300
300
300
300
200
300
400
400
300


EM vertical, mS/m
0.00
250.00
500.00
750.00
1000.00
500
400
300
200
100
0
0.00
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400
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400
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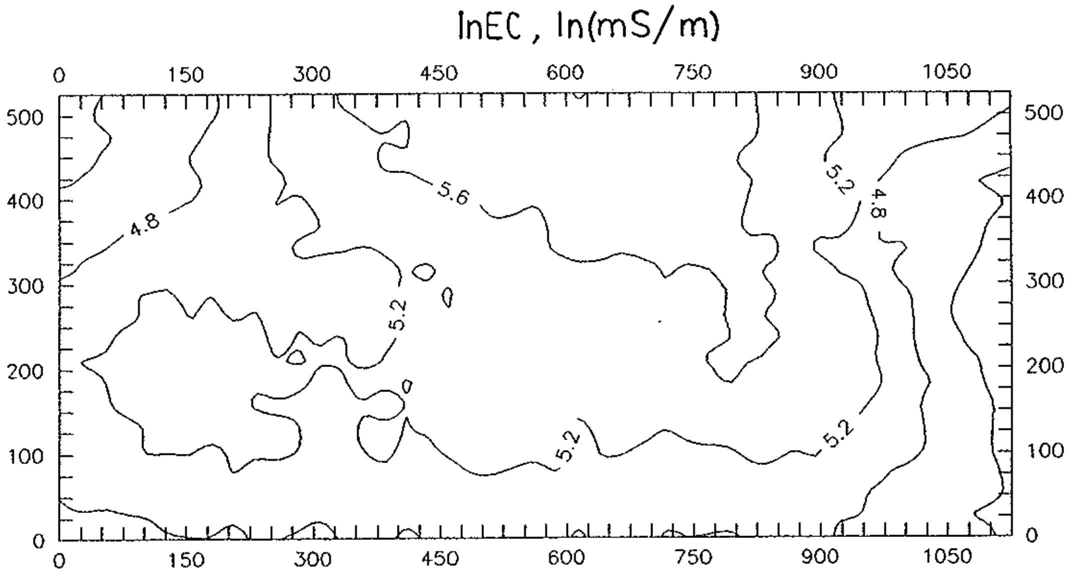
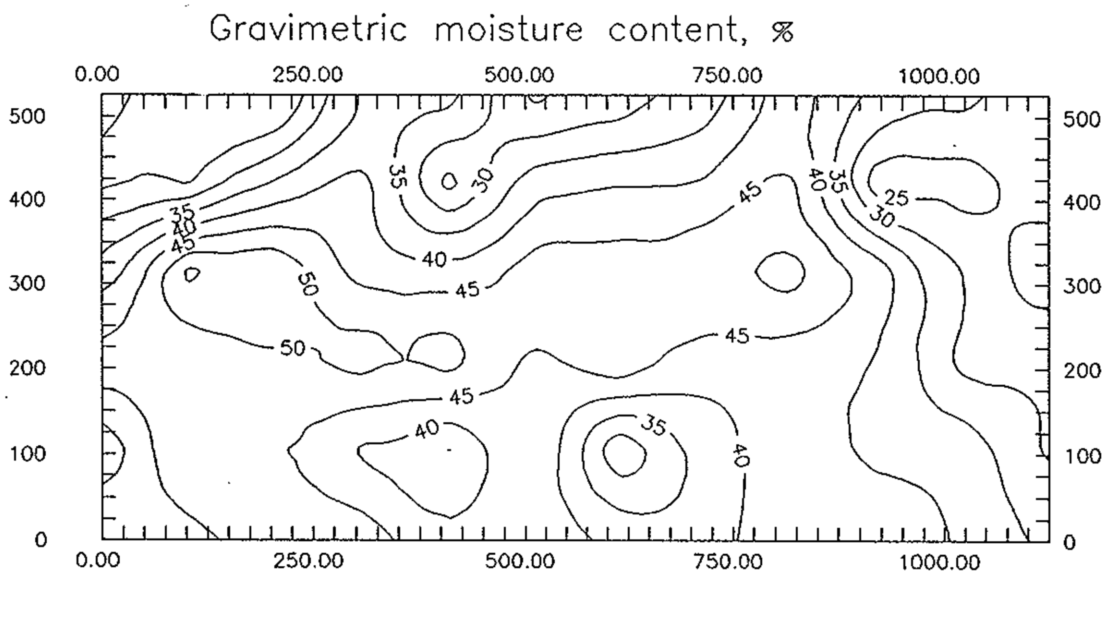
300
200
200
200
300


lnEC, ln(mS/m)
0
150
300
450
600
750
900
1050
500
400
300
200
100
4.8
5.6
5.2
5.2
5.2
5.2
4.8


Gravimetric moisture content, %
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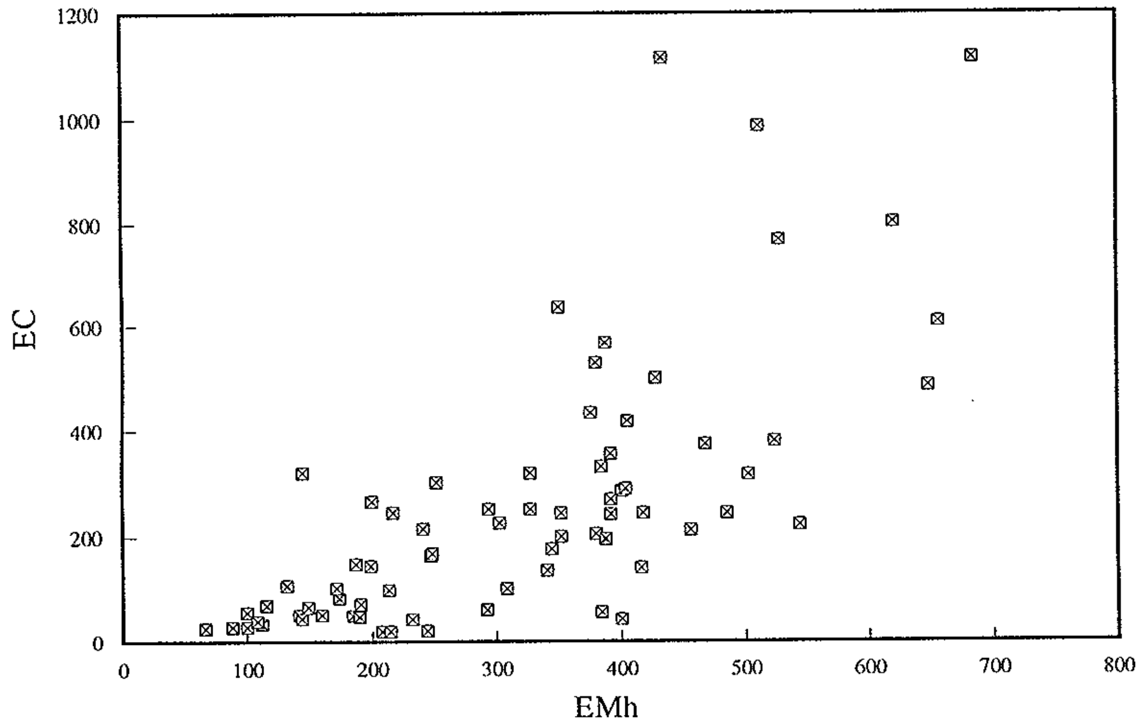
500.00
750.00
1000.00
500
400
300
200
100
0
35
40
45
50
30
25
45
40
35

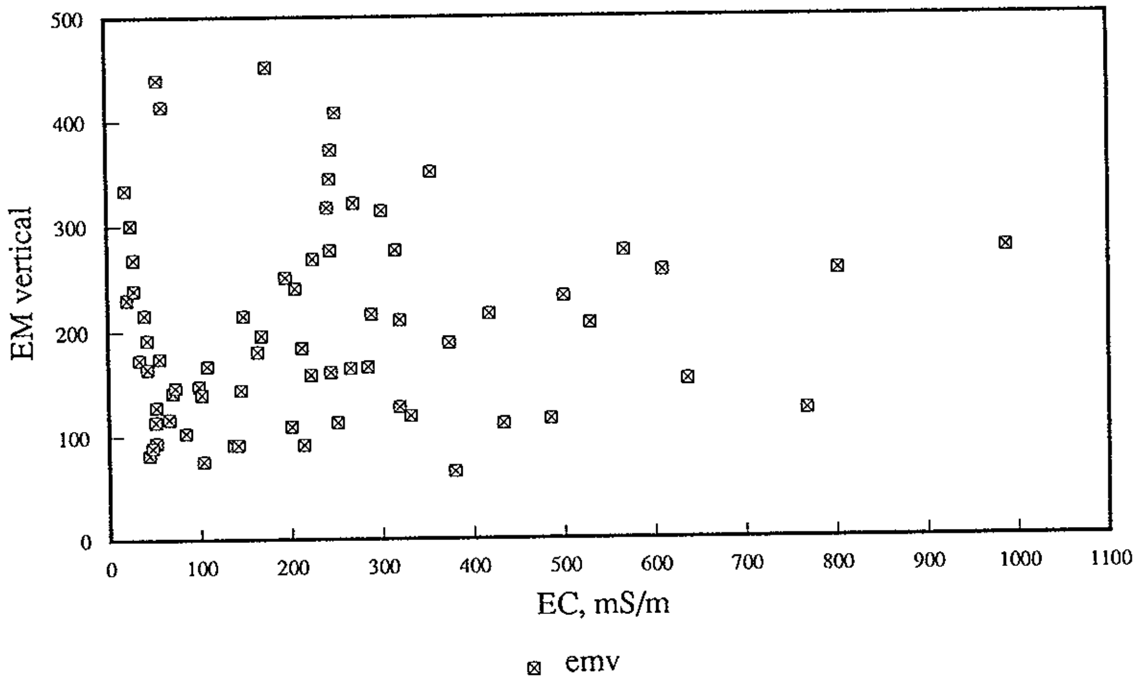
Appendix 3

EMh vs. EC



EC versus EM vertical

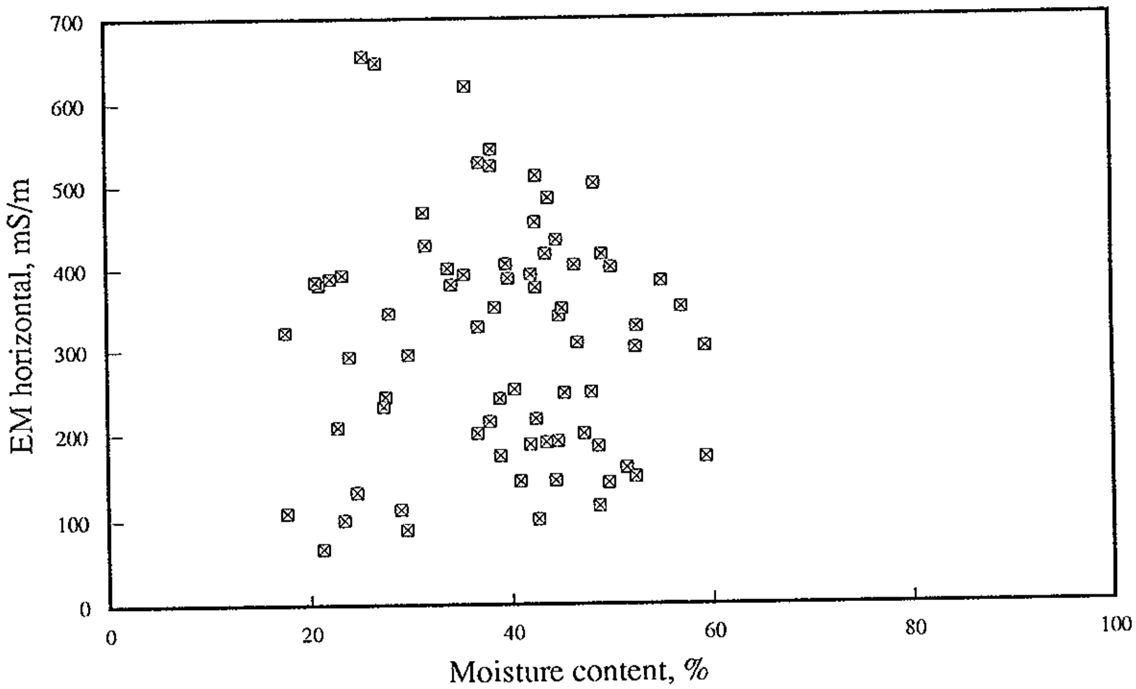
for grid data



Appendix 4

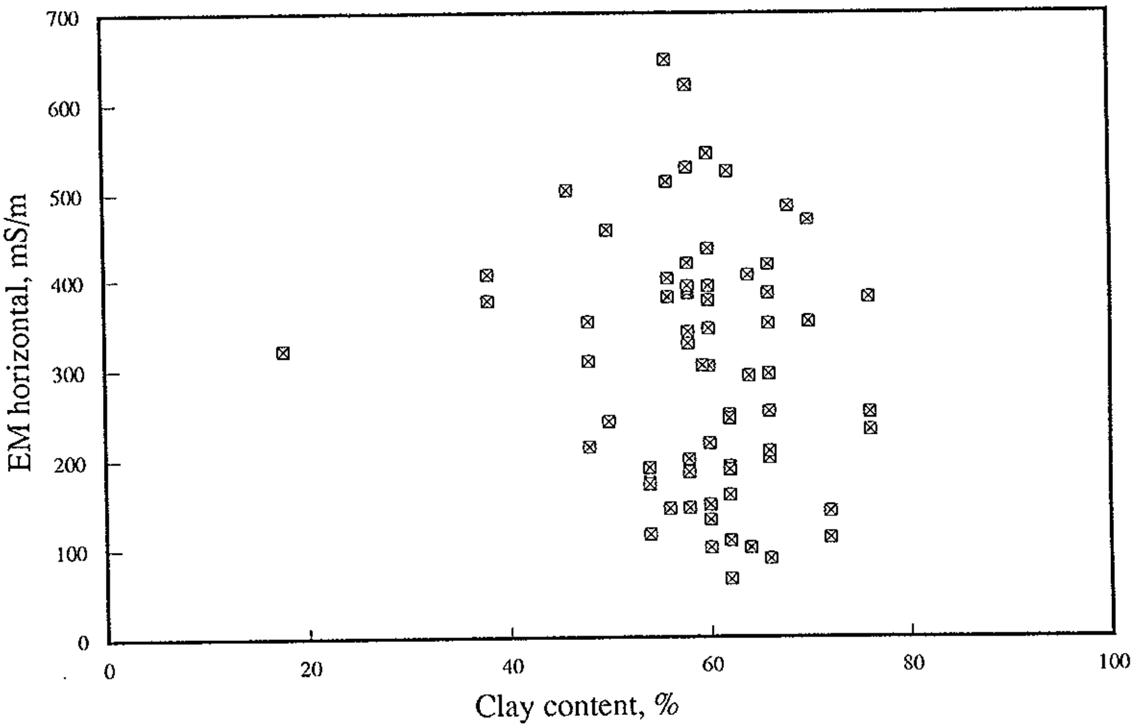
Moisture versus EMh

for grid points



Clay percentage versus EMh

for grid points



Appendix 5

Kimorigo data file

Contains data on grid points. Location numbers contain row and column number of the grid (point 103 is the third column of the first row). coordinates are given in meters relative to point 101. EM and EC values are given in mS/m. Gravimetric moisture content and clay content in % . Missing values have been given the value *-1*.

Point nr.	X	Y	EMh	EMv	EC	Moist.	Clay	
101	0	0	141.6	93.6	52.0	49.70	72	2
102	25	0	127.2	85.2	-1.0	-1.00	-1	2
103	50	0	163.2	128.4	-1.0	-1.00	-1	2
104	75	0	224.8	124.8	-1.0	-1.00	-1	2
105	100	0	159.6	141.6	52.0	51.50	62	2
106	125	0	177.6	99.6	-1.0	-1.00	-1	2
107	150	0	133.2	114.0	-1.0	-1.00	-1	2
108	175	0	133.2	99.6	-1.0	-1.00	-1	2
109	200	0	115.2	81.6	70.0	48.80	54	2
110	225	0	140.4	104.4	-1.0	-1.00	-1	2
111	250	0	141.6	91.2	-1.0	-1.00	-1	2
112	275	0	164.4	109.2	-1.0	-1.00	-1	2
113	300	0	184.8	103.2	51.0	48.70	58	2
114	325	0	262.8	87.6	-1.0	-1.00	-1	2
115	350	0	246.0	147.6	-1.0	-1.00	-1	2
116	375	0	158.4	100.8	-1.0	-1.00	-1	2
117	400	0	144.0	88.8	44.0	40.90	56	2
118	425	0	250.8	176.4	-1.0	-1.00	-1	2
119	450	0	166.8	146.4	-1.0	-1.00	-1	2
120	475	0	200.4	121.2	-1.0	-1.00	-1	2
121	500	0	340.8	193.2	136.0	44.90	58	2
122	525	0	308.4	169.2	-1.0	-1.00	-1	2
123	550	0	270.0	192.0	-1.0	-1.00	-1	2
124	575	0	217.2	142.8	-1.0	-1.00	-1	2
125	600	0	174.0	99.6	84.0	38.90	54	2
126	625	0	133.2	92.4	-1.0	-1.00	-1	2
127	650	0	116.4	81.6	-1.0	-1.00	-1	2
128	675	0	141.6	92.4	-1.0	-1.00	-1	2
129	700	0	213.6	117.6	99.0	37.90	48	2
130	725	0	168.2	122.4	-1.0	-1.00	-1	2
131	750	0	241.4	192.0	-1.0	-1.00	-1	2
132	775	0	172.8	138.0	-1.0	-1.00	-1	2
133	800	0	189.6	158.4	48.0	43.50	54	2
134	825	0	223.2	175.2	-1.0	-1.00	-1	2
135	850	0	175.2	146.4	-1.0	-1.00	-1	2
136	875	0	201.6	160.8	-1.0	-1.00	-1	2
137	900	0	190.8	159.6	73.0	44.70	62	2
237	900	25	274.8	261.6	-1.0	-1.00	-1	2
236	875	25	186.0	190.8	-1.0	-1.00	-1	2
235	850	25	9999.0	1000.0	-1.0	-1.00	-1	2
234	825	25	300.0	211.2	-1.0	-1.00	-1	2
233	800	25	540.0	201.6	-1.0	-1.00	-1	2
232	775	25	456.0	242.4	-1.0	-1.00	-1	2
231	750	25	384.0	280.0	-1.0	-1.00	-1	2
230	725	25	408.0	316.0	-1.0	-1.00	-1	2
229	700	25	312.0	348.0	-1.0	-1.00	-1	2
228	675	25	337.0	340.0	-1.0	-1.00	-1	1

332	775	50	296.0	260.0	−1.0	−1.00	−1	2
333	800	50	192.0	192.0	−1.0	−1.00	−1	2
334	825	50	180.0	180.0	−1.0	−1.00	−1	2
335	850	50	460.0	156.0	−1.0	−1.00	−1	2
336	875	50	316.0	136.0	−1.0	−1.00	−1	2
337	900	50	532.0	248.0	−1.0	−1.00	−1	2
437	900	75	384.0	324.0	−1.0	−1.00	−1	2
436	875	75	184.0	152.0	−1.0	−1.00	−1	2
435	850	75	184.0	160.0	−1.0	−1.00	−1	2
434	825	75	348.0	224.0	−1.0	−1.00	−1	2
433	800	75	236.0	180.0	−1.0	−1.00	−1	2
432	775	75	368.0	248.0	−1.0	−1.00	−1	1
431	750	75	512.0	392.0	−1.0	−1.00	−1	1
430	725	75	168.0	132.0	−1.0	−1.00	−1	1
429	700	75	240.0	240.0	−1.0	−1.00	−1	1
428	675	75	241.0	156.0	−1.0	−1.00	−1	1
427	650	75	226.0	134.4	−1.0	−1.00	−1	1
426	625	75	176.0	202.8	−1.0	−1.00	−1	1
425	600	75	310.6	291.6	−1.0	−1.00	−1	1
424	575	75	292.2	229.2	−1.0	−1.00	−1	1
423	550	75	748.0	198.0	−1.0	−1.00	−1	1
422	525	75	332.0	84.0	−1.0	−1.00	−1	1
421	500	75	320.0	148.0	−1.0	−1.00	−1	2
420	475	75	148.0	144.0	−1.0	−1.00	−1	2
419	450	75	228.4	176.4	−1.0	−1.00	−1	2
418	425	75	540.6	183.6	−1.0	−1.00	−1	2
417	400	75	224.0	76.0	−1.0	−1.00	−1	2
416	375	75	195.0	104.0	−1.0	−1.00	−1	2
415	350	75	240.0	138.0	−1.0	−1.00	−1	2
414	325	75	138.6	111.6	−1.0	−1.00	−1	2
413	300	75	187.6	129.6	−1.0	−1.00	−1	2
412	275	75	424.4	248.4	−1.0	−1.00	−1	2
411	250	75	216.0	120.0	−1.0	−1.00	−1	2
410	225	75	390.2	271.2	−1.0	−1.00	−1	2
409	200	75	404.2	115.2	−1.0	−1.00	−1	2
408	175	75	29.6	140.0	−1.0	−1.00	−1	2
407	150	75	289.0	202.8	−1.0	−1.00	−1	2
406	125	75	330.0	147.6	−1.0	−1.00	−1	2
405	100	75	596.0	190.8	−1.0	−1.00	−1	2
404	75	75	208.0	132.0	−1.0	−1.00	−1	2
403	50	75	172.8	82.8	−1.0	−1.00	−1	2
402	25	75	259.2	90.0	−1.0	−1.00	−1	2
401	0	75	121.2	108.0	−1.0	−1.00	−1	2
501	0	100	171.6	112.8	103.0	59.40	54	2
502	25	100	309.6	229.2	−1.0	−1.00	−1	2
503	50	100	406.8	259.2	−1.0	−1.00	−1	2
504	75	100	360.0	229.2	−1.0	−1.00	−1	2
505	100	100	434.4	252.0	1115.0	44.70	60	2
506	125	100	403.2	174.0	−1.0	−1.00	−1	2
507	150	100	120.0	82.8	−1.0	−1.00	−1	2
508	175	100	366.0	172.8	−1.0	−1.00	−1	2
509	200	100	350.4	207.6	636.0	45.20	66	2
510	225	100	466.8	219.6	−1.0	−1.00	−1	2
511	250	100	189.6	220.8	−1.0	−1.00	−1	2
512	275	100	394.8	222.0	−1.0	−1.00	−1	2
513	300	100	241.2	120.0	214.0	38.90	50	2
514	325	100	319.2	213.6	−1.0	−1.00	−1	2
515	350	100	336.0	297.6	−1.0	−1.00	−1	2

516	375	100	340.0	164.0	-1.0	-1.00	-1	2
517	400	100	380.0	140.0	529.0	34.20	56	2
518	425	100	376.0	208.0	-1.0	-1.00	-1	2
519	450	100	376.0	180.0	-1.0	-1.00	-1	2
520	475	100	144.0	128.0	-1.0	-1.00	-1	2
521	500	100	145.0	91.2	320.0	44.40	58	2
522	525	100	135.6	114.0	-1.0	-1.00	-1	
523	550	100	118.8	116.4	-1.0	-1.00	-1	
524	575	100	116.4	98.4	-1.0	-1.00	-1	
525	600	100	132.0	127.2	108.0	24.70	60	
526	625	100	103.2	132.0	-1.0	-1.00	-1	
527	650	100	174.0	160.8	-1.0	-1.00	-1	
528	675	100	169.2	136.8	-1.0	-1.00	-1	
529	700	100	327.6	165.6	251.0	36.80	58	
530	725	100	336.0	248.4	-1.0	-1.00	-1	
531	750	100	604.0	372.0	-1.0	-1.00	-1	
532	775	100	348.0	316.0	-1.0	-1.00	-1	
533	800	100	376.0	184.0	433.0	42.60	60	
534	825	100	236.0	176.0	-1.0	-1.00	-1	
535	850	100	320.0	216.0	-1.0	-1.00	-1	
536	875	100	39.0	384.0	-1.0	-1.00	-1	
537	900	100	544.0	452.0	222.0	38.30	60	
538	925	100	356.0	376.0	-1.0	-1.00	-1	
539	950	100	284.0	268.0	-1.0	-1.00	-1	
540	975	100	324.0	308.0	-1.0	-1.00	-1	
541	1000	100	352.0	276.0	200.0	38.50	48	
542	1025	100	292.0	316.0	-1.0	-1.00	-1	
543	1050	100	312.0	324.0	-1.0	-1.00	-1	
544	1075	100	516.0	432.0	-1.0	-1.00	-1	
545	1100	100	112.0	124.0	34.0	29.00	72	
645	1100	125	112.8	132.0	-1.0	-1.00	-1	
644	1075	125	408.0	434.4	-1.0	-1.00	-1	
643	1050	125	284.0	300.0	-1.0	-1.00	-1	
642	1025	125	368.0	344.0	-1.0	-1.00	-1	
641	1000	125	344.0	340.0	-1.0	-1.00	-1	
640	975	125	372.0	384.0	-1.0	-1.00	-1	
639	950	125	488.0	456.0	-1.0	-1.00	-1	
638	925	125	364.0	288.0	-1.0	-1.00	-1	
637	900	125	452.0	440.0	-1.0	-1.00	-1	
636	875	125	344.0	288.0	-1.0	-1.00	-1	
635	850	125	568.0	132.0	-1.0	-1.00	-1	
634	825	125	276.0	152.0	-1.0	-1.00	-1	
633	800	125	520.0	264.0	-1.0	-1.00	-1	
632	775	125	220.0	196.0	-1.0	-1.00	-1	
631	750	125	508.0	236.0	-1.0	-1.00	-1	
630	725	125	456.0	152.0	-1.0	-1.00	-1	
629	700	125	320.0	28.8	-1.0	-1.00	-1	
628	675	125	175.0	188.4	-1.0	-1.00	-1	
627	650	125	268.8	284.4	-1.0	-1.00	-1	
626	625	125	98.4	108.0	-1.0	-1.00	-1	
625	600	125	139.0	121.2	-1.0	-1.00	-1	
624	575	125	121.0	134.4	-1.0	-1.00	-1	
623	550	125	104.4	153.6	-1.0	-1.00	-1	
622	525	125	139.2	118.8	-1.0	-1.00	-1	
621	500	125	268.8	157.2	-1.0	-1.00	-1	
620	475	125	105.6	141.6	-1.0	-1.00	-1	
619	450	125	364.0	232.8	-1.0	-1.00	-1	
618	425	125	180.0	124.0	-1.0	-1.00	-1	

617	400	125	306.0	235.2	-1.0	-1.00	-1
616	375	125	532.0	234.0	-1.0	-1.00	-1
615	350	125	195.0	129.6	-1.0	-1.00	-1
614	325	125	186.0	150.0	-1.0	-1.00	-1
613	300	125	354.0	282.0	-1.0	-1.00	-1
612	275	125	309.6	234.0	-1.0	-1.00	-1
611	250	125	348.0	144.0	-1.0	-1.00	-1
610	225	125	548.0	296.0	-1.0	-1.00	-1
609	200	125	848.0	272.0	-1.0	-1.00	-1
608	175	125	300.0	212.0	-1.0	-1.00	-1
607	150	125	144.0	120.0	-1.0	-1.00	-1
606	125	125	396.0	308.0	-1.0	-1.00	-1
605	100	125	312.0	212.0	-1.0	-1.00	-1
604	75	125	416.0	140.4	-1.0	-1.00	-1
603	50	125	308.0	148.0	-1.0	-1.00	-1
602	25	125	464.0	288.0	-1.0	-1.00	-1
601	0	125	132.0	114.0	-1.0	-1.00	-1
701	0	150	124.8	102.0	-1.0	-1.00	-1
702	25	150	267.6	195.6	-1.0	-1.00	-1
703	50	150	428.0	200.4	-1.0	-1.00	-1
704	75	150	260.0	280.0	-1.0	-1.00	-1
705	100	150	516.0	276.0	-1.0	-1.00	-1
706	125	150	468.0	232.0	-1.0	-1.00	-1
707	150	150	304.0	144.0	-1.0	-1.00	-1
708	175	150	484.0	372.0	-1.0	-1.00	-1
709	200	150	388.0	240.0	-1.0	-1.00	-1
710	225	150	436.0	252.0	-1.0	-1.00	-1
711	250	150	312.0	168.0	-1.0	-1.00	-1
712	275	150	400.0	276.0	-1.0	-1.00	-1
713	300	150	240.0	116.0	-1.0	-1.00	-1
714	325	150	252.0	132.0	-1.0	-1.00	-1
715	350	150	264.0	216.0	-1.0	-1.00	-1
716	375	150	240.0	144.0	-1.0	-1.00	-1
717	400	150	228.0	164.0	-1.0	-1.00	-1
718	425	150	388.0	280.0	-1.0	-1.00	-1
719	450	150	428.0	344.0	-1.0	-1.00	-1
720	475	150	132.0	104.0	-1.0	-1.00	-1
721	500	150	198.0	118.8	-1.0	-1.00	-1
722	525	150	277.2	186.0	-1.0	-1.00	-1
723	550	150	267.6	174.0	-1.0	-1.00	-1
724	575	150	226.8	184.8	-1.0	-1.00	-1
725	600	150	356.0	214.8	-1.0	-1.00	-1
726	625	150	133.2	148.0	-1.0	-1.00	-1
727	650	150	264.0	195.6	-1.0	-1.00	-1
728	675	150	346.0	276.0	-1.0	-1.00	-1
729	700	150	145.2	144.0	-1.0	-1.00	-1
730	725	150	163.2	146.4	-1.0	-1.00	-1
731	750	150	648.0	276.0	-1.0	-1.00	-1
732	775	150	452.0	232.0	-1.0	-1.00	-1
733	800	150	460.0	268.0	-1.0	-1.00	-1
734	825	150	404.0	212.0	-1.0	-1.00	-1
735	850	150	516.0	276.0	-1.0	-1.00	-1
736	875	150	288.0	304.0	-1.0	-1.00	-1
737	900	150	420.0	408.0	-1.0	-1.00	-1
738	925	150	392.0	344.0	-1.0	-1.00	-1
739	950	150	300.0	300.0	-1.0	-1.00	-1
740	975	150	416.0	312.0	-1.0	-1.00	-1
741	1000	150	404.0	396.0	-1.0	-1.00	-1

742	1025	150	316.0	288.0	−1.0	−1.00	−1
743	1050	150	348.0	372.0	−1.0	−1.00	−1
744	1075	150	320.0	372.0	−1.0	−1.00	−1
745	1100	150	168.0	248.0	−1.0	−1.00	−1
845	1100	175	96.0	136.0	−1.0	−1.00	−1
844	1075	175	264.0	276.0	−1.0	−1.00	−1
843	1050	175	252.0	308.0	−1.0	−1.00	−1
842	1025	175	268.0	292.0	−1.0	−1.00	−1
841	1000	175	296.0	324.0	−1.0	−1.00	−1
840	975	175	264.0	248.0	−1.0	−1.00	−1
839	950	175	304.0	232.0	−1.0	−1.00	−1
838	925	175	296.0	276.0	−1.0	−1.00	−1
837	900	175	380.0	428.0	−1.0	−1.00	−1
836	875	175	224.0	248.0	−1.0	−1.00	−1
835	850	175	448.0	380.0	−1.0	−1.00	−1
834	825	175	392.0	312.0	−1.0	−1.00	−1
833	800	175	372.0	260.0	−1.0	−1.00	−1
832	775	175	344.0	304.0	−1.0	−1.00	−1
831	750	175	260.0	176.0	−1.0	−1.00	−1
830	725	175	188.0	172.0	−1.0	−1.00	−1
829	700	175	164.0	128.0	−1.0	−1.00	−1
828	675	175	292.0	228.0	−1.0	−1.00	−1
827	650	175	544.0	356.0	−1.0	−1.00	−1
826	625	175	336.0	328.0	−1.0	−1.00	−1
825	600	175	256.0	260.0	−1.0	−1.00	−1
824	575	175	308.0	284.0	−1.0	−1.00	−1
823	550	175	568.0	304.0	−1.0	−1.00	−1
822	525	175	412.0	340.0	−1.0	−1.00	−1
821	500	175	284.0	176.0	−1.0	−1.00	−1
821	475	175	188.0	176.0	−1.0	−1.00	−1
819	450	175	80.0	100.0	−1.0	−1.00	−1
818	425	175	240.0	152.0	−1.0	−1.00	−1
817	400	175	484.0	264.0	−1.0	−1.00	−1
816	375	175	484.0	228.0	−1.0	−1.00	−1
815	350	175	188.0	160.0	−1.0	−1.00	−1
814	325	175	272.0	164.0	−1.0	−1.00	−1
813	300	175	200.0	84.0	−1.0	−1.00	−1
812	275	175	220.0	196.0	−1.0	−1.00	−1
811	250	175	200.0	168.0	−1.0	−1.00	−1
810	225	175	408.0	364.0	−1.0	−1.00	−1
809	200	175	556.0	288.0	−1.0	−1.00	−1
808	175	175	588.0	280.0	−1.0	−1.00	−1
807	150	175	236.0	180.0	−1.0	−1.00	−1
806	125	175	308.0	276.0	−1.0	−1.00	−1
805	100	175	376.0	344.0	−1.0	−1.00	−1
804	75	175	500.0	328.0	−1.0	−1.00	−1
803	50	175	328.0	260.0	−1.0	−1.00	−1
802	25	175	220.0	112.0	−1.0	−1.00	−1
801	0	175	156.0	112.0	−1.0	−1.00	−1
901	0	200	308.4	204.0	102.0	46.70	48
902	25	200	300.0	235.2	−1.0	−1.00	−1
903	50	200	423.6	334.8	−1.0	−1.00	−1
904	75	200	266.4	182.4	−1.0	−1.00	−1
905	100	200	247.2	199.2	164.0	45.40	62
906	125	200	548.4	400.8	−1.0	−1.00	−1
907	150	200	217.2	108.0	−1.0	−1.00	−1
908	175	200	333.6	250.8	−1.0	−1.00	−1
909	200	200	416.4	244.8	141.0	49.20	66

910	225	200	403.2	174.0	−1.0	−1.00	−1
911	250	200	338.4	186.0	−1.0	−1.00	−1
912	275	200	439.2	249.6	−1.0	−1.00	−1
913	300	200	148.8	99.6	66.0	52.40	60
914	325	200	224.4	158.4	−1.0	−1.00	−1
915	350	200	277.2	183.6	−1.0	−1.00	−1
916	375	200	279.6	176.4	−1.0	−1.00	−1
917	400	200	327.6	230.4	319.0	52.60	58
918	425	200	405.6	231.6	−1.0	−1.00	−1
919	450	200	412.8	333.6	−1.0	−1.00	−1
920	475	200	391.2	154.8	−1.0	−1.00	−1
921	500	200	484.8	240.0	244.0	43.90	68
922	525	200	336.0	253.2	−1.0	−1.00	−1
923	550	200	396.0	216.0	−1.0	−1.00	−1
924	575	200	446.4	405.6	−1.0	−1.00	−1
925	600	200	400.8	313.2	285.0	50.10	56
926	625	200	214.8	156.0	−1.0	−1.00	−1
927	650	200	363.6	274.8	−1.0	−1.00	−1
928	675	200	200.4	174.0	−1.0	−1.00	−1
929	700	200	217.2	64.8	245.0	42.50	60
930	725	200	150.0	139.2	−1.0	−1.00	−1
931	750	200	259.2	250.8	−1.0	−1.00	−1
932	775	200	356.4	295.2	−1.0	−1.00	−1
933	800	200	456.0	320.4	212.0	42.60	50
934	825	200	400.8	368.4	−1.0	−1.00	−1
935	850	200	442.8	350.4	−1.0	−1.00	−1
936	875	200	478.8	392.4	−1.0	−1.00	−1
937	900	200	405.6	414.0	418.0	39.60	38
938	925	200	308.4	358.8	−1.0	−1.00	−1
939	950	200	253.2	238.8	−1.0	−1.00	−1
940	975	200	309.6	392.4	−1.0	−1.00	−1
941	1000	200	344.4	292.8	176.0	28.00	60
942	1025	200	383.6	247.2	−1.0	−1.00	−1
943	1050	200	336.0	268.0	−1.0	−1.00	−1
944	1075	200	164.0	176.0	−1.0	−1.00	−1
945	1100	200	88.0	108.0	29.0	29.60	66
1045	1100	225	112.0	128.0	−1.0	−1.00	−1
1044	1075	225	216.0	232.0	−1.0	−1.00	−1
1043	1050	225	244.0	232.0	−1.0	−1.00	−1
1042	1025	225	364.0	300.0	−1.0	−1.00	−1
1041	1000	225	364.0	348.0	−1.0	−1.00	−1
1040	975	225	476.0	324.0	−1.0	−1.00	−1
1039	950	225	184.0	184.0	−1.0	−1.00	−1
1038	925	225	308.0	344.0	−1.0	−1.00	−1
1037	900	225	388.0	380.0	−1.0	−1.00	−1
1036	875	225	528.0	380.0	−1.0	−1.00	−1
1035	850	225	496.0	424.0	−1.0	−1.00	−1
1034	825	225	404.0	352.0	−1.0	−1.00	−1
1033	800	225	384.0	340.0	−1.0	−1.00	−1
1032	775	225	440.0	420.0	−1.0	−1.00	−1
1031	750	225	228.0	260.0	−1.0	−1.00	−1
1030	725	225	432.0	184.0	−1.0	−1.00	−1
1029	700	225	248.0	120.0	−1.0	−1.00	−1
1028	675	225	228.0	184.0	−1.0	−1.00	−1
1027	650	225	380.0	136.0	−1.0	−1.00	−1
1026	625	225	192.0	176.0	−1.0	−1.00	−1
1025	600	225	500.0	292.0	−1.0	−1.00	−1
1024	575	225	524.0	316.0	−1.0	−1.00	−1

1023	550	225	760.0	196.0	-1.0	-1.00	-1
1022	525	225	496.0	316.0	-1.0	-1.00	-1
1021	500	225	808.0	344.0	-1.0	-1.00	-1
1020	475	225	252.0	172.0	-1.0	-1.00	-1
1019	450	225	556.0	328.0	-1.0	-1.00	-1
1018	425	225	384.0	308.0	-1.0	-1.00	-1
1017	400	225	304.0	244.0	-1.0	-1.00	-1
1016	375	225	356.0	140.0	-1.0	-1.00	-1
1015	350	225	368.0	176.0	-1.0	-1.00	-1
1014	325	225	192.0	176.0	-1.0	-1.00	-1
1013	300	225	200.0	148.0	-1.0	-1.00	-1
1012	275	225	608.0	396.0	-1.0	-1.00	-1
1011	250	225	660.0	336.0	-1.0	-1.00	-1
1010	225	225	408.0	280.0	-1.0	-1.00	-1
1009	200	225	396.0	364.0	-1.0	-1.00	-1
1008	175	225	540.0	320.0	-1.0	-1.00	-1
1007	150	225	180.0	80.0	-1.0	-1.00	-1
1006	125	225	384.0	184.0	-1.0	-1.00	-1
1005	100	225	604.0	240.0	-1.0	-1.00	-1
1004	75	225	656.0	268.0	-1.0	-1.00	-1
1003	50	225	304.0	252.0	-1.0	-1.00	-1
1002	25	225	324.0	320.0	-1.0	-1.00	-1
1001	0	225	272.0	212.0	-1.0	-1.00	-1
1102	25	250	360.0	312.0	-1.0	-1.00	-1
1103	50	250	216.0	200.0	-1.0	-1.00	-1
1104	75	250	440.0	244.0	-1.0	-1.00	-1
1105	100	250	232.0	200.0	-1.0	-1.00	-1
1106	125	250	468.0	280.0	-1.0	-1.00	-1
1107	150	250	284.0	256.0	-1.0	-1.00	-1
1108	175	250	572.0	404.0	-1.0	-1.00	-1
1109	200	250	736.0	496.0	-1.0	-1.00	-1
1110	225	250	492.0	160.0	-1.0	-1.00	-1
1111	250	250	740.0	308.0	-1.0	-1.00	-1
1112	275	250	428.0	360.0	-1.0	-1.00	-1
1113	300	250	132.0	136.0	-1.0	-1.00	-1
1114	325	250	380.0	252.0	-1.0	-1.00	-1
1115	350	250	336.0	216.0	-1.0	-1.00	-1
1116	375	250	236.0	192.0	-1.0	-1.00	-1
1117	400	250	292.0	256.0	-1.0	-1.00	-1
1118	425	250	316.0	292.0	-1.0	-1.00	-1
1119	450	250	288.0	232.0	-1.0	-1.00	-1
1120	475	250	124.0	124.0	-1.0	-1.00	-1
1121	500	250	186.0	164.0	-1.0	-1.00	-1
1122	525	250	492.0	204.0	-1.0	-1.00	-1
1123	550	250	364.0	276.0	-1.0	-1.00	-1
1124	575	250	398.0	192.0	-1.0	-1.00	-1
1125	600	250	188.0	188.0	-1.0	-1.00	-1
1126	625	250	136.0	176.0	-1.0	-1.00	-1
1127	650	250	104.0	116.0	-1.0	-1.00	-1
1128	675	250	192.0	152.0	-1.0	-1.00	-1
1129	700	250	396.0	316.0	-1.0	-1.00	-1
1130	725	250	196.0	220.0	-1.0	-1.00	-1
1131	750	250	96.0	124.0	-1.0	-1.00	-1
1132	775	250	320.0	332.0	-1.0	-1.00	-1
1133	800	250	204.0	256.0	-1.0	-1.00	-1
1134	825	250	228.0	280.0	-1.0	-1.00	-1
1135	850	250	160.0	216.0	-1.0	-1.00	-1
1136	875	250	440.0	436.0	-1.0	-1.00	-1

1137	900	250	444.0	440.0	-1.0	-1.00	-1
1138	925	250	236.0	292.0	-1.0	-1.00	-1
1139	950	250	212.0	192.0	-1.0	-1.00	-1
1140	975	250	244.0	216.0	-1.0	-1.00	-1
1141	1000	250	256.0	244.0	-1.0	-1.00	-1
1142	1025	250	176.0	208.0	-1.0	-1.00	-1
1143	1050	250	176.0	180.0	-1.0	-1.00	-1
1144	1075	250	196.0	196.0	-1.0	-1.00	-1
1145	1100	250	9999.0	1000.0	-1.0	-1.00	-1
1245	1100	275	74.4	100.8	-1.0	-1.00	-1
1244	1075	275	258.0	307.2	-1.0	-1.00	-1
1243	1050	275	146.0	189.6	-1.0	-1.00	-1
1242	1025	275	210.0	229.2	-1.0	-1.00	-1
1241	1000	275	208.8	196.8	-1.0	-1.00	-1
1240	975	275	290.4	290.4	-1.0	-1.00	-1
1239	950	275	122.4	128.4	-1.0	-1.00	-1
1238	925	275	351.6	316.8	-1.0	-1.00	-1
1237	900	275	416.4	435.6	-1.0	-1.00	-1
1236	875	275	235.2	321.6	-1.0	-1.00	-1
1235	850	275	538.8	481.2	-1.0	-1.00	-1
1234	825	275	424.8	333.6	-1.0	-1.00	-1
1233	800	275	328.8	241.2	-1.0	-1.00	-1
1232	775	275	121.2	156.0	-1.0	-1.00	-1
1231	750	275	183.6	195.6	-1.0	-1.00	-1
1230	725	275	423.6	396.0	-1.0	-1.00	-1
1229	700	275	308.4	240.0	-1.0	-1.00	-1
1228	675	275	315.6	224.4	-1.0	-1.00	-1
1227	650	275	528.0	382.8	-1.0	-1.00	-1
1226	625	275	84.0	111.6	-1.0	-1.00	-1
1225	600	275	87.6	123.6	-1.0	-1.00	-1
1224	575	275	244.8	198.0	-1.0	-1.00	-1
1223	550	275	258.0	193.2	-1.0	-1.00	-1
1222	525	275	367.2	246.0	-1.0	-1.00	-1
1221	500	275	268.8	198.0	-1.0	-1.00	-1
1220	475	275	494.4	204.0	-1.0	-1.00	-1
1219	450	275	340.8	315.6	-1.0	-1.00	-1
1218	425	275	434.4	321.6	-1.0	-1.00	-1
1217	400	275	363.6	321.6	-1.0	-1.00	-1
1216	375	275	380.4	220.8	-1.0	-1.00	-1
1215	350	275	309.6	229.2	-1.0	-1.00	-1
1214	325	275	280.8	252.0	-1.0	-1.00	-1
1213	300	275	141.6	145.2	-1.0	-1.00	-1
1212	275	275	428.4	325.2	-1.0	-1.00	-1
1211	250	275	294.0	294.0	-1.0	-1.00	-1
1210	225	275	423.6	277.2	-1.0	-1.00	-1
1209	200	275	405.6	298.8	-1.0	-1.00	-1
1208	175	275	488.4	205.2	-1.0	-1.00	-1
1207	150	275	181.2	162.0	-1.0	-1.00	-1
1206	125	275	350.4	285.6	-1.0	-1.00	-1
1205	100	275	320.4	195.6	-1.0	-1.00	-1
1204	75	275	408.6	318.0	-1.0	-1.00	-1
1203	50	275	285.6	297.6	-1.0	-1.00	-1
1202	25	275	319.2	252.0	-1.0	-1.00	-1
1201	0	275	110.4	144.0	-1.0	-1.00	-1
1301	0	300	200.1	139.2	266.0	36.70	66
1302	25	300	288.0	193.2	-1.0	-1.00	-1
1303	50	300	345.6	250.8	-1.0	-1.00	-1
1304	75	300	384.0	321.6	-1.0	-1.00	-1

1305	100	300	352.0	384.0	244.0	57.10	70
1306	125	300	288.0	208.0	-1.0	-1.00	-1
1307	150	300	88.0	108.0	-1.0	-1.00	-1
1308	175	300	492.0	180.0	-1.0	-1.00	-1
1309	200	300	384.0	280.0	331.0	55.10	58
1310	225	300	492.0	372.0	-1.0	-1.00	-1
1311	250	300	468.0	364.0	-1.0	-1.00	-1
1312	275	300	504.0	436.0	-1.0	-1.00	-1
1313	300	300	100.0	116.0	56.0	42.70	60
1314	325	300	213.6	186.0	-1.0	-1.00	-1
1315	350	300	229.2	228.0	-1.0	-1.00	-1
1316	375	300	219.6	224.4	-1.0	-1.00	-1
1317	400	300	187.2	175.2	148.0	41.90	62
1318	425	300	134.4	170.4	-1.0	-1.00	-1
1319	450	300	142.8	164.4	-1.0	-1.00	-1
1320	475	300	475.2	247.2	-1.0	-1.00	-1
1321	500	300	248.4	228.0	168.0	48.10	62
1322	525	300	332.4	314.4	-1.0	-1.00	-1
1323	550	300	476.4	415.2	-1.0	-1.00	-1
1324	575	300	352.8	306.0	-1.0	-1.00	-1
1325	600	300	199.2	171.6	145.0	47.30	58
1326	625	300	91.2	116.4	-1.0	-1.00	-1
1327	650	300	380.4	272.4	-1.0	-1.00	-1
1328	675	300	346.8	249.6	-1.0	-1.00	-1
1329	700	300	502.8	351.6	316.0	48.50	46
1330	725	300	328.8	297.6	-1.0	-1.00	-1
1331	750	300	332.4	289.2	-1.0	-1.00	-1
1332	775	300	93.6	116.4	-1.0	-1.00	-1
1333	800	300	302.4	236.4	225.0	52.50	60
1334	825	300	250.8	278.4	-1.0	-1.00	-1
1335	850	300	409.2	340.8	-1.0	-1.00	-1
1336	875	300	460.8	506.4	-1.0	-1.00	-1
1337	900	300	417.6	416.4	244.0	43.60	58
1338	925	300	469.2	456.0	-1.0	-1.00	-1
1339	950	300	91.2	126.0	-1.0	-1.00	-1
1340	975	300	196.8	265.2	-1.0	-1.00	-1
1341	1000	300	294.0	355.2	251.0	29.90	66
1342	1025	300	288.0	357.6	-1.0	-1.00	-1
1343	1050	300	334.8	396.0	-1.0	-1.00	-1
1344	1075	300	156.0	228.0	-1.0	-1.00	-1
1345	1100	300	66.0	92.4	26.0	21.30	62
1445	1100	325	106.8	171.6	-1.0	-1.00	-1
1444	1075	325	204.0	316.0	-1.0	-1.00	-1
1443	1050	325	352.0	452.0	-1.0	-1.00	-1
1442	1025	325	280.0	380.0	-1.0	-1.00	-1
1441	1000	325	180.0	240.0	-1.0	-1.00	-1
1440	975	325	96.0	60.0	-1.0	-1.00	-1
1439	950	325	128.0	208.0	-1.0	-1.00	-1
1438	925	325	212.0	284.0	-1.0	-1.00	-1
1437	900	325	120.0	184.0	-1.0	-1.00	-1
1436	875	325	368.0	320.0	-1.0	-1.00	-1
1435	850	325	232.0	244.0	-1.0	-1.00	-1
1434	825	325	240.0	256.0	-1.0	-1.00	-1
1433	800	325	380.0	292.0	-1.0	-1.00	-1
1432	775	325	140.0	156.0	-1.0	-1.00	-1
1431	750	325	162.0	195.6	-1.0	-1.00	-1
1430	725	325	456.0	408.0	-1.0	-1.00	-1
1429	700	325	664.0	320.0	-1.0	-1.00	-1

1428	675	325	348.0	372.0	-1.0	-1.00	-1
1427	650	325	292.0	312.0	-1.0	-1.00	-1
1426	625	325	120.0	184.0	-1.0	-1.00	-1
1425	600	325	352.0	328.0	-1.0	-1.00	-1
1424	575	325	312.0	320.0	-1.0	-1.00	-1
1423	550	325	404.0	380.0	-1.0	-1.00	-1
1422	525	325	312.0	288.0	-1.0	-1.00	-1
1421	500	325	236.0	184.0	-1.0	-1.00	-1
1420	475	325	192.0	176.0	-1.0	-1.00	-1
1419	450	325	228.0	212.0	-1.0	-1.00	-1
1418	425	325	256.0	280.0	-1.0	-1.00	-1
1417	400	325	276.0	292.0	-1.0	-1.00	-1
1416	375	325	216.0	240.0	-1.0	-1.00	-1
1415	350	325	212.0	240.0	-1.0	-1.00	-1
1414	325	325	204.0	214.8	-1.0	-1.00	-1
1413	300	325	75.6	86.4	-1.0	-1.00	-1
1412	275	325	336.0	265.2	-1.0	-1.00	-1
1411	250	325	298.8	270.0	-1.0	-1.00	-1
1410	225	325	273.6	242.4	-1.0	-1.00	-1
1409	200	325	416.0	302.4	-1.0	-1.00	-1
1408	175	325	368.0	208.0	-1.0	-1.00	-1
1407	150	325	108.0	140.0	-1.0	-1.00	-1
1406	125	325	252.0	252.0	-1.0	-1.00	-1
1405	100	325	348.0	248.0	-1.0	-1.00	-1
1404	75	325	328.0	268.0	-1.0	-1.00	-1
1403	50	325	316.0	304.0	-1.0	-1.00	-1
1402	25	325	216.0	240.0	-1.0	-1.00	-1
1401	0	325	9999.0	999.0	-1.0	-1.00	-1
1501	0	350	360.0	336.0	-1.0	-1.00	-1
1502	25	350	192.0	176.0	-1.0	-1.00	-1
1503	50	350	360.0	284.0	-1.0	-1.00	-1
1504	75	350	612.0	304.0	-1.0	-1.00	-1
1505	100	350	276.0	296.0	-1.0	-1.00	-1
1506	125	350	300.0	264.0	-1.0	-1.00	-1
1507	150	350	404.0	308.0	-1.0	-1.00	-1
1508	175	350	308.0	340.0	-1.0	-1.00	-1
1509	200	350	208.0	196.0	-1.0	-1.00	-1
1510	225	350	327.6	273.6	-1.0	-1.00	-1
1511	250	350	444.0	324.0	-1.0	-1.00	-1
1512	275	350	360.0	300.0	-1.0	-1.00	-1
1513	300	350	84.0	108.0	-1.0	-1.00	-1
1514	325	350	368.0	328.0	-1.0	-1.00	-1
1515	350	350	384.0	248.0	-1.0	-1.00	-1
1516	375	350	132.0	152.0	-1.0	-1.00	-1
1517	400	350	252.0	220.0	-1.0	-1.00	-1
1518	425	350	316.0	244.0	-1.0	-1.00	-1
1519	450	350	120.0	144.0	-1.0	-1.00	-1
1520	475	350	324.0	180.0	-1.0	-1.00	-1
1521	500	350	220.0	208.0	-1.0	-1.00	-1
1522	525	350	264.0	276.0	-1.0	-1.00	-1
1523	550	350	276.0	280.0	-1.0	-1.00	-1
1524	575	350	9999.0	1000.0	-1.0	-1.00	-1
1525	600	350	9999.0	1000.0	-1.0	-1.00	-1
1526	625	350	9999.0	1000.0	-1.0	-1.00	-1
1527	650	350	9999.0	1000.0	-1.0	-1.00	-1
1528	675	350	724.0	532.0	-1.0	-1.00	-1
1529	700	350	336.0	332.0	-1.0	-1.00	-1
1530	725	350	416.0	456.0	-1.0	-1.00	-1

227	650	25	304.0	188.0	−1.0	−1.00	−1	1
226	625	25	152.0	128.0	−1.0	−1.00	−1	1
225	600	25	76.0	60.0	−1.0	−1.00	−1	1
224	575	25	104.0	104.0	−1.0	−1.00	−1	1
223	550	25	108.0	112.0	−1.0	−1.00	−1	2
222	525	25	172.0	144.0	−1.0	−1.00	−1	2
221	500	25	228.0	156.0	−1.0	−1.00	−1	2
220	475	25	120.0	128.0	−1.0	−1.00	−1	2
219	450	25	324.0	164.0	−1.0	−1.00	−1	2
218	425	25	204.0	180.0	−1.0	−1.00	−1	2
217	400	25	192.0	144.0	−1.0	−1.00	−1	2
216	375	25	108.0	124.0	−1.0	−1.00	−1	2
215	350	25	128.0	128.0	−1.0	−1.00	−1	2
214	325	25	144.0	88.0	−1.0	−1.00	−1	2
213	300	25	88.0	100.0	−1.0	−1.00	−1	2
212	275	25	176.0	96.0	−1.0	−1.00	−1	2
211	250	25	128.4	108.0	−1.0	−1.00	−1	2
210	225	25	170.4	106.8	−1.0	−1.00	−1	2
209	200	25	160.0	139.2	−1.0	−1.00	−1	2
208	175	25	168.0	121.2	−1.0	−1.00	−1	2
207	150	25	139.2	115.2	−1.0	−1.00	−1	2
206	125	25	297.6	184.8	−1.0	−1.00	−1	2
205	100	25	176.4	148.8	−1.0	−1.00	−1	2
204	75	25	306.0	162.0	−1.0	−1.00	−1	2
203	50	25	219.0	114.0	−1.0	−1.00	−1	2
202	25	25	220.8	108.0	−1.0	−1.00	−1	2
201	0	25	100.8	78.0	−1.0	−1.00	−1	2
301	0	50	108.0	75.6	−1.0	−1.00	−1	2
302	25	50	122.4	81.6	−1.0	−1.00	−1	2
303	50	50	234.0	99.6	−1.0	−1.00	−1	2
304	75	50	159.6	159.6	−1.0	−1.00	−1	2
305	100	50	237.6	152.4	−1.0	−1.00	−1	2
306	125	50	433.2	136.8	−1.0	−1.00	−1	2
307	150	50	148.8	91.2	−1.0	−1.00	−1	2
308	175	50	254.0	253.2	−1.0	−1.00	−1	2
309	200	50	354.0	206.4	−1.0	−1.00	−1	2
310	225	50	454.8	102.0	−1.0	−1.00	−1	2
311	250	50	292.8	210.0	−1.0	−1.00	−1	2
312	275	50	375.6	235.2	−1.0	−1.00	−1	2
313	300	50	183.6	166.8	−1.0	−1.00	−1	2
314	325	50	147.6	117.6	−1.0	−1.00	−1	2
315	350	50	166.8	112.8	−1.0	−1.00	−1	2
316	375	50	225.6	99.6	−1.0	−1.00	−1	2
317	400	50	145.2	111.6	−1.0	−1.00	−1	2
318	425	50	556.0	160.8	−1.0	−1.00	−1	2
319	450	50	172.8	158.4	−1.0	−1.00	−1	2
320	475	50	166.8	109.2	−1.0	−1.00	−1	2
321	500	50	135.6	109.2	−1.0	−1.00	−1	2
322	525	50	346.8	102.0	−1.0	−1.00	−1	2
323	550	50	174.0	172.8	−1.0	−1.00	−1	1
324	575	50	145.0	120.0	−1.0	−1.00	−1	1
325	600	50	156.0	114.0	−1.0	−1.00	−1	1
326	625	50	87.8	70.8	−1.0	−1.00	−1	1
327	650	50	266.8	178.8	−1.0	−1.00	−1	1
328	675	50	529.6	213.6	−1.0	−1.00	−1	1
329	700	50	522.0	300.0	−1.0	−1.00	−1	1
330	725	50	344.6	381.6	−1.0	−1.00	−1	1
331	750	50	432.0	356.0	−1.0	−1.00	−1	1