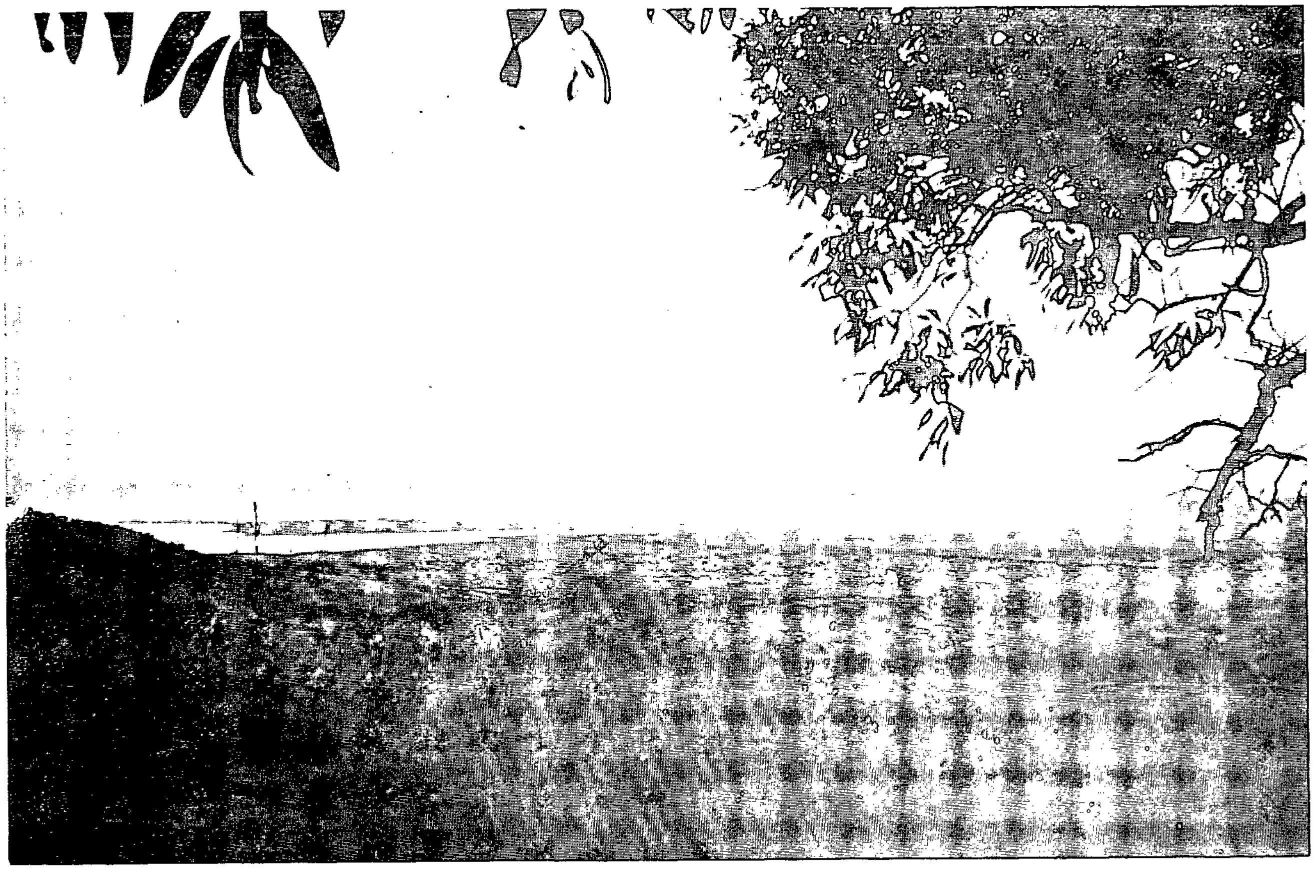
TRAINING PROJECT IN PEDOLOGY

KISII KENYA



A Detailed Soil Survey of the Irrigation Trial Plot in Kirindo Valley, South Nyanza.

PRELIMINARY REPORT NO 10

AGRICULTURAL UNIVERSITY

WAGENINGEN - THE NETHERLANDS

A Detailed Soil Survey of the Irrigation Trial Plot in Kirindo Valley

by

A.P. Oosterom

Preliminary Report no. 10
1975

TRAINING PROJECT IN PEDOLOGY, KISII KENYA.

Agricultural University, Wageningen - The Netherlands.

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Preface

This report of the Training Project in Pedology at Kisii, Kenya of the section on Tropical Soil Science of the Agricultural University at Wageningen, Netherlands, is the tenth one of a series to be presented to Kenyan officials.

The project started in November 1973 after assent had been granted by the Office of the President of Kenya. It is meant for training of postgraduate students of the Agricultural University at Wageningen and for furnishing research opportunities to the staff. The activities of students and staff are directed to obtaining a better knowledge of the soils and the agricultural conditions of the project area to provide a basis for the futher agricultural development of the area.
The project in Kisii is conducted by:
Ir. W.G. Wielemaker, teaching and research
Ing. H.W. Boxem, management.
Visiting specialists from the Agricultural University at Wageningen help to resolve special problems.

This report has been written by Mr. A.P. Oostrom who also drew the maps. The compilation and editing of the report has been done by Mr. H.W. Boxem.

We hope to pay back with these reports a small part of the great debt we owe to Kenya in general and to many Kenyans in particular for their valuable contributions to the good functioning of the project.

The supervisor of the project

J. Bennema, Professor of Tropical Soil Science

Introduction

During the end of August to the beginning of September 1975, a detailed soil survey was carried out in an Irrigation trial plot in Kirindo Valley. This trial plot is made by local people with Government support of the Ministry of Agriculture.
The purpose of the survey was to obtain more information about the soil and its potential, especially with regards to irrigation.
The results are put in this report with three maps: a soil map, a salinity hazard map and an irrigation suitability map, scale 1:1000.
Aerial photographs scale 1:12,500 and 1:25,000 were used to study the position of the trial plot and its relation to the surroundings. Due to the scale it was not possible to use these photographs for making a base map of the trial plot. That's why this work was done with the help of hand-measurements in the field. Chemical analysis and measurements were carried out in the laboratories of the Training Project in Pedology in Kisii.
It should be stressed that the present report with its maps is preliminary, because no exact data are known yet of physical properties as permeability, hydraulic conductivity, and water holding capacity.

2. ENVIRONMENTAL CONDITIONS.

2.1 Location.

Kirindo Valley is situated in Mbita division of Homa Bay district, South Nyanza Province; North of the road from Homa-Bay to Mbita, between Kirindo and Luanda, near Kirindo.
The trial plot is about 5 hectares. The longest distance to Lake Victoria is 1000 metres and its highest position above present lake level (august 1975) is 18 metres. (see sheet 115/3, topographical map of Kenya).

2.2 Geology.

Kirindo Valley is surrounded by hills which consists of volcanic highly calcareous rocks, mainly tuff agglomerate. About the valley fill is some doubt. Investigations to origin and kind of material are not yet finished. Anyway it is clear that:

1: The valley consists of two essentially different parts: an eroding part and a part where the eroded material is deposited. (see Fig. 1.)

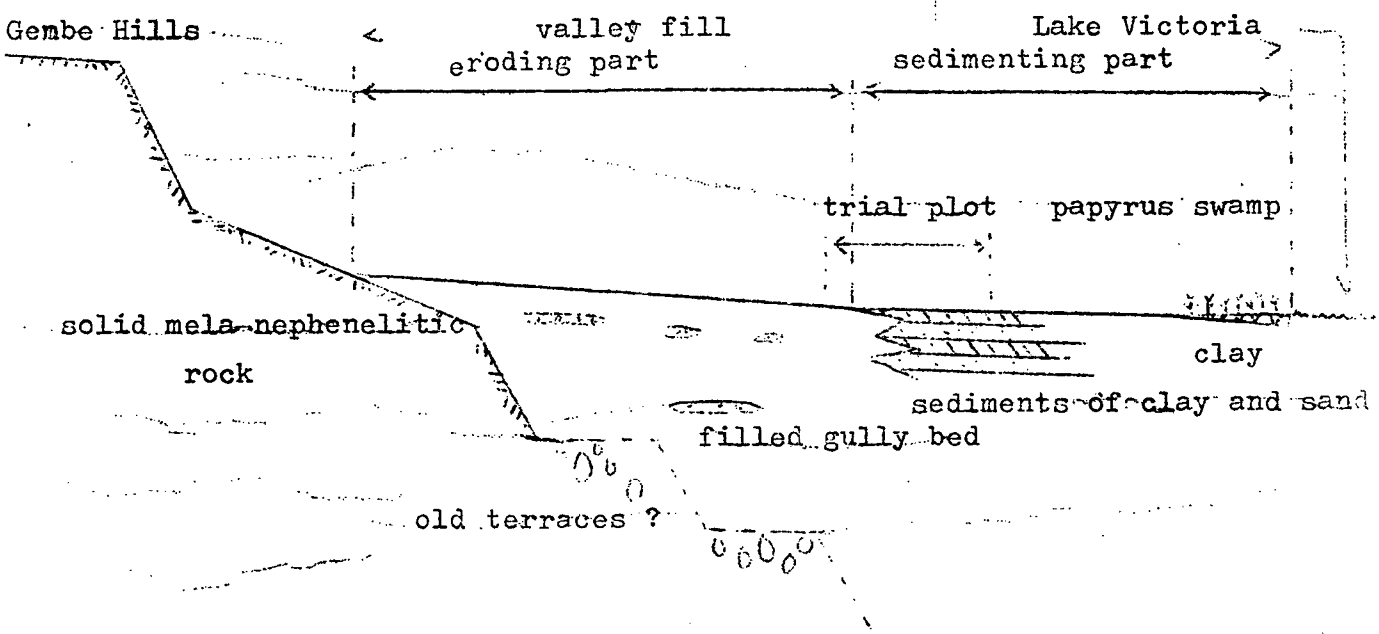


Fig 1. Longitudonal Section trough the Kirindo valley

2. The valley fill in the eroding part consists mainly of a very porous, calcareous loamy clay to clayloam, including shells, locally sand and gravel beds are found. The clay-loam has an allophanic character and this may be an indication of volcanic origin.
Anyway during the filling up of the valley there was an important volcanic influence, pure ash layers of more than 30 centimeter thick were found.
In the whole complex of sediments a black soil profile has developed (Black Cotton Soil), which shrinks when dry and swells when wet.

3. The valley fill in the part where the eroded material is deposited, consists of layers of sand and clay. In the beds of recent or old gullies pure sand and gravel is found. Near the Lake only very fine material is deposited.

2.3. Topography.

Kirindo Valley is bordered by Lake Victoria in the North. In the East and West are gently sloping hills, connected with Gembe Hills, part of an old erosion level. In the South the border is formed by Gembe Hills, with slopes of 20 - 40%. The valley has a slope of 4-6%. Only near the lake it is flat or nearly flat. On the trial plot slopes are measured of 2-4%. In a cross-section along the road from Mbita to Homabay (Fig. 2) it can be seen that the trial plot has a higher position than its surroundings. This is very important because the lower parts of the valley have a very high flooding hazard during heavy rains. These places are characterised by a concentration of Accacia trees and shrubs.

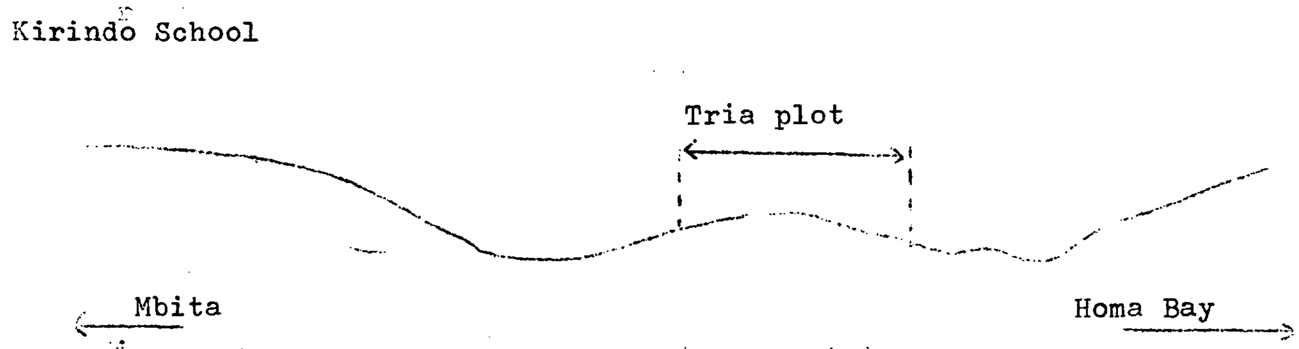


Fig. 2. Crossection trough the Kirindo valley.

2.4. Climate.

The main rainfall peak is in April with an average of 205 mm. There are two variable dry periods viz. January till February and June till November. The total rainfall is 760-1015 mm per year. The mean annual temperature is 23.2° C, with annual mean maximum of 30-34° C, and annual mean minimum of 14-18° C.

2.5. Vegetation.

The hills around Kirindo Valley are covered with spare grasses and scattered shrubs. Where the valley fill starts, much more tall grasses are growing. On formerly used arable land many different kinds of herbs are found.
Trees are very rare, except on places where the gullies, which dissect Kirindo Valley, are ending. These trees are mainly Accacia species. Sisal is used for fencing of the cropland.
Near the lake a big papyrus swamp extends.

2.6. Water resources.

The gullies through Kirindo Valley, which have an important part of their catchment area in the Gembe Hills, are not permanently filled with water. Only near the foot of Gembe Hills there is always some water coming out of the rock. This water is very important for the people living near these places, because the lake is very far. However this water does not reach the lake, it disappears in the soil where the valley fill starts. Only during a short time in the wet season and during a very heavy shower, the water can reach the lake. Groundwater must be present, but until this moment no investigations as far as quality and quantity of this probably important water source is concerned have been carried out. Only near the lake some samples were taken of groundwater which is there very near the surface. This water was salty (EC 12 mmhos), but it is not sure that this is true for the whole valley. It may be caused by accumulation of salts due to capillary rise and evaporation of groundwater.
So lake Victoria remains as the permanent and most important water source for as well as domestic and livestock use, as for irrigation. The quality of this water changes from place to place, due to the influence of groundwater, surface runoff, and the locally somewhat acid circumstances of the papyrus swamps. (see also 3.2. The salinity hazard map).

3. MAPS OF KIRINDO IRRIGATION TRIAL PLOT.

3.1. Soilmap

The soilmap is based on a systematic survey. Every 30 meter an augering was done till 2 meter deep, with an Edelman auger. Also in each soil unit a pit was dug, and the soil profile was described (for location see: pit and augering location map)
Three soil mapping units are distinguished:
Unit R: (see description pit 11)

As the soilmap shows, this is a very small spot on the west side of the trial plot. It is typical for the filled up and also the still active gully beds. The material consists of almost pure gravel and sand. Only the very thin toplayer has a finer texture. The main problem of this soil is the very low water holding capacity, compared with the other soil units. Plants will very soon suffer of drought, as it may not be possible to adjust the irrigation scheme to this small spot. During heavy rains there is also a flooding hazard.

Unit M: (see description pit 1)
This unit dominated on the trial plot. The whole profile is very dark brown, and shows an irregular decrease of organic matter.
The subsoil is layered, and shows abrupt textural changes from pure sand to loamy clay. The whole profile is calcareous, very porous, and has a good structure.
The loamy to clayey topsoil gives a good waterholding capacity. The layered and sandy subsoil will be very favourable for drainage of the excess of irrigation water.
The only disadvantage of this unit is the salinity hazard of the soil where the groundwater rises reach the rooting zone. (see salinity hazard map)

Unit S: (see description pit 111)
The soil has a very dark brown topsoil with good structural properties. The subsoil is brown and calcareous. The whole profile is very porous. The pH of the topsoil is 7.00 and of the subsoil 7.50. In general it can be stated that the soil properties of unit S are good. But especially in view of irrigation the drainage capacity will give problems. It may be difficult to remove the excess of irrigation water from the subsoil to prevent salinisation.
On the trial plot the problem of slow permeability is not so big because here the soils of unit S are dissected and surrounded by the permeable soils of unit M and this gives possibilities for drainage of excess irrigation water. But when the whole valley is taken into account, it is a real problem because this soiltype occurs here most and even with a lower permeability

3.2. Salinity hazard map:

This map is made by combination of soil properties and actual salinity condition in view of irrigation.
To determine the actual salinity, samples were taken every 50 meters on three lines. The depth of sampling was: 0 - 10 cm
30 - 40 cm
70 - 80 cm

The electric conductivity and the pH were measured in the saturated extract of each sample, with an Cenco conductivity bridge and a Pye unicam pH meter respectively.
The results can be found in table 1.
It should be stressed that these data give the salt condition on the moment of sampling. These data are mostly dependent on the season but it is not known yet for this area.
On the map three zones are distinguished:

Zone 1: High salinity hazard.
Due to the groundwater influence the soil has become very salty in comparison to the soils of the other zones.
The EC (electric conductivity of the saturated extract) of the upper 10 cm is low (less than 1 mmhos). But of the subsoil the EC is around 3 mmhos and this is already harmful for some crops. In this zone groundwater is found within 1.50 m with an EC of 12.4 mmhos.
It is clear, that for successful irrigation, in no case the groundwater level may rise due to irrigation and that measures must be taken to lower the groundwater level in this zone. After this is arranged, excess of irrigation water can be given in order to lower the salt content of the soil. Drainage is possible due to the good permeability of the subsoil (see soil map).

Zone 11: Moderate salinity hazard.
This zone is strongly related with unit S of the soil map. The actual salinity condition is still very low (highest EC is 0.680). Here the salinity hazard consists of possible accumulation of salts by evaporation of irrigation water, as the salts are very difficult to leach due to the low permeability of this soil.

Zone 111: Low salinity hazard

Also in this zone the actual salinity condition is very low (highest EC is 0.690). With a good irrigation and drainage management it seems to be possible to keep the salt content of the soil in this low condition.

In general it can be stated that the trial plot is not free of salinity hazard. And also in this connection the quality of the irrigation water is very important. Therefore water samples were taken on different places in the irrigation scheme. (see Fig. 3.)

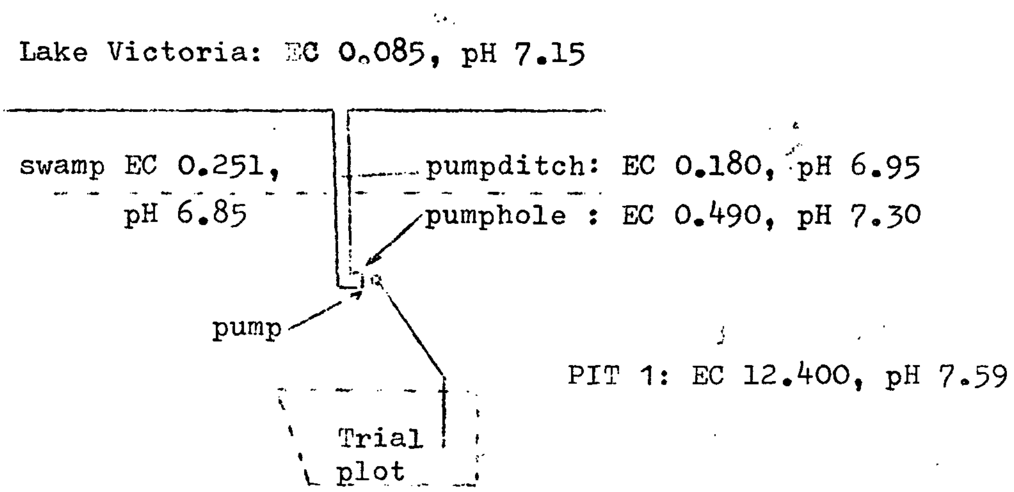


Fig.3. Layout of the trial field with some EC and pH determinations

From this data it can be seen, that the EC of the pumpditch is two times as high as the EC of the lake water, and the EC of the water in the pumphole even more as five times higher. This difference must be caused by the groundwater and it is clear that this affects the quality of the irrigation water in a very bad way.

The pH of the soil is everywhere more than 7.00, and never where higher than 8.00. No data are known yet of the sodium content of the soils, but according to the pH data there is no actual alkalinity.

3.3. Irrigation suitability map.

This map is mainly based on the soil map and the salinity hazard map. As the trial scheme uses sprinkler irrigation, costs of leveling are not taken into consideration. However the costs of drainage management are considered as an important factor.
Four classes are distinguished:

Class 1: Very well suited.
It occurs within the boundaries of zone 111 of the salinity hazard map and unit M of the soil map.
Drainage for the removal of the excess of irrigation water will be easy and cheap, due to the good permeable subsoil.

Class 2: Moderately well suited.
This class occurs within the boundaries of zone 11 of the salinity hazard map and it includes soils of unit M and unit S of the soil map. The soil is not salty, but drainage of the exess of irrigation water will be more difficult as in class 1.

Class 3: Poorly suited.
The boundaries are the same as that of zone 1 of the salinity hazard map. Unless the subsoil permeable, drainage will be an expensive factor, because first of all the ground water level must be lowered. After this, the accumulated salt must be washed down and also this will raise the costs of irrigation.

Class 4: Very poorly suited.
The boundary of this class is determined by the soil unit R. And only reason that this soil is very poorly suited to irrigation, is the very low waterholding capacity.

4. CONCLUSION AND RECOMMENDATIONS.

4.1. Conclusions.

1° . Most of the soils of the trial plot in Kirindo Valley are well suited to irrigation.

2° . The main problem will be to prevent salinisation.

3° . The present salinity is strongly influenced by the presence of ground water, and increases towards the lake.

4° . Excess of irrigation water will be needed to depress the capilary rise of salty groundwater and to prevent accumulation of salt by evaporation of irrigation water.

5°. Soils of unit M have the most suitable possibilities for an open or closed drainage system. Drainage will be needed to lower the ground water level, or at least to prevent a rise of the ground water level.

6° . In the present irrigation scheme the position of the pump may give several problems (see fig. 3.):

a. The use of a pumphole at the end of a ditch through the swamp, is very disadvantageous to the quality of the irrigation water.

b. The ditch from the lake towards the pumphole will be a source of obstruction of the pump due to the very rapid growth of plants in the swamp.

c. During irrigation the water in the ditch will take up much fine clay and silt, because the bottom consists of a very heavy clay and the velocity of the water will be rather high.

7° . The trial plot is representative for the soils near the lake, but not for the soils which are situated higher up in the valley, towards Gembe Hills. On this side permeability and character of the soil are different.

4.2. Recommendations.

1° . To know something about soil fertility it will be necessary to send some soil samples to the National Agricultural Laboratories.

2° . To do more research, in order to get exact data about permeability, hydraulic conductivity, etc.

3° . To make calculations how much water is needed as excess of irrigation water, to prevent salinisation.

4° . To do permanent measurements of the groundwater level movement, in order to know what is the influence of rainfall and irrigation.

5° . To make a platform for the pump in the swamp at the border with the lake. Here the bottom of the swamp consists of a very tough clay and is not very deep (1-1.5 meter), so that foundation will not be a problem.
This in order to obtain water of a better quality.

6° . To irrigate in the morning, when possible, at that time the wind is offshore and the water is very clear (no suspended clay and silt), and there will be no rubbish which can obstruct the pumping activity.

7°. To extent the trial plot in direction of Gembe Hills, at the other side of the road, because soils there are representative for the majority of the valleys near Lake Victoria.

Table 1.

Sample no.	Dept (cm)	ECe (mmhos)	pH (sat. ext.)
Ki 1	0 - 10	0.590	7.35
	30 - 40	2.080	7.82
	70 - 80	3.500	7.32
Ki 2	0 - 10	0.930	7.85
	30 - 40	2.210	7.10
	70 - 80	2.270	7.31
Ki 3	0 - 10	0.310	7.32
	30 - 40	0.360	8.00
	70 - 80	0.810	7.23
Ki 4	0 - 10	0.340	7.71
	30 - 40	1.460	7.60
	70 - 80	3.000	7.45
Ki 5	0 - 10	0.495	7.38
	30 - 40	0.274	7.40
	70 - 80	1.155	7.40
Ki 6	0 - 10	0.274	7.40
	30 - 40	0.690	7.40
	70 - 80	0.430	7.49
Ki 7	0 - 10	0.390	7.29
	30 - 40	0.290	7.16
	70 - 80	0.300	7.63
Ki 8	0 - 10	0.294	7.29
	30 - 40	0.261	7.32
	70 - 80	0.267	7.40
Ki 9	0 - 10	0.420	7.20
	30 - 40	0.265	7.30
	70 - 80	0.350	7.31
Ki 10	0 - 10	0.282	7.00
	30 - 40	0.249	7.00
	70 - 80	0.279	7.50
Ki 11	0 - 10	0.560	7.10
	30 - 40	0.310	7.29
	70 - 80	0.320	7.30
Ki 12	0 - 10	0.620	7.19
	30 - 40	0.310	7.06
	70 - 80	0.360	7.36
Ki 13	0 - 10	0.680	7.11
	30 - 40	0.310	7.19
	70 - 80	0.310	7.50

Profile No. I. Mapping unit: M

Classification	: Fluventic Ustropept (Soil Taxonomy 1970). Calcaric Fluvisol. (FAO 1970).
Date and author	: 11-9-1975, A.P. Oosterom.
Location	: Kirindo valley, (see pit and aug. loc. map).
Elevation	:
Physiographic position	: straight slope.
Surrounding land form	: flat or almost flat.
Microtopography	: termite mounds.
Slope	: 1 %.
Vegetation/land use	: arable land (mais).
Climate	: dry savannah.
Parent material	: alluvial deposits derived of valley fill-sediments and Nephelinite agglomerate rock.
Drainage	: well drained.
moistness	: upper 10 cm dry, moist below.
Ground water	: sometimes up to 100 cm below surface.
Surface stones	: class 0, no stones.
Rock outcrops	: class 0, no rocks.
Erosion	: none.
Presence of salts	: locally class 1, slightly affected.
Human influences	: agricultural practices.

A_p 0- 15 cm - Very dark brown (10 YR 2/2) moist and dark gray (10 YR 4/1) dry, clay; strong, very fine subangular blocky; slightly sticky, slightly plastic, very friable moist, soft dry; many very fine pores; strongly calcareous; very many very fine and many fine roots, clear, smooth boundary.

A/B 15- 40 cm - Very dark brown (10 YR 2/3) moist, clay loam; weak fine angular blocky; slightly sticky, slightly plastic, friable moist, hard dry; many very fine and few fine pores; strongly calcareous; very many very fine and few fine roots; clear, wavy boundary.

C 40-150 cm - Mixed colours of very dark gray brown (10 YR 3/2) moist and black (10 YR 1/1) moist , layerd sediments of sandy clay to pure sand; non structure, massive very friable moist; many very fine pores; strongly calcareous; many very fine and very few fine roots; visable salt cristals.

Profile No. II. Mapping unit: R

Classification	: Typic tropofluvent (Soil Taxonomy 1970) Calcaric Fluvisol. (FAO 1970)
Date and author	: 11-9-1975, A.P. Oosterom.
Location	: Kirindo Valley.
Physiographic position	: end of erosion gully.
Surrounding landform	: flat to almost flat.
Microtopography	: low rills and small gullies.
Slope	: 1%.
Vegetation/land use	: arable land.
Climate	: dry savannah.
Parent material	: alluvial deposits mainly derived of Nephelinite agglomerate.
Drainage	: excessively drained.
Moistness	: dry throughout profile.
Ground water	: below profile.
Surface stones	: class 0, too few to interfere with tillage.
Rock out crops	: class 0, no rocks.
Erosion	: none.
Presence of salts	: free.
Human influences	: agricultural practices.

A_p 0- 15 cm - Very dark brown (10 YR 2/2) when moist and dark gray when dry, fine gravelly sandy clay; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable when moist and very soft when dry; many very fine pores; much rounded to angular small gravel of various rock; strongly calcareous; very many very fine and fine roots; clear and smooth boundary.

C 15-180^{+}cm - Mixed colours, layered sediments of sand and gravel; non structure, singel grain; few very fine pores; vary much rounded and angular small gravel of various rock; strongly calcareous; very few fine roots.

Profile No. III. Mapping unit: S

Classification	: Vertic Argiustoll (Soil Taxonomy 1970). Luvic Phaeozem (FAO 1970).
Date and author	: 1-12-1975, A.P. Oosterom.
Location	: Ogono (see pit and augering location map).
Physiographic position	: flat valley bottom.
Surrounding land form	: almost flat to undulatigg.
Microtopography	: termite mounds.
Slope	: 4 %.
Vegetation/land use	: arable land.
Climate	: dry savannah.
Parent material	: loamy sediments probably lacustrine and influenced by volcanic ash and material derived of Nephelinite agglomerate.
Drainage	: well drained.
Ground water	: no influence on profile.
Surface stones	: class 0, no stones.
Rock outcrops	: class 0, no rocks.
Erosion	: strong gully erosion.
Presence of salts	: free.
Human influences	: agricultural purposes.

A_p 0- 15 cm - Very dark brown (10 YR 2.5/3) moist and very dark gray brown (10 YR 3/2) dry, clay loam; strong, very fine, granular; slightly sticky, slightly plastic, very friable moist, soft dry; many micro, very fine, and fine pores; non calcareous; many very fine and common fine roots; gradual, smooth boundary.

B_{2t1} 15- 30 cm - Very dark brown (10 YR 2/3) moist and very dark gray brown (10 YR 2.5/2) dry, clay loam; strong very fine subangular to angular blocky; slightly sticky, slightly plastic, very friable moist, slightly hard dry; many micro,very fine and fine pores; patchy, moderately thick clay cutans; non calcareous; many very fine and common fine roots; gradual, smooth boundary.

B_{2t2} 30-120 cm - Very dark brown (10 YR 2/3) moist and very dark gray brown (10 YR 3/2) dry, clay; strong very fine angular blocky; slightly sticky, slightly plastic, very friable moist; continuous, thick clay cutans; many very fine pores; non calcareous; common very fine and very few roots; gradual smooth boundary.

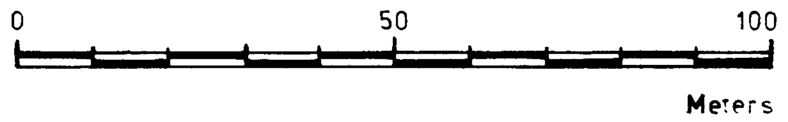
B_3 120-180 cm$^+$- Very dark brown (10 YR 2/3) moist and dark gray brown (10 YR 4/2) dry, clay loam; weak very fine angular to subangular blocky; slightly sticky, slightly plastic, very friable moist; patchy, moderately thick, clay cutans;many very fine pores; few small soft irregular white calcium carbonate nodules (rotten shells ?); from 140 cm strongly calcareous; few very fine roots.

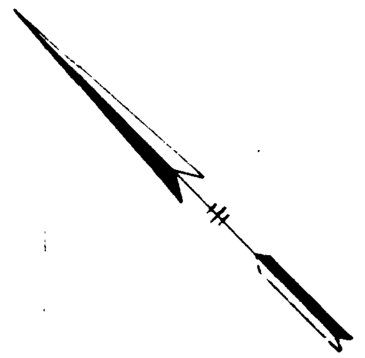
2733d

KIRINDO VALLEY

SOIL MAP of IRRIGATION TRIAL PLOT

SCALE 1:1000





LEGEND

R SOILS WITH A VERY RAPID PERMEABILITY

Very thin (less than 30 cm), very dark brown topsoil calcareous, sandy clay loam, and very deep dark coloured, very sandy and fine gravely, calcareous subsoil

M SOILS WITH A MODERATE TO MODERATELY RAPID PERMEABILITY

Moderately thick (25 - 100 cm), very dark brown topsoil, calcareous, clay loam to sandy clay loam, and very deep, dark coloured, layerd (sandy clay loam and sand), calcareous subsoil

S SOILS WITH A MODERATELY SLOW PERMEABILITY

Thick (more than 100 cm), very dark brown topsoil, calcareous, clay to clay loam, and dark yellowish brown, very deep, fine textured calcareous subsoil

Training Project in Pedology, Kisii

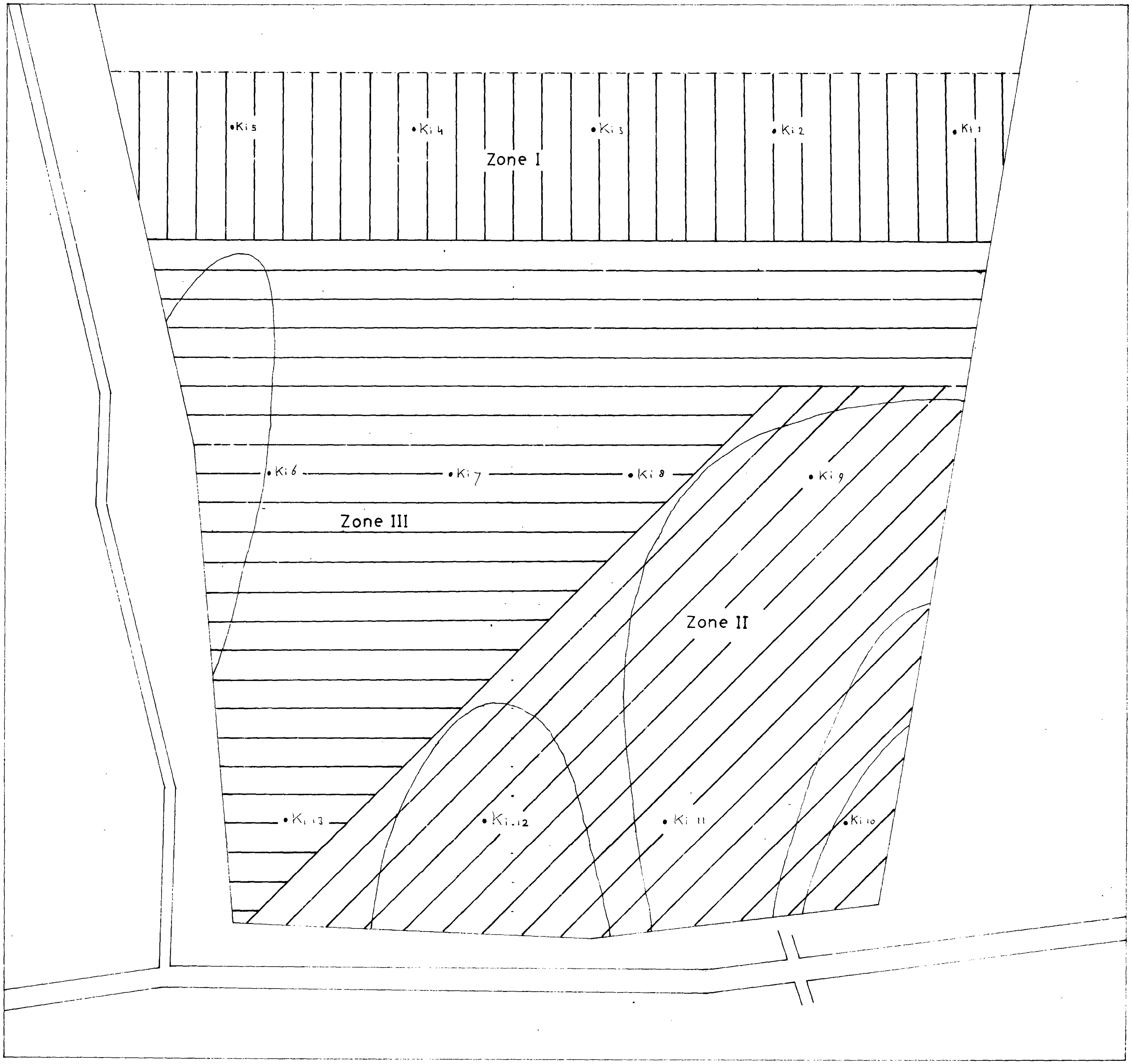
Department for Tropical Soil Science

Soil survey, Map compilation and Cartography: A.P. Oosterom
August, 1975
Kisii, Kenya

2733c

SALINITY HAZARD MAP

SCALE 1:1000



ZONE I : high

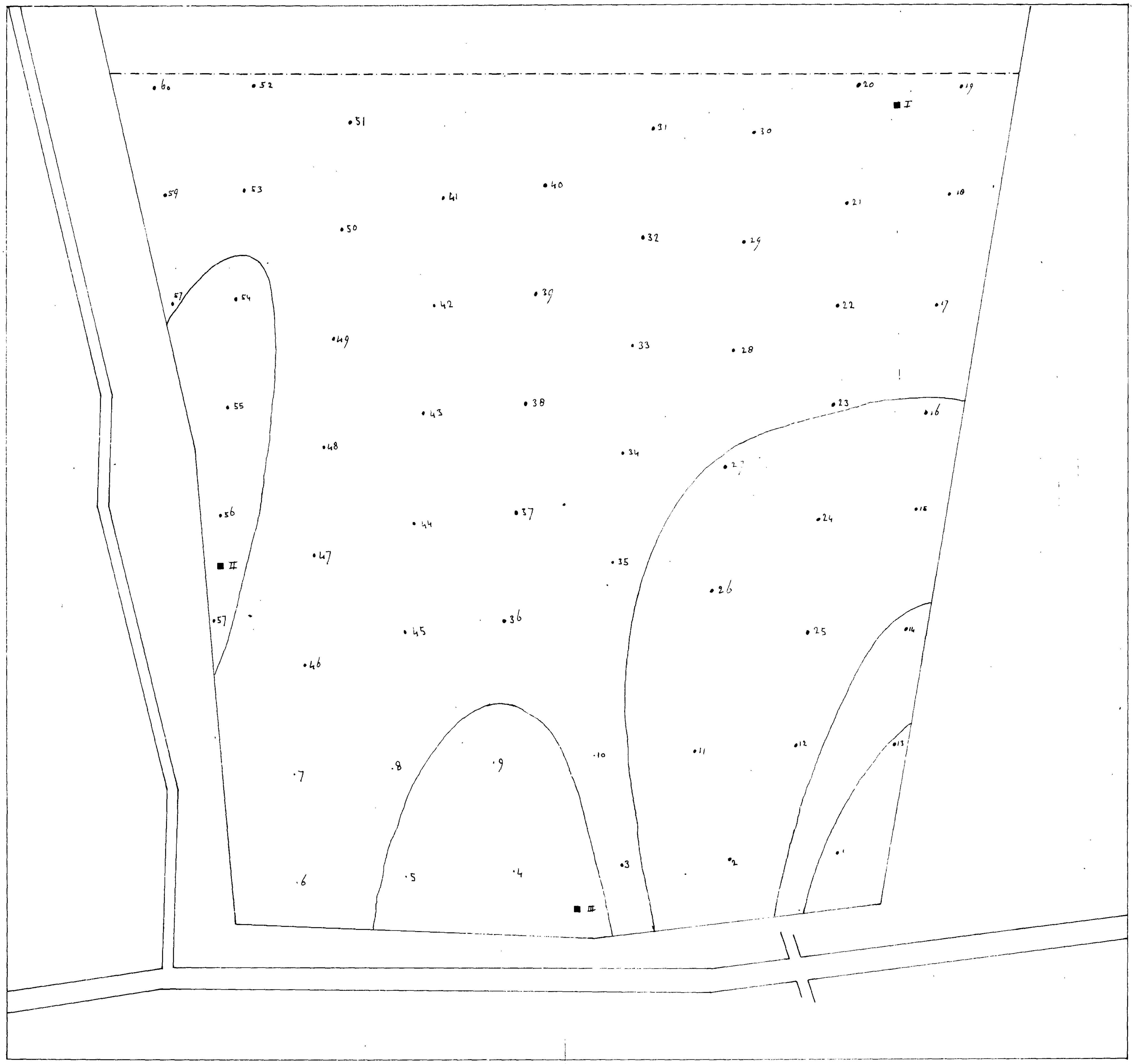
ZONE II : moderate

ZONE III : low

2733 b

PIT and AUGERING LOCATION MAP

SCALE 1:1000

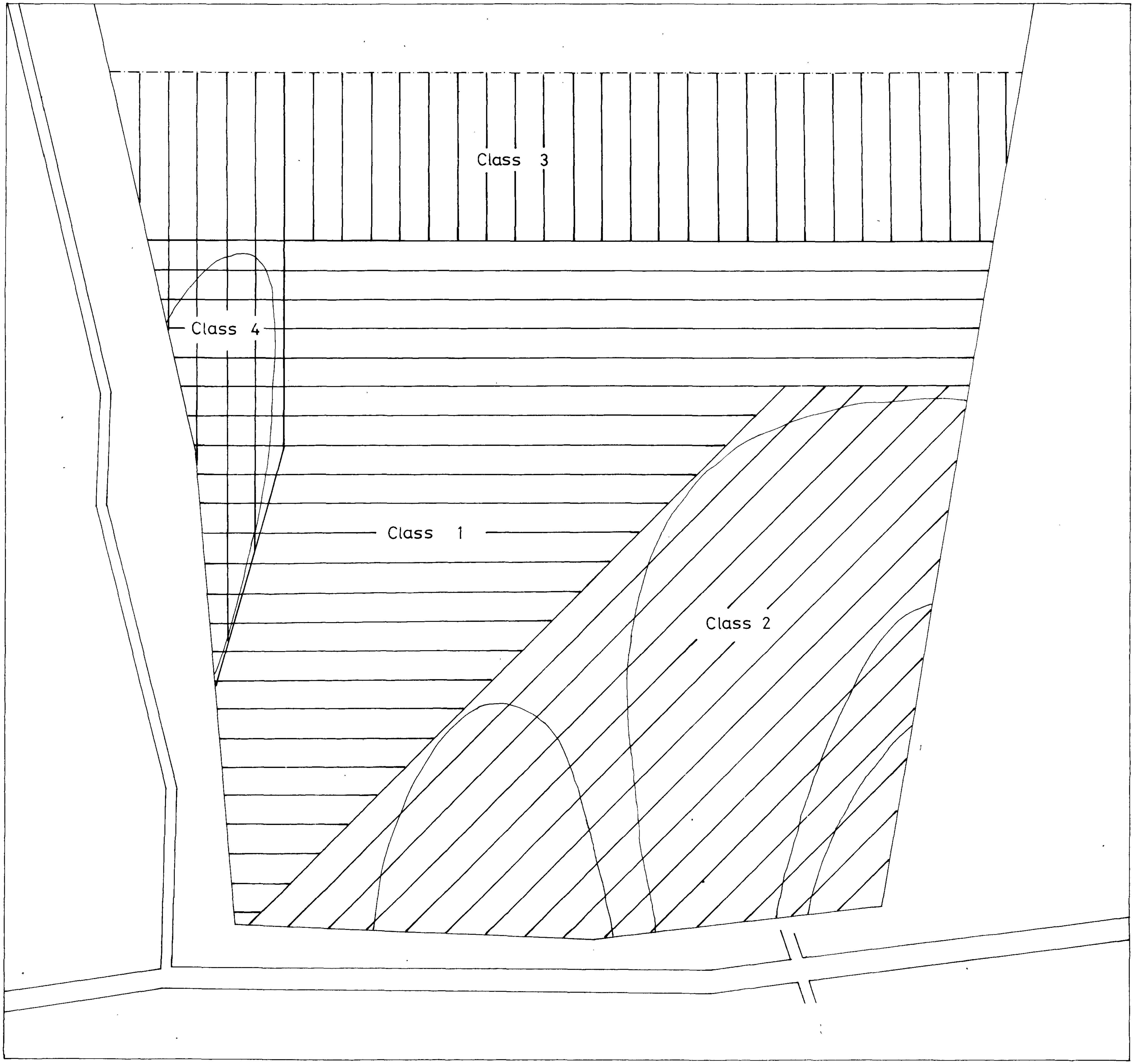


□ PIT

. AUGERING

2733a IRRIGATION SUITABILITY MAP

SCALE 1:1000



CLASS 1 : very well suited

CLASS 2 : moderately well suited

CLASS 3 : poorly suited

CLASS 4 : very poorly suited