

THE SOILS OF THE SETTLEMENT SCHEME

AT

SUNGEI MANILA.

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GENERAL REPORT OF THE SOILS
AND LAND-USE POTENTIAL

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OF THE
SETTLEMENT SCHEME

AT
SUNGEI MANILA.

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GENERAL REPORT OF THE SOILS OF THE SUNGEI
MANILA SETTLEMENT SCHEME.

Introduction.

A semi-detailed soil survey of the Sungei Manila Settlement Scheme, Sandakan was carried out during March, April and May of 1965.

The main purpose of the survey was to assess the extent of the soils suitable for oil palm cultivation within the boundary of the Scheme.

The following report of this survey is divided into four sections:-

- I. General description of the area
- II. Method of carrying out the investigation
- III. General descriptions of the soils of the area.
- IV. Recommendations for land use.

There are attached appendices giving detailed generalised profile descriptions of the different soils present in the area, chemical analyses of selected soils and meteorological data, together with a topography - rentis map, soil map and land use recommendations map. Field work on this Survey was carried out by R.G. Barber who wrote the main bulk of this report. The Chemical analyses were made by the Chemistry Division of the Agricultural Research Branch. The section on land-use recommendations has been compiled by P. Thomas.

I. General Description of the Area

1. The Sungei Manila Settlement Scheme occupies approximately 10,250 acres and is situated approximately 10 miles to the North-East of Sandakan town, between the rivers Gum Gum Besar in the West and the Sebyte in the East. The settlement scheme area is bounded to the North-West and East by swamp land and to the South by the Sandac Estate.

2. The topography and minor drainage are intimately related to the geological structure and history of the area. Petrologically rocks outcropping within the area are very pale coloured siltstones, buff fine grained sandstones showing varying amounts of iron-staining, and brown and grey mudstones. The rocks are generally non-feldspathic and non-calcareous but certain of the sandstones are micaceous. The rock strata dip steeply to the South and South-West in the western part of the area whereas in the East the Strata are more gently inclined. Differential weathering of the more resistant sandstones and siltstones and of the less resistant mudstones and shales has resulted in a cuesta-type topography in the West where the steeply dipping strata are found. The harder sandstone beds form elongated steep-sided ridges trending in East-West and East North East- West South West directions with the softer mudstones and shales occupying the intervening areas, which have since been etched out by subsequent streams to form valleys. This differential weathering however has had a much more subdued effect in the East where the strata are gently inclined giving a rolling topography. This was followed by the deposition of fluvial terrace alluvium deposits which due to subsequent erosion are now found only in the extreme East.

3. Thus the topography in the West is of a hilly nature with slopes between 15° and 30° whereas in the East the topography is of a rolling nature with most slopes between 5° and 15° . The flat land is restricted to a North-South trending tongue of land in the central part of the scheme area separating the moderately steep country from the rolling country and to small areas in valley bottoms in the North-East and North-West.

Mangrove and Nipah swamps occupy approximately 260 acres within the scheme area occurring towards the extreme north-eastern and western margins.

4. The area has a moderately good drainage system, the western and central areas being drained by tributaries of the River Gum Gum Kechil and the eastern area by north-east-ward flowing tributaries of the Loboh River. The minor drainage pattern of the area is controlled by the geological structure such that the streams trend predominantly in East to West and East-North-East to West-South-West directions.

5. All meteorological data were taken from Sandakan Aerodrome which is approximately 4 miles from Sungei Manila Settlement Scheme. Precipitation in the area is high, the average annual rainfall being of the order of 124 inches; December and January are the wettest months and April and May the driest months, no month having less than $4\frac{1}{2}$ inches of rain per month. Temperatures throughout the year are high and fairly constant the mean minimum and maximum monthly temperatures being 73.2°F and 87.6°F . Climatic data regarding rainfall, air temperatures, earth temperatures at 1 foot and 4 foot depths, relative humidity and hours of sunshine are included in appendix III.

6. The vegetation is directly related to the soils except where it has been modified by anthropic causes as in the South-East. The predominant primary vegetative cover is a Dipterocarp high forest which is to be found on the rolling, hilly, non saline alluvial and the terrace alluvial soils. To the North-West and North-East the Dipterocarp forest passes into a Nipah-Mangrove vegetation which is restricted to the saline alluvial soils. In the East and North-East the vegetation changes abruptly into a very weak open forest characterised by distinctive impoverished and poorly developed trees which are restricted to the areas of the podsol soils. Further to the South another distinctive vegetation of Stag-Horn Fern and fire resistant bushes occurs on the loamy sand terrace alluvial soils. The land in the South-East however has been subjected to shifting cultivation in the past resulting in a modified vegetation consisting of lalang and young secondary regrowth.

II. Method of Carrying Out the Investigation

7. A preliminary study of the aerial photograph coverage was made prior to commencing field-work. From this study the pedological grain of the country could be deduced and the rentis grid was then drawn on the base map such that the rentises intersected the pedological boundaries as frequently as possible.

8. Field work was mainly restricted to observations along twenty one rentises along which detailed records of drainage, slope and vegetation together with over 350 soil profiles to depths of 54 inches were studied. These recordings were plotted and interpolated on the aerial photographs enabling the soil boundaries to be demarcated.

III. The Soils of the Area

9. Three soil units, the upland soils, the active alluvial soils and the terrace alluvial soils were recognised in this area. The upland soils were subdivided into rolling and hill phases, the former being characterised by slopes in the 5° to 15° range and the latter by slopes in the 15° to 30° range. The active alluvial soils were further subdivided into saline and non-saline groups and the terrace alluvial soils into podsolised and non-podsolised series.

10. The upland soils occupy approximately 8,170 acres and are largely derived from fine grained sandstones, siltstones, mudstones and shales. They are predominantly yellow brown, deep, well drained clayey soils with moderate structure, and are similar to the upland soils of the Suan Lamba Settlement Scheme, and so have been classified as Rumidi soils.

11. The Rumidi Hill soils are almost restricted to the western half of the scheme area where they occupy approximately 610 acres occurring on hills where the slopes are generally in the 15° to 30° range. They are characterised by a shallow, dark brown humic top horizon which gradually merges into a yellow brown moderately structured friable sub-soil. Texturally the soil grades from a sandy clay loam in the top-soil to a fine sandy clay at depth. A few fragments of weathered fine grained sandstone occur within the profile and increase in number with depth.

12. Chemical analyses of two typical Rumidi Hill soils show, that these soils are extremely acid in reaction and have a low to very low cation exchange capacity dependant on the organic matter content. Figures for the total bases held within the colloidal complexes are also very low of which the exchangeable cations calcium, potassium and sodium are of very low concentration: the magnesium ions however are very variable ranging from very low to medium concentration. Base saturation figures are low to very low indicating that these soils are strongly leached. Figures for organic carbon and total nitrogen in the surface horizon are low and medium respectively and both rapidly decrease to very low values with depth; the carbon-nitrogen ratios being medium to very low with depth. The phosphates available for plant nutrition are also very low.

13. The Rumidi Rolling soils comprise the predominant soil unit in the Scheme area and occupy approximately 7,560 acres occurring on slopes within the 5° to 15° range. They are characterised by a shallow dark brown humic top horizon overlying a yellow brown moderately structured firm sub soil containing common fragments of weathered sandstone which merges at depth into a pale coloured firm horizon containing abundant sandstone fragments. The top soil has a fine sandy loam texture grading into a clay which persists with depth from 12 inches below the surface. This high clay content of the Rumidi Rolling soils is the main distinguishing criterion between the Rumidi Hill and Rumidi Rolling soils.

14. Chemical analyses of three typical Rumidi Rolling soils showed the soils to be strongly to extremely acid in reaction. Figures for the organic carbon and nitrogen contents in the surface soil are of medium values and both rapidly decrease to very low values with depth: the carbon-nitrogen ratio varies similarly from a medium value in the top soil to very low at depth. The available phosphate for plant nutrition is very low throughout the profile. Figures for the cation exchange capacity vary but tend to medium values. The total bases held within the colloidal complexes varied from medium values in the surface soil to very low values in the sub-soil, of which the magnesium and potassium tend to be present in higher concentrations than the sodium and calcium ions. Although the values of the Ca, Mg, K and Na concentrations vary

considerably they do exhibit higher values in the surface horizon as compared with the underlying soil. The base saturation figures however vary from medium values in the top soil to low values in the sub soil which reflect the effects of a strong degree of leaching.

15. The active alluvial soils occupy approximately 1130 acres and have been subdivided into saline and non-saline groups. They are derived from fine grained sandstones, siltstones, mudstones and shales.

16. The saline alluvial soils occupy approximately 260 acres occurring in the West and North-East only and support a typical mangrove and nipah vegetation, the former occurring on the highly saline soils and the latter on the less saline soils. The saline alluvial soils are characterised by poor drainage conditions imposed by a swamp regime which is manifested in the profile by typical gleying. Texturally these soils appear to be fine grained with silty clay predominating.

17. The non-saline alluvial soils occupy 870 acres approximately and occur in the central part of the area, and also in the North-West and the North-East. Three drainage classes could be recognised in the field but it was found impossible to demarcate these classes as separate units owing to the scale of mapping. The non-saline alluvial soils have therefore been mapped as a complex in which the following drainage classes were recognised: well drained, imperfectly drained and poorly drained. The latter are the most predominant.

18. The well drained alluvial soils have been classified as Gum Gum Soils. They occur mainly as narrow tracts immediately adjacent to water courses. These soils are well drained and are characterised by a water table which rarely approaches to within 48 inches of the surface. They are clayey and have a shallow dark greyish brown humic top horizon overlying a brown moderately structured friable soil which grades into a yellow brown strongly structured firm soil containing a few very fine soft black concretions.

19. Chemical analyses of a typical Gum Gum soil profile showed it to be extremely acid in reaction and with a medium cation exchange capacity. The predominant exchangeable cations present in the colloidal complexes are

magnesium ions which are present in medium concentration. The calcium, potassium and sodium ions are low in the surface horizon and very low below. In the top horizon both the cation exchange capacity and the concentration of the exchangeable cations have slightly higher values which probably reflects the higher percentage of colloidal organic matter in the top humic horizon than in the underlying soil. Figures for the total exchangeable bases withheld in the colloidal complexes and for the base saturation vary from medium in the top horizon to very low in the sub-soil indicating that the inherent well drained nature of these soils has induced a strong degree of leaching. The phosphates available for plant nutrition are present in very low concentrations throughout the profile. Figures for the organic carbon content tend to low in the top horizon, but those for nitrogen are medium, both decreasing rapidly to very low values in the underlying horizons. The carbon-nitrogen ratios vary from low in the top humic soil to very low in the sub-soil.

20. The imperfectly drained alluvial soils are characterised by seasonal fluctuations of the water table which seldom approaches to within 20 inches of the soil surface. This is manifested in the profile by the presence of a gleyed horizon usually at a depth of around 30 inches below the soil surface. These soils have a dark greyish brown shallow humic top horizon which becomes progressively lighter in colour and weaker in structure with depth. The sub-soil also exhibits an increase in the percentage of poor drainage mottling and in the abundance of very fine soft black concretions culminating in a weakly structured gleyed horizon at around 30 inches depth. Texturally the soil grades from a loam in the top horizon to a silty clay at depth. These soils have been tentatively classified as the Buran soils.

21. The chemical analyses of a typical imperfectly drained alluvial soil indicates moderate acidity in the top horizon rapidly becoming extremely acidic with depth. Figures for the organic carbon content vary from low in the top horizon to very low in the sub-soil whereas the total nitrogen content varies from medium in the top soil to very low at depth. The carbon-nitrogen ratios range from medium in the top horizon to very low at depth.

The phosphates available for plant nutrition are present in very low concentrations. The cation exchange capacity varies from high to medium but figures for the total exchangeable bases present vary from very high in the top horizon to low increasing to medium with the depth of the sub-soil. Of the exchangeable bases present within the colloidal complexes magnesium is of high concentration and potassium is high in the surface soil decreasing to medium below whereas calcium has high values in the top humic soil decreasing to very low values in the sub-soil and sodium has low to medium values. Base saturation as a criterion of leaching indicates a moderately leached soil.

22. The poorly drained alluvial soils are classified as the Buloh Soils. They are the most extensive non-saline alluvial soil in the Sungei Manila area and are found in the areas adjacent to and surrounding the saline alluvial soils and on the river flood plains. These soils are characterized by a shallow top humic horizon overlying a yellow brown weakly structured friable horizon which passes at a depth of some 9 inches into a weakly structured plastic and sticky gleyed horizon which is indicative of permanent to intermittent waterlogging. Very fine soft black concretions are frequently found throughout the soil which are probably formed by the periodic fluctuations of the water table. Textures grade from a humic loam in the top horizon to a silty clay at depth.

23. Chemical analyses of ^atypical poorly drained alluvial soil showed that the soil is moderately acidic in reaction in the top horizon becoming strongly to extremely acidic in the sub-soil. Figures for the organic carbon content vary from medium in the top humic soil to very low in the sub-soil, whereas the total nitrogen present varies from very high in the top humic soil to low in the sub-soil. The carbon-nitrogen ratios vary from low in the top soil to very low in the sub-soil and the available phosphates are very low in concentration throughout the profile. Figures for both cation exchange capacity and the total bases present vary from very high surface soil values to medium values below in the topsoil increasing to high values in the sub-soils. The cations calcium, and potassium present within the colloidal complexes have high values in the surface soil but medium values below.

Magnesium has very high concentration values apart from the sub-surface topsoil which has high values. Exchangeable sodium is medium to low; the unusually high value given in the appendix for the lowest horizon suggests a subterranean incursion of brackish water from the adjacent saline areas. Base saturation values vary from medium to high which is indicative of a weakly leached soil, this being the result of these soils poorly drained nature.

24. The terrace alluvial soils occupy a total of approximately 950 acres in the East of the area. They have been subdivided into two non-podsolised soil types the Sebyte Soils, and one ~~one~~ podsolised soil, the Loboh Soil. Unexpectedly, no correlation could be found between the distribution of the podsolised and non-podsolised soils and their respective topographical heights, which suggests that the extent of the podsolisation processes are more dependant here on the nature of the terrace deposits than on other factors, such as age. Thus the more sandy deposits would have a better internal drainage than the deposits with a high clay fraction and so would be more susceptible to a higher rate of podsolisation. All three terrace alluvial soils are characterised by the presence of occasional thin horizons of white, gravel-sized, sub-rounded vein-quartz pebbles.

25. The Sebyte Soils are generally clayey and well structured. They are predominantly yellowish brown in colour with a pronounced variegated mottled zone at shallow depths. The characteristic rounded quartz pebbles are found scattered throughout the profile. Weathered fragments of sandstones and shales normally occur in the subsoil, increasing in quantity with depth. Two soil types are recognised here, based on the texture of the topsoil, which is a sandy clay loam in the Sebyte Normal Soils and a loamy sand in the Sebyte Loamy Sand Soils.

26. The Sebyte Normal soils occupy approximately 670 acres and are characterised by a brown to dark brown sandy clay loam top horizon overlying a reddish yellow, mottled, and strongly structured firm sub-soil containing a few gravel size rounded quartz pebbles. The texture of the sub-soil grades from a fine sandy clay to a clay at around 11 inches depth. At depth the soil is a moderately structured clay containing frequent shale and subordinate sandstone fragments.

27. Chemical analyses of a typical Sebyte Normal Soil showed the soil to be strongly acid in reaction changing to moderately acid at depth. Figures for the organic carbon and total nitrogen contents of the soil are of medium values in the top soil rapidly decreasing to very low values for carbon and low values for nitrogen with depth. The carbon-nitrogen ratio decreases from a medium value in the top soil to very low values at depth. The phosphates available for plant nutrition are present in very low concentrations. The cation exchange capacity is of a low value in the surface soil increasing to a medium value below: this increase is probably associated with the increase of the clay content with depth. Figures for the total exchangeable bases present vary from a medium value in the top soil to very low values in the sub-soil of which the cations of calcium, magnesium, potassium and sodium are present in low to very low concentrations except in the top humic soil where magnesium and potassium are present in medium and high concentrations respectively. Base saturation figures as a criterion of leaching indicate a very strongly leached soil.

28. The Sebyte Loamy Sand Soils occupy only 70 acres approximately and are confined to a small area within the Sebyte Normal soils. They are characterised by a brown to dark brown, deep slightly humic top horizon of a strongly structured, friable loamy sand. This changes at a depth of around 7 inches into a reddish yellow, moderately structured firm horizon of a sandy clay texture becoming strong brown in colour and a fine sandy clay in texture at depth. Sandstone and subordinate shale fragments and quartz pebbles increase in number with depth.

29. The chemical analyses of two typical Sebyte Loamy Sand Soils showed the soils to be strongly to moderately acid in reaction. Both the organic carbon and total nitrogen contents are very low but the carbon-nitrogen ratio varies from medium in the top horizon to very low in the sub-soil. Figures for the available phosphates are very low throughout the profile. The figures for the cation exchange capacity are of very low to low values in the top horizon and increase to medium values in the lower horizons. This reflects the higher clay content of the subsoil. The total exchangeable bases present within the colloidal complexes are of very low concentration of which sodium tends to low

concentration values and calcium, magnesium and potassium tend to very low concentration values. Base saturation figures as a criterion of the extent of leaching indicate that these soils are very strongly leached.

30. The Loboh Soils are very distinctive soils occupying approximately 210 acres. Below a dark reddish brown mor horizon occurs an eluviated zone from which there has been a shift of clay and iron into the lower illuviated zone. The eluviated horizons comprise a light brownish grey, loose, loamy sand of a single grain structure which passes into a light grey, moderately structured loamy sand of friable to loose consistence containing abundant quartz pebbles. This horizon merges at a depth of some 26 inches into an illuviated zone of clay and iron enrichment which is a light grey, strongly mottled, firm, weakly structured fine sandy clay. The iron enrichment is conspicuous by the presence of brownish yellow mottles and weakly cemented, dark reddish brown deposits.

31. Chemical analyses of two typical Loboh Soils showed the soils to be extremely acid in the top soil becoming strongly acid with depth. Both the organic carbon content and total nitrogen content of the top soil below the mor horizon are of low concentrations and rapidly decrease to very low concentration with depth. The carbon-nitrogen ratio is of a medium value in the top soil below the mor horizon and similarly decreases to very low values with depth. Figures for the available phosphates present give very low values throughout the profile. The figures for the cation exchange capacities vary from low to very low in the eluviated zone and then increase to low and then medium values in the illuviated zone. These figures reflect the leaching out of cations and clay content from the eluviated zone and the corresponding enrichment of the cations and clay content in the illuviated zone. The total exchangeable bases present tend to be very low of which calcium and magnesium are present in very low concentrations whereas potassium increases from a very low concentration in the eluviated zone to a low concentration in the illuviated zone. Similarly there is a slight increase in the calcium content with depth. Base saturation figures as a criterion of the extent of leaching indicate that these soils are very strongly leached.

IV. Recommendations for Land-Use.

32. Oil palms have already been planned as the main crop for this Settlement Scheme. Therefore this part of the report has particular reference to the potentiality of this crop. However in certain areas mapped on the Scheme various conditions militate against the development of oil palms, and for these areas other tentative land-use recommendations are given.

33. The meteorological data for the area indicate that a suitable climate exists for oil palms. The data given for Sandakan Airport is probably a very reliable guide to the climatic conditions on the Scheme. The average annual rainfall would therefore be in the 120 to 130 inches range, which is fairly ideal for this crop, especially since average monthly figures rarely fall below 5 inches. Air temperature statistics indicate a mean annual range between 73°F and 87°F with no extreme figures from these means occurring, giving a temperature range very suitable for oil palms. The high atmospheric humidity values given would enhance the development of this crop. The figures for sunshine indicate that on average relatively very few days have less than 5 hours of sunshine per day, and the mean annual total is as high as 2,361 hours. This will be a valuable contribution to the performance of the oil palms, since it is generally accepted that there is a direct correlation between sunshine and fruit yields with this crop.

34. The Rumidi Soils are considered suitable for development under oil palms mainly because of their well drained, moderately well structured, generally fairly deep profiles. Oil Palm development on the Hill Phase of the Rumidi Soil would however be severely limited topographically. To overcome this, such anti-erosion control measures as terracing or platforming would be necessary. In addition the planning of an efficient road system, which is essential for economic fruit collection, would pose many problems. This is because the roads of such a system would have to follow both the natural contours of the land as much as possible so as to avoid accelerated soil erosion, and would also have to be arranged so as to minimise the distance along which the fruit bunches ~~be~~ carried to the road collection point. In satisfying both these conditions it is quite likely that it will be found that the cost of

development and maintaining these soils under oil palms will not be economic. The Rumidi Hill Soils are therefore not recommended for oil palms. An alternative crop, which would be particularly suited to terraced agriculture and which would not require an elaborate road system, would be rubber. If this is not considered feasible with the present uncertainties as to the future of this crop, it is recommended that these areas should be maintained under forest so as to maintain a readily available supply of wood for domestic use by the inhabitants of the Scheme area, and also to afford protection to the water supplies of the area, the collection and storage of which will probably be found to be necessary and associated with these hilly areas. The topography of the Rolling Phase of the Rumidi Soils do not have these slope limitations. Therefore anti-erosion control measures would not be required and also a regular patterned road network would be possible. They are therefore recommended for oil palms. The rather limited amount of data on the chemistry of the Rumidi Soils in the area indicate an unexpectedly low nutrient status. This is particularly seen in the Hill Phase of these soils, where the only major nutrients probably above threshold values are nitrogen and magnesium only, and these values are restricted to the surface soil and top-soil respectively. Hence it can be seen that if these soils are to be developed under rubber liberal fertilizer applications would be necessary, particularly with the very low cation exchange capacity described for these soils. However a slightly better soil nutrient status is seen in the chemical data given for the Rolling Phase of these soils. In these soils the bulk of the nutrients are held in the surface soil, where carbon, nitrogen, potassium and in particular magnesium are reasonably well supplied. The subsoil values indicate deficiencies of all the major plant nutrients excepting possibly magnesium. Therefore it can be seen that to maintain this fertility it will be essential to minimise the disturbance of the topsoil, which is always prone to occur with logging operations. Fairly liberal applications of a N.P.K.- type fertilizer would be necessary to sustain economic yields, and the maintenance of a cover crop would of course be necessary.

35. The saline alluvial soils because of their swampy nature together with high salinity will not support oil palms or any other agricultural crop. Reclamation would therefore be a necessary pre-requisite to agricultural development. This would initially mean drainage, thereby lowering the water table, followed by leaching out of the salts inherent to these soils by fresh water, either in the form of rain or irrigation water. This type of soil reclamation is expensive because it involves elaborate engineering works. With the present availability of agricultural land in the area such reclamation would not warrant such expense and is therefore not recommended.

36. The non saline alluvial soils because of their deep nature, predominantly clayey texture, and moderately well developed structure can be considered for development under oil palms, but a seriously limiting factor militates against the use of these soils for this crop. This is the general tendency for the presence of a high water table at various times of the year. This will inhibit root development therefore adequate draining will be necessary with the Buran Soil and the Buloh Soils, thereby lowering the water table to below 48 inches. The nutrient status of these soils would appear to be adequate for oil palms, but marked responses would probably be found to applications of nitrogen, potassium and particularly phosphate fertilizers.

37. In addition to, or as an alternative to oil palm cultivation, the non-saline alluvial soils would be suitable for padi cultivation because of their topographic location, high clay content and seasonally high water tables. This is especially so if drainage schemes, which would be an essential pre-requisite to oil palm cultivation, are not considered feasible for these soils. The cultivation of padi on a Settlement Scheme would require fairly strict water control, and irrigation would be advisable. The physiographic distribution of these soils however do not readily lend themselves to irrigation because of their occurrence as narrow strips on these separate valley floors. Water control in the catchments of these valleys would be necessary to irrigate the entire area of these soils, and it would be doubtful whether this would be practical economically. It is however tentatively suggested that this might be feasible for the approximately 430 acres of these soils occurring in the central area of Scheme land. The nutrient status of

these soils are considered suitable for padi cultivation.

38. Recommendations for the land-use of the Sebyte soils are only tentatively given. This is because these soils were first described during this Survey and they have not been recognised as occurring else-where. Therefore definite recommendations soundly based on observed crop soil relationships can be given here. Physically however these soils appear to be suited to oil palm cultivation, because of their development on a gently rolling terrain, their moderately deep profiles and well drained nature. Severe limitations might be found to oil palm yields with the inherent low nutrient status of these soils, and this has been accentuated by the effects of prolonged shifting cultivation over large areas of these soils. Very liberal fertilizer applications and cover cropping might alleviate this situation

but this is not made easier by the rather poor cation exchange capacity of these soils. It is therefore recommended that trial plots under oil palms be established on these soils.

39. The Lohoh Soils, because of their podzolic nature and therefore extremely low fertility are not recommended for oil palms or any other agricultural crop. Their best use would be as a source of gravel, for engineering purposes, provided by the quartz pebbles frequently found in these soils.

40. In conclusion therefore it can be seen that the immediate results of this survey indicate that out of a total of approximately 10,250 acres of land contained within the Settlement Scheme Area, there are approximately 9,040 acres suited to agricultural development. Of this figure approximately 7,560 acres are readily suited for oil palm cultivation and ^{the} further approximately 870 acres is suited for this crop with adequate draining, making the total figure suited for development under oil palms approximately 8,430 acres. The remaining land with an established agricultural potential, consisting of approximately 610 acres is recommended for rubber or as an alternative to be maintained as water protection forests and thereby also supplying the Settlement's domestic requirements for wood. In addition, of the land indicated as being suited for

agricultural development, areas of approximately 430 acres of land particularly suited for wet padi cultivation are shown, although the total acreage mapped as suitable for this crop is 870 acres. A total of 740 acres of land considered marginal for oil palm cultivation is described. The areas considered unsuitable for agricultural development amount to approximately 470 acres. Approximately 260 acres of this acreage consists of mangrove and nipah swamp and should remain so. The remaining area of non-agricultural land, consisting of approximately 210 acres is considered to be a valuable mining source for gravel where there are sufficient concentrations of the quartzitic pebbles.

APPENDIX I

DETAILED GENERALISED PROFILE DESCRIPTIONS OF THE
SOILS FROM THE SUNGAI MANILA SETTLEMENT SCHEME
AREA

1) RUMIDI HILL SOIL

- 0"- $\frac{3}{4}$ " Dark brown 10YR 3/3, humic sandy clay loam; moderately developed fine crumb structure; friable; abundant roots; merging wavy and abrupt to
- $\frac{3}{4}$ "-18" Yellow brown 10YR 5/6 mottled 1% pale brown 10YR 6/3, fine sandy clay loam; moderately developed very fine sub-angular blocky structure; friable; frequent roots; merging smooth and gradual to
- 18"-31" Yellow brown 10YR 5/7 mottled 5% pale brown 10YR 6/3, fine sandy clay; moderately developed fine sub-angular blocky structure. friable: roots common: few gravel size angular weathered fragments of fine grained sandstone: merging smooth and gradual to
- 31"-48" Yellow brown 10YR 5/8 mottled 5% light grey to grey 10YR 6/1, fine sandy clay: moderately developed fine sub-angular blocky structure; friable; few roots; frequent gravel size angular weathered fragments of fine grained sandstone.

2. RUMIDI ROLLING SOIL

- 0"- $\frac{3}{4}$ " Brown to dark brown 10YR 4/3, humic fine sandy loam; moderately developed fine granular structure; friable; abundant roots; merging wavy and abrupt to
- $\frac{3}{4}$ "-12" Yellow brown 10YR 5/6, clay loam; moderately developed fine sub-angular blocky structure; friable to firm; roots common; few gravel sized angular fragments of weathered fine grained red sandstone; merging smooth and gradual to

12"-28" Yellow brown 10YR 5/8 mottled 3% pale yellow 2.5 Y 7/4, clay; moderately developed fine sub-angular blocky structure; friable to firm; few roots; frequent small to medium stone sized fragments of weathered fine grained sandstones; merging smooth and gradual to

28"-48" Pale brown 10YR 6/3 mottled 2% light yellow brown 10YR 6/4 and 3% yellow brown 10YR 5/8; clay; moderately developed fine sub-angular blocky structure; firm; very few roots; abundant gravel sized fragments of red weathered sandstone.

3) NON-SALINE ALLUVIAL SOILS

a) Gum Gum Soil

0"-1½" Dark greyish brown 10YR 4/2, humic loam; strongly developed fine granular structure; friable; frequent roots; merging wavy and abrupt to

1½"-20" Brown to dark brown 10YR 4/4, clay loam; moderately developed fine to medium granular structure; friable; few roots; merging smooth and diffuse to

20"-32" Yellow brown 10YR 5/4 mottled 5% pale brown 10YR 6/3, fine sandy clay; strongly developed fine angular blocky structure; firm; few roots; few very fine soft black concretions; merging smooth and diffuse to

32"-48" Yellow brown 10YR 5/4 mottled 5% pale olive 5Y 6/3, silty clay; strongly developed angular blocky structure; firm; few roots; few very fine soft black concretions.

b) Buran Soil

0"-1" Dark greyish brown 10YR 4/2, humic loam; moderately developed fine sub-angular blocky structure; friable; frequent roots; merging wavy and abrupt to

- 1"-13" Dark yellow brown 10YR 4/4, fine sandy clay loam: moderately developed fine sub-angular blocky structure; friable; roots common; merging smooth and gradual to
- 13"-31" Pale brown 10YR 6/3 mottled 7% light grey 5 YR 7/1 and 5% strong brown 7.5 YR 5/6, clay loam; weakly developed very fine sub-angular blocky structure; firm; few roots; frequent very fine soft black concretions; merging smooth and gradual to
- 31"-48" Light grey to grey 5Y 6/1 mottled 5% strong brown 7.5 YR 5/8, silty clay; weakly developed very fine sub-angular blocky structure; plastic; very few roots; abundant very fine soft black concretions.

c.) Buloh Soil

- 0"-1" Dark greyish brown 10YR 4/2, humic loam: moderately developed fine granular structure; friable; frequent roots; merging wavy and abrupt to
- 1"-9" Yellow brown 10YR 5/4 mottled 3% light grey 10YR 7/2, clay loam; weakly developed fine sub-angular blocky structure; friable and slightly sticky; few roots; frequent very fine soft black concretions; merging smooth and gradual to
- 9"-28" Light grey to grey 10YR 6/1 mottled 5% yellow brown 10YR 5/8 and 2% brown to dark brown 7.5 YR 4/2; clay; weakly developed very fine sub-angular blocky structure; sticky and plastic; few roots; frequent very fine soft black concretions; merging smooth and gradual to
- 28"-48" Light grey 2.5Y 7/0 mottled 20% yellow brown 10YR 5/8, silty clay; weakly developed very fine sub-angular blocky structure; sticky and plastic; very few roots; frequent fine soft dark brown concretions.

4) NON-PODZOLISED TERRACE ALLUVIAL SOILa) Sebyte Normal.

- 0"-2" Brown to dark brown 10YR 4/3, sandy clay loam; strongly developed fine sub-angular blocky structure; friable; frequent roots; merging clear and wavy to
- 2"-11" Reddish yellow 7.5YR 6/6 mottled 3% pale yellow 2.5Y 7/4 and 1% yellowish red 5 YR 5/8: fine sandy clay, strongly developed fine to medium sub-angular blocky structure: friable to firm: few gravel sized rounded white quartz pebbles; merging clear and smooth to
- 11"-33" Reddish yellow 7.5YR 6/6 mottled 7% red 2.5YR 5/8 and 5% very pale brown 10YR 7/4; clay; strongly developed fine to medium sub-angular blocky structure: firm; few roots; few gravel size rounded white quartz pebbles; merging smooth and clear to
- 33"-48" Reddish yellow 7.5YR 6/6 mottled 2% yellow 2.5Y 7/6 and 7% light grey 5Y 7/2; clay moderately developed fine to medium sub-angular blocky structure; firm: very few roots; frequent small gravel sized fragments of pale red shale.

b) Sebyte Loamy Sand. 10YR

- 0"-7½" Brown to dark brown 10YR 4/3, humic loamy sand; strongly developed fine sub-angular **blocky** structure friable; frequent roots; merging smooth and clear to
- 7½"-37" Reddish yellow 7.5YR 6/6 mottled 2% pale yellow 2.5Y 7/4 and 1% yellowish red 5YR 5/8; sandy clay; moderately developed fine to medium sub-angular blocky structure; firm: few roots; common gravel sized fragments of weathered sandstone and few gravel sized sub-rounded quartz pebbles; merging smooth and abrupt to

37"-48" Strong brown 7.5YR 5/8 mottled 5% pale yellow 2.5Y 7/4, fine sandy clay; moderately developed fine to medium sub-angular blocky structure; firm; very few roots; frequent gravel and small stone-sized weathered fine grained sandstone fragments and few rounded vein-quartz pebbles.

5) PODZOLISED TERRACE ALLUVIAL SOIL
Loboh soil.

2"-0" Dark reddish brown mor; merging wavy and clear to

0"-6" Light brownish grey 10YR 6/2; loamy sand; single grain structure; loose; frequent roots; few gravel sized rounded vein-quartz pebbles; merging wavy and diffuse to

6"-26" Light grey 10YR 7/1, loamy sand; moderately developed fine sub-angular blocky structure; friable to loose; very few roots; abundant gravel to small stone sized rounded vein-quartz pebbles; merging smooth and gradual to

26"-48" Light grey 2.5Y 7/0 mottled 5% brownish yellow 10YR 6/8 and 15% dark reddish brown 2.5 YR 3/4; fine sandy clay; weakly developed medium sub-angular blocky structure; firm, very few roots, common small stone sized rounded vein-quartz pebbles and weakly cemented iron deposits.

APPENDIX II

SELECTED CHEMICAL ANALYSES OF THE SOILS
OF THE AREA

1. RUMIDI HILL SOIL

SAMPLE NO.	A 2090	A 2091	A 2092	A 2093	A 2094	
HORIZON	0"-1/4"	1/2"-9"	9"-28"	28"-45"	45"-54"	
pH	4.80	3.83	4.10	4.20	4.70	
ORGANIC CARBON %	2.72	0.40	0.19	0.17	0.14	
TOTAL NITROGEN %	0.25	0.06	0.05	0.03	0.04	
C/N RATIO	11	7	4	6	4	
AVAILABLE P ₂ O ₅ , p.p.m.	17	5	2	1	3	
CATION EXCHANGE CAP- ACITY m.e. %	11.74	5.56	5.15	4.55	4.19	
TOTAL EXCHANGEABLE BASES m.e. %	1.88	1.73	0.41	0.52	0.96	
BASE SATURATION %	16	31	8	11	23	
EXCHANGEABLE CATIONS m.e. %	Ca	0.33	0.27	0.21	0.32	0.32
	Mg	1.31	1.34	0.11	0.11	0.54
	K	0.15	0.03	0.02	0.02	0.03
	Na	0.09	0.09	0.07	0.07	0.07

2. RUMIDI ROLLING SOIL

SAMPLE NO.	3323	3324	3325	3326
Horizon	0"-1"	2"-12"	12"-24"	24"-54"
pH	5.45	5.00	4.45	4.75
Organic Carbon %	4.50	0.44	0.33	0.25
Total Nitrogen %	0.29	0.11	0.10	0.11
C/N Ratio	16	4	3	2
Available P ₂ O ₅ p.p.m.	10	2	1	0
Cation Exchange capacity m.e.%	16.70	11.17	14.19	15.97
Total Exchangeable Bases m.e. %	9.77	2.50	2.66	4.05
Base Saturation %	97	22	19	25
Ca	4.66	0.54	0.76	1.64
Mg	4.65	1.62	1.52	1.97
K	0.31	0.24	0.23	0.25
Na	0.15	0.10	0.15	0.19

3. NON-SALINE ALLUVIAL SOILS.a) Gum Gum Soil.

SAMPLE NO.	A2054	A2055	A2056	A2057
HORIZON	0"- $\frac{1}{2}$ "	$\frac{1}{2}$ "-11 $\frac{1}{2}$ "	11 $\frac{1}{2}$ "-40"	40"-54"
pH	4.45	3.92	3.92	4.10
ORGANIC CARBON %	2.47	0.42	0.25	0.25
TOTAL NITROGEN %	0.30	0.10	0.08	0.08
C/N RATIO	8	4	3	3
AVAILABLE P ₂ O ₅ , p.p.m.	9	2	-	-
CATION EXCHANGE CAPACITY m.e.%	16.17	11.27	14.18	16.37
TOTAL EXCHANGEABLE BASES m.e.%	3.38	1.81	2.21	3.03
BASE SATURATION %	46	16	17	19
EXCHANGEABLE CATIONS m.e.%				
Ca	3.93	0.38	0.65	0.44
Mg	2.84	1.19	0.24	2.18
K	0.45	0.15	0.18	0.19
Na	0.16	0.09	0.14	0.22

b) BURAN SOIL

SAMPLE NO.	A2032	A2033	A2034	A2035	A2036
HORIZON	0"-1½"	1½"-8"	8"-23"	23"-39"	39"-54"
pH	5.81	5.08	4.10	4.20	4.27
ORGANIC CARBON %	3.86	1.88	0.38	0.17	0.11
TOTAL NITROGEN %	0.38	0.23	0.10	0.08	0.08
C/N RATIO	10	8	4	2	1
AVAILABLE P ₂ O ₅ ; p.p.m.	16	9	1	1	2
CATION EXCHANGE CAPACITY m.e. %	28.34	21.01	24.54	26.10	25.17
TOTAL EXCHANGEABLE BASES m.e. %	25.53	16.26	5.84	6.96	10.25
BASES SATURATION %	90	77	24	27	41
EXCHANGEABLE CATIONS m.e. %					
Ca	18.52	10.70	0.61	0.66	1.54
Mg	5.65	4.86	4.63	5.57	7.99
K	0.73	0.48	0.37	0.41	0.41
Na	0.33	0.22	0.23	0.32	0.31

c) Buloh Soil

SAMPLE NO.	A2082	A2083	A2084	A2085	
HORIZON	0"-2"	2"-11"	11"-33"	33"-54"	
pH	5.95	4.60	4.42	4.55	
ORGANIC CARBON %	8.33	0.71	0.63	6.11	
TOTAL NITROGEN %	1.00	0.17	0.15	0.31	
C/N RATIO	8	4	4	20	
AVAILABLE P_2O_5 , p.p.m.	26	-	26	20	
CATION EXCHANGE CAPACITY m.e. %	48.79	24.80	31.61	41.27	
TOTAL EXCHANGEABLE BASES m.e. %	29.03	13.97	19.66	22.14	
BASE SATURATION %	59	56	62	54	
EXCHANGEABLE CATIONS m.e. %	Ca	16.90	7.17	7.18	6.46
	Mg	10.55	6.17	11.00	13.21
	K	1.11	0.36	0.51	0.52
	Na	0.47	0.27	0.97	1.95

4. NON-PODZOLISED TERRACE ALLUVIAL SOILa) Sebyte Normal Soil

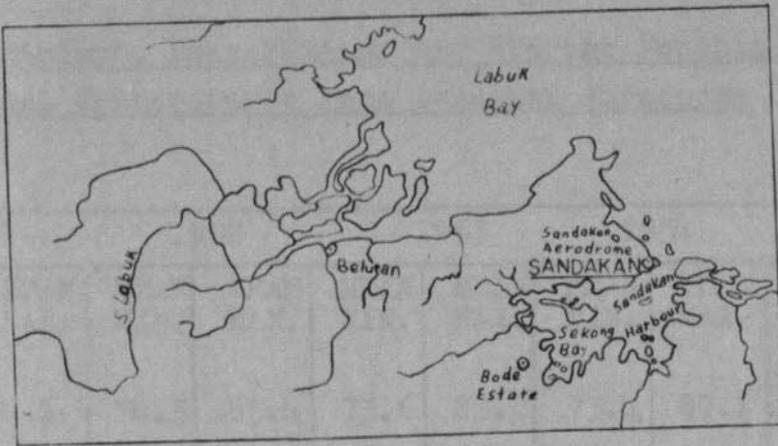
SAMPLE NO.	3339	3340	3341	3342	
HORIZON	0"- $\frac{1}{2}$ "	$\frac{1}{2}$ "-12"	12"-34"	34"-54"	
pH	4.78	4.62	5.25	5.38	
Organic Carbon %	5.10	1.64	0.33	0.22	
Total Nitrogen %	0.46	0.19	0.11	0.11	
C/N Ratio	11	9	3	2	
AVAILABLE P ₂ O ₅ p.p.m.	10	3	0	0	
Cation Exchange capacity m.e.%	9.48	12.14	13.77	14.33	
Total Exchangeable Bases m.e.%	7.68	2.33	0.94	0.82	
Base Saturation %	81	19	7	6	
EXCHANGEABLE CATIONS m.e. %	Ca	4.65	1.41	0.49	0.21
	Mg	2.07	0.54	0.11	0.33
	K	0.78	0.27	0.21	0.11
	Na	0.18	0.11	0.13	0.17

b) Sebyte Loamy Sand Soil.

SAMPLE NO.	3354	3355	3356	
Horizon No.	0"-7"	7"-44"	44"-54"	
pH	5.29	4.98	5.29	
Organic Carbon %	0.82	0.30	0.17	
Total Nitrogen %	0.10	0.05	0.05	
C/N Ratio	8	6	3	
Available P_2O_5 , p.p.m.	4	1	0	
Cation Exchange capacity m.e.%	5.35	12.75	20.35	
Total Exchangeable Bases m.e.%	2.20	0.98	0.84	
Base Saturation %	41	8	4	
Exchangeable Cations m.e.%	Ca	1.72	0.66	0.45
	Mg	0.21	0.11	0.12
	K	0.17	0.11	0.13
	Na	0.10	0.10	0.14

METEOROLOGICAL DATA

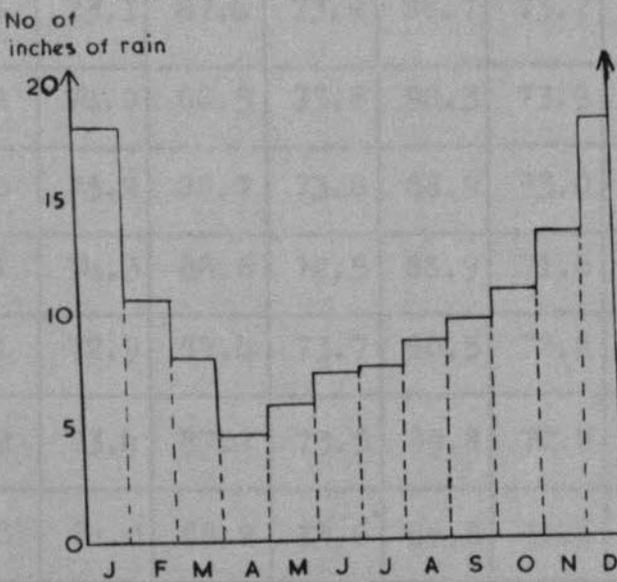
(a) RAINFALL



Location Map Of Rainfall Stations

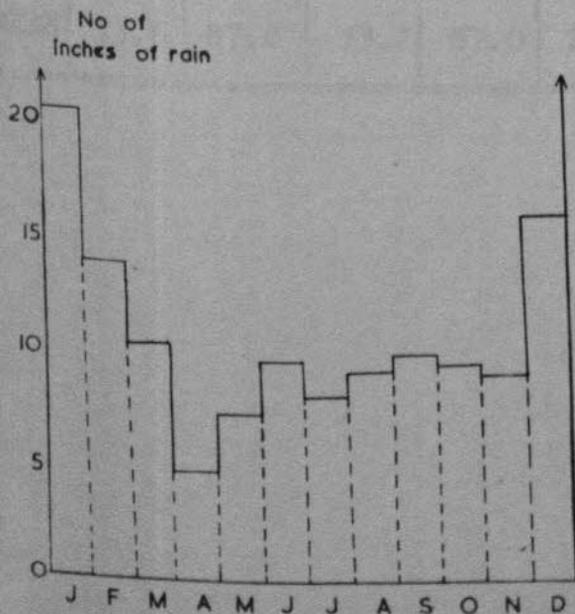
SANDAKAN AERODROME

Av. ANNUAL RAINFALL 123.6 ins.



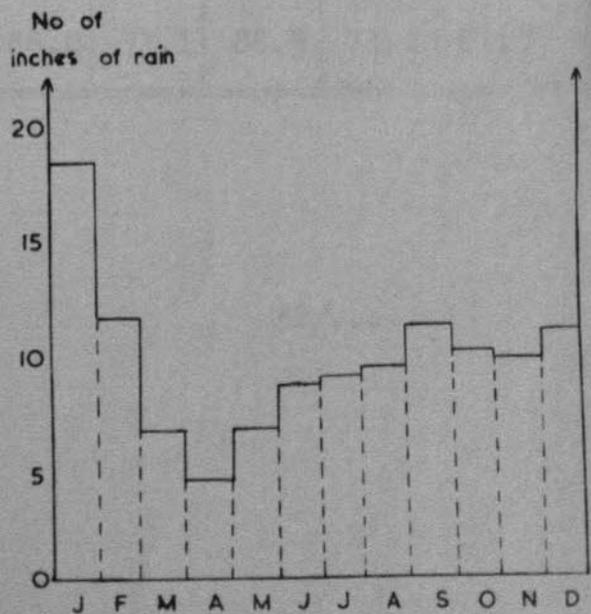
BELURAN

Av. ANNUAL RAINFALL 129.1 ins



BODE ESTATE

Av. ANNUAL RAINFALL 118.8 ins.



b) Air temperature.Mean Minimum, Mean Maximum and Average Monthly and Annual Temperatures from Sandakan Aerodrome

MONTH	1951		1952		1953		1954		1955	
	MEAN MIN.	MEAN MAX.								
Jan.	74.1	84.1	74.5	85.4	73.6	83.7	73.4	87.1	73.6	84.1
FEB.	73.2	84.0	74.1	84.9	73.4	84.0	73.3	87.3	74.1	85.3
MARCH	73.3	85.8	73.7	86.0	73.8	86.5	73.5	87.3	72.9	87.2
APRIL	74.0	87.6	73.1	87.4	73.9	88.7	73.7	90.0	73.6	88.7
MAY	73.9	88.2	74.0	88.5	73.8	90.3	73.9	90.4	73.9	89.8
JUNE	73.8	88.0	73.9	88.7	73.8	88.9	73.0	89.6	73.0	89.0
JULY	72.6	87.1	74.3	88.6	72.5	88.9	71.8	88.6	72.1	89.0
AUG.	73.1	89.1	72.9	87.4	73.7	90.5	72.2	90.4	72.0	89.5
SEPT.	74.2	87.9	73.4	87.7	73.5	89.8	72.2	89.5	72.3	88.5
OCT.	73.6	88.8	74.0	88.2	73.6	88.8	72.6	89.8	73.1	89.2
NOV.	74.0	87.4	73.5	86.1	73.6	87.5	73.6	87.5	72.8	87.1
DEC.	73.6	85.9	72.8	84.9	73.6	88.2	73.6	85.2	72.5	85.0
MEAN	73.6	87.0	73.7	87.0	73.6	88.0	73.1	88.5	73.0	87.7

MEAN MINIMUM, MEAN MAXIMUM AND AVERAGE MONTHLY AND ANNUAL TEMPERATURES FROM SANDAKAN AERODROME

MONTH	1956		1957		1958		1959		1960	
	MEAN MIN.	MEAN MAX.								
JAN.	72.1	83.7	71.9	85.7	74.4	85.9	72.8	85.2	74.4	84.7
FEB.	72.7	85.7	72.2	85.3	73.4	86.0	72.5	85.9	73.8	84.5
MARCH	73.0	87.1	73.0	87.0	74.1	87.3	73.8	86.7	73.1	86.9
APRIL	73.1	88.6	72.4	88.2	73.9	88.8	74.1	87.7	74.0	88.3
MAY	73.0	87.7	72.0	90.7	74.8	91.0	73.9	89.5	74.2	89.8
JUNE	72.2	89.2	72.4	90.7	74.0	91.4	73.2	89.5	73.7	89.8
JULY	71.4	89.3	77.4	88.5	73.1	90.7	72.1	88.8	73.0	89.0
AUG.	71.6	89.1	73.1	89.8	72.8	88.7	72.1	89.1	73.2	90.4
SEPT.	71.6	89.6	72.9	89.3	73.2	90.2	72.1	89.0	72.8	88.3
OCT.	72.4	88.5	73.5	88.6	73.6	88.6	72.1	88.1	73.1	88.5
NOV.	72.2	86.7	73.3	87.2	73.4	85.9	72.5	87.4	73.0	86.3
DEC.	71.8	84.9	74.3	86.2	73.1	85.3	73.2	86.1	72.3	85.1
MEAN	72.3	87.5	72.8	88.1	73.7	88.3	72.9	87.7	73.4	87.6

MEAN MINIMUM, MEAN MAXIMUM AND AVERAGE MONTHLY AND ANNUAL TEMPERATURES FROM SANDAKAN AERODROME.

MONTH	1961		1962		1963		MEAN MIN.	MEAN MAX.	AVERAGE
	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.			
JAN.	73.2	83.5	73.8	82.6	73.9	82.3	73.5	84.5	79.0
FEB.	73.9	85.1	73.7	83.0	73.9	82.3	73.4	84.9	79.1
MARCH	73.3	86.9	73.9	85.2	73.9	83.8	73.5	86.5	80.0
APRIL	73.6	88.7	73.9	87.6	73.4	86.7	73.6	88.2	81.0
MAY	73.3	89.1	74.3	88.9	74.1	89.4	73.8	89.5	81.6
JUNE	72.6	88.8	72.4	89.5	73.4	91.0	73.2	89.6	81.4
JULY	71.6	90.1	73.1	89.1	72.5	90.0	72.5	89.1	80.8
AUG.	71.9	89.4	72.9	88.9	73.0	88.1	72.7	89.3	81.0
SEPT.	71.3	89.3	72.8	89.0	72.7	89.9	72.7	89.1	80.9
OCT.	71.2	87.6	73.3	88.6	72.9	88.1	73.0	88.6	80.8
NOV.	72.0	86.0	73.3	86.9	73.2	87.4	73.1	86.9	80.0
DEC.	73.3	84.6	73.8	84.5	73.6	86.7	73.2	85.6	79.4
MEAN	72.6	87.4	73.4	87.0	73.4	87.1	73.2	87.6	80.4

C. ATMOSPHERIC HUMIDITY:

RELATIVE HUMIDITY VALUES (%) AT 0800, 1400, 2000 HOURS
FROM SANDAKAN AERODROME

YEAR	JANUARY			FEBRUARY			MARCH			APRIL		
	0800	1400	2000	0800	1400	2000	0800	1400	2000	0800	1400	2000
1954	94.5	73.0	87.2	93.6	71.1	86.5	94.1	72.9	87.9	92.2	71.6	89.4
1955	93.5	82.6	90.0	88.9	75.8	84.9	91.3	69.3	81.4	92.7	70.0	83.6
1956	94.8	78.1	88.6	93.4	74.4	84.2	92.5	69.8	83.3	92.6	73.5	88.0
1957	94.1	74.0	87.9	92.5	71.5	82.1	93.9	70.4	84.9	91.4	71.1	85.0
1958	92.5	75.6	84.3	94.6	74.2	83.1	91.7	71.0	83.3	90.3	69.4	82.6
1959	91.6	74.3	83.3	92.0	71.6	82.6	90.2	71.7	83.9	89.8	70.4	83.8
1960	91.5	79.2	87.3	94.3	78.2	87.2	93.3	69.9	82.5	91.6	70.3	84.4
1961	87.3	75.6	81.5	88.9	74.3	82.6	90.9	72.7	83.3	91.4	72.7	84.9
1962	95.5	84.5	91.5	89.9	79.2	86.4	93.6	75.9	86.8	92.0	71.5	84.1
1963	93.7	83.0	90.8	88.4	80.1	86.6	90.5	77.9	86.3	89.6	69.2	80.7
MEAN	92.9	78.0	87.2	91.7	75.0	84.6	92.3	73.4	84.4	91.4	71.0	84.7

C. ATMOSPHERIC HUMIDITY:

RELATIVE HUMIDITY VALUES (%) AT 0800, 1400, 2000 HOURS
FROM SANDAKAN AERODROME

YEAR	JANUARY			FEBRUARY			MARCH			APRIL		
	0800	1400	2000	0800	1400	2000	0800	1400	2000	0800	1400	2000
1954	94.5	73.0	87.2	93.6	71.1	86.5	94.1	72.9	87.9	92.2	71.6	89.4
1955	93.5	82.6	90.0	88.9	75.8	84.9	91.3	69.3	81.4	92.7	70.0	83.6
1956	94.8	78.1	88.6	93.4	74.4	84.2	92.5	69.8	83.3	92.6	73.5	88.0
1957	94.1	74.0	87.9	92.5	71.5	82.1	93.9	70.4	84.9	91.4	71.1	85.0
1958	92.5	75.6	84.3	94.6	74.2	83.1	91.7	71.0	83.3	90.3	69.4	82.6
1959	91.6	74.3	83.3	92.0	71.6	82.6	90.2	71.7	83.9	89.8	70.4	83.8
1960	91.5	79.2	87.3	94.3	78.2	87.2	93.3	69.9	82.5	91.6	70.3	84.4
1961	87.3	75.6	81.5	88.9	74.3	82.6	90.9	72.7	83.3	91.4	72.7	84.9
1962	95.5	84.5	91.5	89.9	79.2	86.4	93.6	75.9	86.8	92.0	71.5	84.1
1963	93.7	83.0	90.8	88.4	80.1	86.6	90.5	77.9	86.3	89.6	69.2	80.7
MEAN	92.9	78.0	87.2	91.7	75.0	84.6	92.3	73.4	84.4	91.4	71.0	84.7

RELATIVE HUMIDITY VALUES (%) AT 0800, 1400, 2000 hours
FROM SA NDAKAN AERODROME

YEAR	MAY			JUNE			JULY			AUGUST.		
	0800	1400	2000	0800	1400	2000	0800	1400	2000	0800	1400	2000
1954	91.0	72.3	90.4	92.7	69.1	90.7	94.3	72.9	92.3	92.9	66.0	88.5
1955	91.3	69.6	86.7	93.1	69.5	90.4	92.6	69.2	88.3	93.5	68.2	90.1
1956	83.3	72.9	90.9	92.6	66.5	88.3	91.0	64.6	86.1	91.7	66.6	86.8
1957	88.6	65.7	86.7	92.8	69.1	89.7	93.0	70.1	89.5	90.7	67.4	87.2
1958	89.1	66.5	87.0	91.0	65.7	86.2	92.4	62.7	84.1	94.6	71.2	88.8
1959	90.6	70.9	87.0	92.6	69.2	89.2	93.8	66.9	87.6	90.4	64.9	86.6
1960	89.8	68.1	85.3	91.1	66.3	88.1	92.7	69.8	89.0	90.3	65.5	87.5
1961	91.9	69.9	88.1	91.3	68.2	88.1	91.5	62.3	85.4	91.9	67.0	88.9
1962	91.0	73.0	89.1	92.2	68.9	88.8	92.6	67.4	87.3	91.6	67.6	88.7
1963	89.5	66.7	84.2	89.1	63.6	85.3	90.7	64.1	86.7	92.2	68.7	87.2
MEAN	90.6	69.9	87.5	91.9	67.6	88.5	92.5	67.0	87.7	92.0	67.3	87.6

RELATIVE HUMIDITY VALUES (%) at 0800, 1400, 2000 HOURS
FROM SANDAKAN AERODROME

YEAR	SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	0800	1400	2000	0800	1400	2000	0800	1400	2000	0800	1400	2000
1954	92.9	67.1	81.3	91.4	65.0	89.3	91.8	72.7	90.2	93.8	78.6	90.2
1955	92.5	69.9	89.4	90.9	68.3	88.1	92.4	75.1	90.8	93.8	77.4	90.2
1956	92.1	66.5	90.2	92.7	69.3	90.9	93.6	75.0	90.3	94.9	80.7	92.4
1957	92.7	68.7	89.8	93.6	73.7	90.3	92.9	71.3	86.7	92.8	76.8	85.3
1958	93.8	67.0	89.0	91.7	72.9	89.6	92.0	77.8	89.0	94.2	76.2	85.6
1959	92.2	68.6	89.2	91.1	71.8	88.3	91.3	72.5	89.5	93.2	74.5	85.9
1960	91.0	67.3	89.9	91.2	69.7	87.5	93.8	75.5	89.2	95.5	76.3	88.3
1961	91.2	65.4	88.0	92.1	70.8	88.6	92.6	74.2	88.1	94.9	79.7	90.7
1962	91.3	67.6	88.7	90.8	70.3	86.5	92.9	73.9	88.4	93.8	80.1	89.6
1963	90.7	66.9	87.0	91.5	70.3	88.8	92.0	70.6	85.4	91.3	72.5	85.7
MEAN	92.0	67.5	89.3	91.7	70.2	88.8	92.5	73.9	88.8	92.8	77.3	88.4

RELATIVE HUMIDITY VALUES (%) at 0800, 1400, 2000 HOURS
FROM SANDAKAN AERODROME

YEAR	SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	0800	1400	2000	0800	1400	2000	0800	1400	2000	0800	1400	2000
1954	92.9	67.1	82.3	91.4	65.0	89.3	91.8	72.7	90.2	93.8	78.6	90.2
1955	92.5	69.9	89.4	90.9	68.3	88.1	92.4	75.1	90.8	93.8	77.4	90.2
1956	92.1	66.5	90.2	92.7	69.3	90.9	93.6	75.0	90.3	94.9	80.7	92.4
1957	92.7	68.7	89.8	93.6	73.7	90.3	92.9	71.3	86.7	92.8	76.8	85.3
1958	93.8	67.0	89.0	91.7	72.9	89.6	92.0	77.8	89.0	94.2	76.2	85.6
1959	92.2	68.6	89.2	91.1	71.8	88.3	91.3	72.5	89.5	93.2	74.5	85.9
1960	91.0	67.3	89.9	91.2	69.7	87.5	93.8	75.5	89.2	95.5	76.3	88.3
1961	91.2	65.4	88.0	92.1	70.8	88.6	92.6	74.2	88.1	94.9	79.7	90.7
1962	91.3	67.6	88.7	90.8	70.3	86.5	92.9	73.9	88.4	93.8	80.1	89.6
1963	90.7	66.9	87.0	91.5	70.3	88.8	92.0	70.6	85.4	91.3	72.5	85.7
MEAN	92.0	67.5	89.3	91.7	70.2	88.8	92.5	73.9	88.8	92.8	77.3	88.4

d) Soil temperatures

MEAN EARTH TEMPERATURE - 1 FOOT (°F)
FROM SANDAKAN AERODROME

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	SUM	MEAN
1956	81.1	82.6	85.0	85.3	85.1	85.6	85.1	84.4	84.8	84.5	83.2	81.3	1008.0	84.0
1957	81.9	83.0	84.9	85.3	87.9	85.2	83.7	84.6	83.7	83.1	82.6	82.4	1009.3	84.1
1958	82.2	82.9	84.9	89.3	89.8	88.3	85.1	84.9	84.7	84.4	83.0	82.2	1021.7	85.1
1959	81.7	83.1	84.7	86.0	87.0	85.7	84.1	84.1	84.5	84.4	83.7	83.1	1012.1	84.3
1960	82.0	81.3	84.5	86.1	86.2	84.5	84.3	84.7	83.3	83.9	82.7	81.5	1005.0	83.7
1961	80.3	82.5	84.6	87.1	84.5	83.8	84.0	83.6	83.9	82.9	82.6	81.5	1001.3	83.4
1962	79.9	79.4	82.3	84.5	86.3	84.8	83.5	83.4	83.6	84.6	83.1	81.7	997.1	83.1
1963	79.6	79.4	81.1	84.5	87.3	85.5	84.7	84.2	85.1	84.3	84.5	83.2	1003.4	83.6
MEAN	81.1	81.8	84.0	86.1	86.7	85.4	84.3	84.2	84.2	84.0	83.2	82.1	1007.2	83.9

MEAN EARTH TEMPERATURE - 4 FEET (°F)
FROM SANDAKAN AERODROME.

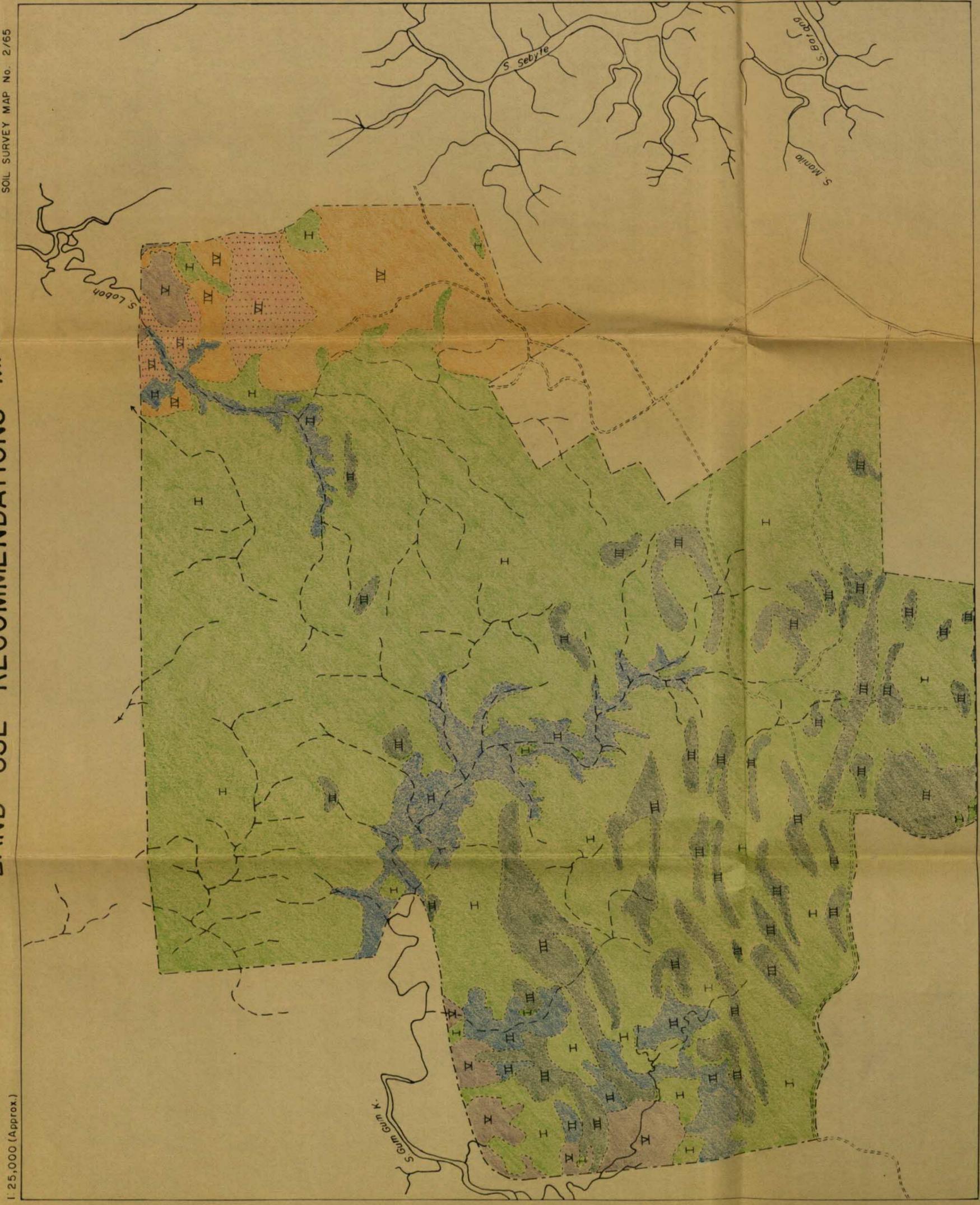
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM.	MEAN
1956	83.0	83.7	86.2	86.5	86.4	87.0	86.6	85.8	86.1	85.7	84.6	82.9	1023.5	85.3
1957	83.3	84.2	86.0	87.1	88.9	87.1	85.5	86.0	85.4	84.5	84.0	83.9	1026.3	85.5
1958	83.7	84.6	86.1	90.1	90.0	90.0	87.7	87.0	86.5	86.0	84.9	84.0	1040.8	86.7
1959	83.6	84.5	86.0	87.1	88.1	87.4	86.1	85.9	86.1	85.8	85.3	84.8	1030.7	85.9
1960	83.7	82.7	85.7	87.3	87.7	86.9	86.2	86.6	85.4	85.6	84.4	83.4	1025.6	85.5
1961	82.4	83.9	85.9	88.3	86.6	85.9	86.0	85.7	86.2	84.9	84.5	83.6	1023.9	85.3
1962	82.0	81.0	83.4	85.6	87.6	86.7	85.5	85.5	85.6	86.1	85.2	83.9	1018.1	84.8
1963	82.1	81.3	82.4	85.3	88.0	87.0	86.6	86.2	86.7	86.1	85.9	85.1	1022.7	85.2
MEAN	83.0	83.2	85.2	87.2	87.9	87.2	86.2	86.1	86.0	85.6	84.8	83.9	1020.4	85.5

SANDAKAN
MEAN HOURLY VALUES OF SUNSHINE (HOURS)

YEAR	JAN	FEB.	MAR	APR.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC.
1953	4.91	5.15	8.23	9.28	8.95	5.89	7.99	7.19	7.41	7.07	5.35	6.81
1954	6.37	6.78	6.20	8.21	7.27	6.72	5.72	7.45	5.72	7.71	6.56	4.13
1955		4.36	8.51	7.98	7.06	5.52	7.43	6.79	6.07	6.77	4.04	4.19
1956	3.95	6.48	7.40	6.24	5.58	7.23	7.26	5.87	6.73	6.58	4.60	3.37
1957	5.57	7.32	6.49	7.74	9.31	7.60	5.89	7.39	6.56	7.05	6.46	6.02
1958	6.40	7.05	7.90	9.59	7.66	7.19	6.51	5.63	6.56	5.78	4.66	6.39
1959	6.69	7.95	7.47	7.91	7.79	7.28	6.07	6.46	7.45	6.48	6.04	6.23
1960	4.93	4.57	7.93	7.40	7.86	6.28	7.37	7.63	5.11	6.36	5.45	5.23
1961	4.77	6.33	8.25	8.23	7.18	6.13	8.62	7.14	7.10	5.95	7.22	4.16
1962	2.19	3.16	5.47	7.64	6.95	8.03	5.41	7.15	6.37	7.29	5.52	3.39
1963	1.90	2.50	4.18	8.78	7.80	7.63	9.66	4.82	7.50	5.78	7.54	6.41
MEAN	4.77	5.61	7.09	8.09	7.58	6.86	7.09	6.68	6.60	6.62	5.58	5.12

SUNGEI MANILA SETTLEMENT SCHEME LAND USE RECOMMENDATIONS MAP

SERIES D - 4
SOIL SURVEY MAP No. 2/65

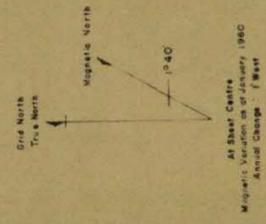
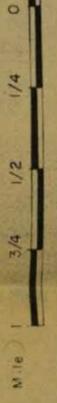


1:25,000 (Approx.)

Prepared by the Cartographic Division,
Agricultural Research Centre, Tuaran, Sabah.
Dated August 1965.

- I** Soils suitable for Oil Palms, approximately 7,560 acres
- II** Soils suitable for Wet Padi, or Oil Palms with drainage, approximately 870 acres.
- III** Soils suitable for Rubber, approximately 608 acres.
- IV** Soils considered marginal for Oil Palms, approximately 740 acres
- V** Soils not recommended for agriculture, approximately 260 acres.
- VI** Soils not recommended for agriculture but recommended as a source of gravel for engineering purposes, approximately 210 acres

SCALE 1:25,000

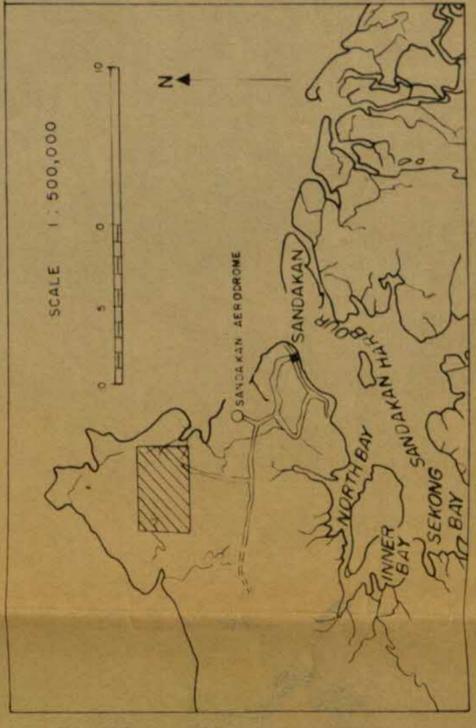


- Road
- Boundary of Area
- Soil Boundary
- Water Course

2 Miles

Detailed and Surveyed by P. Thomas, Soil Scientist
And R. Barber, V. S. O. Soil Surveyor,
Agricultural Research Centre, Tuaran.
24th August, 1965.

LOCATION MAP



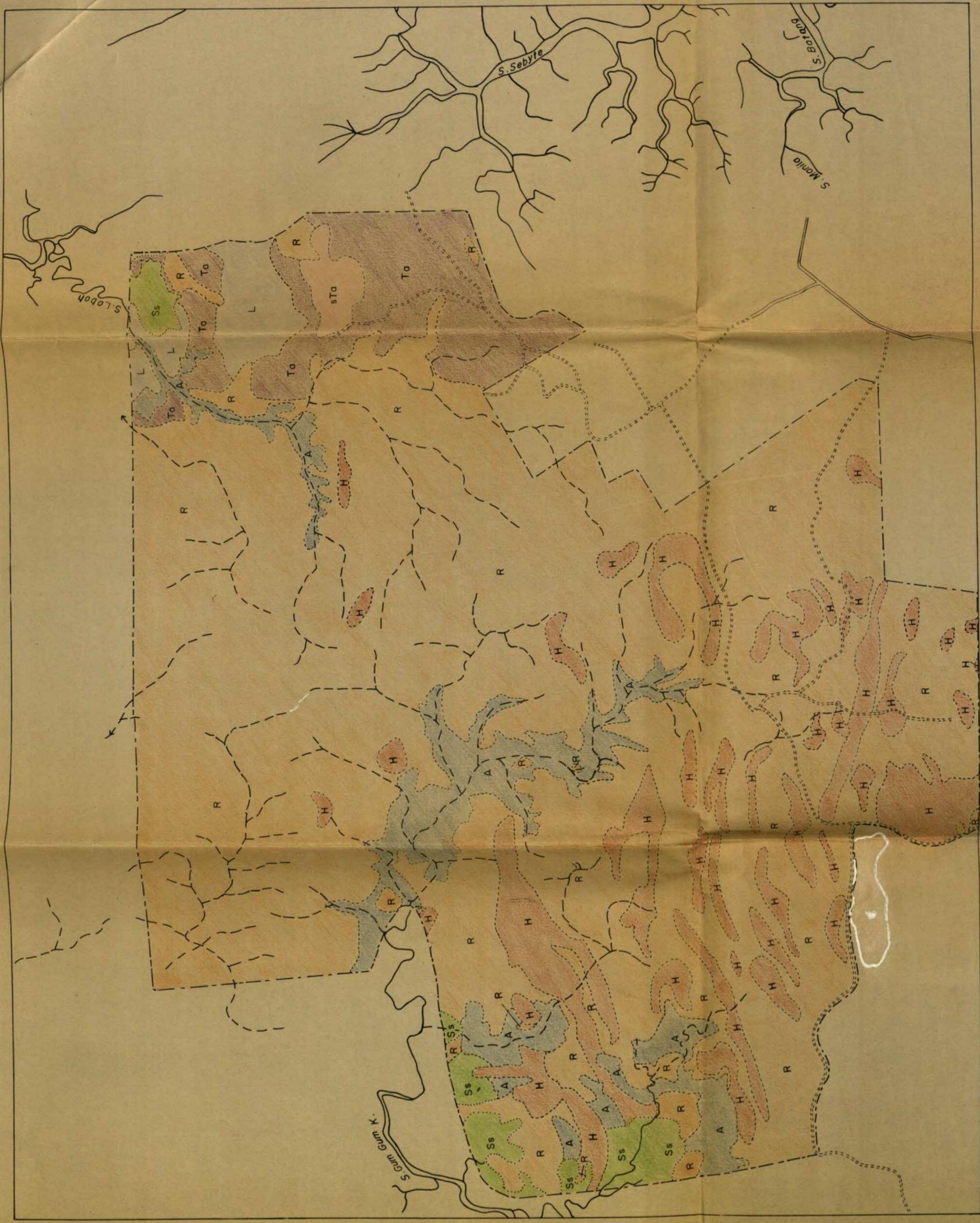
SCALE 1:500,000

SOIL MAP OF THE SUNGEI MANILA SETTLEMENT SCHEME AREA.

Series D-3

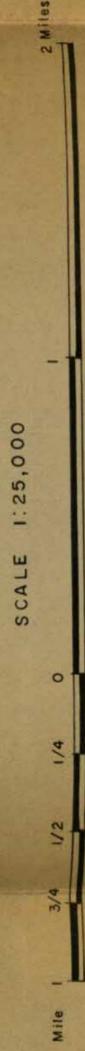
Soil survey Map No. 9/65

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Prepared by the Cartographic Division,
Agricultural Research Centre, Tuaran, Sabah.
Date June, 1965.

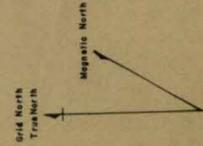
Detailed and Surveyed by R. Barber,
Agricultural Research Centre, Tuaran.
5th July, 1965.



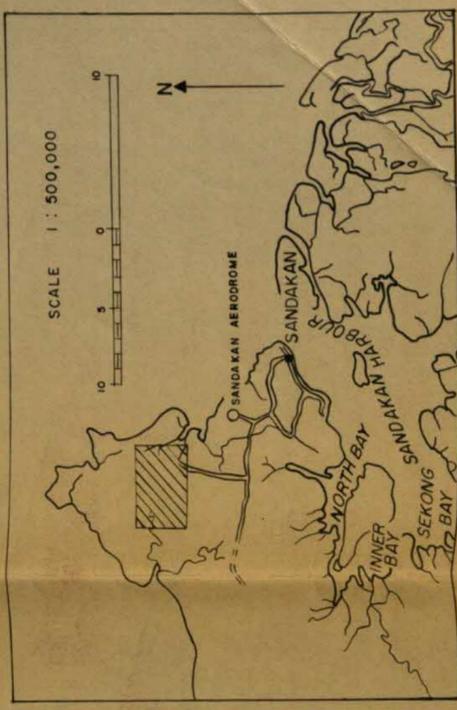
KEY

- H Rumidi Hill Soils
- R Rumidi Rolling Soils
- A Non Saline Alluvial Soils
- Ss Saline Alluvial Soils
- To Sebyte Terrace Alluvial Soils

- sTo Sebyte Loamy Sand Terrace Alluvial Soils
- L Loboh Clay Podsol Terrace Alluvial Soils
- Road
- Boundary of Area
- Soil Boundary
- Water Course



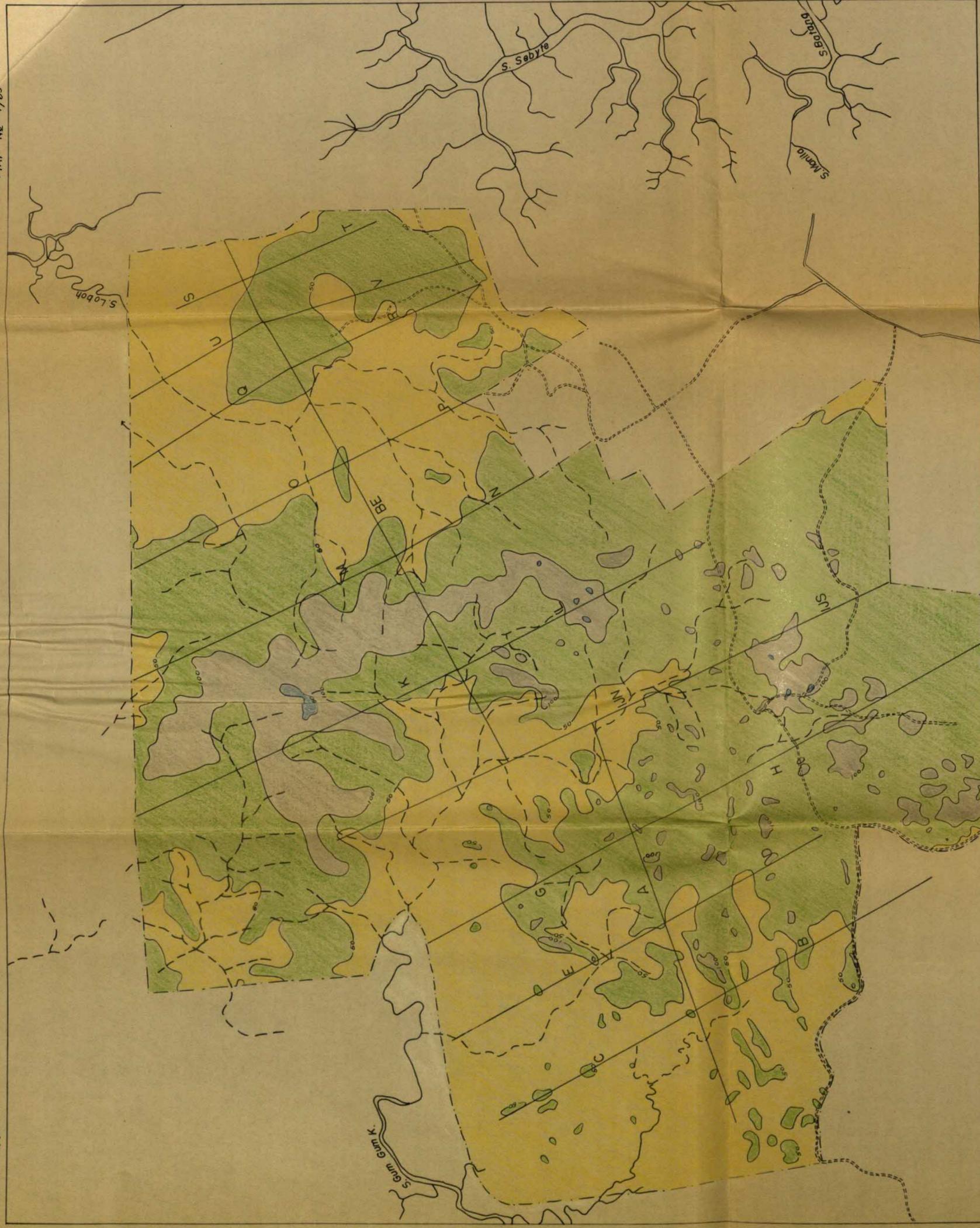
LOCATION MAP



TOPOGRAPHICAL AND RENTIS MAP OF THE SUNGEI MANILA SETTLEMENT SCHEME AREA.

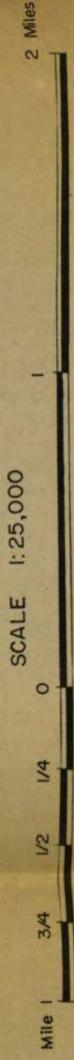
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SERIES D-5
MAP No 1/65

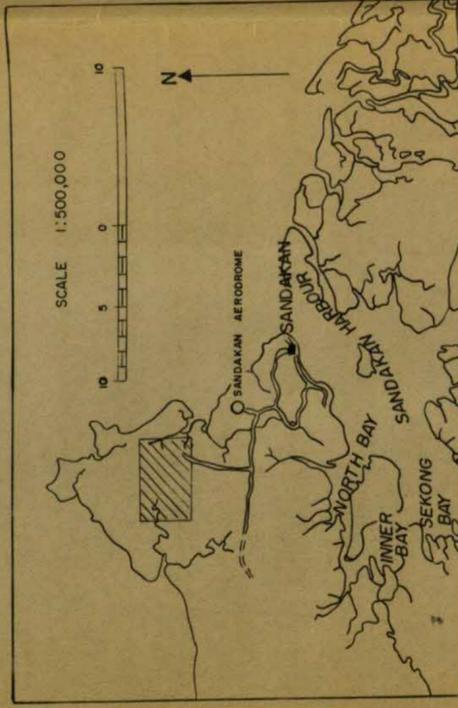


Prepared by the Cartographic Division,
Agricultural Research Centre, Tuaran, Sabah.
Date June, 1965.

Detailed and surveyed by R. Barber,
Agricultural Research Centre,
Tuaran.
5th July, 1965



LOCATION MAP



KEY

