THE KINGDOM OF THAILAND
ROYAL IRRIGATION DEPARTMENT
MINISTRY OF AGRICULTURE AND COOPERATIVES

THE FEASIBILITY STUDY ON THE INTEGRATED AGRICULTURE AND WATER RESOURCES DEVELOPMENT PROJECT OF THE MENAM CHUMPHON BASIN

APPENDIXES

JANUARY 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

THE KINGDOM OF THAILAND
ROYAL IRRIGATION DEPARTMENT
THE FEASIBILITY STUDY ON THE INTEGRATED AGRICULTURE AND WATER RESOURCES DEVELOPMENT PROJECT OF THE MENAM CHUMPHON BASIN
APPENDIXES
JANUARY 1993

THE KINGDOM OF THAILAND
ROYAL IRRIGATION DEPARTMENT
MINISTRY OF AGRICULTURE AND COOPERATIVES

THE FEASIBILITY STUDY ON THE INTEGRATED AGRICULTURE AND WATER RESOURCES DEVELOPMENT PROJECT OF THE MENAM CHUMPHON BASIN

APPENDIXES

JANUARY, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

CONTENTS

APPENDIX A. GEOLOGY

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX A. GEOLOGY

A - 1 MENAM CHUMPHON BASIN

A - 1 - 1 Topography

The Study Area has an approximately long and narrow shape, about 100 km long in the north-south direction and about 30 km wide in the east-west direction. The north of the Study Area, about 11° N, is the beginning point of the Phuket range, one of the 2 main systems running through the peninsula. The famous Isthmus of Kra, the narrowest part of the Malay Peninsula, is located closely south of the Study Area.

The Study Area may be divided into 4 different river basins: Tha Sae, Rap Ro, Tha Taphao and Chumphon. In the Tha Sae river basin, the alluvial plain, which is surrounded in the north, east and west by hills and mountains, extends to the south towards the Tha Taphao river basin. The Tha Sae river springs from the northern mountains, about 500 m high, and flows southward to join in the Tha Taphao river. The Rap Ro river originates in the northwestern mountains reaching about 500 m, and flows southward in parallel with the Tha Sae river, to join in the Tha Taphao river.

After 2 rivers of Tha Sae and Rap Ro are joined, the river is named Tha Taphao. The Tha Taphao river basin is composed of the alluvial plain extending towards the Gulf of Thailand. The Chumphon river basin is composed of the mountains and the alluvial plain in the upstream and the downstream respectively. The river, which springs from the southwestern mountains with an elevation of around 500 m, flows northward in the mountainous areas and then turns to the eastward along the National Highway Route 4; the river turns again its direction to the southward, after crossing the National Railway, to drain in the Gulf of Thailand.

The mountains in the Study Area are generally arranged more or less in a direction parallel to NE-SW and the river flows in a direction parallel to NE-SW or NW-SE in the mountainous areas, which may suggest that there are 2 major fault systems, the NE-SW and NW-SE trending faults.

A - 1 - 2 Geology

As far as the geological structure is concerned, Thailand can be divided into 3 major tectonic units; they are the Shan-Thai, the South Chins and the Indochina. The Study Area is situated on the Shan-Thai Craton of which the basement is composed of the Precambrian high-grade metamorphic crystalline rocks. In the southern Thailand, the basement is exposed in comparatively small isolated occurrence at Hua Hin, Prachuap Kiri Khan and Surat Thani. The basement does not crop out in the Study Area.

The cover rocks of the basement in the Study Area are composed of 4 sedimentary formations: Kraburi, Matsi, Chumphon and Fangdang. The Silurian-Devonian Kraburi formation is formed of graywacke, pebbly sandstone, pebbly shale and mudstone, which is massive to thick-bedded with intercalated terbidities, and is extensively distributed in the western part of the Study Area (refer to FIGURE A-1). The Carboniferous Matsi formation, being made up of orthoquartzite, siltstone and shale, is extensively distributed in the eastern part of the Study Area. Furthermore, this formation sporadically appears in the folded and faulted structures in the western part of the Study Area; however, the boundary between the Matsi formation and Kraburi formation in not clear.

The Permian Chumphon formation, consisting of bedded fossiliferous limestone, brecciated liemstone and partly dolomitic, is scattered in various sized bodies in the eastern part of the Study Area. The Jurassic Fangdang formation is scattered in small bodies in the southeastern part of the Study Area. The formation is composed of red to reddish-brown, cross-bedded sandstone, quartzitic sandstone and conglomerate.

Besides, the Igneous rocks are locally exposed in the northwestern part of the Study Area. The Quaternary deposits accumulated along the major valleys and rivers comprise unconsolidated sediments; they are sandy silt and interbedded with gravel and clay.

The Study Area had been affected by many orogenic movements and igneous activities. The main folding phases probably took place during the Post-Triassic and Late Cretaceous or Early-Tertiary period, resulting in tight and isoclinal folds of the Permo-Carboniferous rocks with slaty axial-plane cleavage. 2 major fault systems can be recognized; the NE-SW and NW-SE fault. The former, namely Ranong Fault Zone, is strikeslip showing right lateral movements, whereas the latter is usually minor and off-set the previous fault.

A - 1 - 3 Geological Conditions of Nominated Reservoirs

The bed rocks at 10 sites of nominated reservoir are composed of the Silurian-Denonian Kraburi formation (refer to FIGURE A - 1). These points are underlain mainly by pebbly siltstone, with a slight variation at each site. The following summary describes each geological situation.

(1) Tha Sae Reservoir (RID) (Figure A-2)

The area is underlain mainly by pebbly slaty shale and siltstone, and partly by sandstone. The bed mostly strikes N20 ~ 40° E and dips 20 ~ 40° E. The sandstone is joined EW, 80N.

The terrace deposits made up of sandy silt predominate in the riverside plain, and alluvial deposits of sand and gravel predominate along the river. This area is considered relatively appropriate for the foundation of the dam because both the weathered zone and the talus deposits are comparatively thin. However, a careful survey is necessary for constructing the dam, and the points are summarized as follows;

- Scale and conditions of the fault on the left bank.
- Knowledge of the heavily weathered zone, which is necessary to obtain core materials.

(2) Rap Ro Reservoir (RID) (Figure A-3)

The area is underlain by pebbly siltstone. The bed strikes N20 ~ 30° E and dips 30 ~ 40° E, and is joined N70 ~ 80° W, 50 ~ 70° N. The talus deposits and the weathered zone are thicker at the proposed damsite than upstream, therefor, in constructing the dam, a comprehensive survey should be made to determine the location of the axis.

In regard to the materials, all the rock, the transition and the core are presumably obtainable.

(3) Kaeng Phra Chao Reservoir (NEA) (Figure A-4)

This area is underlain by volcanic rocks composed mainly of tuff, agglomerate with andesitic dike. At the proposed damsite, a quartz dike is emplaced in the bed dozens of meters in width. Slaty shale is distributed downstream. The volcanic rocks is jointed N40 ~ 50° E, 70° NW. The shale strikes N40 ~ 50° E and dips 60 ~ 70° SE. The volcanic rock dominating in the Study Area is fresh and hard, and has a good strength for the dam. Nevertheless, a full investigation on leakage is necessary in constructing the dam because of some reasons; (A) the fault dominate along the river, (B) the volcanic rocks are possibly distributed along the Ranong Fault Zone.

As for the materials, the rock and the transition are available, but as to the core a careful survey is needed.

(4) Ma La Reservoir (NEA) (Figure A-5)

The area is underlain mainly by siltstone and partly by sandstone. The bed strikes N10° E ~W and dips 30 ~ 50° E. The terrace deposits composed of sandy silt with gravel dominate in the plain on the left bank. A fault (shear zone) which is nearly parallel to the dam axis is present upstream of the proposed damsite; nevertheless it is small in scale and both the talus deposits and the weathered zone are comparatively thin. This indicates the geological situations are relatively suitable for constructing the dam.

With respect to the materials, all the rock, the transition and the core are presumably available.

(5) Upper Rap Ro Reservoir (Figure A-6)

The area is underlain mainly by pebbly siltstone and partly by conglomerate. The bed strikes N30 ~ 60° E, dips 60° SE and is jointed N 80° W, 90°. The terrace deposits are made up of sandy silt with gravel dominating on the plain at the right bank. A fault is possibly present in the mountainside on the left bank. The talus deposits and the weathered zone are thin as a whole and therefore the geological situations are relatively appropriate for the dam construction.

In respect to the materials, the rock and the transition will be obtainable, but as to the core a full survey is necessary.

(6) Pha-Ngan Reservoir (Figure A-7)

The area is underlain by siltstone an the bed strikes N60° W and dips 80° N. The thick terrace deposits composed of sand and gravel are distributed on the plain at the left bank. No large fault has been found. The geological conditions are relatively suitable for the dam site.

As for the materials, all the rock, the transition and the core are obtainable.

(7) Nam Ron Reservoir (Figure A-8)

The area is underlain by siltstone and orthoquatzite. The bed strikes N40° E, dips 60 ° E and is jointed N50° W, 70 ~ 90° N. The terrace deposits are made up of silty sand dominating the riverside plain. The exposed bed is fresh and hard. The geological conditions are suitable for constructing the dam.

With respect to the materials, the rock and the transition will be available, but as to the core a careful investigation is needed.

(8) Kum Reservoir (Figure A-9)

The thick talus deposits composed of clay with gravel are distributed from the side of the mountain to the foot. The riverbed is overlain by sand and

gravel. No outcrop of the bed rock is found, but the gravel of overlain stratum indicates that the area is underlain by sandstone and siltstone.

The landform which includes the axis of the dam on the left bank, indicates possible landslides and so, the geological conditions are unsuitable for the dam construction.

(9) Upper Kum Reservoir (Figure A-10)

The area is underlain by sandstone. The bed is jointed N40° W, 50° E. The terrace deposits composed of silty sand with gravel are distributed in the riverside plain. The thick talus deposits are made up of silt, clay and gravel, dominating the full side of the mountain on the right bank. The upstream topography on the left bank indicates possible landslides, therefore, and exhaustive investigations is necessary.

As for the materials, all the rock, transition and the core will be available.

(10) Kaphon Reservoir (Figure A-11)

The area is underlined mainly by pebbly siltstone which is partly intercalated with sandstone. The bed on the right bank strikes N10 ~20° W and dips 80 ° W, and on the left bank N60 ~ 70° W, 70 ~ 80° N or S. The terrace deposits are composed of silty sand dominating the riverside plain, and the thick talus deposits made up of clay with gravel are distributed the side length of the mountain on the right bank. The bed rock is deep and faults are presumably present on the left bank. A careful survey of these possible fault points is needed.

In respect to the materials, all the rock, the transition and the core will be obtainable.

A-2 NONG YAI PROJECT AREA

A-2-1 Topography

The project area is located in the Tha Taphao river basin above the Chumphon city and is mainly composed of hills and alluvial plains. The Tha Taphao river meanders southeastward from the confluence of Tha Sae river and Rap Ro river, and then turns southward at the point of the proposed Hua Wang Phanang Tuk canal; the river again flows southeastward, after crossing the National Railway, into the Gulf of Thailand.

The Sam Kaeo Canal starts from the Tha Taphao river near RID office to Phanang Tuk river, and flows into the Gulf of Thailand.

Water from some small rivers which flow from the northern hills is stored in the northern part of the project area that forms the Nong Yai Swamp.

In the central-northern part of the project area, the land is almost formed like a terrace, and alluvial plains can be seen surrounding the Nong Yai Swamps and along the rivers. The alluvial plains predominate in the lower area about 1 km above the Sam Kaeo canal - the phanang Tuk river. Isolated hills with an elevation of about 100 - 200 m are sporadically scattered in the project area.

A-2-2 Geology

The basement of the project area is mainly composed of Carboniferous Matsi formation whereas the western part is composed of the Permian Chumphon formation. Isolated hills surrounding the project area can be observed in the basement area.

The diluvial deposits overlie the basement and form terraces of about 5 m high. Besides, the alluvial deposits are also distributed on the surface of the alluvial plains.

The Matsi formation consists of orthoquartzite, siltstone and shale. The Chumphon formation consists of bedded fossiliferous limestone and brecciated limestone. The diluvial deposit are composed mainly of stiff cohesive

soil, partly sandy and partly gravelly soil with multiple-sized gravel (max ø300 mm). The alluvial deposits are composed of very soft cohesive soil and very loose sandy soil.

A - 2 - 3 Geological and Soil Investigation

Geological investigations were executed to ascertain the condition of the ground foundation at the main site and the geological conditions along the proposed canals. The investigations consist of boring and auger drilling as shown below.

	Number of Bore Hole (unit)	Drilling Length (m)	S.P.T. (Time)
Soil Investigation along Hua Wang Phanang Tuk Canal	28	128.75	141
Soil Investigation Along Pak Phraek Canal	38	163.2	
Soil Investigation Along Irrigation Canal	7	15.1	
Soil Investigation Along Sam Kaeo Canal	33	162.25	

RID carried out geological investigations of the ground foundation at the sites of proposed heavy structures by drilling with 25 bore holes (ℓ = 398.0 m, 418 times S.P.T, 111 times permeability test).

A - 2 - 4 Geological Conditions at Main Structure Sites

The geological cross sections based on the results of each site investigation are shown in the attached drawings. The geological cross sections at the proposed tidal regulator site are shown in the attache drawings presuming from the results of investigation at other sites.

The geological condition at each site is mentioned below. The formations are divided not only by types of soil, but also by N values = 20, 30, 50.

(1) Site 1 Head Regulator of Sam Kaeo

The formations at site 1 are composed of 2 alluvial cohesive soils, 2 diluvial sandy soils, and the basement. Groundwater table is situated at soil depths ranging from 2.6 to 4.4 meters and tilted to the east.

a) Alluvial 1st cohesive layer (Acl)

The layer is regarded to be formed of marsh deposits, and is about 5 metethicks. It consists of brown silty clays, clayey silts, and sandy silts. It has moderate moisture and is classified under (CL) - (ML). The N value is average 8.5 and the average permeability value is 1.2×10^{-3} (cm/sec).

b) Alluvial 2nd cohesive layer (Ac2)

The layer is regarded to be formed of marine deposits and the thickness ranges from 5 to 8 meters. the layer manly consists of dark gray silty clay and partly of clayey silt. It has high content water and is classified under (CL). The N values and the coefficients of permeability show an average of 0 (cm/sec).

c) Alluvial sandy layer (Asl, As2)

The layers are regarded to be formed of fluvial-coastal deposits and consist of gray silty fine sand. It is moist and classified as (SM). The average permeability value is 9.6×10^{-4} (cm/sec).

The thickness of the Asl layer is about 4 meters and its N value shows an average of 16. The thickness of the As2 layer ranges from 0 to 2 meters and the N values show an average of 33.

d) Basement (R)

Drilling condition suggest that this layer is the basement. It lays at 15 to 18 meters deep with N values greater than 50. The average permeability is 0 (cm/sec).

(2) Site 2 head Regulator of Hua Wang Phanang Tuk

The formation is regarded to be made of terrace deposits and is divided into 5 layers. Groundwater table is located in 2.1. to 2.2 meters.

a) Diluvial 1st cohesive layer (Dc1)

This layer is 3 m thick and consists of brown sandy silt. The texture of the sand is fine, and the layer has moderate moisture content. The N values show an average of 6.4.

b) Diluvial 2nd and 3rd cohesive layers (Dc2, Dc3)

These layers are composed of grayish brown clayey silt and contain fine sands and round gravels ($\phi = 10$mm). It is moist or wet and classified under (ML g).

The thickness of Dc2 is about 2 meters. Its N value averages 12 and its coefficient of permeability shows an average of 3.0×10^{-3} (cm/sec).

Dc3 layer ranges from 0 to 1 meter thick with an N value averaging 27 and a coefficient of permeability averaging 2.7×10^{-4} (cm/sec).

c) 4th diluvial cohesive layer (Dc4)

This layer consists of brown clayey silts containing fine sand and round gravel, and grayish brown silty clay. It's about 10 meters thick. The N value averages 37 and the coefficients of permeability averages 2.7×10^{-3} (cm/sec) at the upper portion and 0 (cm/sec) at the lower portion.

d) 5th diluvial cohesive layer (Dc5)

This layer consists of grayish brown clay. It is moist and classified under (CL). The N value is larger than 50 and the coefficients of permeability show an average of 9 (cm/sec). It lays below 15 to 17 meters deep.

(3) Site 3 head Regulator of Pak Phraek

This formations is regarded to be made of terrace deposits and divided into 3 layers. The groundwater table is located at a depth ranging from 3.0 to 3.25 meters.

a) 1st diluvial cohesive layer (Dc1)

The upper part of this layer consists of brown sandy silt. The sand is fine and moist and is classified under (ML). The lower part of this layer mainly consists of dark brown clayey silt containing rounded gravel (ø=10 mm). It is moist or wet and classified as (ML g).

This layer tends to thicken northwest and its overall thickness form 4 to 7 meters. The N value averages 12 and the coefficients of permeability averages 2.7×10^{-2} (cm/sec).

b) 2nd diluvial cohesive layer (Dc2)

This layer consists of the same cohesive soil as the lower part of Dcl layer, and grayish brown clayey silt with fine sand. It is moist and classified under (ML).

This layer tends to thicken northwest and its overall thickness ranges from 5 to 8 meters. The N value averages 23 and the coefficients of permeability mainly show 0 (cm/sec).

c) 3rd diluvial cohesive layer (Dc3)

This layer consists of the same cohesive soil as the lower part Dc2 layer. The N value are generally larger than 50 and the coefficients of permeability show 0 (cm/sec). It is observed at depths from 9 to 15 meters and deepens northwest.

(4) Site 4 road Crossing Site at Ban Mau Sila

The formations are regarded to be made of terrace deposits and divided into 4 layers. Groundwater table is not confirmed.

a) 1st diluvial cohesive layer (Dc1)

This layer is composed of brown sandy silts. It is fine sand and moist, and classified under (ML). the thickness is more than 1 meters and the N value averages of 15.

b) 2nd to 4th diluvial cohesive layers (Dc2 - Dc4)

This layers consist of dark brown clayey silt containing round gravel (ϕ=10mm). It is moist and classified under (ML g).

The thickness of Dc2 layer is about 3 meters with N values averaging 22. The thickness of Dc3 layer is about 3 meters with N values averaging 41. The Dc4 layer is lain below a depth of 7 meters with N values generally greater than 50.

(5) Site 5 Railway Crossing Site at Ban Khuan Sarika

The formation is regarded to be made of terrace deposits and is divided into 4 layers. Groundwater table is not confirmed.

a) 1st diluvial cohesive layer (Dc1)

The upper portion of this layer consists of brown sandy silt. The sand is fine in the grain size and is moist and classified under (ML). the lower portion of this layer consists of dark brown clayey silt containing round gravel (ϕ=10 mm). It is moist and classified under (ML g) and is 4 to 5 meters thick. The N values show an average of 13.

b) 2nd diluvial cohesive layer (Dc2)

This layer consists of the same soil as the lower portion of the Dc1 layer. The thickness is about 1 meters and the N values average 26.

c) 3rd diluvial cohesive layer (Dc3)

The upper portion of this layer consists of the same soil as the Dc2 layer. The layer portion consists of dark brown clayey silt containing fine sand. It is moist and classified under (ML).

d) 4th diluvial cohesive layer (Dc4)

This layer consists of the same soil as the lower portion of Dc3 layer with N values generally grater than 50. It lays at a depth of 8 to 9 meters.

(6) Site 6 Road Crossing Site at Ban Khuan Sarika

The formation is regarded to be made of terrace deposits and is divided into 1 sandy layer and 3 cohesive layers. Groundwater table is not confirmed.

a) diluvial sandy layer (Ds)

The layer consists of brown silty sand. The sand is fine, moist and classifies under (SM). The thickness ranges from 0 to 1 meter with N values averaging 20.

b) 1st diluvial cohesive layer (Dc1)

The upper portion of this layer consists of brown clayey silt containing round gravel (ϕ=10mm). It is moist and classified under (ML g). The lower portion of this layer consists of brown silty clay which is moist and classified under (CL).

The thickness ranges from 2 to 3 meters and the N values average 19.

c) 2nd diluvial cohesive layer (Dc2)

This layer consists of the same soil as the lower portion of Dc1 layer and the thickness ranges from 3 to 4 meters. The N values show an average of 32.

d) 3rd diluvial cohesive layer (Dc3)

This layer consists of grayish brown clayey silts. In the northeast area, this layer contains round gravel (ø=10mm). It is moist and classified under (ML), and (ML g).

The N value is greater than 50. It can be observed from 6.0 to 6.5 meters deep.

(7) Site 7 Pump Station at Nong Yai

This formation is divided into alluvial sandy layer and 2 diluvial cohesive layers. Groundwater table is located at depths from 1.0 to 1.2 meters.

a) Alluvial sandy layer (As)

This layer is regarded to be made of flood deposits and is from 0 to 2 meters thick. It consists of brown silty fine sand. It is wet and classified under (SM). The N values show an average of 7.5.

b) Diluvial cohesive layer (Dc1, Dc2)

The layer is regarded to be made of terrace deposits. It mainly consists of silty clay, and partly of clayey silts. It show various colors such as gray, brown, reddish brown and grayish red. It is wet and classified mainly under (CL), and partly under (ML).

The thickness of Dc1 leyer ranges from 2 to 4 meters. The N values show an average of 14.

The Ds layer intercalated by Dc1 layer consists of brown silty fine sand. It is moist or wet and classified under (SM).

The thickness is 1.6 meters and the N values show 37.

The Dc2 layer can be observed of 1.0 to 1.5 meters deep and the N values are greater than 50.

(8) Site 8 Pump station at Ban Thap Tanot

The alluvial deposits are composed of cohesive soil in the western portion and sandy soil in the eastern portion. The diluvial deposits are regarded to be made of terrace deposits and divided into cohesive layers and 2 sandy layers. Groundwater table is located at depths from 1.2 to 2.0 meters deep.

a) Alluvial cohesive layer (Ac)

The layer is regarded to be made of marine deposits and is about 15 meters thick. It is composed of grayish brown sandy silt with clay. The texture of sand is fine. It is moist or wet and classified under (ML). The N values shown an average of 3.0.

b) Alluvial sandy layer (As)

The layer is regarded to be made of fluvial - coastal deposits and is about 11 meters thick. It consists of grayish brown silty sand (fine to coarse), is moist or wet and classified under (SM). The N values show an average of 2.4.

c) 1st diluvial cohesive layer (Dc1)

This layer consists of brown silty clay. It is moist and classified under (CL). It is about 10 m thick to the west and about 6 m thick east, underlying Dc2 and Ds layers. The N values show an average of 34.

d) 2nd diluvial cohesive layer (Dc2)

This layer consists of brown sandy silt. The grain size of sand is fine. It is moist and classified under (ML). It is about 6 meters thick in the eastern part. The N values show an average of 20.

e) Diluvial sandy layers (Ds1, Ds2)

This layer, which can only be observed in the eastern-part, consists of brown silty sand (fine to coarse), including round gravel (ϕ=10~30mm). It is moist and classified under (SM g).

The thickness of Ds1 layer is about 3 meters and the N values show an average of 38.

The Ds2 layer is located below a depth of about 26 meters and the N values show an average of 47.

f) 3rd diluvial cohesive layer (Dc3)

The composition of this layer is the same as Dc1 layer. It lays below a depth of about 25 meters and the N values average 48.

(9) Site 9 Tail Regulator Kholong Phanang Tuk

The alluvial deposits are regarded as the fluvial -coastal deposits consisting of 2 sandy layers. whereas the marine deposits consists of cohesive layer. The diluvial deposits are regarded as the terrace deposits and is divided into 4 cohesive layers. Groundwater table is located at a depth of 3 to 4.5 meters.

a) 1st alluvial sandy layer (As1)

This layer consists of gray-brown silty fine sand. It is moist or wet and classified under (SM) and is 6.5 to 8.5 m thick. The N values show an average of 3.8 and the coefficients of permeability show an average of 3.5×10^{-3} (cm/sec).

b) Alluvial cohesive layer (Ac)

This layer consists of grayish clayey silt. It is wet and classified under (ML) and is 5 to 6.5 meters thick. The N values show an average of 3.3 and the coefficients of permeability show an average of 0 (cm/sec).

c) 2nd alluvial sandy layer (As2)

This layer consists of gray silty find sand. It is wet and classified under (SM). It is distributed only in the northern part and is about 4 meters thick. The N values show an average of 8.3 and the coefficients of permeability show an average 0 (cm/sec).

d) Diluvial cohesive layers (Dc1-Dc4)

This layer mainly consists of gray-brown sandy silt and partly is silty clay. Sand texture is fine. It is moist and classified mainly under (ML) and partly under (CL). The coefficients of permeability has a 0 average (cm/sec).

The Dcl layer is 1 to 2 meters thick and the N values show an average of 12. The thickness of Dc2 layer ranges from 10 to 14 meters and the N values show an average of 25. The thickness of Dc3 layer ranges form 3 to 4 meters and the N values show an average of 41. The Dc4 layer can be observed at a depth ranging from 31 to 33 meters and the N values are larger than 50.

(10) Site 10 Road Crossing Site

The alluvial deposits are regarded as fluvial deposits consisting of 1 cohesive layer. The diluvial deposits are regarded as terrace deposits and are divided into 2 cohesive layers.

a) Alluvial cohesive layer (Ac)

This layer consists of brown sandy silt and the sand texture is fine. It is moist and classified under (ML). Its thickness ranges form 1.5 to 2.0 meters. The N values show an average of 4.3.

b) Diluvial cohesive layer (Dcl, Dc2)

These layers consist of reddish gray silty clay mainly containing round gravel. They are moist and classified under (CL) g. The thickness of Dcl layer ranges from 1 to 2.5 meters with an N value averaging 20. The Dc2 layer can be observed at a depth of 3 to 4 meters with N values larger than 50.

(11) Abstract

The foundation ground condition and the depth of bearing stratum at the main sites are shown in TABLE A-1 and 2.

A - 2 - 5 Geological Condition Along Hua Wang Phanag Tuk Canal

The geological cross section based on the results of the investigation along the proposed canal is shown in attached drawings.

The formations along the canal are composed of alluvial cohesive layer (Ac), alluvial sandy layer (As), diluvial cohesive layer (Dc), diluvial sandy layer (Ds), and diluvial general layers (Dg).

The characteristic and distribution of each layer are as follows:

(1) Alluvial cohesive layer (Ac)

The distribution area of this layer is divided into 4 portions.

- Sta.0 + 150 ~ 1 + 270

  This layer is mainly composed gray-brown silt and partly contains fine sand and clay. It is moist and classified under (ML). The thickness ranges generally from 1 to 2 meters and it is about 3.5 meters thick at Sta.0+440. The N values show an average of 4.9.

- Sta.1 + 350 ~ 1 + 620

  This layer consists of brown sandy silt. The sand is fine in size. It is moist and classified under (ML). The maximum thickness of the layer is about 6 meters at Sta.1+460. The N values shown an average of 6.0.

- Sta.2 + 910 ~ 3 + 690

  This layer is mainly composed of clayey silt, partly with fine sand. It is moist and classified under (ML), and is 2 to 3 meters thick. The N values shown an average of 5.9.

- Sta.4 + 590 ~ 5 + 720

  This layer consists of gray silty-sandy clay and grayish brown-reddish brown clayey silt. The former is moist and classified under (CL) with an N value averaging 1.7. The latter is moist and

classified under (ML) with an N values averaging 5.7. It is generally more than 5 meters thick, but it is about 1 meter thick at Sta.5+60.

(2) Alluvial Sandy Layer (As)

The distribution area of this layer is divided into 4 portions.

- Sta.0 + 0 ~ 1 + 160

  This layer consists of brown-gray silty fine sand. It is moist and classified under (SM). The N values show an average of 4.0. It can be observed below Ac layer with more than 3 meters thick but after STA 0+850 thins off.

- Sta.3 + 30 ~ 3 + 450

  This layer consists of gray silty fine sand. It is moist and classified under (SM). The N values show an average of 6. It can be observed below Ac layer with less than 1 meter thick.

- Sta.3 + 500 ~ 3 + 630

  This layer consists of brown fine sand. It is moist and classified under (SP). The N values average 2, and is less than 4 meters deep.

- Sta.4 + 0 ~ 4 + 670

  This layer consists of gray silty fine sand. It is moist and classified under (SM). The N values show an average of 5. The thickness is about 2 meters.

(3) Diluvial Cohesive Layer (Dc)

Diluvial deposits are mainly composed of this layer and crop out without overlying alluvial deposits in the area where the elevation is more than 5 meters.

This layer mainly consists of brown-gray sandy silt and clayey silt, partly containing silty clay. It contains sand and round gravel (ϕ max = 50mm) at random. It is moist and classified mainly under (ML) and partly under (CL). The N values show and average of 11.

(4) Diluvial Sandy Layer (Ds)

This layer is distributed only at Sta. 1 + 250. It consists of gray sand, is moist and classified under (SP). The N values show an average of 19.

(5) Diluvial Gravely Layer (Dg)

This layer is graded from Ac layer and distributed less than 1 meter thick only at Sta. 4 + 0. It consists of gray silty gravel. It is moist and classified under (GM). The N values show an average of 14.

A - 2 - 6 Geological Condition Along Pak Phraek Canal

The geological cross section based on the results of investigations carried along the proposed canal is shown in attached drawings.

The formation along the canal are mainly composed of diluvial deposits, and of alluvial deposits at the lowly elevated area.

Diluvial deposits mainly consist of cohesive layers (Dc) and partly of sandy layers (Ds).

Alluvial deposits mainly consist of cohesive layers (Ac) and partly of sandy layers (As) too.

A - 2 - 7 Geological Condition Along Irrigation Canal

The geological cross sections based on the results of investigations conducted along the irrigation canal are shown in attached drawings.

The formations along canal 1 are composed of 2 alluvial cohesive layers (Acl, Ac2) and diluvial cohesive layer (Dc). The Acl layer is wet and very soft.

The formation along canal 2 is composed of alluvial sandy layer (As), alluvial cohesive layer (Ac), and diluvial cohesive layer (Dc).

A - 2 - 8 Geological Condition Along Sam Kaeo Canal

The geological cross section based on the results of investigation along Sam Kaeo canal is shown in attached drawings.

The formations along the canal are composed of alluvial cohesive layer (Ac) and alluvial sandy layer (As).

Ac layer is distributed mainly in the eastern part, and As layer mainly in the western part.

TABLE A - 1 CONDITIONS OF GROUND FOUNDATION AT MAIN STRUCTURE SITES

Site No.	Object	Formation	Kind of Soil	Thickness (m)	$\bar{N}$	$\bar{K}$ (cm/sec)	C (tf/m^3)	ø (°)	E (Kgf/cm^2)	Classi - fication
1	Head Regulator	Ac1	Silty Clay - Sandy Silt	5	8.5	1.2×10^{-3}	5	0	60	CL, ML
		Ac2	Silty Clay	5-8	0	0	0	0	0	CL
		As1	}	4	16	}	0	24	110	}
		As2	} Silty Sand	0-2	33	9.6×10^{-4}	0	37	230	} SM
		R	Base Rock	(GL-15-18)	50	0	0	42	350	
2		Dc1	Sandy Silt	3	6.4		4	0	45	ML
		Dc2	}	2	12	3.0×10^{-3}	7.5	0	84	}
		Dc3	} Clayey Silt, Some Gravel	0-1	27	2.7×10^{-4}	17	0	190	} MLg
		Dc4	Clayey Silt, Silty Clay	10	37	$0-2.7\times10^{-3}$	23	0	260	MLg, CL
		Dc5	Silty Clay	(GL-15-17)	50	0	31	0	350	CL
3		Dc1	Sandy Silt, Clayey Silt	4-7	12	2.7×10^{-2}	7.5	0	84	ML, MLg
		Dc2	Clayey Silt, Some Sand, Gravel	5-8	23	0	14.5	0	160	MLg, ML
		Dc3	Clayey Silt, Some Sand	(GL-9-15)	50	0	31	0	350	ML
4	Crossing Site	Dc1	Sandy Silt	1	15	---	9.5	0	110	ML
		Dc2	}	3	22	---	13.5	0	150	}
		Dc3	} Clayey Silt, Some Gravel	3	41	---	25.5	0	290	} MLg
		Dc4	}	(GL-7)	50	---	31	0	350	}
5		Dc1	Sandy Silt, Clayey Silt	4-5	13	---	8	0	91	ML, MLg
		Dc2	} Clayey Silt, Some Gravel	1	26	---	16	0	180	MLg
		Dc3	}	3	44	---	27.5	0	310	MLg, ML
		Dc4	Clayey Silt	(GL-8-9)	50	---	31	0	350	ML
6		Ds	Silty Sand	0-1	20	---	0	32	140	SM
		Dc1	Clayey Silt, Silty Clay	2-3	19	---	12	0	130	MLg, CL
		Dc2	Silty Clay	3-4	32	---	20	0	220	CL
		Dc3	Clayey Silt, Some Gravel	(GL-6-6.5)	50	---	31	0	350	ML, MLg
10		Ac	Sandy Silt	1.5-2	4.3	---	2.5	0	30	ML
		Dc1	}	1-2.5	20	---	12.5	0	140	}
		Dc2	} Silty Clay, Some Gravel	(GL-3-4)	50	---	31	0	350	} CLg
7	Pump Station	As	Silty Sand	0-2	7.5	---	0	26	53	SM
		Dc1	Silty Clay	2-4	14	---	8.5	0	98	CL
		Ds	Silty Sand	0-1.6	37	---	0	39	260	SM
		Dc2	Silty Clay, Clayey Silt	(GL-4)	50	---	31	0	350	CL, ML
8		Ac	Sandy Silt	15	3.0	---	2	0	21	ML
		As	Silty Sand	11	2.4	---	0	21	17	SM
		Dc1	Silty Clay	6-10	34	---	21	0	240	CL
		Dc2	Sandy Silt	0-6	20	---	12.5	0	140	ML
		Ds1	}	3	38	---	0	39	270	}
		Ds2	} Silty Sand, Some Gravel	(GL-26)	47	---	0	42	330	} SMg
		Dc3	Silty Clay	(GL-25)	48	---	30	0	340	CL
9	Tail Regulator	As1	Silty Sand	6.5-8.5	3.8	3.5×10^{-3}	0	23	27	SM
		Ac	Clayey Silt	5-6.5	3.3	0	2	0	23	ML
		As2	Silty Sand	0-4	8.3	0	0	26	58	SM
		Dc1	}	1-2	12	0	7.5	0	84	}
		Dc2	} Sandy Silt, Silty Clay	10-14	25	0	15.5	0	180	} ML, CL
		Dc3	}	3-4	41	0	25.5	0	290	}
		Dc4	}	(GL-31-33)	50	0	31	0	350	}
11	Tidal Regulator	As	Silty Sand	7.5	3.1	3.5×10^{-3}	0	22	22	SM
		Ac	Sandy Silt, Clayey Silt	5	3.2	0	2	0	22	ML
		Dc1	}	1.5	12	0	7.5	0	84	}
		Dc2	} Sandy Silt, Silty Clay	6.5	24	0	15	0	170	} ML, CL
		Dc3	}	7.5	40	0	25	0	280	}
		Dc4	}	(GL-27)	50	0	31	0	350	}

(Note) $C = \bar{N}/1.6\ (tf/m^3)$
$\phi = \sqrt{15\bar{N}} + 15\ (°)$
$E = 7\bar{N}\ (Kgf/cm^2)$

TABLE A-2 DEPTH OF BEARING STRATUM AT MAIN STRUCTURE SITES

Site No.	Object	Depth of Bearing Stratum (GL-m)			Kind of Soil
		N ≧ 20	N ≧ 30	N ≧ 50	
1	Head Regulator	---	15.0-15.5	15.0-17.5	Sandy
2		4.5-5.5	4.5-6.5	14.5-17.5	Cohesive
3		4.0-7.0	8.0-12.0	9.0-15.0	ditto
4	Crossing Site	1.0	4.0	7.0	ditto
5		4.0-5.0	5.0-6.0	8.0-9.0	ditto
6		---	3.0	6.0-6.5	ditto
10		---	---	3.0-4.0	ditto
11	Tidal Regulator	14.0	20.5	28.0	ditto
7	Pump Station	---	---	4.0	ditto
8		11.0-15.0	16.0-23.0	25.0-26.0	Cohesive Sandy
9	Tail Regulator	15.0-18.0	28.0-29.0	31.0-33.0	Cohesive

FIGURE A-1 GEOLOGICAL MAP

① Tha Sae Reservoir. (RID)
② Rap Ro Reservoir. (RID)
③ Kaeng Phra Chao Reservoir. (SEA)
④ Ma La Reservoir. (SEA)
⑤ Upper Rap Ro Reservoir.
⑥ Pha-ngam Reservoir.
⑦ Nam Ron Reservoir.
⑧ Kum Reservoir.
⑨ Upper Kum Reservoir.
⑩ Kaphoo Reservoir.

Priority Project Area

MYANMAR

GULF OF THAILAND

EXPLANATION

SEDIMENTARY ROCKS	FORMATION	AGE
Alluvial, fan deposits; sandy silt, silty sand with gravel and clay		QUATERNARY
Sandstone, quartzitic sandstone, and conglomerate, red to reddish-brown, cross-bedded; interbedded red siltstone and maroon shale	PANG DANG	JURASSIC
Limestone, bedded, fossiliferous and brecciated limestone, partly dolomitic	CHUMPHON	PERMIAN
Orthoquartzite, siltstone, and shale	MAISI	CARBONIFEROUS
Graywacke, pebbly sandstone, pebbly shale, and mudstone, massive to thick-bedded; with intercalated terbidites	KRABURI	DEVONIAN SILURIAN
IGNEOUS ROCKS		
Biotite-muscovite granite, medium- to fine-grained		TRIASSIC
Andesite, rhyolite and lamprophyre dike		CRETACEOUS

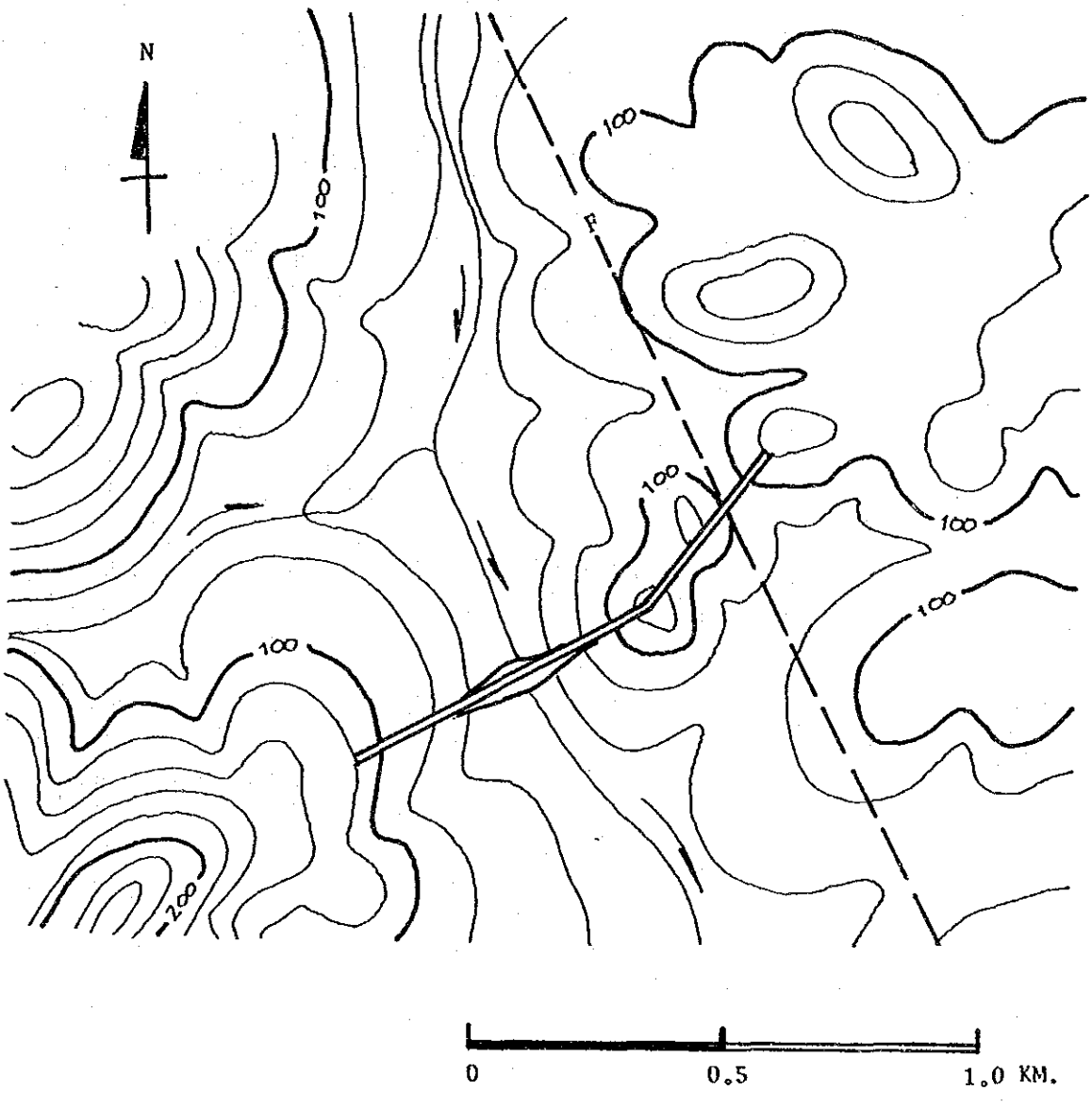
SYMBOLS

Boundary

Fault

SCALE

FIGURE A-2 MAP OF THA SAE RESERVOIR (RID)

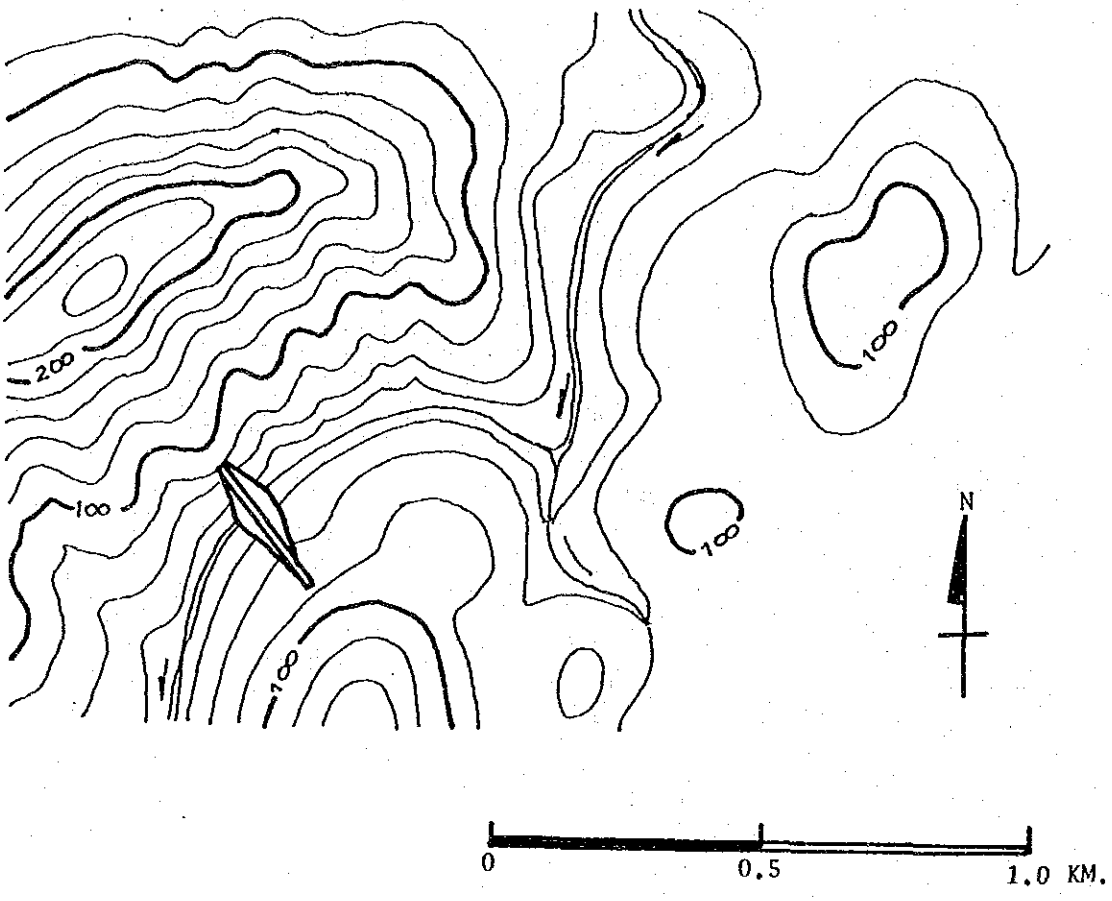


° Pebbly slaty shale, siltstone, partly sandstone

° N 20~40° E, 20~40° E

° A fault probably runs the left bank of the Tha Sae river.

FIGURE A-3 MAP OF RAP RO RESERVOIR (RID)

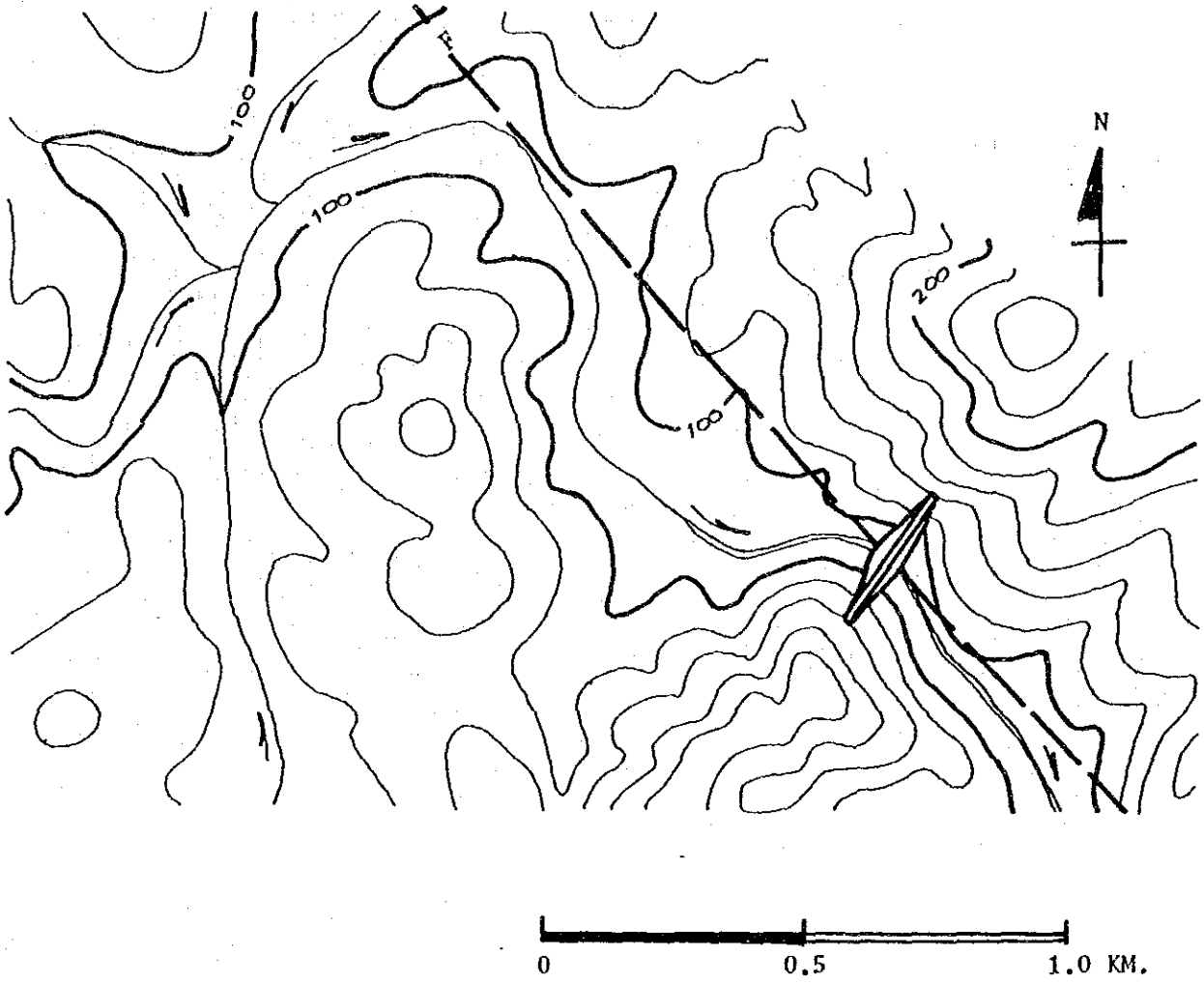


° Pebbly siltstone

° N 20~30° E, 30~40° E

° The talus is deposited thickly at the proposed damsite.

FIGURE A-4 MAP OF KAENG PHRA CHAO RESERVOIR (NEA)

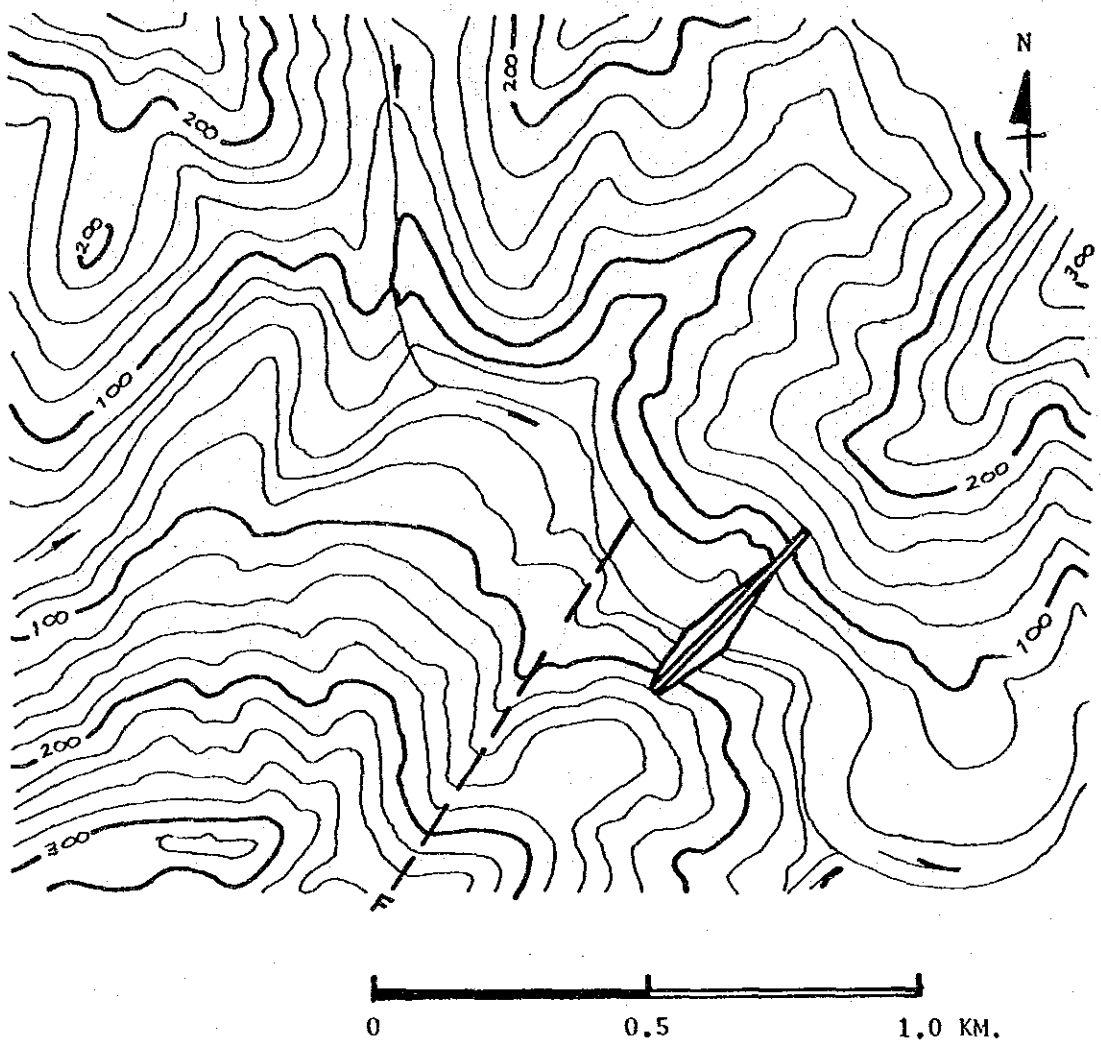


° Tuff, agglomerate, andesitic dike, quartz dike

° Slaty shale (down stream) N 40~50° E, 60~70° SE

° A fault probably runs along the Rap Ro River.

FIGURE A - 5 MAP OF MA LA RESERVOIR (NEA)

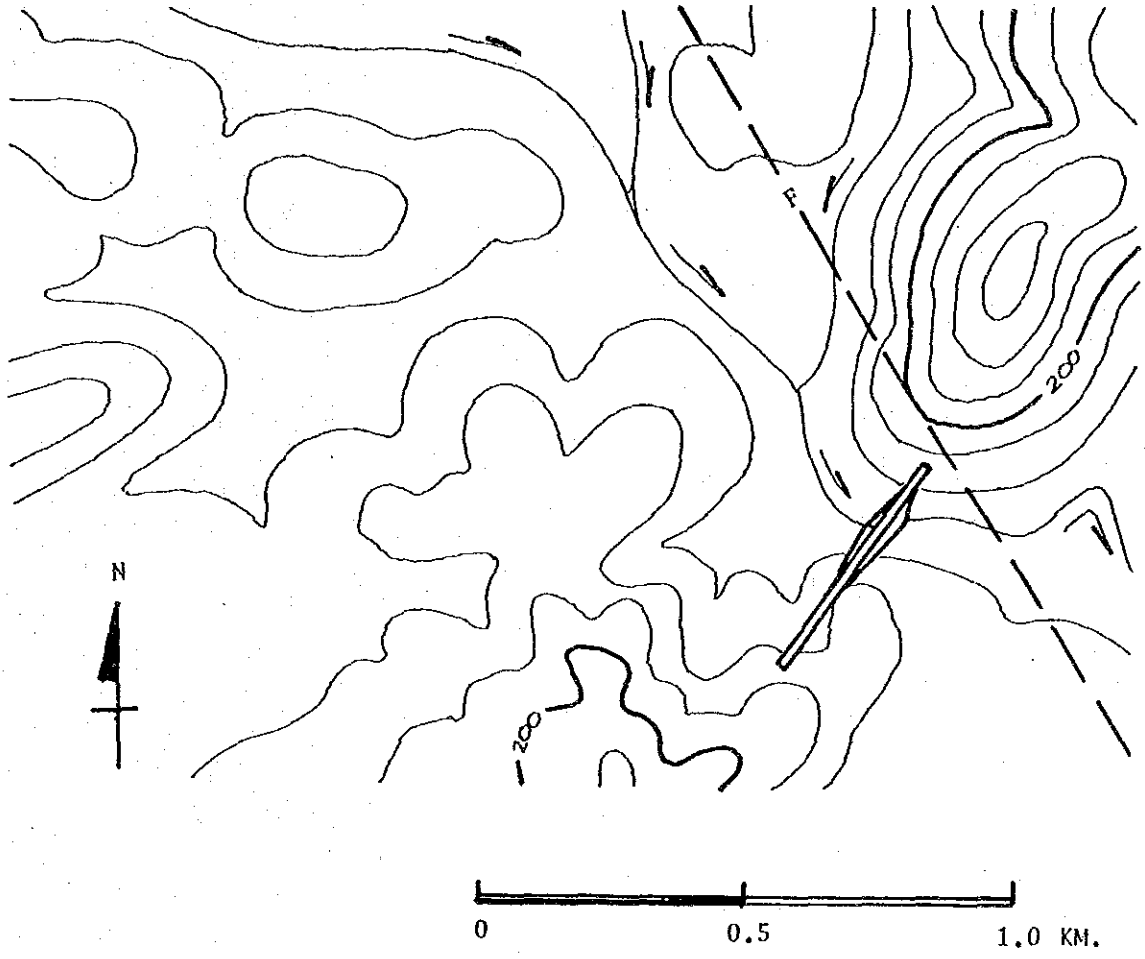


° Pebbly siltstone, partly sandstone

° N 10° E~W, 30~50° E

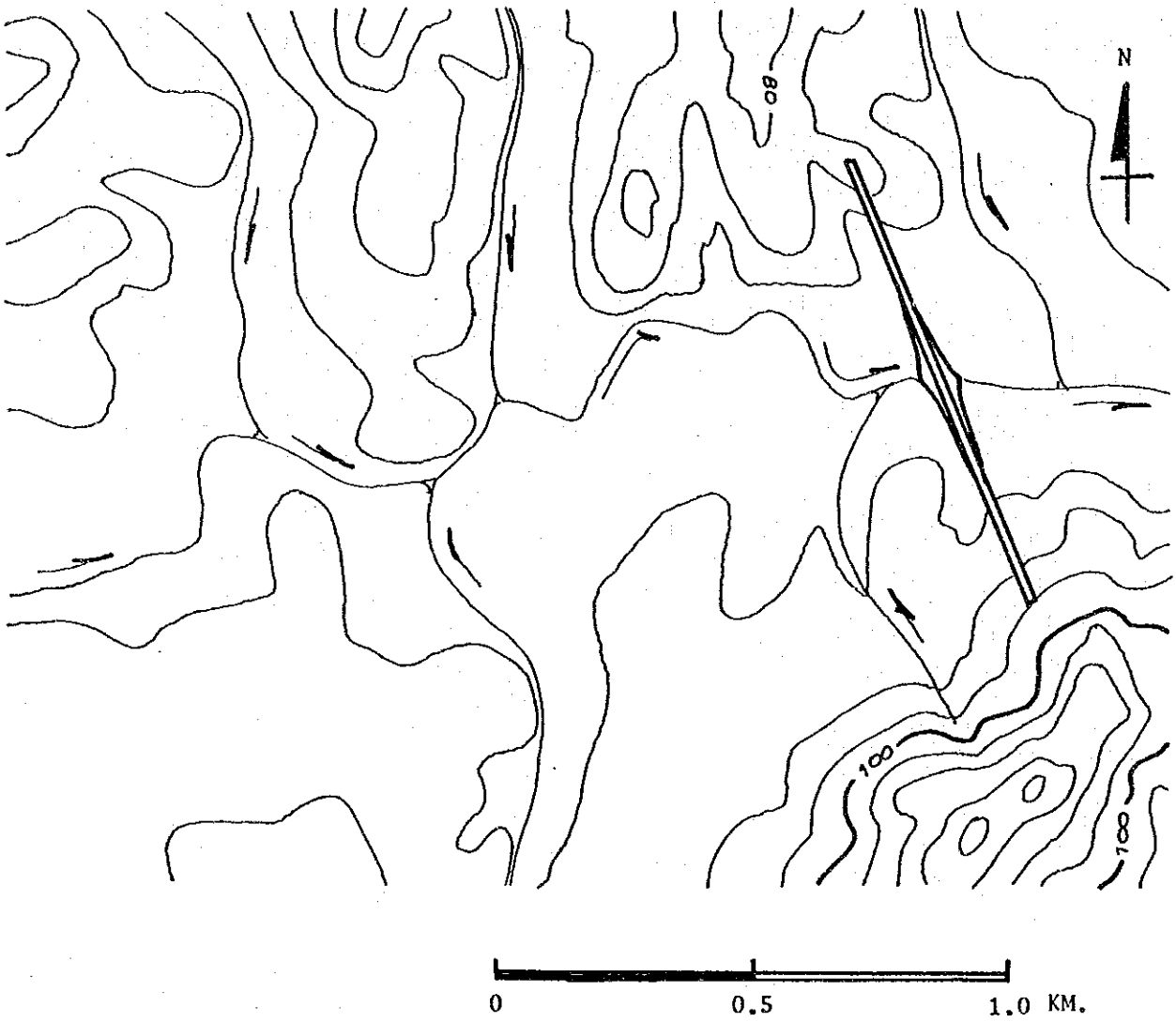
° A fault probably runs more or less in a direction parallel to the proposed damsite at the upstream.

FIGURE A-6 MAP OF UPPER RAP RO RESERVOIR



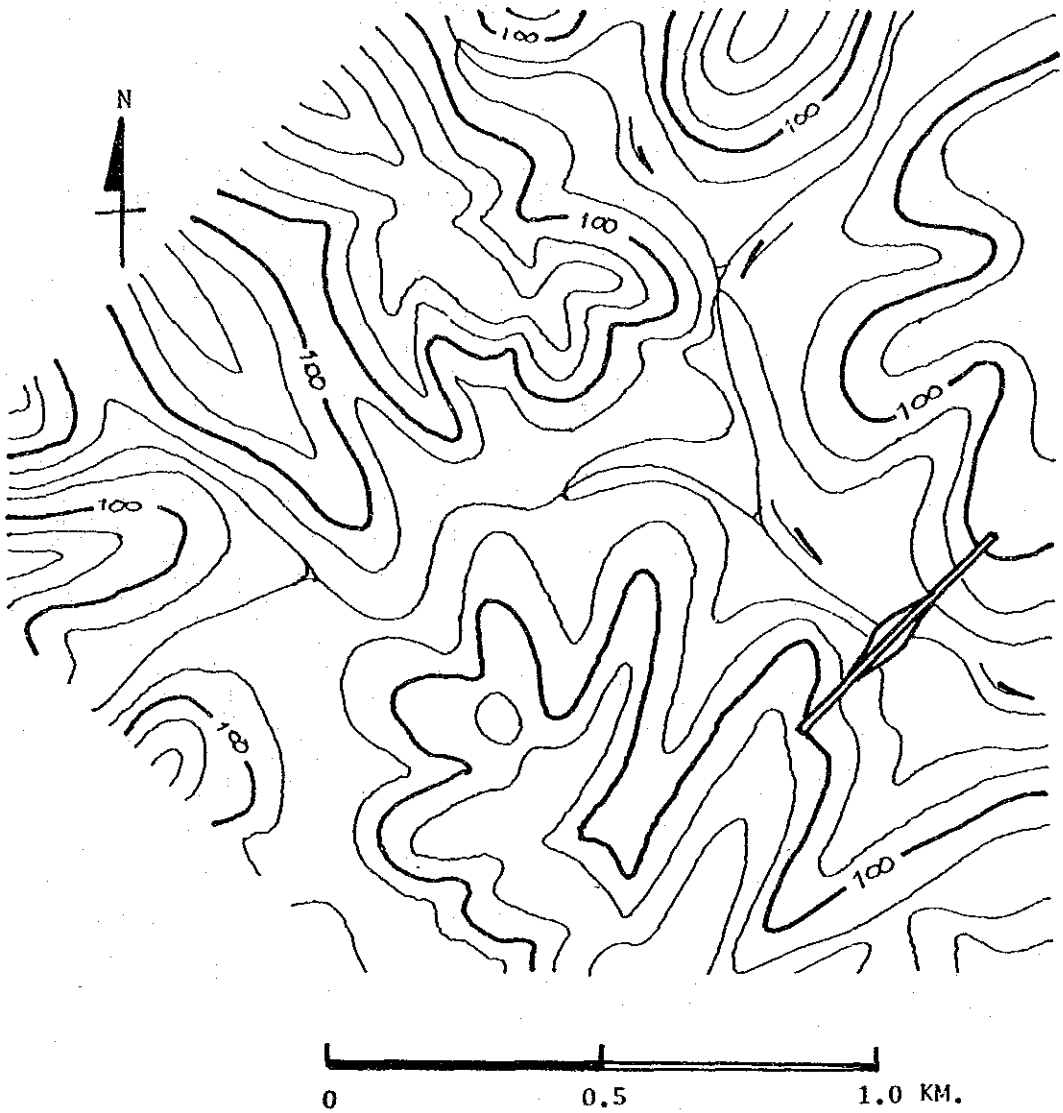
- Pebbly siltstone, partly conglomerate
- N 30~60° E,60° SE
- A fault probably runs the left bank of the Rap Ro river at the proposed damsite.

FIGURE A-7 MAP OF PHA-NGAN RESERVOIR



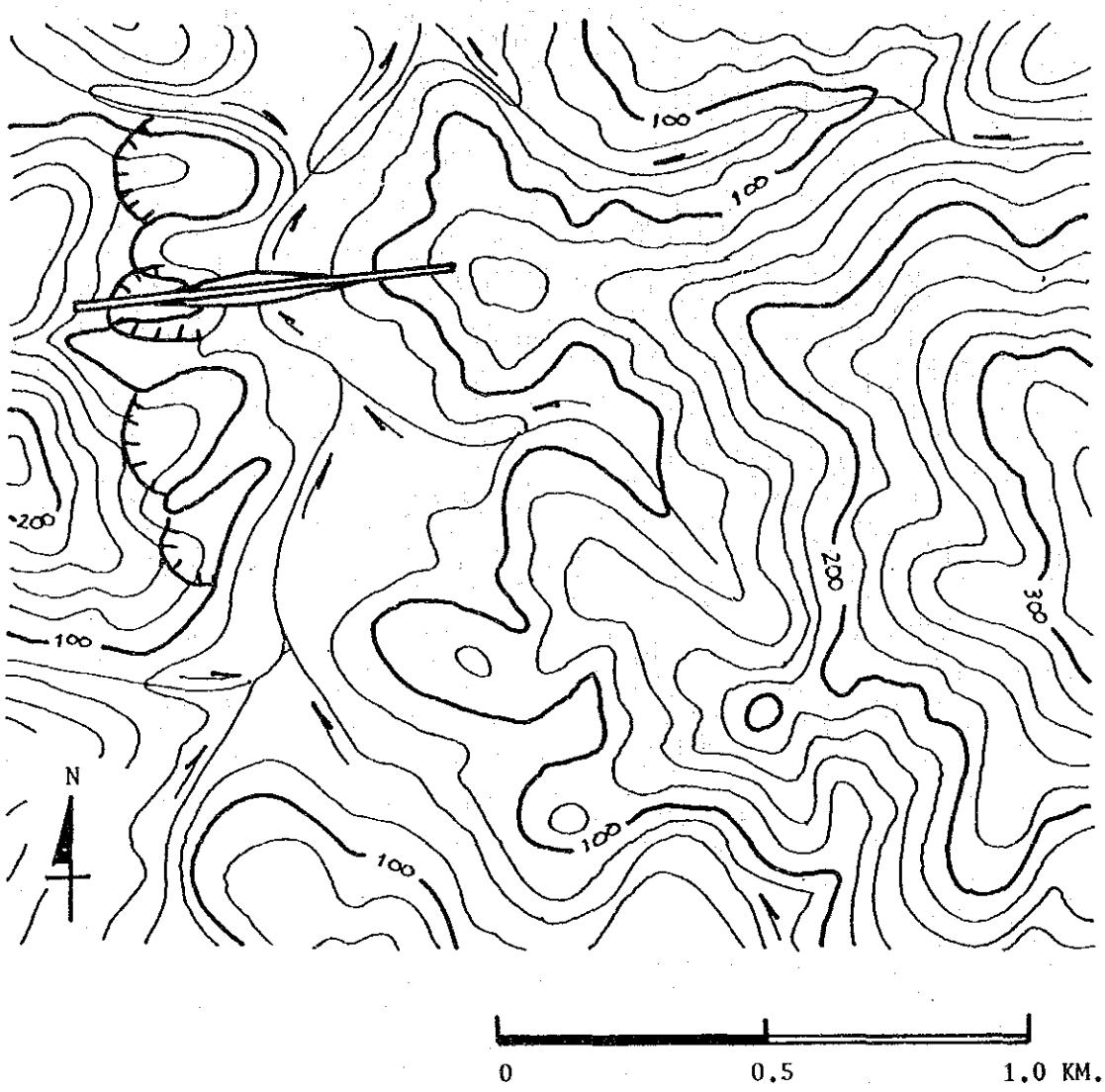
- Siltstone
- N 60° W, 80° N
- The terrace is deposited thickly at the left bank of the Pha-ngan river.

FIGURE A-8 MAP OF NAM RON RESERVOIR



- Shale, orthoquatzite
- N 40° E,60° E
- Bed rock is comparatively fresh though well jointed in a direction to N 50° W, 70~90° N.

FIGURE A-9 MAP OF KUM RESERVOIR

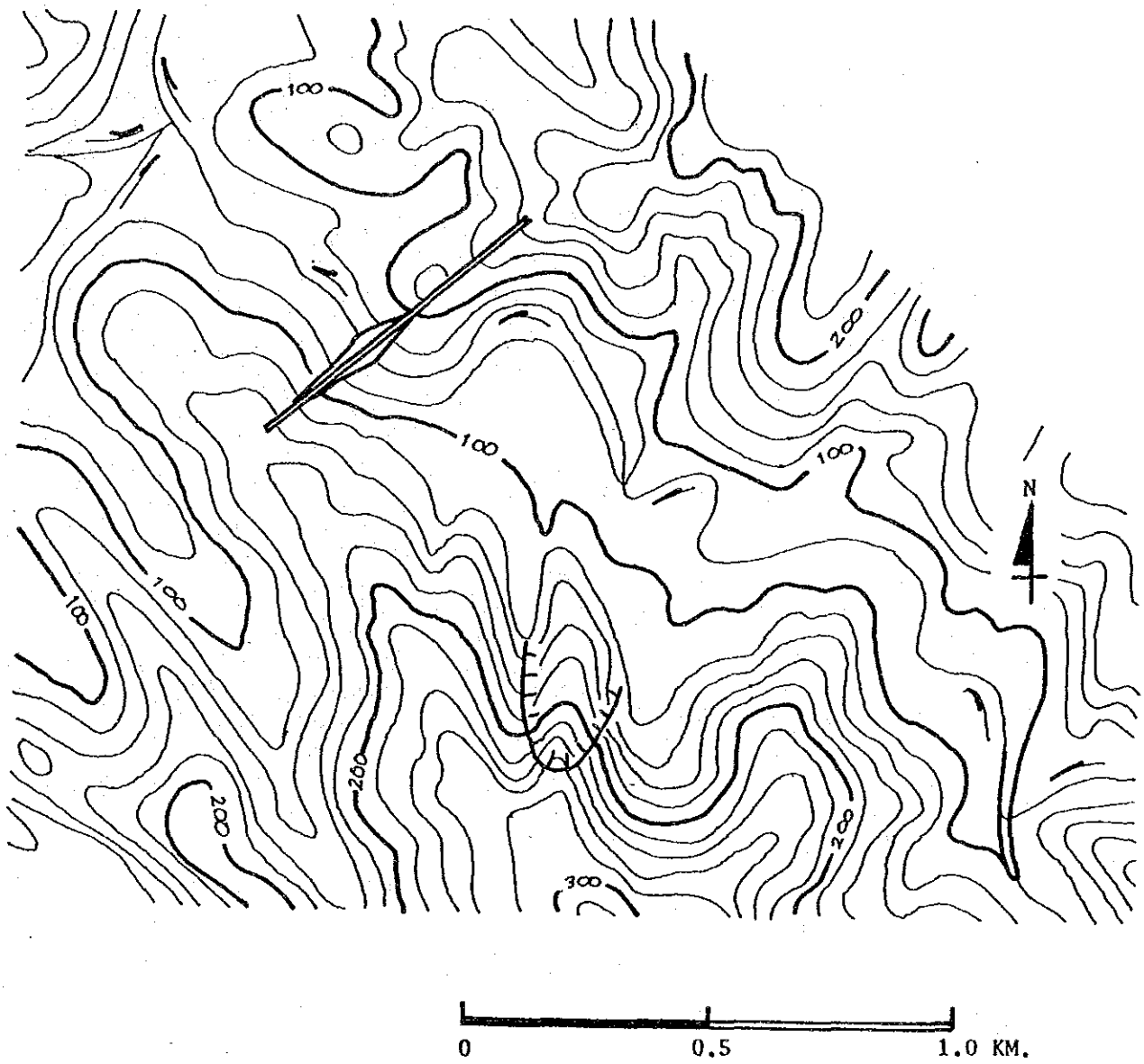


° Sandstone, siltstone

° The talus is deposited thickly.

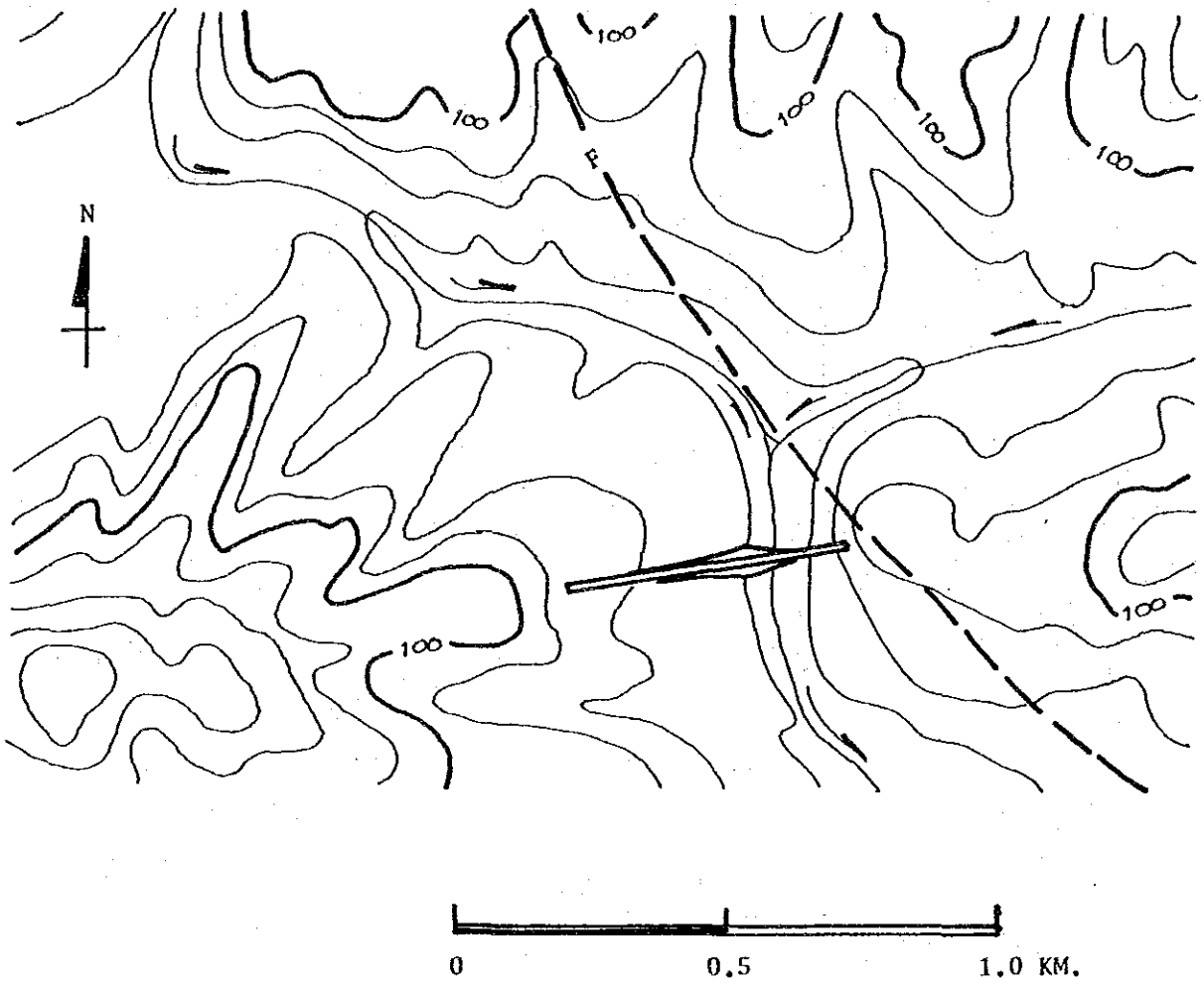
° The land form of the landslide is recognized at the leftside slope of the proposed damsite.

FIGURE A-10 MAP OF UPPER KUM RESERVOIR



- Sandstone
- N40° W 50° E (joint)
- The land form of landslide is recognized at the left bank of the upstream.
- The talus and the terrace are deposited somewhat thickly at the right bank of the Kum river.

FIGURE A - 11 MAP OF KAPHON RESERVOIR



° Pebbly siltstone, partly sandstone

° N 10~20° W, 80° W (the right bank of the river)

° N 60~70° W, 70~80° NorS (the left bank of the river)

° At the slope of the right bank of the river, the bed rock is weathered deeply.

° A fault probably runs the left bank of the river.

APPENDIX B. SOIL AND LAND USE

CONTENTS

APPENDIX B. SOILS AND LAND USE

LIST OF TABLES

LIST OF FIGURES

B. SOILS AND LAND USE

B-1 List of Maps, Aerial photos and References

B-1-1 Maps

- Topographical map, 1:50,000, US Topographic Command, Sathani Wisai (4729 I), Changwat Chumphon (4829 IV), Ban Pak Chan (4730 II), Amphoe Tha Sae (4830 III), Amphoe Pathiu (4830 II), Khao Phra Chao (4730 I), Ban Noen Thong (4830 IV), Sathani Map Ammarit (4830 I), Amphoe Bang Saphan (4831 II), Khao Daen Yai (4831 III)

- Detailed reconnaissance soil map of Chumphon Province, 1:100,000, DLD, 1972

- Detailed reconnaissance soil map of Prachuap Khiri Khan Province, 1:100.000, DLD, 1972

- Present land use map of Chumphon Province, 1:100,000, DLD, 1985

- Present land use map of Prachuap Khiri Khan Province, 1:100,000, DLD, 1982

- Present land use map of Amphoe Tha Sae, Amphoe Pathiu, Amphoe Muang, 1:50,000, DLD, 1990

- Land use planning map of Amphoe Tha Sae, Amphoe Pathiu, Amphoe Muang, 1:50,000, DLD, 1990

- Soil classification map, 1:50,000, DLD, revised based on the following topographical maps: Sathani Wisai (4729 I), Changwat Chumphon (4829 IV), Ban Pak Chan (4730 II), Amphoe Tha Sae (4830 III), Amphoe Pathiu (4830 II), Khao Phra Chao (4730 I), Ban Noen Thong (4830 IV), Sathani Map Ammarit (4830 I), Amphoe Bang Saphan (4831 II), Khao Daen Yai (4831 III)

- Topographical map of the Project Area, 1:10,000, Survey Division, RID, 1992

B-1-2 Aerial photos

- Aerial photos (scale 1:15,000) taken in 1975

B-1-3 Data and Publications

- Land use planning report of Chumphon Province, DLD, 1990 (Thai)

- Land use planning report of Prachuap Khiri Khan

Province, DLD, 1990 (Thai)

- Soil suitability of Amphoe Muang, Chumphon, DLD, 1991 (Thai)

B-2 SOILS

B-2-1 Methods of Soil Survey

The following works were carried out during the study period:

- Data and maps collection and reviewal
- Soil profile investigation (the Study Area and Project Area)
- Soil Analyses (the Study area and Project Area)
- Water Analyses (the Project Area)

(1) Soil Profile Investigation

a) Study Area

The soil profiles in soil pits as deep as 150 cm at the 10 main soil series site in the Study Area (Pit numbers range from 1 to 10) were investigated. For every soil profile, the soil texture, color, moisture status, mottling, concretions, gravel and pH were checked on the site. Forty nine disturbed soil samples for chemical and physical analysis were taken from each soil layer of the profile and 25 soil core samples were extracted from depths ranging from at 20, 90 and 150 cm.

b) Project Area

Firstly, 90 soil profiles were surveyed at a grid of 500 m apart. Soil Profile survey was made by auger boring at a depth of 250 cm. For every soil profile, similar observation

and descriptions for the Study Area were made. Then, additional ten soil profile surveys of the representative soil series were made at soil pits in the Project Area. Sixty two disturbed soil samples from each soil layer and 25 soil core samples from ten pits ranging at a depth of 20, 90 and 150 cm and 57 disturbed soil samples from every soil layer of 13 augers were taken for analysis.

(2) Soil Analysis

Soil analyses on chemical and physical properties were carried out by the Soil Science Laboratory of the Research and Laboratory Division. Items analyzed were as follows: (a) Bulk density, (b) Soil texture, (c) pH (H2O, KCl, CaCl2, paste if necessary), (d) Total carbon, (e) Total nitrogen, (f) Available Phosphate (Bray 2), (g) Cation Exchange Capacity, (h) Exchangeable Cation, (i) Electric conductivity.

(3) Water Quality Investigation

Fifteen water samples, 5 samples from groundwater (well), 8 samples from surface water including Nong Yai swamp, Sam Keao Canal and other small canal, and 2 samples from soil pit water were subjected to analyses.

Items analyzed were as follows: (a) pH, (b) Electric conductivity, (c) Total solid (TS), (d) Total dissolved solid (TDS), (e) Soluble sodium percentage, (f) Sodium absorption ratio (SAR), (g) Residual sodium percentage (SSP), (h) Boron, (i) Iron, (j) Total hardness, (k) Silica, (l) Cation (Ca, Mg, Na, K, NH4), (m) Anion (CO3, HCO3, Cl, SO4, NO3, PO4)

B-2-2 THE STUDY AREA

(1) Soil Classification and Outline of Soil Distribution

a) Land form and parent material

The soils in the Study area are derived from three main parent materials, that is, marine deposit, riverine deposit, residuum and colluvium deposits.

Main landform in the Study Area are divided into 6 types including old and recent beach ridges, active and former tidal flats, plains (lower terrace and flood plain), undulating and rolling terrains, hills and foot-slopes and mountains. Soils and their distribution patterns are highly correlated with the landform they cover.

There are 49 series, including 9 variants and 6 associations, in the study area (TABLE B-1, FIGURE B-1). These soil series are classified based on the land forms as follows (FIGURE B-2):

b) Soils derived from marine deposits

i) Soils on old and recent beach ridges and dunes

This landform covers about 36 km2, which is about 1.4 % of the Study Area. Beach ridges are formed by accumulation of sand and shells due to strong waves. The slope of the beach ridge is about 2-4 %.

There are 5 soil series in these landform, one is Spodosols and the other is Entisols.

ii) Active and former tidal flats, depression (swamp)

This landform covers about 109 km2, which is about 4.1 %of the Study Area. Tidal flats are flooded by sea water during high tide. The depressions behind the beach ridge is a low land (swamp) flooded all year round. Land in this area is formed from sea water and rare brackish water sediments, is flat or rather flat with a slope of not more than 2 %.

The former tidal flat is the plain behind the beach ridge or swamp. It is accumulatively formed from fresh water sediments or brackish water sediments and sea water sediment.

There are six soil series in these land forms, and they are all Entisols.

c) Soils derived from riverine deposits

i) Plains (lower terraces and flood plains)

This landform covers about 274 km2, which is about 10.4 % of the Study Area. The land in this area is flat or rather flat with a slope of not more than 4 %.

Levees are formed from flooding sediments. This area is usually flooded, but only for a short time in the flooding season.

Low terraces are situated next to the levee and are rather plain and flooded in the rainy season. They are rather poorly drained. This landform is formed from fluvial deposits and are paralleled along both sides of the river.

There are sixteen soil series in this landform. Among them, six are Ultisols, five are Entisols, three are Alfisols and the rest, Inceptisols and Histosols.

ii) Undulating and rolling terrains (middle and high terraces, coalescing fans)

This landform covers about 301 km2, which is about 11.5 % of the Study Area, and is originally formed from old river sediments. It is next to the low terrace and an upland with a slope ranging from 2-8 %.

There are fourteen soil series in this landform. Among them, twelve are Ultisols and the rest are Entisols and Inceptisols.

d) Soils derived from residuum and colluvium

i) Hill-slopes and low hills

This landform covers about 567 km2, which is about 21.6 %

of the Study Area, and is originally formed from old alluvium, residuum and colluvium. This landform are found next to the slope complex near the hill with a gradient of 16-30 %. There are eight soil series in this landform, seven of which are Ultisols and one of which is Mollisols.

ii) Hills and mountains

This landform covers about 1339 km2, which is about 51.1 % of the Study Area. This landform consists of a succession of mountain ranges from north to south which are the biggest and longest in the western part of Thailand. The ranges border between the line of Thailand and Myanmar and also between Chumphon province and Ranong Province.

Soils in mountains are generally shallow in depth, but some in gentle slopes are similar to those in hill-slopes and hills, that is, Ultisols.

It can be said, therefore, that there are two main soils in the study area, that is, Ultisols (35 %), Entisols (11 %). Ultisols are mainly distributed in the upland area, i.e. hills and foot-slopes, while Entisols are distributed in the lowland area, i.e., beach ridges, tidal flats and plans.

(2) Distribution of Problem Soils

There are two problem soils in the Study Area. One is the coastal saline soil and the other is acid sulfate soil. Saline soils such as Sm, Wp and Tc, cover 86.6 sq.km, which is 3.3 percent of the Study Area, and is distributed in swamps and tidal flats. Potential acid sulfate soil, such as Bp-gy, covers 17.8 sq.km, which is 0.7 percent of the Study Area, and are distributed in former tidal flat areas.

Besides these problem soils, soils in the Study Area are generally low in fertility, i.e., low CEC, low Base Saturation Percentage and low Available Phosphate (TABLE B-2).

(3) Land Capability Classification

The land capability classification according to crops is the only primary classification based on the soil information from the detailed reconnaissance survey. Chemical and physical quality of soil, topography, flooding condition, soil drainage condition at present are considered(TABLE omitted).

The area of each land capability classification according to crops is summarized below (TABLE-5).

AREA OF LAND SUITABILITY CLASSIFICATION ACCORDING TO CROPS

Class	Area (sq.km)					
	Paddy	Upland crops	Coconut	Rubber	Fruit tree	Pasture
I	31		-	668		997
II	86	78	1218	353	190	221
III	109	618	1407	1604	28	1407
IV	1	324			324	
V	2398	1605			2083	
			(%)			
I	1.2			25.5		38.0
II	3.3	3.0	46.5	13.5	7.2	8.4
III	4.2	23.6	53.5	61.0	1.1	53.6
IV	0.02	12.4			12.4	
V	91.4	61.0			79.3	

Note: There are five classes of soils suited for paddy, upland crops and fruit tree. I: very suitable, II: well suitable, III: marginally suitable, IV: poorly suitable, V: not suitable

There are 3 classes of soils for coconut, rubber, pasture. I: well suitable, II: poorly suitable, III: not suitable

B-2-3 THE PROJECT AREA

(1) Soil Classification and Outline of Soil Distribution

a) Landform

Soil profiles of the representative site were studied to review and modify the existing detailed reconnaissance soil map at a scale of 1:100,000 prepared by DLD. Soil

distribution in the Project area is shown in Figure B-6. As shown in the map, the distribution of soils is generally related to the landform sequence.

Landform in the Project Area can be classified into 6 types as follows:

LANDFORM AND AREA

Landform	Area (ha)	(%)
(a)Old and recent beach ridges	269	9.6
(b)Active tidal flats and depressions	256	9.1
(c)Plains (lower terrace and flood plain)	922	32.9
(d)Undulating and rolling terrain	807	28.8
(e)Hills (Khao Na Cha-Ang)	6.3	0.2
(f)Swamp (Nong Yai swamp)	543	19.4
Total	2,803	100.0

i) Soils distributed in the old and recent beach ridges are sandy soils, i.e., the Bacho series (Typic Quartzipsamments, USDA Soil Taxonomy) and Ban Thon series (Typic Tropohumods), formed by accumulation of sand and shells due to the tidal current and the strong waves. This topography covers about 269 ha, which is about 9.6 percent of the Project Area, coconut palm trees are planted on a part of this area while the rest is covered with shrub and grasses.

ii) Soils distributed on the active tidal flats and depressions are characterized by fine and medium texture soils i.e., the Bang Pakong series (Typic Sulfaquents) and Wan Priang series (Typic Tropaquents), formed from sea water or brackish water sediments. This topography covers about 256 ha, which is about 9.1 percent of the Project Area, and is used to grow mangroves and nipa palm trees. But now, some parts of this area is being converted to shrimp ponds.

iii) Soils distributed in the plains are of a very fine and fine texture and consist of the Tha muang series (Typic Ustifluvents), Bangnara series (Typic Paleaquults) and Klaeng series (Oxic Plinthaquults), formed from new fluvial deposits. This topography covers about 921 ha, which is about 33 percent of the Project Area, and is used for cultivation of paddy rice

and vegetables at a relatively lower area and fruit trees, coconut palm trees and others at a relatively higher area.

iv) Soils distributed on the undulating and rolling terrains are of medium and coarse texture and consist of the Kohong series (Typic Paleaquults), Sawi series (Typic Paleudults), Pathiu series (Typic Paleudults), Chumphon series (Typic Paleudults), formed from old river sediments. The topography covers about 543 ha, which is about 19 % of the Project Area, and land is widely used to grow fruit trees, coconut palm trees and others.

b) Soils

The soils in the Project Area are classified into 4 orders (USDA Soil Taxonomy), that is Ultisols (1092 ha, 39 %), Entisols (914 ha, 32.6 %), Spodosols (224 ha, 8 %), Histosols (30 ha, 1 %). General physical-chemical properties of the soils are summarized as: All soil series in the Project Area have deep effective soil depth. Some soil series (Bangnara, Klaeng, Wan Priang, Bang Pakong, Narathiwat series) are poorly drained. All soil series have inferior chemical properties such as very strongly acid, except for Entisols (medium acid), low cation exchange capacity, low base saturation percentage, low organic matter, except for the Narathiwat and Bang Pakong series, and very low available phosphate.

(2) Distribution of Problem Soils

Two problem soils can be observed in the Project Area, they are saline soil and potential acid sulfate soil. According to the Saline Soil Research Laboratory of DLD, only Wan Priang series is identified in the Project Area. However, according to our Survey, saline soil was identified in the Bangnara series distributed north of the Sam Kaeo Canal, used for paddy cultivation. This salinity may be caused by irrigation water from the Sam Kaeo Canal where inflow of sea

water or brackish water is observed. Therefore, the paddy yield may decrease by 10 to 25 percent, judging from the ECe value (FAO Irrigation and drainage paper No. 33, 1979). The Wan Priang series is used for coconut palm tree production and for shrimp ponds.

Acid sulfate soil, distributed in the active tidal flats and depression in the Project Area, is used for the production of coconut palm trees, orchards in some parts, and the rest is planted with nipa palm trees, however some places are presently converted into shrimp ponds.

(3) NECESSITY FOR SOIL IMPROVEMENT

In consideration of the above observations, following management will be required for furthering agricultural development in the Project Area, (1) As potential acid sulfate soils contain a high content of pyrite (FeS2) under submerged and reduced condition, pyrite is oxidized by drainage or exposure to air, producing sulfuric acid and the pH of the soil by 3.0. To prevent pyrite from oxidization, the groundwater level should be controlled and kept above the layer rich in pyrite. (2) Irrigation water of good quality should be used to leach soluble salts of saline soils. (3) Drainage facilities are needed not only for the ill-drained field but for saline soil area. (4) proper soil improvement measures are needed for strongly acidic soil area. (5) proper manuring practices are needed for all type of soils in the Project Area.

B-3 LAND USE

B-3-1 Methods of Land Use Survey

(1) For the Study Area

The present situation of land use in the Study Area was reviewed on the field on the basis of the present land use map on a scale of 1:50,000, prepared by DLD in 1990.

(2) Project Area

The present land use in the Project Area was checked based on aerial photos on a scale of 1:15,000, taken in 1975 as supplementary map.

B-3-2 The Study Area

(1) Present Land Use

The number of forests in Chumphon Province is gradually decreasing. For example, a total of 4146 sq.km or 69 % of the total land in 1961 and a total of 2,883 sq.km or 49.1 % of the total land in 1975 in Chumphon Province were covered by forests. In 1989, it has decreased to 1425 sq.km or 23.7 % of the total area. This circumstance is attributed to illegal cultivation and concession to private companies or ALRO (Agricultural Land Reform Office).

In the Study Area, forests are officially classified into reserved forests, wild life sanctuaries, concession areas for oil palms and ALRO areas, all measuring 635 sq.km, 454 sq.km, 49 sq.km, 455 sq.km, respectively.

The present land use in the Study Area is classified as follows:

PRESENT LAND USE IN THE STUDY AREA

Land Use	Area (sq.km)	(%)
Forestry	960.9	36.6
Paddy	151.1	5.8
Upland crops	76.1	2.9
Tree crops	634.5	24.2
Fruit trees	243.4	9.3
Mixed Orchard & Vegetables	74.7	2.8
Others (idle land, etc.)	484.3	18.4
Total	2,625.0	100.0

Note: Mixed fruit orchard comprises of coconuts, citrus, rambutans, coffee, bananas, papaya, mangosteen, etc.

From the above table, it can be said that the main crops in the Study Area are tree crops and fruit, while the minor crop is paddy.

Based on the landform, the land use in the Study Area is as follows:

a) Old and recent beach ridges and dunes

Most of the land is covered with coconut trees and some parts are deserted and covered with bushes and grasses.

b) Active and former tidal flats, depressions (swamp)

The depressions (swamp) and active tidal flats have been covered with mangroves. But now some areas are being converted into shrimp ponds. Paddies were grown in areas which were formerly tidal flats.

c) Plains (lower terrace and flood plain)

Fruits, rubber trees, vegetables and paddy are grown in this area. Paddy rice is cultivated at the lower plain, while fruit trees, coconut palms, oil palms and other tree crops are cultivated at the upper plain.

d) Undulating and rolling terrains (middle and high terrace, coalescing fans)

This area is widely used to grow rubber trees, coconut palms and some fruits. Some infertile areas are left as idle lands and are covered with weeds.

e) Hillslopes and Low Hills

Rubber trees, coconut palms, coffee, oil palms and some upland crops were mostly grown in this areas.

f) Hills and Mountains

This area was mostly covered with forest before, but due to deforestation, the forest area has rapidly decreased. After deforestation, rubber trees, coconut palms, coffee, oil palms and some upland crops are being grown in some of the areas by private companies or migrants.

(2) Problems in the Study Area

a) Problems on mangrove destruction

There are several mangrove forests in the Study Area. Individuals and private companies develop it into shrimp ponds. Mangrove forests are important to preserve natural life, including that of fishes. Therefore, an evaluation should be carried out to compare the benefits from shrimp production and loss from the effect of mangrove destruction on inshore fishery production.

b) Deforestation and soil erosion

Deforestation does not only cause flood as it reduces water holding ability, but also destroys the ecosystem in the surrounding forest. Furthermore, soil erosion problems are

also caused by forest destruction in the steep slope area. The major causes are due to wrong management of land such as the tilling of soil in the slopes, no materials or crops to cover the soil, no terracing for crop cultivation, etc.

c) Coastal saline soils

Saline soils are distributed in tidal flat areas used to be filled with mangroves and nipa palms. These areas are not important agricultural lands and are being converted into shrimp ponds which produces more benefit compared to agricultural production.

d) Actual acid sulfate soils

Actual acid sulfate soils are distributed in former tidal flat areas. Paddy is grown in this area. Soils in this area contain a high content of pyrite (FeS2) under submerged and reduced conditions. But once pyrite is oxidized by drainage or exposure to air, sulfuric acid is produced decreasing the pH of the soil by 3.0. To prevent pyrites from oxidization, groundwater level should be controlled and kept above the pyrite rich layer (about 15-20 cm), unless soil improvement is carried out thoroughly. Groundwater table at present is enough to maintain soil at reduced condition.

e) Others

Besides the above two problem soils, soils in the Study Area are generally low in fertility, i.e., low CEC, Base Saturation Percentage and Available Phosphate (TABLE B-2). These soil properties are closely related to the soil characteristics of Ultisols and Inceptisols Alfisols. Appropriate fertilizer application is needed to maintain soil fertility and to obtain a reasonable yield.

(3) Basic Concept

The basic concept of the land use plan for the Project constitutes (a) stabilization of agricultural productivity, (b) to increase farm income, (c) to increase crop diversification, and (d) to increase crop intensity, i.e., double cropping of rice. But, inundation at low-lying areas in the rainy season and water shortage in all areas in the dry season are serious agricultural problems in the study area.

Therefore, based on the preliminary investigation on land resources including land use and the topography and socioeconomic condition of the Study Area, the location of irrigation and drainage projects are proposed on the planes, i.e., the active and former tidal flats, lower terraces and flood plains along the Tha Sae river, Rap Ro river and Tha Taphao river.

The present land use in the irrigable area are as follows:

PRESENT LAND USE IN THE IRRIGABLE AREA

Crops	Area sq.km	(%)
Paddy	84.3	18.3
Upland crops	0.7	0.2
Coconut	115.8	25.2
Coffee	2.1	0.5
Oil palm	7.4	1.6
Rubber	12.7	2.8
Fruit tree	1.0	0.2
Forest	26.7	5.8
Mangrove forest	10.4	2.3
Vegetable and mixed fruit orchard	157.1	34.2
Idle land	39.3	8.5
Water resources	1.6	0.2
Total	460.0	100.0

From this table, it can be said that lands in the irrigable area are mainly used for growing vegetables and mixed orchards, coconuts and paddy, to fully occupying 78 % of this land area.

There are two problem soils in the Study Area, the saline

soil and actual acid sulfate soil. The saline soil area is excluded from the irrigation project, because mangroves and nipa palms are grown in this area and because it is being changed into shrimp ponds. Actual acid sulfate soil area remain as it is, because paddy is grown in this area and in order to control groundwater level and keep it above pyrite rich layer to prevent oxidization of pyrite.

(4) Land Use Planning

a) Land Use Plan for the Irrigable Area

Land suitability classification for intensive irrigated agriculture is undertaken by means of the soil survey interpretation. Intensive irrigated agriculture implies adequate irrigation water supply, adequate drainage condition, adequate soil improvement with adequate amount of fertilizer application. Land suitability classification for intensive irrigated agriculture is shown in TABLE B-4 and summarized as follows:

LAND CLASSIFICATION FOR IRRIGATED AGRICULTURE IN PLAIN AREAS

Class	Paddy	Upland crop	Coconut	Coffee	Rubber	Fruit tree	Oil palm
			Area (sq.km)				
S1	89	57	140		140		111
S2	5	170	12	229	1	141	59
S3	175	31	106	29	117	117	88
N	2	13	13	13	13	13	13
Total	271	271	271	271	271	271	271
			(%)				
S1	32.8	21.0	51.7		51.7		41.0
S2	1.8	62.6	4.5	84.5	0.3	52.0	21.7
S3	64.6	11.6	39.0	10.7	43.2	43.2	32.5
N	0.8	4.8	4.8	4.8	4.8	4.8	4.8

S1: Well suited, S2: Moderately suited, S3: Less suited, N: Not suited

From this table, it can be said that most of the soil in the plains is suitable for paddy, tree crops, fruit tree,

mixed fruit orchards cultivation.

On the basis of the present land use and land classification, the proposed land use for the irrigated area is as follows:

LAND USE PLAN FOR IRRIGATION AREA

Crops	(%)
Paddy	20
Upland crops	5
Vegetables & Mixed orchard	60
Coconut	5
Tree crops	5
Others	5
Total	100

Note: paddy is for double cropping. Land in the surrounding plains not be incorporated in the irrigation project area because of unsuitable topography may be used for growing tree crops and upland crops. On the other hand, the land in the surrounding plains not highly elevated will be incorporated in the irrigation project and may be used for growing fruit trees, tree crops and upland crops.

B-3-3 The Project Area

(1) Present Land Use

The present situation of land use in the Project Area are as follows:

PRESENT LAND USE IN THE PROJECT AREA (ha)

Land Use Type	Name of Tambong Bang Luk	Na Cha-Ang	Na Thung	Sum	Ratio(%)
Farm Land	347	634	1,038	2,019	72.0
Paddy Rice	149	211	356	716	25.5
Mixed Orchard(M)	141	377	572	1,090	38.9
Coconut palm(C)	26	8.2	110	144	5.2
Para Rubber(R)		5.0		5.0	0.2
Vegetables	30	10		40	1.4
C & R		**2.2**		**2.2**	**0.1**
R & field crops		**6.4**		**6.4**	**0.2**
Field crops & grass	**1.3**			**1.3**	**0.0**
C & Shrub		**15**		**15**	**0.5**
Non Farm Land	49	52	87	188	6.7
Shrub	**47**	**49**	**15**	**111**	**4.0**
Nipa palm			68	68	2.4
Grass	**1.7**			**1.7**	**0.1**
Nipa palm & Grass			4.2	4.2	0.2
Shrub & Grass		**3.1**		**3.1**	**0.1**
Others		12	7.8	596	21.3
Shrimp			7.8	7.8	0.3
Hills (Khan Na Cah-Ang)		6.3		6.3	0.2
Borrow pit		6.1		6.1	0.2
Canal(Sam Kaeo)				33	1.2
Swamp (Nong Yai)				543	19.4
Total	395	699	1,134	2,803	100.0

Note: Bold figures indicate the area to be converted to mixed orchard.

Farm land in the Project Area occupies about 70 percent of the Project Area. The main type of farm land use is paddy rice and mixed orchard, covering a total of about 65 percent of the Project Area. Mixed orchard plantation in the Project Area has been observed near the farmer's house, where several kinds of fruit trees are planted, i.e., rambutan, durian, mangosteen, orange, langsat, coconut palm, banana, sato, betelnut palm, etc.

The land use type in the Project Area is related to the landform sequence. For instance, paddy is planted on the relatively lower land area of the plain, while fruit trees are planted on relatively higher land area of the plain and the undulating and rolling terrain.

Area not used as farm lands are converted into shrimp ponds while the rest is covered with nipa palms, shrubs and natural grass lands. Hills are used for borrow pits and the soils are used for road improvement and land development.

(2) PROBLEMS AND NEEDS IN THE PROJECT AREA .

(a) The farm survey indicates the desire of every village resident to continue growing the same type of crops they do. The majority are well-informed about possess agricultural tools/equipment, and are well-informed about the selling sources. They are afraid that the new crops will produce a low market demand and exorbitant compensation or remuneration fees. Further, their reluctance is also cause by the fact that presently cultivated crops suit the climate and condition of the area, are easy to manage and tolerant of insect and diseases.

(b) Low yield of the crops in the Project Area at present is attributed to (i) irrigation water shortage in the dry season, (ii) inundation in the rainy season, (iii) cultivation without fertilizer on low fertility soils, (iv) irrigation water containing salts.

(3) Basic Concept

(a) According to results of land suitability for intensive irrigated agriculture, (i) soils on the lower terrace and flood plain are suitable for paddy cultivation, (ii) as cashew nut requires sandy soil with a good drainage and low water table, the Ban Thon series distributed in the active tidal flats, Kohong series, Lan Suan series and Chumphon series distributed in the undulating terrain are assessed to be suitable for cashew nut cultivation, (iii) as other fruits trees only require deep effective soil depth, most of the soil series in the Project Area are suitable for fruit trees besides cashew nut.

(b) As the land area to be converted to farm land is limited, only 115 ha of land, excluding the plantation of nipa palm trees, can be converted into a mixed orchard and developed into a meadow. Meadow will be used in the future

pilot farm for the development of livestock farming in the Project Area. The plantation land of nipa palm tree may be changed into shrimp ponds in the future.

(c) Agricultural production in the Project Area will be increased by introducing intensive irrigated agriculture for paddy and fruit tree cultivation. Intensive irrigated agriculture implies adequate irrigation water supply, adequate drainage condition, adequate soil improvement with adequate amount of fertilizer application.

(4) Land Use Planning

Land use plan proposed for the Study Area is as follows:

Land Use Plan in the Project Area by Tambong (ha)

Crops	Bang Luk	Na Cha-Ang	Na Thung	Total	(%)
Transplanted rice	149	211	356	716	25.5
Mixed orchard	**156**	**448**	**587**	**1,191**	**42.5**
Coconut	26	8	110	144	5.2
Rubber		5		5	0.2
Vegetables	30	10		40	1.4
Meadow	**34**	**4**		**38**	**1.4**
Sum	394	686	1,054	2,135	76.2
Non farm land			68	68	2.4
Shrub					
Nipa palm			68	68	2.4
Grass					
Coconut & shrubs					
Coconut & rubber					
Rubber & field crops					
Field crops & grass					
Nipa palm & grass			4	4	0.2
Others					
Shrimp pond			8	8	0.3
Borrow pit		6		6	0.2
Khao Na Cha-Ang		6		6	0.2
Sam Kaeo				33	1.2
Nong Yai				543	19.4
Sum		12	8	596	21.3
Total	394	699	1,134	2,803	100.0

Note: Bold figures indicate increased farm area.

TABLE B-1 SOIL CLASSIFICATION AND DISTRIBUTION IN THE STUDY AREA

Symbol	Soil series Name	Subgroup	Order	Area (Km²)	(%)
	Old and Recent Beach Ridges and Dunes			35.8	1.4
Bh	Ban Thon series	Typic Tropohumods	Spodsols	12.7	0.5
Hh	Hua Hin series	Typic Quartzipsamments	Entisols	10.7	0.4
Bc/Bh	Bacho/Ban Thon Association	Bc(50%), Bh(50%)	Entisols	9.6	0.4
Ry	Rayong sries	Typic Quartizipsamments	Entisols	1.8	0.1
Bc	Bacho series	Typic Quartizipsamments	Entisols	1.0	0.0
	Active & Former Tidal Flats and Depressions between Beach Ridges			108.7	4.1
Tc	Tha Chin series	Typic Hydraquents	Entisols	52.5	2.0
Sm	Sumut Prakan series	Typic Tropaquents	Entisols	18.8	0.7
Bp-gy	Bang Nam Prieo, gypsum variant	Sulfic Tropaquent	Entisols	17.8	0.7
Wp	Wan Priang series	Typic Tropaquents	Entisols	15.3	0.6
Lm	Bang Lamung series	Typic Tropaquents	Entisols	3.0	0.1
U7/58	Bang Lamung series, overwashed phase	Typic Tropaquents	Entisols	1.0	0.0
Lm/Sw	Bang Lamung/Sawi Association	Lm(70%), Sw(30%)	Entisols	0.3	0.0
	Plains (lower terraces and flood plains)			270.6	10.3
Tm	Tha Muang series	Typic ustifluvents	Entisols	107.1	4.1
Ba	Bangnara series	Typic Paleaquults	Ultisols	56.1	2.1
Sa	Sanphaya series	Typic ustifluvents	Entisols	27.5	1.0
Vi	Visai series	Typic Paleaquults	Ultisols	22.8	0.9
U6/58	Bangnara, moderately alkaline variant	Typic Paleaqualfs	Alfisols	19.1	0.7
U9/58	On, moderately alkaline varaiant	Typic Plinthaqualfs	Alfisols	11.8	0.5
To-gr	Tha Tako, gray subsoil variant	Tropaquepts	Inceptisol	9.9	0.4
Kl	Klaeng series	Oxic Plinthaquults	Ultisols	4.5	0.2
AC-pd	Alluvial soils, poorly drained complex		Entisols	3.6	0.1
U12/58	Bangnara series, overwashed phase	Typic Paleaquults	Ultisols	2.2	0.1
Bu-al	Sai Buri, alkaline variant	Aeric Paleaquults	Ultisols	1.8	0.1
Nw	Narathiwat series	Tropofibrists	Histosols	1.5	0.1
AC-wd	Alluvial soils, well drained complex		Entisols	1.3	0.1
U8/58	Visai , moderately alkaline variant	Typic Paleaqualfs	Alfisols	0.8	0.0
Ni	Nam Krachai series	Oxic Plinthaquults	Ultisols	0.6	0.0
	Undulating and Rolling Terrain (middle and high terraces, coalescing fans)			301.1	11.5
Cp	Chumphon	Typic Paleudults	Ultisols	196.0	7.5
Kh	Kohong series	Typic Paleaquults	Ultisols	33.8	1.3
Km	Khlong Thom series	Typic Quartzipsaments	Entisols	26.6	1.0
Lan	Lang Suan series	Typic Paleudults	Ultisols	17.0	0.6
Sr	Si Racha series	Rhodic Paleudults	Ultisols	9.1	0.3
Lan/Kh/Cp/Sw	Lan/Kh/Cp/Sw Association	Lan(40%), Kh(20%), Cp(20%), Sw(20%)	Ultisols	4.9	0.2
Sw	Sawi series	Typic Paleudults	Ultisols	3.8	0.1
Ll	Lamphu La series	Typic Paleudults	Ultisols	3.8	0.1
Kh/Sw	Kohong/Sawi Association	Kh(60%), Sw(50%)	Inceptisol	3.1	0.1
Pw	Pathiu series	Rhodic Paleudults	Ultisols	2.4	0.1
Te-m	Tha Sae, mottle variant	Typic Paleudults	Ultisols	0.5	0.0
	Hillslopes and Low Hills			566.6	21.6
Pto/Rg	Phato/Ranong Association	Pto(50%), Rg(50%)	Ultisols	466.7	17.8
Ak	Ao Luk series	Rhodic Paleudults	Ultisols	53.2	2.0
Pto	Phato series	Typic Paleudults	Ultisols	11.0	0.4
Rg	Ranong series	Typic Paleudults	Ultisols	11.0	0.4
Tk	Takhli series	Typic calciustolls	Mollisols	6.8	0.3
Tg-al	Thung Wa, alkaline variant	Udoxic Dystropepts	Ultisols	6.6	0.3
Kc	Khlong Chak series	Rhodic Paleudults	Ultisols	6.0	0.2
Pk-fl	Phuket, fine loamy variant	Typic Paleudults	Ultisols	3.9	0.1
Knk-al	Khlong Nok Krathung, alkaline variant	Typic Paleudults	Ultisols	1.0	0.0
Kbi	Krabi series	Typic Paleuduts	Ultisols	0.2	0.0
Klt/Ntn	Khlong Teng/Na Thon association	Typic Paleuduts	Ultisols	0.2	0.0
	Hills and Mountains			1338.6	51.0
SC	Slope Complex (Sandstone, Shale, Quartzite, Phyllite, Limestorne)			1338.6	51.0
	Total			2625.0	100.0

TABLE B-2 RESULTS OF SOIL ANALYSIS IN THE STUDY AREA (CHEMICAL PROPERTIES)

Pit No.	Symbol	Soil Series Name	Depth	Particle Size Distribution				pH	S.P.	EC	EC	CEC	ESP	Exchangeable Cation				Base	Org.	Total	Avail. P
				Sand	Silt	Clay	Texture	1:5		1:5	Sat. Ext.	NH4 Ext.	NH4 Ext.	NH4 Extract meq/100 g				Saturation	Matter	N	Bray 2
			cm	%	%	%		H2O	%	mS/cm	mS/cm	me/100 g	%	Na	Ca+Mg	Ca	K	%	%	%	ppm
1	Kh	Kohong series (Ultisol)	0- 12	69.0	26.0	5.0	SL	5.3	21.7	0.04	0.24	5.5	13	0.70	0.74	0.66	0.05	27	0.76	0.02	7.3
			12- 35	67.0	29.0	4.0	SL	5.5	16.6	0.03	0.29	3.2	13	0.43	0.25	0.21	0.03	22	0.09	0.005	7.5
			35- 59	62.0	26.0	12.0	SL	5.0	20.1	0.02	< 0.20	7.7	7.3	0.56	0.47	0.44	0.03	14	0.54	0.02	6.3
			59-103	69.0	23.0	8.0	SL	5.3	17.8	0.03	< 0.20	3.6	6.1	0.22	0.13	0.10	0.05	11	0.09	0.01	7.7
			103-150	69.0	24.5	6.5	SL	5.2	17.1	0.01	< 0.20	3.6	7.5	0.27	0.11	0.08	0.05	12	0.03	0.002	2.3
2	Tm	Tha Muang series (Entisol)	0- 13	39.6	41.2	19.2	L	6.6	45.0	0.14	0.66	17	< 2	0.26	9.6	7.6	0.62	62	1.8	0.13	106
			13- 35	34.0	46.0	20.0	L	5.4	31.5	0.05	< 0.20	11	2.6	0.29	3.0	2.2	0.27	32	0.53	0.04	3.3
			35- 70	41.0	39.0	20.0	L	4.8	35.8	0.05	0.48	8.8	4.0	0.35	1.2	0.65	0.13	19	0.31	0.02	1.4
			70-125	51.0	29.0	20.0	L+	4.9	39.9	0.07	0.47	9.5	5.4	0.51	1.4	0.79	0.09	21	0.18	0.02	3.2
			125-150	41.0	43.0	16.0	L	5.1	36.1	0.04	< 0.20	7.9	3.0	0.24	1.3	0.75	0.08	20	0.067	0.01	4.0
3	Cp	Chumphon series (Ultisol)	0- 20	71.5	21.5	7.0	SL	5.6	23.0	0.03	0.31	5.0	4.8	0.24	2.0	1.7	0.08	46	0.81	0.06	15
			20- 57	75.0	19.0	6.0	SL-	5.2	17.8	0.03	0.23	2.8	7.1	0.20	0.52	0.47	0.03	27	0.15	0.01	7.6
			57- 80	68.0	16.0	16.0	SL	5.4	37.3	0.02	< 0.20	6.2	3.5	0.22	0.69	0.58	0.05	15	0.14	0.02	1.3
			80-129	64.0	15.0	21.0	SCL-	4.7	51.0	0.03	< 0.20	10	2.1	0.21	0.37	0.31	0.08	6.6	0.12	0.02	2.8
			129-150	62.0	17.0	21.0	SCL-	4.7	51.0	0.02	< 0.20	8.7	2.1	0.18	0.57	0.47	0.08	9.5	0.099	0.01	2.3
4	Pto/Rg	Phato/Ranong Association (Ultisol)	0- 17	62.8	21.2	16.0	SL	5.7	28.5	0.05	0.45	8.0	2.7	0.22	2.5	2.2	0.15	36	0.99	0.08	2.2
			17- 30	58.0	21.0	21.0	SCL-	5.5	22.5	0.02	0.22	8.1	2.6	0.21	2.1	1.8	0.12	30	0.49	0.05	6.9
			30- 57	53.8	16.2	30.0	SCL	5.6	32.5	0.03	0.20	12	< 2	0.21	2.2	1.6	0.13	21	0.46	0.05	1.2
			57- 98	52.0	14.0	34.0	SCL+	5.6	55.8	0.02	< 0.20	14	< 2	0.20	1.2	0.57	0.29	12	0.29	0.04	0.40
			98-129	18.8	16.2	65.0	C+	5.4	79.4	0.02	< 0.20	21	< 2	0.20	2.2	0.93	0.26	13	0.25	0.06	0.20
			129-160	18.8	17.2	64.0	C	5.6	78.5	0.02	< 0.20	20	< 2	0.32	2.3	0.96	0.24	14	0.14	0.05	1.9
5	SC	Slope complex	0- 21	28.8	35.2	36.0	CL	5.4	43.8	0.05	0.24	13	< 2	0.23	2.6	2.2	0.53	26	0.82	0.07	13
			21- 56	21.6	27.2	51.0	C	5.1	81.6	0.02	< 0.20	20	< 2	0.20	2.0	1.5	0.19	12	0.54	0.06	0.34
			56- 72	32.8	21.2	46.0	C	5.3	76.8	0.03	< 0.20	18	< 2	0.22	0.81	0.47	0.22	6.9	0.46	0.05	1.9
			72-106	21.0	26.0	53.0	C	5.0	92.1	0.06	< 0.20	21	< 2	0.34	0.67	0.45	0.25	6.0	0.35	0.04	0.27
			106-150	17.0	37.0	46.0	C	5.0	83.1	0.03	< 0.20	18	< 2	0.26	0.41	0.28	0.16	4.6	0.25	0.04	0.20
6	Ba	Bangnara series (Ultisol)	0- 15	30.8	39.2	30.0	CL	6.1	52.3	0.08	0.46	17	< 2	0.22	11	9.9	0.20	67	1.1	0.08	1.8
			15- 37	24.8	33.2	42.0	C-	7.0	63.0	0.04	< 0.20	22	< 2	0.21	13	12	0.19	61	0.33	0.03	0.54
			37- 56	23.0	31.0	46.0	C	7.1	77.0	0.05	< 0.20	20	< 2	0.26	13	12	0.17	67	0.22	0.03	0.20
			56- 70	30.2	26.8	43.0	C-	6.8	61.8	0.05	< 0.20	17	< 2	0.30	12	11	0.14	73	0.18	0.03	0.14
			70- WT(1)																		
7	Cp	Chumphon (Ultisol)	0- 14	66.2	20.8	13.0	SL	6.3	28.3	0.06	0.53	7.9	3.2	0.25	3.0	2.7	0.26	44	0.96	0.06	3.3
			14- 36	60.0	21.0	19.0	SL+	5.2	32.9	0.03	< 0.20	9.8	2.7	0.26	0.53	0.45	0.17	9.8	0.32	0.03	1.7
			36- 62	58.0	20.0	22.0	SCL-	5.1	38.6	0.03	< 0.20	9.9	2.5	0.25	1.6	1.5	0.07	19	0.23	0.03	1.1
			62-102	56.0	16.0	28.0	SCL	5.1	44.3	0.02	< 0.20	12	2.3	0.27	1.5	1.4	0.14	16	0.21	0.01	1.7
			102-131	59.2	14.8	26.0	SCL	5.5	43.2	0.02	< 0.20	9.6	2.5	0.24	1.5	1.4	0.11	19	0.23	0.03	2.6
			131-150	51.2	18.8	30.0	SCL	5.4	41.9	0.02	< 0.20	13	3.4	0.44	1.7	1.6	0.24	18	0.17	0.02	0.74
8	SC	Slope complex	0- 9	46.8	31.2	22.0	L	4.9	39.3	0.04	0.31	9.9	2.9	0.29	1.6	1.4	0.20	21	0.64	0.06	0.40
			9- 38	36.8	30.2	33.0	CL	4.8	66.2	0.12	0.71	14	3.6	0.51	0.52	0.38	0.16	8.5	0.37	0.04	0.07
			38- 82	37.8	25.2	37.2	CL	5.1	79.7	0.02	< 0.20	18	< 2	0.28	0.48	0.37	0.14	5.0	0.23	0.04	0.47
			82-126	36.8	25.2	38.0	CL+	5.4	63.5	0.01	< 0.20	18	< 2	0.28	0.49	0.42	0.09	4.8	0.32	0.03	0.20
			126-150	37.8	23.2	39.0	CL+	5.3	59.3	0.03	< 0.20	18	< 2	0.36	0.21	0.14	0.12	3.8	0.25	0.03	0.07
9	Pto/Rg	Phato/Ranong Association (Ultisol)	0- 26	75.4	19.6	5.0	LS+	4.2	23.0	0.03	< 0.20	2.5	15	0.38	0.74	0.73	0.07	48	0.15	0.02	8.8
			26- 63	72.4	22.1	5.0	SL-	4.7	17.8	0.02	< 0.20	3.1	8.1	0.25	0.83	0.67	0.06	37	0.044	0.006	2.8
			63- 88	72.9	18.1	9.0	SL	4.6	16.4	0.01	< 0.20	3.0	6.3	0.19	0.88	0.76	0.06	38	0.06	0.01	1.7
			88-130	66.8	20.2	13.0	SL	4.5	24.2	0.04	< 0.20	7.9	9.0	0.71	1.1	0.96	0.09	24	0.094	0.01	2.1
			130- HP(2)																		
10	Bp-gy	Bang Nam Prieo gypsum variant (Entisol)	0- 15	41.2	32.8	26.0	CL-	4.7	120.0	0.11	0.25	79	< 2	0.36	0.89	0.79	0.28	1.9	10	0.41	1.9
			15- 27	12.0	22.0	66.0	C+	4.2	94.9	0.08	< 0.20	40	< 2	0.35	0.86	0.67	0.17	3.4	1.9	0.14	2.3
			27- 42	29.8	17.2	53.0	C	3.9	75.7	0.10	0.25	31	< 2	0.30	0.54	0.48	0.27	3.6	1.6	0.08	0.82
			42- 75	39.0	16.0	45.0	C-	3.7	69.2	0.13	0.34	21	< 2	0.29	0.79	0.69	0.22	6.2	0.85	0.05	0.14
			75-WT(1)																		

(1) WT: Water table, (2) HP: Hard pan
Analysed by Soil Seience Laboratory, Research and Laboratory Division, RID.

TABLE B-3 RESULTS OF SOIL ANALYSIS IN THE STUDY AREA (PHYSICAL PROPERTIES)

Pit No.	Symbol	Soil Series Name	Depth	Moisture Retention (%) 1/3 Tention in bar	Moisture Retention (%) 15	Avil. Moisture % to 15 bars	Percolation Rate 6 hr. flow	Percolation Rate Near uniform flow	Percolation Rate Instability	Depth	Bulk dencity	Particle density	Porosity
			cm				cm/hr	cm/hr	Index	cm	g/m3	g/m3	%
1	Kh	Kohong series (Ultisol)	0- 12	10.3	2.4	7.9	0.98	1.0	5.4	20	1.45	2.61	44.4
			12- 35	6.5	0.8	5.7	0.30	0.32	3.4	90	1.71	2.60	34.2
			35- 59	11.1	3.5	7.6	1.8	1.9	2.6	150	1.95	2.57	24.1
			59-103	8.9	1.9	7.0	0.83	0.85	0.27				
			103-150	6.8	1.3	5.5	0.31	0.26	11.0				
2	Tm	Tha Muang series (Entisol)	0- 13	26.4	7.9	18.5	0.55	0.54	7.1	20	1.27	2.59	51.0
			13- 35	21.3	6.5	14.8	0.33	0.35	2.8	90	1.56	2.63	40.7
			35- 70	20.5	6.5	14.0	0.24	0.25	3.7	150	1.58	2.61	39.5
			70-125	18.4	7.0	11.4	0.37	0.37	6.5				
			125-150	14.4	5.8	8.6	1.0	1.0	5.3				
3	Cp	Chumphon series (Ultisol)	0- 20	10.4	3.1	7.3	1.7	1.8	3.8	20	1.58	2.59	39.0
			20- 57	6.6	1.5	5.1	1.2	1.2	5.7	90	1.67	2.56	34.8
			57- 80	12.7	5.5	7.2	0.67	0.22	29	150	1.64	2.60	36.9
			80-129	15.7	7.6	8.1	1.2	0.91	13.8				
			129-150	13.9	7.7	6.2	2.0	1.4	15.8				
4	Pto/Rg	Phato/Ranong Association (Ultisol)	0- 17	14.4	4.6	9.8	0.83	0.80	7.4	20	1.56	2.61	40.2
			17- 30	14.6	5.5	9.1	0.44	0.46	4.5	90	1.55	2.72	43.0
			30- 57	17.7	9.1	8.6	0.40	0.41	5.3	150	1.61	2.74	41.2
			57- 98	23.1	13.8	9.3	0.64	0.65	5.5				
			98-129	30.9	19.8	11.1	0.85	0.65	13.3				
			129-160	29.6	16.1	13.5	0.41	0.35	10.6				
5	SC	Slope complex	0- 21	29.7	12.5	17.2	0.32	0.31	7.4	20	1.37	2.60	47.3
			21- 56	32.7	20.2	12.5	0.40	0.40	0.22	90	1.26	2.64	52.3
			56- 72	33.2	19.7	13.5	0.45	0.48	2.0	150	1.40	2.67	47.6
			72-106	38.3	21.3	17.0	0.51	0.53	0.55				
			106-150	36.3	15.3	21.0	0.35	0.27	2.1				
6	Ba	Bangnara series (Ultisol)	0- 15	28.3	10.2	18.1	0.18	0.18	5.5	20	1.73	2.63	34.2
			15- 37	24.9	13.4	11.5	0.23	-	-2.1	90	-	-	-
			37- 56	25.4	15.0	10.4	0.16	0.17	3.8	150	-	-	-
			56- 70	24.7	14.2	10.5	0.17	0.18	1.8				
			70- WT(1)										
7	Cp	Chumphon (Ultisol)	0- 14	11.8	5.3	6.5	1.8	1.9	4.5	20	1.46	2.61	44.1
			14- 36	11.8	6.3	5.5	1.7	1.8	4.2	90	1.41	2.59	45.6
			36- 62	12.9	7.8	5.1	2.1	2.1	5.9	150	1.67	2.66	37.2
			62-102	17.1	9.9	7.2	1.9	2.0	3.8				
			102-131	20.1	11.3	8.8	0.70	0.74	1.2				
			131-150	20.8	11.5	9.3	0.73	0.75	0.44				
8	SC	Slope complex	0- 9	18.6	8.9	9.7	0.41	0.42	5.3	20	1.47	2.59	43.2
			9- 38	23.4	13.2	10.2	0.67	0.72	2.1	90	1.38	2.63	47.5
			38- 82	24.8	15.6	9.2	0.65	0.70	3.3	150	1.44	2.66	45.9
			82-126	25.2	15.9	9.3	0.94	1.0	2.8				
			126-150	26.5	17.1	9.4	0.97	1.0	4.5				
9	Pto/Rg	Phato/Ranong Association (Ultisol)	0- 26	7.9	1.6	8.1	1.4	1.5	2.4	20	1.53	2.63	41.8
			26- 63	7.0	1.1	5.9	0.51	0.65	2.8	90	1.82	2.62	30.5
			63- 88	7.9	2.2	5.7	0.40	0.43	1.1	150	-	-	-
			88-130	10.3	4.1	6.2	0.39	0.40	5.2				
			130- HP(2)										
10	Bp-gy	Bang Nam Prieo gypsum variant (Entisol)	0- 15	40.8	33.8	7.0	1.4	1.5	1.5	20	1.32	2.56	48.4
			15- 27	44.2	25.6	18.6	0.70	0.55	12.7	90	-	-	-
			27- 42	34.9	19.3	15.6	0.55	0.52	8.5	150	-	-	-
			42- 75	28.7	15.3	13.4	0.51	0.54	3.9				
			75-WT(1)										

(1) WT: Water table. (2) HP: Hard pan

Analysed by Soil Seience Laboratory, Research and Laboratory Division, RID.

TABLE B-4 LAND CAPABILITY CLASSIFICATION OF THE STUDY AREA

Symbol	Crops						Area
	Paddy (P)	Upland crops (U)	Fruit trees (F)	Pasture (L)	Rubber (R)	Coconut (C)	(Km^2)
	Old and Recent Beach Ridges and Dunes						35.8
Bh	P-IIIs	U-Vf	F-Vf	L-IIf	R-IIId	C-IIs	12.7
Hh	P-Vts	U-IVs	F-IVs	L-IIn	R-IIs	C-IIs	10.7
Bc/Bh	P-Vts	U-IVs	F-IVs	L-IIn	R-IIs	C-IIs	9.6
Ry	P-Vts	U-IVs	F-IVs	L-IIn	R-IIs	C-IIs	1.8
Bc	P-Vts	U-IVs	F-IVs	L-IIn	R-IIs	C-IIs	1.0
	Active & Former Tidal Flats and Depressions between Beach Ridges						108.7
Tc	P-Vfx	U-Vfx	F-Vfx	L-IIIfx	R-IIIfx	C-IIIfx	52.5
Sm	P-IIIx	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	18.8
Bp-gy	P-IIIj	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	17.8
Wp	P-IIIs	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	15.3
Lm	P-IIIx	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	3.0
U7/58	P-IIIx	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	1.0
Lm/Sw	P-IIIx	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	0.3
	Plains (lower terraces and flood plains)						270.6
Tm	P-Vt	U-IIIs	F-IIn	L-I	R-I	C-II	107.1
Ba	P-IIn	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	56.1
Sa	P-IIn	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	27.5
Vi	P-IIIs	U-IIIsd	F-IIId	L-I	R-IId	C-IIn	22.8
U6/58	P-I	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	19.1
U9/58	P-IIIc	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	11.8
To-gr	P-I	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	9.9
Kl	P-IIIs	U-IIIsd	F-IIId	L-I	R-IId	C-IIn	4.5
Ac-pd	P-Vt	U-IIIs	F-IIn	L-I	R-I	C-II	3.6
U12/58	P-IIn	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	2.2
Bu-al	P-I	U-Vf	F-Vf	L-IIf	R-IIId	C-IIf	1.8
Nw	P-Vfo	U-Vfo	F-Vfo	L-IIIfo	R-IIIfo	C-IIIfo	1.5
Ac-wd	P-Vt	U-IIIs	F-IIn	L-I	R-I	C-II	1.3
U8/58	P-IIIs	U-IIIsd	F-IIId	L-I	R-IId	C-IIn	0.8
Ni	P-IVt	U-IIIsd	F-IIIsd	L-I	R-IId	C-IIn	0.6
	Undulatiing and Rolling Terrains (middle and high terraces coalescing fans)						301.1
Cp	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	196.0
Kh	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	33.8
Km	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	26.6
Lan	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	17.0
Sr	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	9.1
Lan/Kh/Cp/Sw	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	4.9
Sw	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	3.8
Ll	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	3.8
Kh/Sw	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	3.1
Pw	P-Vt	U-IVc	F-IVc	L-I	R-IIc	C-IIc	2.4
Te-m	P-Vt	U-IVs	F-IVs	L-IIn	R-IIs	C-IIs	0.5
	Hillslopes and Low Hills						566.6
Pto/Rg	P-Vt	U-IIIsd	F-IIn	L-I	R-I	C-IIn	466.7
Ak	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	53.2
Pto	P-Vt	U-IIIst	F-Vc	L-I	R-I	C-IIn	11.0
Rg	P-Vt	U-Vc	F-Vc	L-IIIc	R-IIIc	C-IIIc	11.0
Tk	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	6.8
Tg-al	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	6.6
Kc	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	6.0
Pk-fl	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	3.9
Knk-al	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	1.0
Kbi	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	0.2
Klt/Ntn	P-Vt	U-IIn	F-IIn	L-I	R-I	C-IIn	0.2
	Hills and Mountains						
Slope complex	P-Vt	U-Vt	F-Vt	L-IIIt	R-IIIt	C-IIIt	1338.7
	Total						2625.0

Limitations are: c: Depth of compact layer limits drilling of crop root, s: soil texture is unsuitable to crop growth, o: organic layer restricts crop growth, n: soil fertility, a: soil reaction
j: jarosite layer, f: flooding condition

TABLE B-5 LAND SUITABILITY CLASSIFICATION FOR IRRIGATED OF THE STUDY AREA

Soil series symbol	Crops							Area (Km^2)
	Paddy	Upland	Coconut	Coffee	Rubber	Fruit tree	Oil palm	
Tm	S3	S2	S1	S2	S1	S2	S1	107.1
Ba	S1	S2	S3	S2	S3	S3	S3	56.1
Sa	S3	S1	S1	S2	S1	S2	S2	27.5
Vi	S3	S3	S3	S2	S3	S3	S3	22.8
U6/58	S1	S1	S3	S3	S3	S3	S2	19.1
U9/58	S3	N	N	N	N	N	N	11.8
To-gr	S1	S1	S2	S3	S3	S3	S2	9.9
Kl	S2	S3	S3	S2	S3	S3	S3	4.5
AC-pd	S3	S2	S1	S2	S1	S2	S1	3.6
U12/58	S1	S3	S3	S2	S3	S3	S3	2.2
Bu-al	S1	S3	S2	S2	S3	S3	S2	1.8
Nw	N	N	N	N	N	N	N	1.5
AC-wd	S3	S2	S1	S2	S1	S2	S3	1.3
U8/58	S2	S2	S3	S2	S3	S3	S2	0.8
Ni	S3	S2	S2	S2	S2	S2	S3	0.6
Total								270.6

S1: Well suited
S2: Moderately suited
S3: Less suited
N : Not suited

TABLE B-6 SOIL CLASSIFICATION AND DISTRIBUTION IN THE PROJECT AREA

Symbol	Soil Series Name	Subgroup	Order	Area (ha)	Area (rai)	(%)
Old and Recent Beach Ridges and Dunes						
Bc	Bacho series	Typic Quartzipsamments	Entisols	45.4	284	1.6
Bh	Ban Thon series	Typic Tropohumods	Spodsols	223.9	1400	8.0
Active & Former Tidal Flats and Depressions between Beach Ridges						
Bpg	Bang Pakong series	Typic Sulfaquents	Entisols	49.7	311	1.8
Wp	Wan Priang series	Typic Tropaquents	Entisols	176.4	1103	6.3
Nw	Narathiwat series	Typic Tropofibrists	Histosols	30.0	188	1.1
Flats (lower terrace and flood plains)						
Tm	Tha Muang series	Typic Ustifluvents	Entisols	539.7	3373	19.3
Ba	Bangnara series	Typic Paleaquults	Ultisols	292.7	1829	10.4
Kl	Klaeng series	Oxic Plinthaquults	Ultisols	88.7	555	3.2
Undulatiing and Rolling Terian (middle and high terrace, coalescing fans)						
Lan	Lang Suan series	Typic Quartzipsamments	Entisols	102.7	642	3.7
Kh	Kohong series	Typic Paleaquults	Ultisols	468.2	2926	16.7
Sw	Sawi series	Typic Paleudults	Ultisols	66.6	417	2.4
Pw	Pathiu series	Typic Paleudults	Ultisols	142.4	890	5.1
Cp	Chumphon	Typic Paleudults	Ultisols	27.3	170	1.0
Hills and Mountains						
SC	Slope Complex			6.3	39	0.2
Swamp				543	3394	19.4
Total				2803	17519	100.0

TABLE B-7 RESULTS OF SOIL ANALYSIS IN THE PROJECT AREA (CHEMICAL PROPERTIES)

Pit No.	Symbol	Soil Series Name	Depth	Particle Size Distribution				pH	S.P.	EC	CEC	ESP	Exchangeable Cation				Base Saturation	Org. Matter	Total N	Avail. P
				Sand	Silt	Clay	Texture			Sat. Ext.	NH4 Ext.	NH4 Ext	NH4 Extract							Bray 2
			cm	%	%	%		(Paste)	%	mS/cm	me/100 g	%	Na	Ca+Mg	Ca	K	%	%	%	ppm
11	Lan	Long Suan series (Entisol)	0- 11	73.1	22.4	4.5	SL-	5.0	21.1	< 0.20	5.0	4.2	0.21	0.59	0.46	0.02	16	0.39	0.02	5.8
			11- 41	73.1	20.9	6.0	SL-	4.9	19.8	< 0.20	3.1	6.8	0.21	0.36	0.27	0.02	19	0.23	0.02	0.28
			41- 75	75.1	20.9	4.0	LS+	4.8	18.7	< 0.20	1.9	9.9	0.17	0.26	0.20	0.01	23	0.09	< 0.01	0.33
			75-114	76.6	20.4	3.0	LS+	5.1	19.2	< 0.20	2.3	9.3	0.19	0.19	0.13	0.01	16	0.08	< 0.01	2.8
			114-132	73.9	19.0	7.2	SL	4.9	21.1	< 0.20	4.4	7.0	0.31	0.50	0.36	0.01	19	0.04	< 0.01	4.2
			132-160	72.1	19.9	8.0	SL	5.1	19.0	< 0.20	2.9	11	0.32	0.82	0.66	0.02	40	0.09	< 0.01	2.3
			160-220	61.9	15.2	23.0	SCL	4.9	51.9	< 0.20	8.9	3.2	0.28	1.5	1.0	0.03	21	0.07	< 0.01	1.4
12	Pw	Pathiu series (Ultisol)	0- 17	69.9	21.1	9.0	SL	5.9	24.1	0.42	4.2	6.9	0.29	1.4	0.93	0.06	42	0.77	0.06	7.8
			17- 37	65.9	20.0	14.2	SL	4.9	23.4	0.20	4.7	3.8	0.17	0.59	0.38	0.05	17	0.37	0.02	2.7
			37- 79	62.9	15.0	32.2	SCL	4.7	60.6	< 0.20	9.0	2.3	0.21	0.79	0.63	0.09	11	0.23	0.02	1.7
			79- 99	50.9	15.2	34.0	SCL+	4.7	74.4	< 0.20	10	2.2	0.22	0.64	0.49	0.04	9.0	0.22	0.02	1.3
			99-130	48.6	16.2	35.2	SC-	4.7	97.1	< 0.20	11	< 2	0.12	0.49	0.40	0.05	6.0	0.23	0.02	1.5
			130-180	46.9	18.2	35.0	SC,SCL	4.5	75.8	0.27	9.9	4.2	0.37	0.96	0.70	0.03	15	0.20	0.02	1.2
			180-240	36.8	20.2	43.0	C-	4.6	62.1	< 0.20	12	< 2	0.14	0.62	0.35	0.05	6.7	0.11	0.01	1.0
13	Ba	Bangnara series (Ultisol)	0- 17	32.8	38.8	29.2	CL	4.7	58.7	< 0.20	9.6	< 2	0.17	1.8	0.83	0.09	21	0.96	0.10	2.8
			17- 49	19.8	28.0	52.2	C	5.0	95.0	< 0.20	16	< 2	0.18	4.4	2.3	0.16	29	0.24	0.03	0.81
			49- 73	20.8	27.0	52.2	C	4.8	95.2	< 0.20	17	< 2	0.21	4.4	2.3	0.13	28	0.17	0.05	0.67
			73-109	10.8	23.0	67.0	C+	4.8	112.4	< 0.20	18	< 2	0.29	6.7	3.2	0.13	39	0.31	0.04	0.87
			109-127	19.6	24.2	57.2	C	5.0	94.2	< 0.20	19	< 2	0.29	7.7	4.1	0.12	42	0.23	0.04	0.41
			127-170	5.9	41.2	53.0	SIC+	4.7	70.4	< 0.20	17	< 2	0.26	6.1	3.8	0.12	38	0.45	0.04	1.1
			170-200	6.6	41.2	52.2	SIC+	4.4	61.5	0.23	17	2.0	0.34	4.5	2.6	0.18	29	1.2	0.12	2.5
14	Kh/Sw	Kohong/Sawi Association (Inceptisols)	0- 22	71.6	21.4	7.0	SL	5.6	22.9	0.21	4.7	2.1	0.10	2.0	1.7	0.05	46	0.62	0.04	145
			22- 35	67.2	23.8	9.0	SL	5.7	19.0	< 0.20	4.2	< 2	0.08	1.6	1.4	0.03	41	0.26	0.02	62
			35- 75	66.9	21.0	12.2	SL	5.4	24.8	< 0.20	6.0	< 2	0.10	2.3	1.9	0.05	41	0.19	0.01	2.5
			75- HP(2)																	
15	Ba	Bangnara series (Ultisol)	0- 17	43.9	16.0	40.2	C-	3.5	56.2	3.9	16	2.2	0.35	1.9	0.75	0.23	15	3.5	0.22	2.8
			17- 36	60.6	11.2	28.2	SCL	5.6	35.9	2.6	9.5	< 2	0.17	6.6	6.3	0.10	72	1.3	0.09	2.9
			36- 73	66.6	12.4	21.0	SCL-	3.0	32.7	3.1	11	< 2	0.19	0.54	0.32	0.06	7.2	1.7	0.10	2.7
			73- 93	73.6	13.2	13.2	SL	2.2	25.1	2.0 (1)	7.7	2.2	0.17	0.19	0.15	0.01	4.8	1.6	0.10	2.2
			93-131	69.6	20.2	11.2	SL	2.2	19.2	3.5 (1)	4.6	3.9	0.18	1.0	0.96	0.01	26	1.2	0.07	7.3
			131-170	69.6	18.2	15.2	SL	6.4	21.9	0.91 (1)	4.9	6.0	0.26	2.5	2.7	0.05	89	0.49	0.03	2.4
			170-240	69.9	18.0	12.2	SL	4.1	20.2	1.0 (1)	9.5	7.1	0.25	1.1	0.40	0.05	40	0.29	0.03	2.9
16	Bpg	Bang Pakong series (Entisol)	0- 13	23.8	48.0	28.2	CL-	4.0	49.7	1.7 (1)	13	11	1.4	5.6	1.3	0.35	56	1.2	0.09	7.9
			13- 34	13.4	56.4	30.2	SICL	4.2	53.3	3.9	12	9.2	1.1	5.1	1.9	0.32	54	0.72	0.07	7.6
			34- 58	13.8	35.0	51.2	C	3.6	79.6	1.4 (1)	33	6.4	2.1	7.3	2.6	0.75	31	2.7	0.27	10
			58-165	29.4	10.2	60.4	C	2.8	70.7	4.5 (1)	41	9.2	1.9	19	9.1	0.39	48	8.0	0.65	11
			165-235	82.3	15.1	2.6	LS	2.7	28.1	2.2 (1)	4.9	< 2	0.05	1.1	0.73	0.02	24	0.99	0.09	13
17	Kl	Klaeng series (Ultisol)	0- 9	29.8	30.0	40.2	C-	4.4	51.1	0.48	15	< 2	0.26	2.1	1.1	0.25	17	1.2	0.12	1.0
			9- 25	29.2	28.8	50.0	C	4.8	90.9	< 0.20	16	< 2	0.21	3.3	1.7	0.12	24	0.57	0.11	0.13
			25- 69	49.6	28.2	23.2	L+	4.9	46.5	0.24	6.5	2.9	0.15	3.0	2.4	0.07	49	0.04	< 0.01	2.9
			69-109	56.6	34.2	9.2	SL	4.4	34.1	< 0.20	4.9	9.5	0.41	1.1	0.92	0.12	34	0.02	< 0.01	2.1
			109-200	46.8	42.0	11.2	L	3.9	33.7	0.30	4.5	9.1	0.14	0.32	0.23	0.07	12	0.09	< 0.01	0.74
18	Tm	Tha Muang series (Entisol)	0- 15	29.8	35.0	35.2	CL	4.9	48.2	0.31	13	< 2	0.20	4.1	2.9	0.20	35	1.2	0.11	2.8
			15- 31	33.9	37.0	29.2	CL	4.6	51.1	< 0.20	11	< 2	0.15	1.3	0.87	0.09	14	0.46	0.05	6.4
			31- 53	60.9	20.0	19.2	SL+	4.8	41.6	< 0.20	6.9	2.9	0.19	0.83	0.55	0.15	17	0.17	0.02	2.2
			53- 74	80.9	11.5	7.6	LS	5.1	33.3	< 0.20	3.4	2.6	0.09	0.49	0.32	0.03	18	0.05	< 0.01	2.2
			74- 99	81.9	13.0	5.1	LS	5.0	31.1	< 0.20	2.9	3.2	0.09	0.49	0.32	0.03	22	0.05	< 0.01	6.2
			99-141	80.4	13.6	6.0	LS	5.4	32.7	< 0.20	3.0	3.0	0.09	0.79	0.42	0.03	30	0.02	< 0.01	4.6
			141-170	74.9	20.0	5.1	SL-	5.2	32.1	< 0.20	2.5	2.9	0.07	0.62	0.27	0.03	29	0.02	< 0.01	2.0
			170-220	54.8	33.0	13.2	SL+	4.9	36.2	< 0.20	6.1	2.4	0.10	1.0	0.40	0.04	28	0.05	< 0.01	1.8
19	Ba	Bangnara series (Ultisol)	0- 16	13.8	34.0	52.2	C	4.1	74.2	1.3	19	< 2	0.35	5.7	3.4	0.26	33	1.1	0.09	0.68
			16- 31	9.9	31.2	59.0	C	4.6	98.7	0.51	20	3.1	0.63	9.8	4.0	0.21	53	0.61	0.06	1.2
			31- 59	5.9	21.2	70.0	C+	4.5	92.9	0.53	23	3.0	0.69	8.2	3.3	0.19	39	0.50	0.05	1.6
			59- 86	10.0	22.0	68.0	C+	4.3	93.9	0.66	21	3.4	0.72	4.3	1.8	0.19	25	0.44	0.05	1.0
			86-101	21.6	22.0	56.2	C	4.3	82.6	0.61	17	4.1	0.70	2.3	1.2	0.20	25	0.44	0.05	0.5
			101-118	27.4	29.4	43.2	C-	4.3	56.8	0.73	16	4.4	0.70	2.0	1.1	0.19	24	0.64	0.05	14
			118-160	26.9	28.0	45.2	C	4.3	48.5	1.1	19	5.3	1.0	4.1	1.6	0.21	28	1.5	0.12	30
			160-240	35.9	34.0	30.2	CL	3.0	69.1	2.8 (1)	27	< 2	0.06	11	9.0	0.10	30	9.5	0.27	13
20	Rg	Ranong series (Ultisol)	0- 13	59.6	28.2	13.2	SL	6.4	30.1	1.3	6.4	< 2	0.06	2.9	3.6	0.07	63	0.99	0.06	2.1
			13- 29	61.0	23.8	15.2	SL	4.6	24.0	0.29	4.7	< 2	0.06	0.61	0.46	0.05	15	0.59	0.04	2.5
			29- 46	61.6	25.2	13.2	SL	4.8	19.9	0.20	4.9	< 2	0.06	0.50	0.41	0.03	12	0.29	0.02	1.1
			46- 64	55.6	19.2	25.2	SCL	4.7	47.2	< 0.20	6.5	< 2	0.09	0.29	0.27	0.06	8.1	0.19	0.02	1.3
			64-160	87.4	8.1	4.5	S+	5.0	28.4	< 0.20	2.3	4.9	0.10	0.69	0.52	0.03	35	0.10	0.01	2.8
			160- HP(2)																	

(1) after dilution 1:9. (2) Hard Pan
Pit Number 14 and 20 are outside of the Project Area.
Analysed by Soil Science Laboratory, Research and Laboratory Division, RID.

TABLE B-8 RESULTS OF SOIL ANALYSIS IN THE PROJECT AREA

(PHYSICAL PROPERTIES)

Pit No.	Symbol	Soil Series Name	Depth	Bulk dencity	Perticle density	Porosity
			cm	g/m3	g/m3	%
11	Lan	Lang Suan series	20	1.61	2.55	37
		(Entisol)	90	1.70	2.59	34
			150	1.80	2.56	30
12	Pw	Pathiu series	20	1.47	2.59	43
		(Ultisol)	90	1.68	2.59	35
			150	1.54	2.63	41
13	Ba	Bangnara series	20	1.44	2.62	45
		(Ultisol)	90	1.47	2.65	44
			150	1.72	2.63	35
14	Kh/Sw	Kohong/Sawi	20	1.57	2.61	40
		Association	90	-	-	-
		(Inceptisols)	150	-	-	-
15	Ba	Bangnara series	20	1.72	2.56	33
		(Ultisol)	90	1.78	2.68	34
			150	2.2	2.61	16
16	Bpg	Bang Pakong series	20	1.23	2.60	53
		(Entisol)	90	0.69	2.62	74
			150	-	-	-
17	Kl	Klaeng series	20	1.50	2.62	43
		(Ultisol)	90	1.61	2.60	38
			150	1.64	2.65	38
18	Tm	Tha Muang series	20	1.42	2.62	46
		(Entisol)	90	1.44	2.63	45
			150	1.45	2.62	45
19	Ba	Bangnara series	20	1.57	2.65	41
		(Ultisol)	90	1.43	2.63	46
			150	0.83	2.42	66
20	Rg	Ranong series	20	1.37	2.61	47
		(Ultisol)	90	-	-	-
			150	-	-	-

(1) after dilution 1:9, Pit number 14 and 20 are outside of the Project Area. Analysed by Soil Seience Laboratory, Research and Laboratory Division, RID.

TABLE B-9 RESULTS OF SOIL ANALYSIS IN THE PROJECT AREA (CHEMICAL PROPERTIES)

Augar No.	Symbol	Soil Series Name	Depth	Particle Size Distribution				pH	S.P.	EC	CEC	ESP	Exchangeable Cation				Base	Org.	Total	Avail. P
				Sand	Silt	Clay	Texture			Sat. Ext.	NH4 Ext.	NH4 Ext.	NH4 Extract meq/100 g				Saturation	Matter	N	Bray 2
			cm	%	%	%		(Paste)	%	mS/cm	me/100 g	%	Na	Ca+Mg	Ca	K	%	%	%	ppm
17	Ba	Bangnara series	0- 15	27.0	40.2	32.8	CL	4.5	56.8	0.85(1)	11	4.5	0.50	3.4	1.2	0.29	38	1.1	0.08	6.7
		(Ultisol)	15- 50	32.6	33.4	34.0	CL	5.3	54.8	4.1	11	5.2	0.57	5.7	2.4	0.28	59	0.24	0.03	1.7
			50- 60	33.6	35.4	31.0	CL	4.9	45.8	6.2	10	5.5	0.55	6.0	2.4	0.31	69	0.51	0.05	10
			60- 95	34.0	37.0	29.0	CL-	3.7	48.2	1.4 (1)	16	3.3	0.53	6.5	3.2	0.30	46	1.9	0.13	17
			95-150	33.0	39.0	28.0	CL-	3.2	47.1	2.2 (1)	16	< 2	0.25	5.4	2.4	0.30	37	3.5	0.19	15
25	Nw	Narathiwat series	0- 15	31.8	39.4	28.8	CL-	3.8	66.0	5.5 (1)	24	8.7	2.1	9.4	4.6	0.38	49	4.8	0.30	14
		(Histosols)	15- 60	41.6	35.2	23.2	L	3.2	58.9	6.5 (1)	28	6.8	1.9	12	9.6	0.35	51	7.2	0.23	12
			60- 90	48.0	32.0	20.0	L	3.1	48.3	6.4 (1)	24	2.8	0.68	10	6.0	0.32	46	5.6	0.17	17
			90-120	41.8	31.2	27.0	CL,L	2.8	48.3	6.6 (1)	26	5.4	1.4	10	6.0	0.30	45	5.7	0.24	14
			120-150	47.6	28.2	24.2	L+	3.8	50.3	6.3 (1)	22	11	2.4	9.2	7.9	0.25	54	5.7	0.24	21
28	Bc	Bacho series	0- 10	88.9	7.2	3.9	S+	6.2	26.5	0.37	3.6	3.6	0.13	2.6	2.3	0.04	77	0.47	0.03	1.6
		(Entisols)	10- 35	92.0	4.5	3.5	S	6.6	26.1	0.72	2.4	5.4	0.13	1.7	1.6	0.03	77	0.22	0.01	0.13
			35- 90	91.8	3.6	4.6	S	6.2	27.8	< 0.20	3.2	3.7	0.12	1.8	1.7	0.01	60	0.13	0.01	0.40
			90-150	92.3	3.6	4.1	S	6.5	27.0	< 0.20	3.1	6.4	0.20	2.4	2.1	0.02	84	0.09	0.01	0.94
29	Wp	Wang Phriang series	0- 10	57.6	25.2	17.2	SL+	5.3	28.9	0.94	6.9	3.0	0.21	3.1	2.6	0.43	54	0.79	0.06	1.7
		(Entisols)	10- 50	53.8	22.4	23.8	SCL	5.2	45.2	< 0.20	7.5	3.5	0.26	5.0	3.9	0.10	71	0.32	0.02	0.87
			50- 90	63.6	25.2	11.2	SL	6.8	31.0	0.23	4.9	10	0.49	3.5	2.5	0.19	85	0.18	0.01	4.0
			90-120	75.9	17.2	6.9	SL-	6.2	29.9	< 0.20	4.6	3.7	0.17	2.9	2.5	0.04	68	0.10	< 0.01	0.54
			120-150	84.4	9.2	6.4	LS	6.7	30.5	< 0.20	5.3	4.4	0.23	4.0	3.6	0.04	80	0.02	< 0.01	0.67
30	Wp	Wang Phriang series	0- 15	66.8	19.4	13.8	SL	4.2	33.6	0.77(1)	7.3	3.4	0.25	2.4	1.2	0.18	39	1.2	0.07	1.9
		(Entisols)	15- 50	63.6	16.2	20.2	SCL-	4.8	27.5	3.7	8.0	8.5	0.68	4.5	2.0	0.23	68	0.53	0.05	0.80
			50- 90	65.6	18.2	16.2	SL	4.0	30.3	5.5	8.9	5.1	0.45	2.5	0.69	0.17	35	0.61	0.07	3.3
			90-150	65.8	19.2	15.0	SL	2.6	31.6	3.1 (1)	11	4.0	0.44	1.5	0.72	0.06	18	2.7	0.12	6.6
32	Bpg	Bang Pakong series	0- 20	42.8	36.2	21.0	L	5.3	45.1	3.4 (1)	18	9.4	1.7	7.8	3.8	0.35	55	1.9	0.18	16
		(Entisols)	20- 40	49.8	33.2	17.0	L	4.2	50.7	4.8 (1)	27	7.4	2.0	12	5.4	0.28	53	5.4	0.22	12
			40- 85	48.8	32.2	19.0	L	3.6	48.4	4.5 (1)	30	15	4.5	9.4	5.9	0.41	48	5.8	0.21	10
			85-150	45.8	32.2	22.0	L	3.0	38.3	4.0 (1)	18	11	2.0	6.2	3.3	0.30	47	3.2	0.14	10
34	Tm	Tha Muang series	0- 15	30.8	40.4	28.8	CL-	5.5	42.5	0.34	14	< 2	0.24	8.0	6.0	0.23	60	0.98	0.10	10
		(Entisol)	15- 35	24.8	38.4	36.8	CL	4.9	56.9	0.42	13	2.7	0.35	6.6	4.9	0.10	54	0.65	0.07	0.27
			35- 90	25.6	38.2	36.2	CL	4.9	58.1	< 0.20	10	2.5	0.25	3.5	1.6	0.09	38	0.22	0.05	0.13
			90-125	38.0	32.0	30.0	CL	5.0	63.3	< 0.20	9.4	2.2	0.21	3.0	1.1	0.08	35	0.15	0.03	0.54
			125-150	79.0	8.4	12.6	SL	4.9	35.5	< 0.20	4.4	3.2	0.14	1.5	0.71	0.06	39	0.07	0.01	4.0
39	Bh	Ban Thon series	0- 20	93.8	4.3	1.9	S	5.3	32.4	< 0.20	2.6	7.3	0.19	0.37	0.30	0.04	23	0.32	0.02	4.1
		(Spodosols)	20- 50	91.3	4.7	4.0	S	5.1	34.1	< 0.20	10	< 2	0.10	0.24	0.19	0.02	3.6	1.1	0.10	2.7
			50-125	94.8	2.6	2.6	S	5.6	31.5	< 0.20	2.9	3.8	0.11	0.21	0.18	0.02	12	0.14	0.01	9.2
			125-150	94.4	4.1	1.5	S	5.0	30.8	< 0.20	1.6	6.1	0.13	0.21	0.16	0.04	24	0.04	< 0.01	5.4
41	Ba	Bangnara series	0- 20	24.8	28.2	47.0	C	4.3	61.9	0.62	15	3.3	0.49	2.2	1.3	0.18	19	1.6	0.14	0.33
		(Ultisol)	20- 35	40.6	29.2	30.2	CL	4.8	58.3	< 0.20	8.4	3.6	0.30	1.3	0.77	0.09	20	0.40	0.06	0.67
			35- 70	42.2	35.8	22.0	L	4.7	49.7	< 0.20	6.1	2.6	0.16	1.1	0.71	0.08	22	0.08	0.02	0.80
			70-105	47.6	30.2	22.2	L	4.8	39.5	< 0.20	7.3	2.5	0.18	1.5	0.87	0.09	24	0.11	< 0.01	1.6
			105-150	82.2	11.8	6.0	LS	5.1	18.9	< 0.20	2.0	8.0	0.16	0.85	0.37	0.04	39	0.04	< 0.01	1.7
77	Tm	Tha Muang series	0- 10	12.8	47.0	40.2	SiC-	5.1	57.5	0.46	21	< 2	0.22	11	8.8	0.11	54	1.9	0.16	1.1
		(Entisol)	10- 50	10.6	48.4	41.0	SiC-	4.8	51.5	< 0.20	19	< 2	0.14	7.9	6.6	0.09	43	0.89	0.08	0.34
			50- 90	13.6	53.4	33.0	SiCL	4.9	56.6	< 0.20	15	< 2	0.12	5.5	4.5	0.08	38	0.31	0.03	0.34
			90-150	14.8	49.2	36.0	SiCL	4.9	60.9	< 0.20	16	< 2	0.20	6.6	5.0	0.08	43	0.31	0.05	0.13

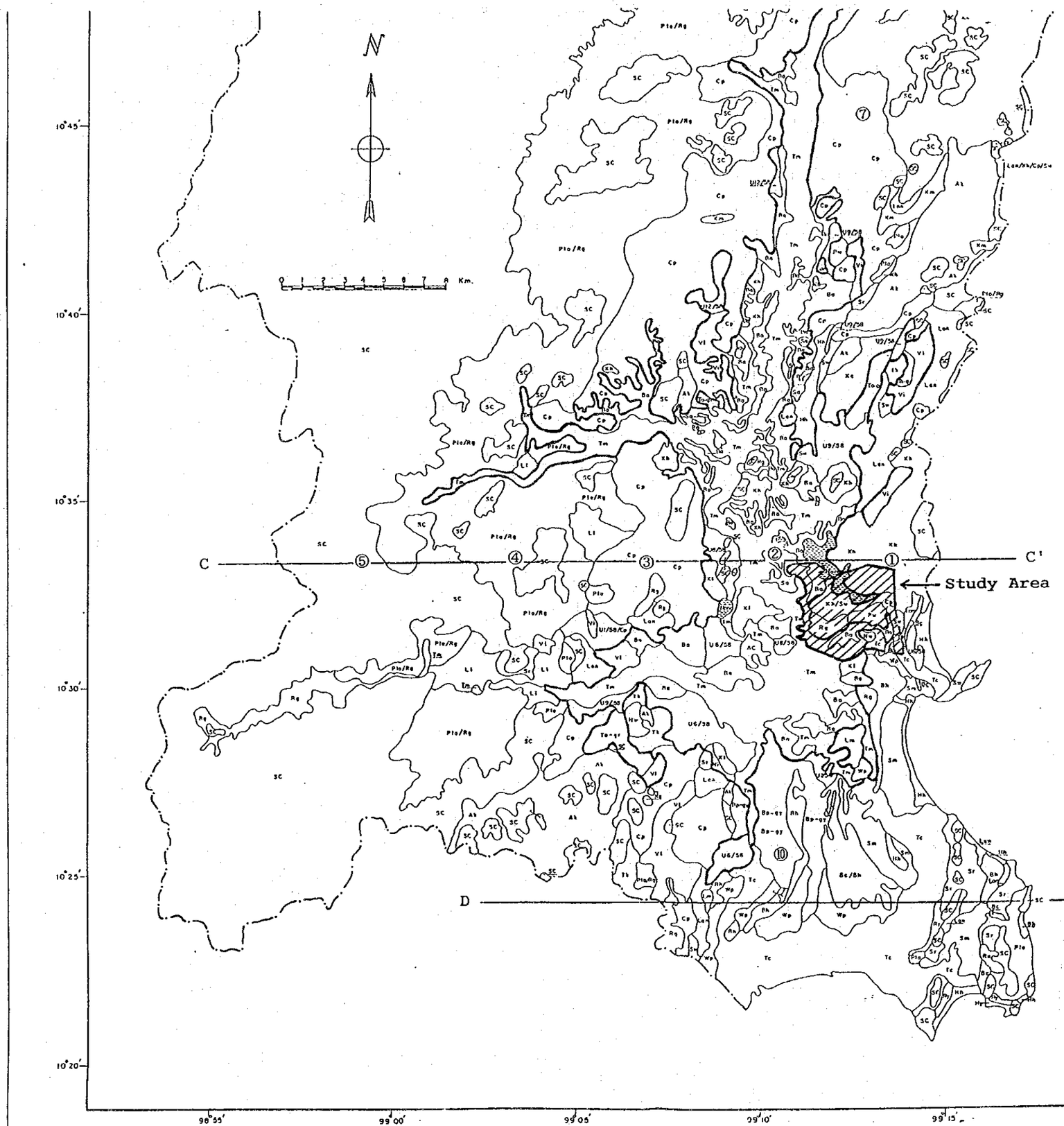
(1) after dilution 1:9.
Analysed by Soil Science Laboratory, Research and Laboratory Division, RID.

TABLE B-10 PRESENT LAND USE IN THE PROJECT AREA

Land Use	Symbols	Area (ha)	Ratio (%)
Farm Land		2019	72.0
Transplanted rice	Rt	716	25.5
Mixed orchard	O	1090	38.9
Coconut	Cn	144	5.2
Rubber	Ru	5.0	0.2
Vegetables	Vg	40	1.4
Coconut & rubber	Cn-Ru	2.2	0.1
Rubber & field crops	Ru-F	6.4	0.2
Field crops & grass	F-Gr	1.3	0.0
Coconut & shrubs	Cn-Sh	15	0.5
Non Farm Land		188	6.7
Shrub	Sh	111	4.0
Nipa palm	Ni	68	2.4
Grass	Gr	1.7	0.1
Nipa palm & grass	Ni-Gr	4.2	0.2
Shrubs & grass	Sh-Gr	3.1	0.1
Others		596	21.3
Shrimp pond	S	7.8	0.3
Borrow pit	Bp	6.1	0.2
Khao Na Cha-Ang	-	6.3	0.2
Sam Kaeo	-	33.0	1.2
Nong Yai	-	543	19.4
Total		2803	100.0

TABLE B-11 LAND USE PLAN IN THE PROJECT AREA

Land Use	Symbols	Area (ha)	Ratio (%)
Farm Land		2,135	76.2
Transplanted rice	Rt	716	25.5
Mixed orchard	O	1,191	42.5
Coconut	Cn	144	5.2
Rubber	Ru	5	0.2
Vegetables	Vg	40	1.4
Meadow	Md	38	1.4
Coconut & rubber	Cn-Ru		
Rubber & field crops	Ru-F		
Field crops & grass	F-Gr		
Coconut & shrubs	Cn-Sh		
Non Farm Land		68	2.4
Shrub	Sh		
Nipa palm	Ni	68	2.4
Grass	Gr		
Nipa palm & grass	Ni-Gr	4	0.2
Shrubs & grass	Sh-Gr		
Others		596	21.3
Shrimp pond	S	8	0.3
Borrow pit	Bp	6	0.2
Khao Na Cha-Ang	-	6	0.2
Sam Kaeo	-	33	1.2
Nong Yai	-	543	19.4
Total		2,803	100.0



SOIL LEGEND

Old and Recent Beach Ridges and Dunes

Bk	Ban Khuan series
Hh	Hua Hin series
Bc/Bk	Bacho/Ban Khuan Association
Ry	Rayong series
Bc	Bacho series

Active & Former Tidal Flats and Depressions between Beach Ridges

Tc	Tha Chin series
Sm	Sumut Prakan series
Bp-gy	Bang Nam Priao, gypsum variant
Wp	Wat Phlaeng series
Lm	Bang Lamung series
U7/58	Bang Lamung series, overwash phase

Flats (lower terrace and flood plains)

Tm	Tha Muang series
Bn	Bangnara series
Sa	Sasphaya series
Vl	Visai series
U6/58	Bangnara, moderately alkaline variant
U9/58	On, moderately alkaline variant
Ta-gr	Tha Toko, gray subsoil variant
Kl	Klaeng series
Ac-pd	Alluvial soils, poorly drained complex
U12-58	Bangnara series, overwash phase
Su-al	Sai Buri, alkaline variant
Nw	Narathiwat series
Ac-wd	Alluvial soils, well drained complex
U8/58	Visai, moderately alkaline variant
Ni	Nam Krachai series

Undulating and rolling terrian (high and middle terrace)

Cp	Chumphon series
Kh	Kohong series
Km	Khlong Thom series
Lea	Leang Suan series
Sr	Si Racha series
Lea/Kh/Cp/Sw	Leang Suan/Kohong/Chumphon/Sawi Association
Sw	Sawi series
Ll	Lamphu Le series
Kh/Sw	Kohong/Sawi Association
Pw	Pathiu series
Ta-m	Tha Sae, mottle variant

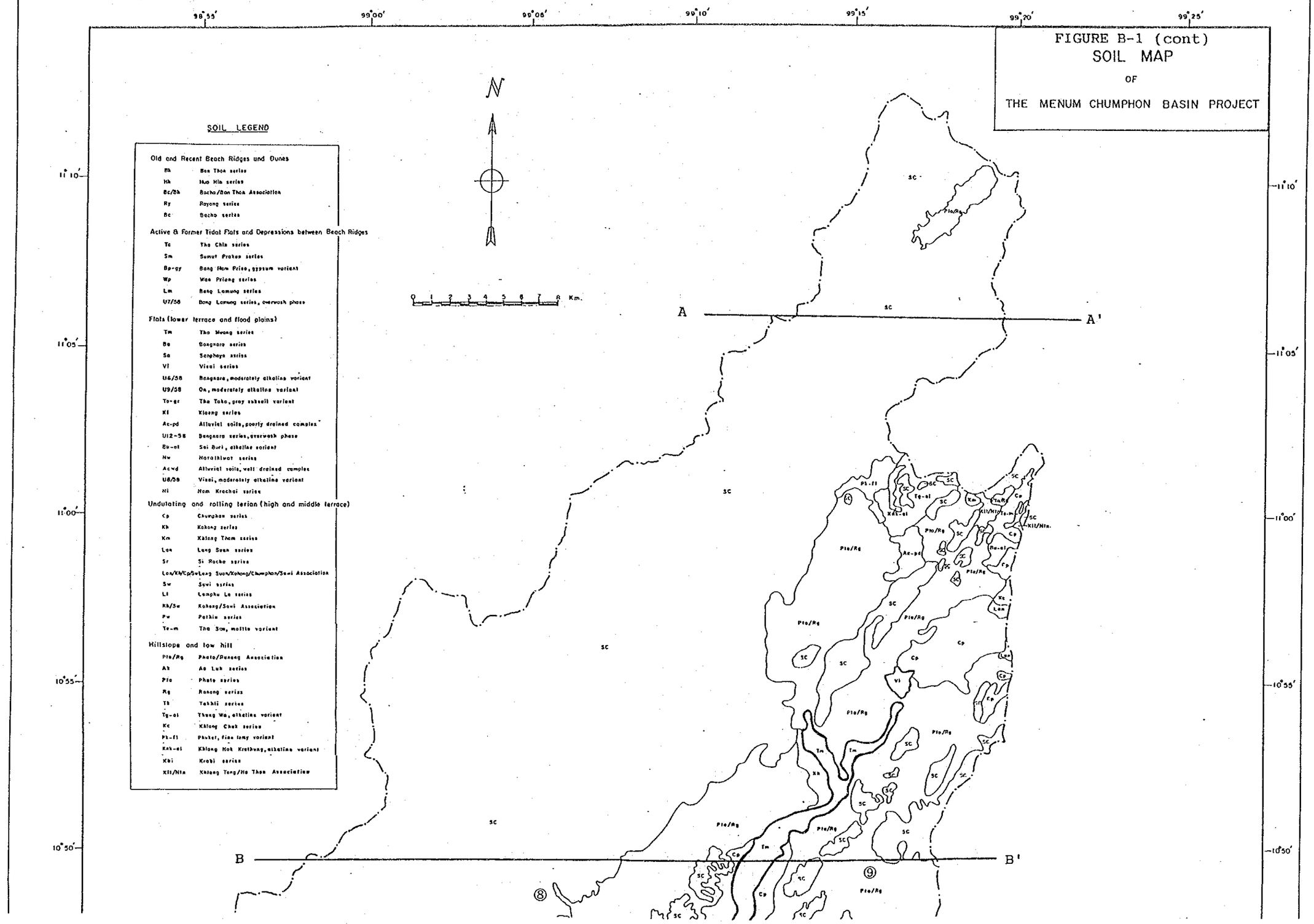
Hillstope and low hill

Pto/Rg	Phato/Ranong Association
Ak	Ao Luk series
Pto	Phato series
Rg	Ranong series
Th	Takhli series
Tg-al	Thung Wa, alkaline variant
Kc	Khlong Chat series
Pk-fl	Phahat, fine loamy variant
Knk-al	Khlong Nok Krathuang, alkaline variant
Kbi	Krabi series
Kll/Nla	Khlong Teng/Na Thon Association

1) Bold line indicates flats areas.
2) Figures in the map indicate pit places.

FIGURE B-1
SOIL MAP
OF
THE MENUM CHUMPHON BASIN PROJECT

FIGURE B-1 (cont)
SOIL MAP
OF
THE MENUM CHUMPHON BASIN PROJECT



SOIL LEGEND

Old and Recent Beach Ridges and Dunes
- Bh — Ban Thoa series
- Hh — Hua Hin series
- Bc/Bh — Bacho/Ban Thoa Association
- Ry — Rayong series
- Bc — Bacho series

Active & Former Tidal Flats and Depressions between Beach Ridges
- Tc — Tha Chin series
- Sm — Sumut Prakan series
- Bp-gy — Bang Pakong Prico, gypsum variant
- Wp — Wat Priang series
- Lm — Bang Lamung series
- U7/58 — Bang Lamung series, overwash phase

Flats (lower terrace and flood plains)
- Tm — Tha Mwang series
- Bs — Bangnara series
- Sa — Sangkhaya series
- Vi — Visai series
- U6/58 — Bangnara, moderately alkaline variant
- U9/58 — Ou, moderately alkaline variant
- Tg-gr — Tha Toko, gray subsoil variant
- Kt — Klaeng series
- Ac-pd — Alluvial soils, poorly drained complex
- U12-58 — Bangnara series, overwash phase
- Su-al — Sai Buri, alkaline variant
- Nw — Nataikiwat series
- Ac-wd — Alluvial soils, well drained complex
- U8/58 — Visai, moderately alkaline variant
- Nt — Nam Krachai series

Undulating and rolling terian (high and middle terrace)
- Cp — Chumphon series
- Kh — Kohong series
- Km — Khlong Thom series
- Lan — Lung Suan series
- Sr — Si Rocha series
- Lan/Kh/Cp/Sw — Lung Suan/Kohong/Chumphon/Sawi Association
- Sw — Sawi series
- Lt — Lamphu Lo series
- Kh/Sw — Kohong/Sawi Association
- Pw — Pathiu series
- Te-m — Tha Sae, mottle variant

Hillslope and low hill
- Pto/Rg — Phato/Ranong Association
- At — Ao Luk series
- Pto — Phato series
- Rg — Ranong series
- Tk — Takhli series
- Tg-al — Thung Wa, alkaline variant
- Kc — Khlong Chak series
- Pt-fl — Phutet, fine loamy variant
- Kat-al — Khlong Nok Krathuang, alkaline variant
- Kbi — Krabi series
- Kt/Nta — Khlong Teng/Na Thon Association

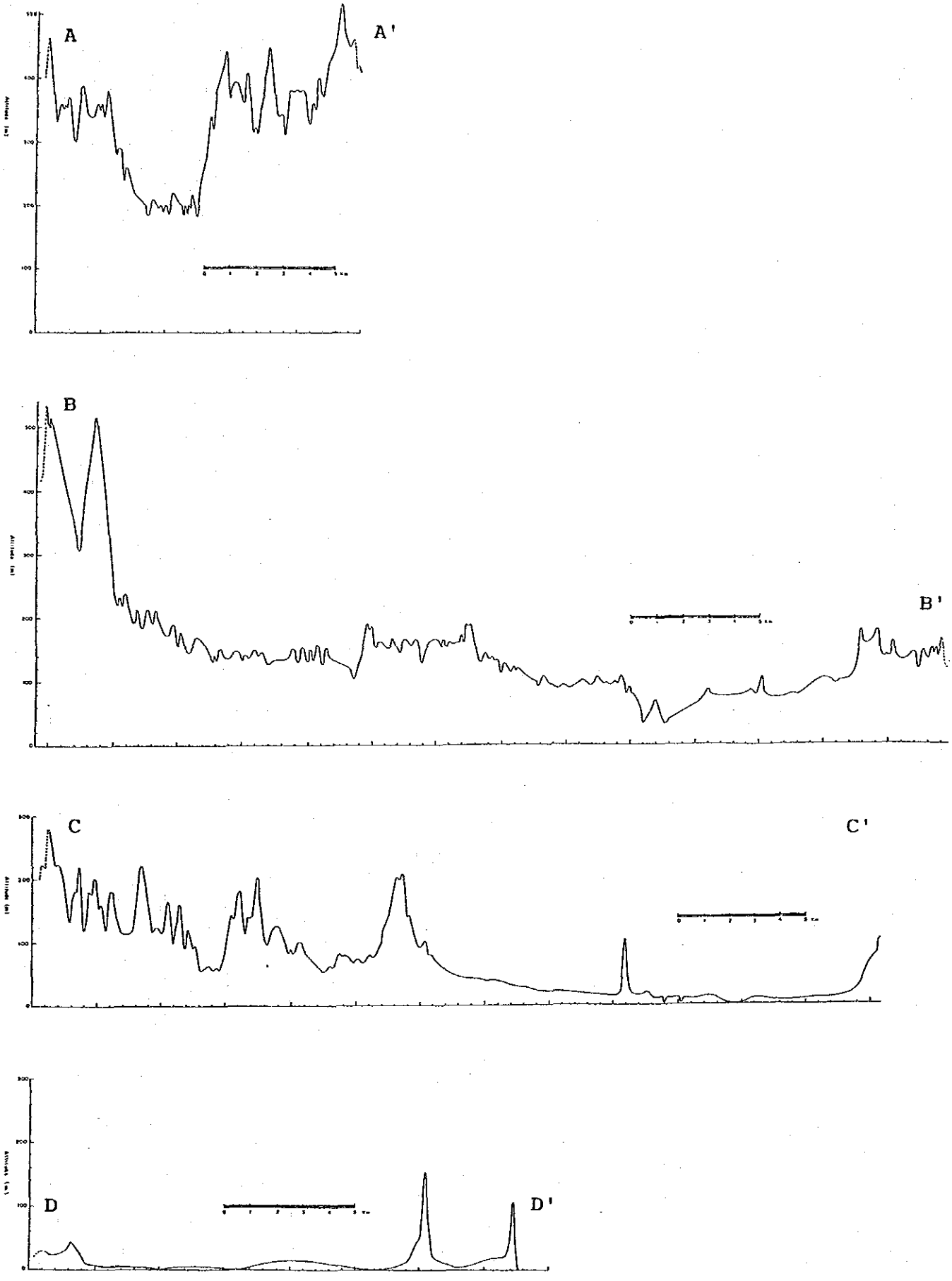
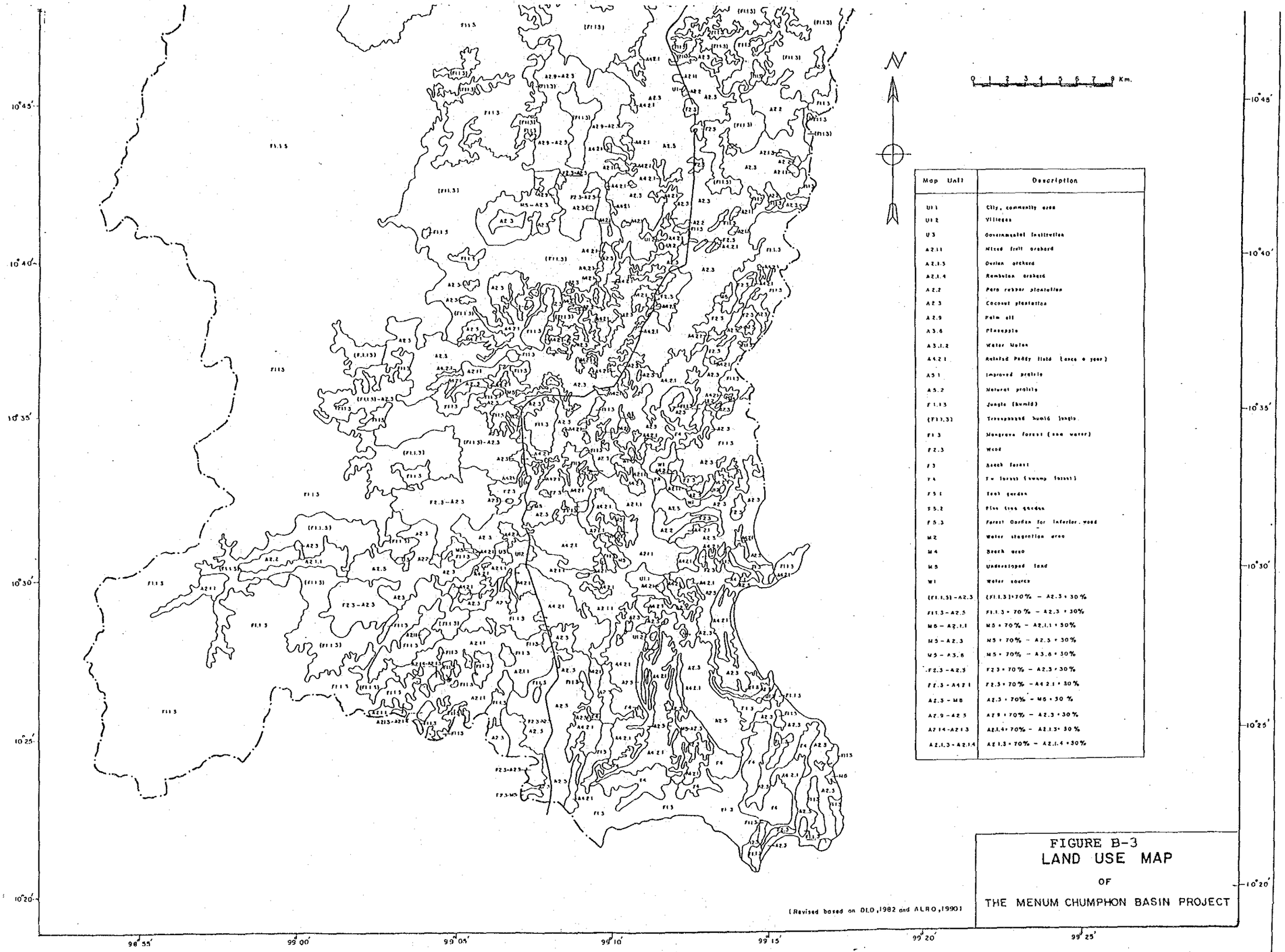


FIGURE B-2 CROSS SECTION OF THE TOPOGRAPHY IN THE STUDY AREA
A-A', B-B', C-C', D-D' indicate the place of cross section.
(SEE FIGURE 1).



Map Unit	Description
U1.1	City, community area
U1.2	Villages
U3	Governmental institution
A2.1.1	Mixed fruit orchard
A2.1.3	Durian orchard
A2.1.4	Rambutan orchard
A2.2	Para rubber plantation
A2.3	Coconut plantation
A2.5	Palm oil
A3.6	Pineapple
A3.1.2	Water Melon
A4.2.1	Rainfed Paddy field (once a year)
A5.1	Improved prairie
A5.2	Natural prairie
F1.1.5	Jungle (humid)
(F1.1.3)	Transitional humid jungle
F1.3	Mangrove forest (near water)
F2.3	Wood
F3	Beech forest
F4	Fir forest (swamp forest)
F5.1	Teak garden
F5.2	Pine tree garden
F5.3	Forest Garden for Inferior wood
M2	Water stagnation area
M4	Beach area
M5	Undeveloped land
W1	Water source
(F1.1.5)-A2.3	(F1.1.5)+70% - A2.3 + 30%
F1.1.3-A2.5	F1.1.3 + 70% - A2.3 + 30%
M6-A2.1.1	M5 + 70% - A2.1.1 + 30%
M5-A2.3	M5 + 70% - A2.3 + 30%
M5-A3.6	M5 + 70% - A3.6 + 30%
F2.3-A2.3	F2.3 + 70% - A2.3 + 30%
F2.3-A4.2.1	F2.3 + 70% - A4.2.1 + 30%
A2.3-M6	A2.3 + 70% - M6 + 30 %
A2.9-A2.3	A2.9 + 70% - A2.3 + 30%
A2.14-A2.1.3	A2.1.4 + 70% - A2.1.3 + 30 %
A2.1.3-A2.1.4	A2.1.3 + 70% - A2.1.4 + 30%

(Revised based on DLD,1982 and ALRO,1990)

FIGURE B-3
LAND USE MAP
OF
THE MENUM CHUMPHON BASIN PROJECT

FIGURE B-3 (cont)
LAND USE MAP
OF
THE MENUM CHUMPHON BASIN PROJECT

Map Unit	Description
U1.1	City, community area
U1.2	Villages
U3	Governmental institution
A2.1.1	Mixed fruit orchard
A2.1.3	Durian orchard
A2.1.4	Rambutan orchard
A2.2	Para rubber plantation
A2.3	Coconut plantation
A2.9	Palm oil
A3.6	Pineapple
A3.1.2	Water Melon
A4.2.1	Rainfed Paddy field (once a year)
A5.1	Improved pasture
A5.2	Natural pasture
F1.1.3	Jungle (humid)
(F1.1.3)	Transformed humid jungle
F1.3	Mangrove forest (near water)
F2.3	Wood
F3	Beach forest
F4	Fw forest (swamp forest)
F5.1	Teak garden
F5.2	Pine tree garden
F5.3	Forest Garden for Inferior wood
M2	Water stagnation area
M4	Beach area
M5	Undeveloped land
W1	Water source
(F1.1.3)-A2.3	(F1.1.3)+70% - A2.3 + 30%
F1.1.3-A2.3	F1.1.3 + 70% - A2.3 + 30%
M5 - A2.1.1	M5 + 70% - A2.1.1 + 30%
M5 - A2.3	M5 + 70% - A2.3 + 30%
M5 - A3.6	M5 + 70% - A3.6 + 30%
F2.3 - A2.3	F2.3 + 70% - A2.3 + 30%
F2.3 - A4.2.1	F2.3 + 70% - A4.2.1 + 30%
A2.3 - M5	A2.3 + 70% - M5 + 30 %
A2.9 - A2.3	A2.9 + 70% - A2.3 + 30%
A2.1.4-A2.1.3	A2.1.4+ 70% - A2.1.3+ 30 %
A2.1.3 - A2.1.4	A2.1.3 + 70% - A2.1.4 +30%

SOIL CLASSIFICATION AND DISTRIBUTION IN THE PROJECT AREA

Symbol	Soil Series Name	Subgroup	Order	Area (ha)	Area (rai)	(%)
Old and Recent Beach Ridges and Dunes						
Bc	Bacho series	Typic Quartzipsamments	Entisols	45.4	284	1.6
Bh	Ban Thon series	Typic Tropohumods	Spodsols	223.9	1400	8.0
Active & Former Tidal Flats and Depressions between Beach Ridges						
Bpg	Bang Pakong series	Typic Sulfaquents	Entisols	49.7	311	1.8
Wp	Wan Priang series	Typic Tropaquents	Entisols	175.4	1103	6.3
Nw	Narathiwat series	Typic Tropofibrists	Histosols	30.0	188	1.1
Flats (lower terrace and flood plains)						
Tm	Tha Muang series	Typic Ustifluvents	Entisols	539.7	3373	19.3
Ba	Bangnara series	Typic Paleaquults	Ultisols	292.7	1829	10.4
Kl	Klaeng series	Oxic Plinthaquults	Ultisols	88.7	555	3.2
Undulating and rolling terian (high and middle terrace)						
Lsn	Lang Suan series	Typic Quartzipsamments	Entisols	102.7	642	3.7
Kh	Kohong series	Typic Paleaquults	Ultisols	458.2	2926	16.7
Sw	Sawi series	Typic Paleudults	Ultisols	56.6	417	2.4
Pw	Pathiu series	Typic Paleudults	Ultisols	142.4	890	5.1
Cp	Chumphon	Typic Paleudults	Ultisols	27.3	170	1.0
Hills and mountains						
SC	Slope Complex			6.3	39	0.2
Swamp				543	3394	19.4
Total				2803	17519	100.0

SCALE 1:10,000

CONTOUR INTERVAL 1 METER

THE FEASIBILITY STUDY
ON
THE INTEGRATED AGRICULTURE
AND WATER RESOURCES DEVELOPMENT PROJECT
OF
THE MENUM CHUMPHON BASIN

SOIL MAP

THE JAPAN INTERNATIONAL COOPERATION AGENCY

SCALE 1:10,000

CONTOUR INTERVAL 1 METER

Present Land Use in the Project Area

Land Use	Symbols	Area (ha)	Ratio (%)
Farm Land		2019	72.0
Transplanted rice	Rt	715	25.5
Mixed orchard	O	1090	38.9
Coconut	Cn	144	5.2
Rubber	Ru	5.0	0.2
Vegetables	Vg	40	1.4
Coconut & rubber	Cn-Ru	2.2	0.1
Rubber & field crops	Ru-F	6.4	0.2
Field crops & grass	F-Gr	1.3	0.0
Coconut & shrubs	Cn-Sh	15	0.5
Non Farm Land		188	6.7
Shrub	Sh	111	4.0
Nipa palm	Ni	68	2.4
Grass	Gr	1.7	0.1
Nipa palm & grass	Ni-Gr	4.2	0.2
Shrubs & grass	Sh-Gr	3.1	0.1
Others		596	21.3
Shrimp pond	S	7.8	0.3
Borrow pit	Bp	6.1	0.2
Khao Na Cha-Ang	-	6.3	0.2
Sam Kano	-	33.0	1.2
Nong Yai	-	543	19.4
Total		2803	100.0

LEGEND

- □ Test Pit
- ● Auger (soil samplimg)
- ○ Auger
- △ Water Sampling

SCALE 1:10,000

CONTOUR INTERVAL 1 METER

THE FEASIBILITY STUDY
ON
THE INTEGRATED AGRICULTURE
AND WATER RESOURCES DEVELOPMENT PROJECT
OF
THE MENUM CHUMPHON BASIN

PRESENT LAND USE MAP

THE JAPAN INTERNATIONAL COOPERATION AGENCY

SCALE 1:10,000

CONTOUR INTERVAL 1 METER

Land Use Plan in the Project Area

Land Use		Symbols	Area (ha)	Ratio (%)
Farm Land			2,135	76.2
	Transplanted rice	Rt	716	25.5
	Mixed orchard	O	1,191	42.5
	Coconut	Cn	144	5.2
	Rubber	Ru	5	0.2
	Vegetables	Vg	40	1.4
	Meadow	Md	38	1.4
	Coconut & rubber	Cn-Ru		
	Rubber & field crops	Ru-F		
	Field crops & grass	F-Gr		
	Coconut & shrubs	Cn-Sh		
Non Farm Land			68	2.4
	Shrub	Sh		
	Nipa palm	Ni	68	2.4
	Grass	Gr		
	Nipa palm & grass	Ni-Gr	4	0.2
	Shrubs & grass	Sh-Gr		
Others			596	21.3
	Shrimp pond	S	8	0.3
	Borrow pit	Bp	6	0.2
	Khao Na Cha-Ang	-	6	0.2
	Sam Kaeo	-	33	1.2
	Nong Yai	-	543	19.4
	Total		2,803	100.0

Meadow

Mixed Orchard

(Meadow (38 ha)

KHAO HA CHA-ANG

KHAO YA MUANG

KHAO

KHAO NOI

Chaopraya Diversion

SCALE 1:10,000

CONTOUR INTERVAL 1 METER

THE FEASIBILITY STUDY
ON
THE INTEGRATED AGRICULTURE
AND WATER RESOURCES DEVELOPMENT PROJECT
OF
THE MENUM CHUMPHON BASIN

LAND USE PLAN MAP

THE JAPAN INTERNATIONAL COOPERATION AGENCY

SCALE 1:10,000

CONTOUR INTERVAL 1 METER