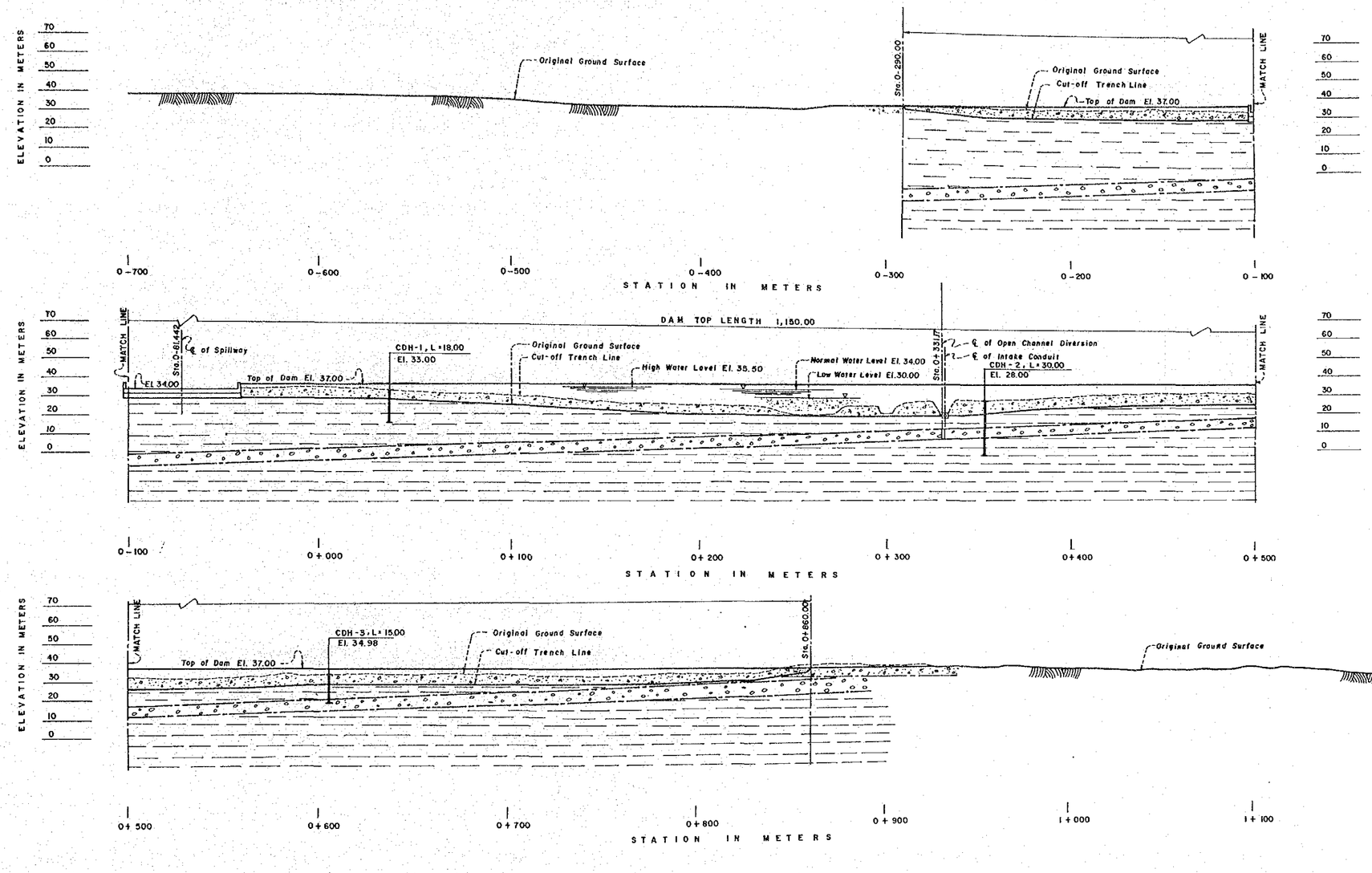
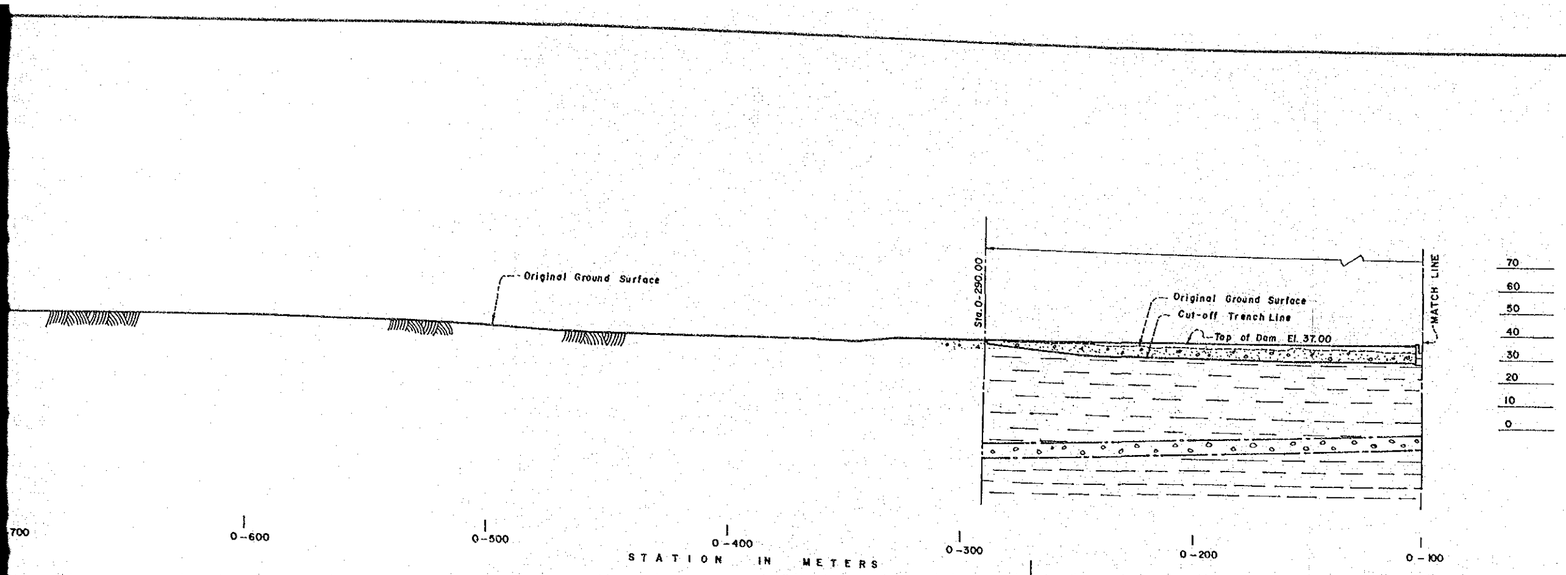


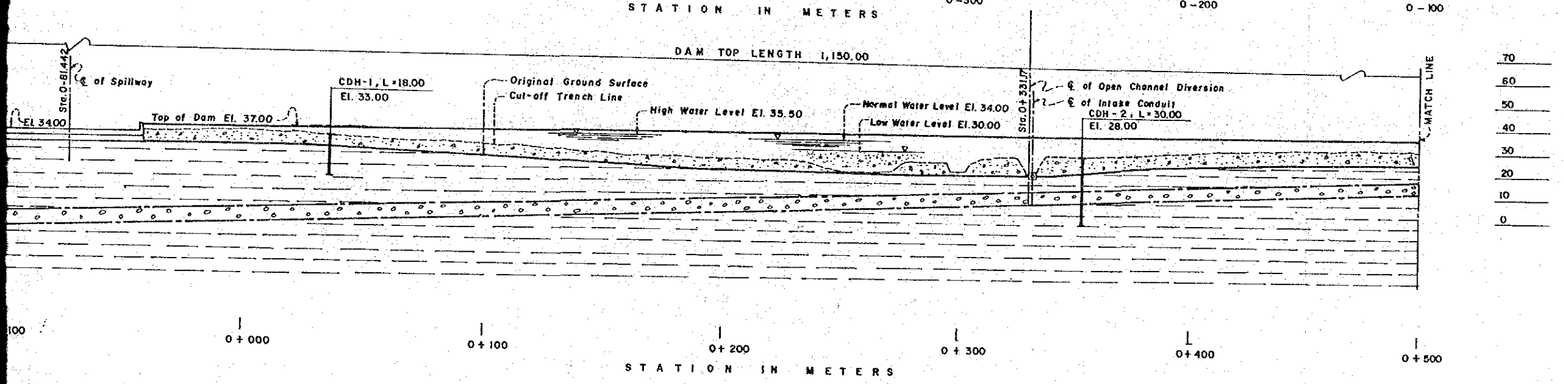
LEGEND

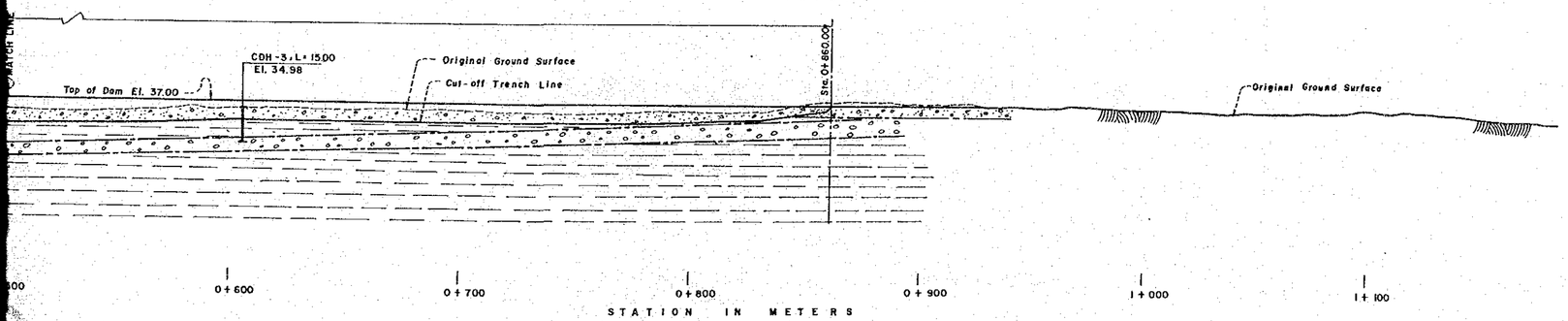
- Soil and weathered rock
- Alternation of siltstone and sand stone
- Conglomerate
- Geological contact line
- Drill holes

CAPAYAS DAM

FIGURE C4–20 GEOLOGICAL PROFILE
(FROM STA. 0-700 TO STA. 1+1







LEGEND

- Soil and weathered rock
- Alternation of siltstone and sand stone
- Conglomerate
- Geological contact line
- Drill holes

0 20 40 60 80 100 m

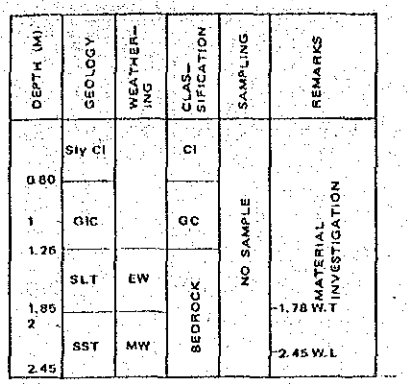
Scale 1 : 2,000

CAPAYAS DAM

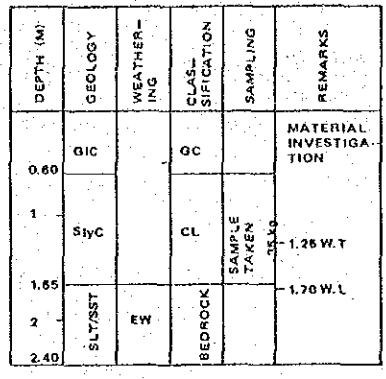
FIGURE C4–20 GEOLOGICAL PROFILE
(FROM STA. 0-700 TO STA. 1+100)

FIGURE C4-21 TEST PIT LOGGINGS AT CAPAYAS DAMSITE

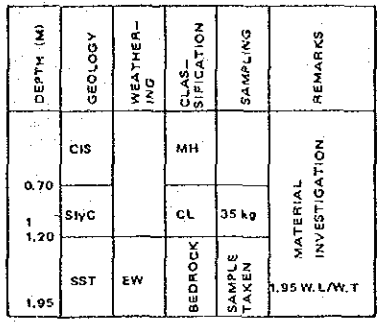
TEST PIT NO. CTP-1
ELEVATION



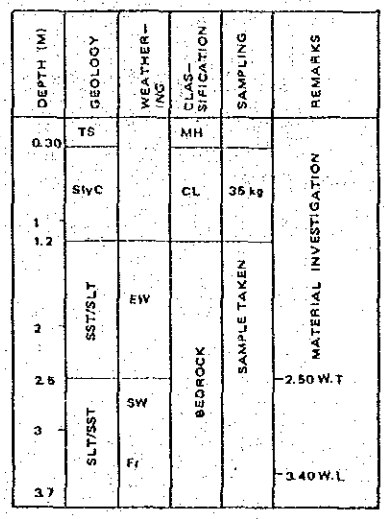
TEST PIT NO. CTP-2
ELEVATION



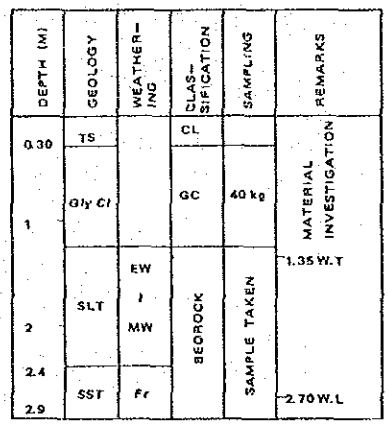
TEST PIT NO. CTP-3
ELEVATION



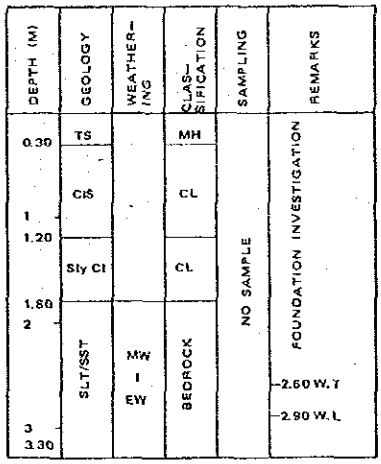
TEST PIT NO. CPT-4
ELEVATION



TEST PIT NO. CPT-5
ELEVATION



TEST PIT NO. CPT-6
ELEVATION



LEGEND:

TS	–	Top Soil	EW	–	Extremely Weathered
CIS	–	Clay Materials	MW	–	Moderately Weathered
GlC	–	Gravely Clay	SW	–	Slightly Weathered
SlyC	–	Silty Clay	Fr	–	Fresh Rock
SLT	–	Siltstone			
SST	–	Sandstone			

FIGURE C4-22 TEST PIT LOGGING OF CTP-1

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: CPT-1
Area Designation: Capayas Damsite Location: Left Abutment Ground El.:
Depth to Ground Water Level: 1.78 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.60 m: Silty Clay (CL)
			Brown to dark brown in color, slight to medium plasticity, presence of larger sized materials, firm and hard in place
	1		0.60 - 1.25 m: Gravelly Clay (GC)
			Inclusions of gravel and sand materials rounded to sub-rounded with matrix of silt and fines, light brown to yellowish in color slight plasticity
	2		
	3		1.25 - 1.85 m: Extremely Weathered Siltstone Layer
			Yellowish brown in color, slightly plastic soft at hand pressure, slightly sticky
	4		1.85 - 2.45 m: Moderately Weathered Sandstone
			Grayish in color, slightly plastic sticky when wet , feels gritty at hand
	5		
	6		Water Table--1.78 m Water Level--2.45 m
	7		Date Investigated: Feb. 11, 1985
	8		
	9		

FIGURE C4-23 TEST PIT LOGGING OF CTP-2

Feature: Material Investigation Project: Bohol Irrigation Project Hole No.: CPT-2
Area Designation: Capayas Damsite Location: Left Abutment Ground El.:
Depth to Ground Water Level: 1.25 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.60 m: Gravelly Clay (GC)
35 kg Feb 10, 1985	1		Light brown in color to dark brown, organic root remnants noted, inclusions/mixture of angular to sub-angular pebbles to cobble sized materials and fines, slightly to medium plasticity
	2		0.60 - 1.65 m: Silty Clay (CL)
	3		Traces of former layerings of bedrock distinct, Medium plasticity, very sticky when wet, angular fragments of uncompletely weathered materials, noticeable yellowish brown in color
	4		1.65 - 2.40 m: Extremely Weathered Siltstone-Sandstone
	5		Grayish to gray in color, very brittle when dry, soft with slight plasticity when wet
	6		Water Table--1.25 m Water Level--1.70 m
	7		Date Investigated: Feb. 10, 1985
	8		
	9		

FIGURE C4-24 TEST PIT LOGGING OF CTP-3

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: CPT-3
Area Designation: Capayas Damsite Location: Left Abutment Ground El.:
Depth to Ground Water Level: 1.90 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
35 kg	0		0.0 - 0.70 m: Clay (MH) Silty and pebbly in character with sand sized materials, medium plasticity, sticky when wet, feels gritty at finger pressure, yellowish brown in color
	1		
	2		0.70 - 1.20 m: Silty Clay (CL) Grayish in color, slight to medium plasticity, derived from sandstone layer as noticed from its harder uncompletely weathered portion
	3		
	4		1.20 - 1.95 m: Extremely Weathered Sandstone Layer Similating sedimentary bedding, soft, slightly plastic, grayigh in color
	5		
	6		Water Table --1.90 m Water Level --1.90 m Bottom Level--1.95 m
	7		Date Investigated: Feb. 9, 1985
	8		
	9		

FIGURE C4-25 TEST PIT LOGGING OF CTP-4

Feature: Material Investigation Project: Bohol Irrigation Project Hole No.: CPT-4
Area Designation: Capayas Damsite Location: Right Abutment Ground El.:
Depth to Ground Water Level: 2.50 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 3-5, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.30 m: Clay (MH) Dark brown in color, medium plasticity very sticky when wet, inclusions of some coarse materials
35 kg Feb. 9, 1985	1		0.30 - 1.20 m: Silty Clay (CL) Yellowish gray in color, traces of former layer of silstone noticeable, coarse materials noted and also angular materials from uncomplete weathering of formation
	2		
	3		1.20 - 2.50 m: Extremely to Moderately Weathered Sandstone/ Siltstone Almost flat lying to slightly dipping of about 10° - 15°, light brown in color, soft and sticky, very wet in place
	4		2.50 - 3.70 m: Fresh to Slightly Weathered Interbeds Sedimentary sequence of sandstone-shale silstone, yellowish brown in color to grayish, hard to medium hard when dry
	5		
	6		
	7		Water Table--2.50 m Water Level--3.40 m
	8		Date Investigated: Feb. 9, 1985
	9		

FIGURE C4-26 TEST PIT LOGGING OF CTP-5

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: CTP-5
Area Designation: Capayas Damsite Location: Right Abutment Ground El.:
Depth to Ground Water Level: 1.35 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
40 kg Feb. 9, 1985	0–9		0.0 - 0.30 m: Silty Clay (CL) Top Soil Dark brown in color, plant roots present, inclusions of pebble and cobble materials, slightly plastic and sticky, firm and hard in place 0.30 - 1.25 m: Gravely Clay (GC) Soil section of silt and fines with mixture of pebbles and cobbles of volcanic origin; slight to medium plasticity, material inclusions are rounded to sub-rounded well distributed on the section 1.25 - 2.40 m: Extreme to Moderate Weathered Silstone Layer Inclusions of volcanic fragments of pebbles and cobbles on the bedding which is almost flat lying to slightly dipping of about 5° 2.40 - 2.90 m: Fresh Bedrock; Siltstone/Sandstone Gray in color, hard brittle when dry Water Table--1.35 m Water Level--2.70 m Date Investigated: Feb. 9, 1985

FIGURE C4-27 TEST PIT LOGGING OF CTP-6

Feature: Foundation Investigation Project: Bohol Irrigation Project Hole No.: CTP-6
Area Designation: Capayas Damsite Location: Right Abutment Ground El.:
Depth to Ground Water Level: 2.60 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.30 m: Top Soil Clay (MH) Light brown in color with pebble sized fragments, medium plasticity, sticky when wet, silty with some organic plant matters
	1		0.30 - 1.20 m: Clay (CL) Derived from silstone layer as seen from fragments of unweathered materials, extremely weathered, slight to moderate plasticity, yellowish in color
	2		1.20 - 1.80 m: Silty Clay (CL) Derived from extreme weathering sandstone bed as noted from its unweathered fragments, grayish to yellowish in color moderately plastic
	3		1.80 - 3.30 m: Silstone/Sandstone Beddings Moderate to extremely weathered formation
	4		
	5		
	6		Water Table--2.60 m Water Level--2.90 m
	7		Date Investigated: Feb. 9, 1985
	8		
	9		

CHAPTER V CONSTRUCTION MATERIALS

5.1 Bayongan Dam

5.1.1 General Description

The location of the borrow areas and quarry sites is shown in FIGURE C5-1. And material investigation is listed up in TABLE C5-1.

a) Earth Material

The Bayongan dam is planned with the zone type earth fill dam taking into account 31 m of the dam height and available embankment material around damsite.

The earth material (the impervious material) shall be obtained mainly from the borrow area located in the upstream left bank of the dam site. This area is composed of soft sedimentary rocks and clayey to silty soils derived from its weathering. No sound and hard rock is distributed near the dam site. So, it is obliged to utilize such soft rocks and soils in order to reduce the construction cost.

The borrow area presents the flat topography with a gentle slope, which is easily provided the drainage trench to decrease the moisture content of earth material and also easily collected material by bulldozer pushing.

This material altered from base rock range from 2 to 3 meters in thickness is extensively distributed in this area. This is no problem concerning the quantity of the earth material.

This impervious material should be used for the core zone but not for the upstream shell zone in the dam.

b) Sand and Gravel Material

1) Embankment Material (Semi-pervious)

The semi-pervious materials consisting of weathered rock and gravel are found in the borrow area located at the right upstream hilly area in the reservoir area. There are two layers of conglomerate zone, that thickness is about 10 to 15 meters in the reservoir site respectively. This conglomerate makes hills, so it shall be obtained easily.

This material shall be used for semi-pervious material and this is no problem concerning the quantity.

2) Filter and Concrete Aggregate Material

Most of the sand and gravel material will be obtained from the Hinlayagan river and the Kinan-oan river about 12 km and 16 km far from the damsite respectively. Both areas have no problem concerning the quantity of the filter and the concrete aggregate material.

c) Rock Material

For the proposed quarry site of rock material the Dagohoy quarry site, the Can Sudiao quarry site and the Barangay. Estaka quarry site shall be mentioned. Specially, as the Dagohoy quarry site[1/] is expected as the quarry site in Phase I project, it shall be mentioned for that first proposed quarry site for this Study Team. And the second shall be the Can Sudiao quarry site. Both quarry sites are mainly composed of good andesite. This rock shall be almost used for the riprap material.

The Dagohoy quarry site is located at about 1 km north of the Dagohoy poblacion. The geology of the vicinity of the Dagohoy quarry site consists of some kind of igneous rocks, mainly andesites, and indicates several stages of intermediate intrusion rendering the rocks highly fractured.

1/: Hauling distance from the Bayongan damsite is 12.5 km.

Three boreholes have been done at this quarry site in Phase I project. In addition to these boreholes four seismic prospecting lines having 980 m length in total have been settled.

According to the results of above mentioned investigations the Dagohoy quarry site has an overburden layer with 3 to 6 m thickness and a weathered zone with 5 to 10 m thickness.

Core samples at borehol named QS-1 has poleshape core and its rate of R.Q.D. below 8.3 meters from the ground surface is 30 to 50 %. Two samples were taken at 19.0 m and 28.3 m in depth for laboratory tests. However, QS-2 and QS-3 boreholes have scarcely any pole-shape core, and their boring cores consist of fragmented one of pea-sized/fist-sized gravels. So, it is not so difficult to forecast that quarry materials might be cracked into small blocks by blasting.

Seismic refraction profiles revealed that this quarry site can be divided into three layers, based on its seismic velocity. First layer has a range from 250 m/sec to 500 m/sec in velocity and from 2 to 5 meters in thickness. Velocity and thickness of the second layer range from 530 m/s to 1,400 m/sec and 5 to 15 meters in thickness. The third layer existing 7 to 20 m below ground surface has a range from 2,400 m/sec to 3,600 m/sec. These layers respectively correspond to extremely weathered rock called D class, moderately weathered rock called CL class and slightly to fresh rock called CM to CH class.

5.1.2 Results of Laboratory Tests

The laboratory tests have been carried out to catch hold of the quality of the construction material for the Bayongan dam as listed up in TABLE C5-2.

The brief description at each item of laboratory tests is as follows;

a) Earth Material

Result of the laboratory tests of earth materials is shown in TABLE C5-3.

According to the laboratory tests, the result is summarized as follows;

1) Physical properties

- Classification: CH, MH
- Specific gravity (Gs): 2.46 - 2.75
- Natural Moisture Content (WN): 27.3 - 41.6 %
- Consistency: The plastic Index (Ip) is ranging 33.7 to 59.0 %, these figures indicate very high plasticity therefore shall be resistible against piping.
- Gradation: Silt and clay content is 66 to 99 %

2) Mechanical properties

- Compaction: The maximum dry dencity (dmax) is between 1.36 to 1.49 g/cm^3. The optimum moisture content (Wopt) is ranging 23.4 to 28.5 %, it is comparatively high by more than 5 % against the natural moisture content (WN).
- Shearing Strength: UU ... C=9.0-11.0 t/m^2, ϕ=12.5-20.5°
  CU ... C'=1.9-2.1 t/m^2, ϕ'=18.0-27.0°
  (of Wopt)
- Permeability: k= 2.0 x 10^{-7} - 7.5 x 10^{-8} cm/sec.
  Permeability is sufficient.
- Consolidation: Cc=0.275-0.29

The material in the borrow area is consisting of a fine clay and silt belonging to MH and CH without weathered rock fragment or gravel and presents the high field moisture content of 23 to 29 %, so that the field moisture should be controlled during dam embankment works so as to decrease the moisture content in the borrow area.

According to the results of the laboratory tests, this earth material shall be available for the impervious material.

b) Sand and Gravel Material

Result of the laboratory tests of the sand and gravel material is shown in TABLE C5-4.

According to the laboratory tests, the result is summarized as follows;

- Specific Gravity (Gs): more than 2.6
- Gradation: Silt and clay are less than 1 %
- Soundness: Corrected loss is less than 10 %

The result shall indicate that this sand and gravel material has a good gradiation distribution curve suitable for the filter and the concrete aggregate material and is available without any problem.

c) Rock Material

Result of the laboratory tests of the rock material is shown in TABLE C5-4.

According to that result, andesite of the Dagohoy quarry site shall be utilized for the rock material, but aggromalate of Barangay. Estaka quarry site shall be not utilized.

5.2 Capayas Dam

5.2.1 General Description

The location of the borrow areas and the quarry sites is shown in FIGURE C5-1. And the material investigations are listed up in TABLE C5-5.

a) Earth Material

The earth material shall be obtained mainly from the borrow areas located on the both abutments of the dam site. This material is mainly composed of sandy clay and silty clay containing moderately to extremely weathered fragment and gravel.

This material altered from base rock range from 2 to 3 meters in thickness is extensively distributed in this area. This is no problem concerning the quantity of the earth material.

b) Sand and Gravel Material

Most of the sand and gravel material shall be used for the filter and the concrete aggregate material. These materials were not collected at the Ilaya river. And the material of reservoir area shall be also utilized for the sand and gravel material. But as in this area laboratory test is not carried out, the Ilaya river site shall be mentioned for the first proposed site.

c) Rock Material

For the proposed quarry site of the rock material the Dagohoy quarry site[1/] shall be mentioned. The semi-pervious material is available at the existing quarry site located at the upstream of damsite and used presently for the paving material of road. This quarry site is mainly composed of andesite, but as the shear zone is observed, this sheared andesite can not be used for the riprap material. If good andesite is obtained, this rock shall be used for the riprap material.

5.2.2 Result of Laboratory Tests

The laboratory tests have been carried out to catch hold of the quality of the construction material for the Capayas dam as listed up in TABLE C5-6.

1/: Hauling distance from the Capayas damsite is 35 km.

The brief description at each item of laboratory tests is as follows;

a) Earth Material

Result of the laboratory tests of the earth material is shown in TABLE C5-7.

According to the laboratory tests, the result is summarized as follows;

1) Physical properties

- Classification: SC, CH, MH
- Specific Gravity (Gs); 2.54 - 2.76
- Natural Moisture Content (WN): 23.1 to 33.2 %
- Consistency: The plastic index (Ip) is ranging from 32.5 to 45.7 %
- Gradation: CH and MH is 63 to 92 % about content of silt and clay. Sc is 38 %.

2) Mechanical properties

- Compaction: The maximum dry dencity (dmax) is between 1.50 to 1.61 g/cm^3. It is comparatively high. The optimum moisture content (Wopt) is range 20.0 to 22.8 %. Wopt is less than 10 % as compared with WN.
- Shearing Strength: UU ... $C=7.8\ t/m^2$, $\phi=7.5°$
  CU ... $C'=3.9\ t/m^2$, $\phi'=15.0°$
- Permeability: $k=7.1 \times 10^{-6}$ cm/s
- Consolidation: Cc=0.149 Cc is comparatively low.

According to the result of laboratory tests, this material shall be available for the impervious material. But the earth material in the borrow area presents rather high field moisture content, which should be controlled during the dam embankment works. The material itself belongs

to class CH and MH consisting of fine particle size of clay and silt, so that dam embankment should be made by using the earth material mixed with weathered rock and gravel.

b) Sand and Gravel Material

Result of the laboratory tests of the sand and gravel material is shown in TABLE C5-8.

According to the laboratory tests, the result is summarized as follows;

- Specific Gravity (Gs): more than 2.6
- Gradation: Silt and clay content are less than 1 %
- Soundness: The corrected loss is 27.5 %
  This is little bit high.

This material shall be utilized sufficiently though as for the soundness that percentage of loss is little bit high and its gradation presents a good distribution curve suitable for the filter and the concrete aggregate material.

c) Rock Material

Result of the laboratory tests of the rock material is shown in TABLE C5-8.

For the riprap material the rock of the Dagohoy quarrysite is provided.

The samples of the Capayas quarry site have been taken from shear zone, so the percentage of loss is higher. According to this result, this material shall be used for the semi-pervious material.

TABLE C5-1 LIST OF CONSTRUCTION MATERIALS AT BAYONGAN DAM

Class of Materials	Location/ Sources	Volume	Geology	Hauling Distance	Sampling	Laboratory Test
Embankment Materials (Impervious)	Damsite Right Abutment	Enough	Clay/Silty Clay	In Site	Samples Taken	Laboratory Soil Test (1985)
	Damsite Left Abutment	"	Clay/Silty Clay	"	"	"
Embankment Materials (Pervious and Semi-Pervious)	Dagohoy Quarry	"	Andesite	12.5 kms	No Sample	Rock Test (1981)
	BO. Estaka	Not Enough	Agglomerate Talus Deposit	20 kms	Sample Taken	Rock Test (1985)
	Reservoir Area Upstream	Enough	Conglomerate	1.5 kms	No Sample	No Test
	Cansudiao Quarry	"	Andesite	11.5 kms	"	"
Sand and Gravel	Kinan-oan River	"	Alluvial Deposit	16 kms	Sample Taken	Rock Test (1985)
	Hinlayagan River	"	"	11 kms	"	"

TABLE C5-2 LIST OF LABORATORY TESTS AT BAYONGAN DAM

Test Items	Earth Material											Rock M	Sand & Gravel Material	
Sample No.	BTP1	BTP2	BTP3	BTP4	BTP5	BTP6	BTP7	BTP8	BTP9	BTP10	BTP11	S.N.4	S.N.5	S.N.6
Grain Size A	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Spec. Gravity	x	x	x	x	x	x	x	x	x	x	x	x	x	x
NMC	x	x	x	x	x	x	x	x	x	x	x			
Atterberg Limit	x	x	x	x		x	x		x	x				
Permeability Test		x		x						x				
Triaxial a) uu		x		x						x				
Triaxial b) cu		x		x						x				
Consolidation Test		x				x			x					
Standard Comp. Test	x	x	x	x		x			Z 1/ x	Z x				
Soundness Test												x	x	x

Note; 1/: Percent Energy is 150.

TABLE C5-3 RESULT OF LABORATORY TESTS AT BAYONGAN DAM (1/4)

Sample No.	BTP-1	BTP-2	BTP-3	BTP-4	BTP-5	BTP-6
Physical Properties Depth	0.2∿1.2m	0.35∿1.45	0.5∿1.65	0.3∿1.1	0.4∿1.45	0.4∿1.4
Classification	MH	CH	CH	MH	-	MH
Specific Gravity	2.608	2.473	2.539	2.460	2.502	2.695
N. Moisture C.	41.6%	34.8	27.3	33.0	37.4	37.4
Gravel Content	1%	0	1	0	1	6
Sand Content	4%	1	6	2	4	28
Silt Content	43%	52	60	73	) 95	41
Clay Content	52%	47	33	25		25
Liquid Limit	90.0 %	66.4	79.3	75.0	-	83.1
Plastic Limit	41.75%	39.7	33.3	40.3	-	41.4
Plastic Index	48.25%	26.7	46.0	34.7	-	41.7

TABLE C5-3 RESULT OF LABORATORY TESTS AT BAYONGAN DAM (2/4)

Sample No.	BTP-1	BTP-2	BTP-3	BTP-4	BTP-5	BTP-6
Mechanical Properties						
Max. dry density	1.360 gr/cu.cm	1.380	1.480	1.448	-	1.491
Optimum M.C.	25.00%	28.40	23.50	24.86	-	23.79
C by uu Test	-	9.4 t/sq.m	-	11.0	-	-
ϕ by uu Test	-	20.0 deg.	-	20.5	-	-
C by cu Test	-	2.1 t/sq.m	-	1.2	-	-
ϕ by cu Test	-	27.0 deg.	-	24.0	-	-
Permeability	-	7.8×10^{-8} cm/s	-	2.0×10^{-7}	-	-
Voil Ratio	-	0.802	-	-	-	0.802
Degree of Saturation	-	87.57%	-	-	-	79.94
Compression Index	-	0.285	-	-	-	0.29
Consolidation Coefficient		$1.64 \times 10^{-2} \sim 1.2 \times 10^{-3}$ sq.cm/sec		-	-	$8.6 \times 10^{-3} \sim 3.1 \times 10^{-3}$

TABLE C5-3 RESULT OF LABORATORY TESTS AT BAYONGAN DAM (3/4)

Sample No.	BTP-7	BTP-8	BTP-9	BTP-10	BTP-11
Physical Properties Depth	0.2∿1.45m	0.4∿1.2	0.35∿1.1	0.3∿1.45	0.1∿1.2
Classification	CH	-	MH	CH	-
Specific Gravity	2.600	2.733	2.459	2.746	2.556
N. Moisture C.	41.6%	36.0	34.8	36.1	27.3
Gravel Content	1%	0	0	1	0
Sand Content	3%	14	7	8	33
Silt Content	36%	} 86	50	46	} 67
Clay Content	60%		43	45	
Liquid Limit	99.3%	-	74.4	81.4	-
Plastic Limit	40.3%	-	40.7	36.8	-
Plastic Index	59.0%	-	33.7	44.6	-

TABLE C5-3 RESULT OF LABORATORY TEST AT BAYONGAN DAM (4/4)

Sample No.	BTP-7	BTP-8	BTP-9	BTP-10	BTP-11
Mechanical Properties					
Max. dry density	-	-	1.380(1.488) gr/cu.cm	1.450(1.563)	-
Optimum M.C.	-	-	28.50(23.43) %	27.50(19.00)	-
C by uu Test	-	-	-	9.0 t/sq.m	-
ϕ by uu Test	-	-	-	12.5 deg.	-
C by cu Test	-	-	-	1.9 t/sq.m	-
ϕ by cu Test	-	-	-	18.0 deg.	-
Permeability	-	-	-	7.5×10^{-8} cm/sec	-
Void Ratio	-	-	0.786	-	-
Degree of Saturation	-	-	89.16%	-	-
Compression Index	-	-	0.275	-	-
Consolidation Coefficient	-	-	$9.5\times10^{-3}\sim1.1\times10^{-3}$ sq.cm/sec	-	-

Note: Figures in parentheses are values that percent energy is 150.

TABLE C5-4 RISULT OF LABOLATORY TESTS AT BAYONGAN DAM

Date	Location & Sample No.	Geology	Specific Gravity, Gr	Absorption W(%)	Gradation Gravel 4.76 (%)	Sand 0.074 (%)	Silt 0.005 (%)	Clay (%)	Unconfined Strength, qu(kg/cm2)	Elastic Strength, E(kg/cm2)	Soundness (%)	Remark
1981	Dagohoy Q. QS-1 (19.0m)	Andesite	2.70	0.1					776	14,620		Rock Material (Pervious)
1981	Dagohoy Q. QS-1 (28.2m)	"	2.69	0.2					649	12,740		"
1985	BO.Estaka S.N.-4	Aggromelate	2.15 1/ 2.21		81	14	5				55.18	"
1985	Kinan-oan River S.N.-5	Alluvial Deposit	2.70 2.795		74	25	1				9.91	Sand and Gravel
1985	Hinlayagan River S.N.-6	"	2.61 2.69		77	22	1				8.21	"

Note; 1/: Upper Column is Fine Aggregate
Lower Column is Coarse Aggregate

TABLE C5-5 LIST OF CONSTRUCTION MATERIALS AT CAPAYAS DAM

Class of Materials	Location/ Sources	Volume	Geology	Hauling Distance	Sampling	Laboratory Test
Embankment Materials (Impervious)	Damsite Right Abutment	Enough	Clay/Silty Clay	In Site	Sample Taken	Laboratory Soil Test (1985)
	Damsite Left Abutment	"	"	"	"	"
Embankment M. (Semi - Pervious)	Capayas Quarry	"	Andesite	0.8 kms	"	Rock Test (1985)
Embankment M. (Pervious)	Dagohoy Quarry	"	Andesite	35 kms	Sample Taken	Rock Test (1981)
Sand and Gravel	Reservoir Area & Damsite	"	Alluvial Depposit	10.5 kms	Sample Taken	Rock Test (1985)
	Guinsularan River	"	"	38 kms	"	"
	Ilaya River	"	Terrace Dep. & Alluvial Dep.	In Site	No Sample	No Test

TABLE C5-6 LIST OF LABORATORY TESTS AT CAPAYAS DAM

Test Items	Earth Material						Rock M.	Sand & Gravel Material	
Sample No.	CTP1	CTP2	CTP3	CTP4	CTP5	CTP6	S.N.1	S.N.2	S.N.3
Grain Size A	x	x	x	x	x	x	x	x	x
Spec. Gravity	x	x	x	x	x	x	x	x	x
NMC	x	x	x	x	x	x			
Atterberg Limit		x	x	x	x				
Permeability Test			x						
Triaxial a) uu			x						
Triaxial b) cu			x						
Consolidation Test			x						
Stand Comp. Test		x	x		x				
Soundness Test							x	x	x

TABLE C5-7 RISULT OF LABORATORY TESTS AT CAPAYAS DAM (2/2)

Sample No.	CTP-1	CTP-2	CTP-3	CTP-4	CTP-5	CTP-6
Mechanical Properties						
Max. dry density	-	1.503 gr/cu.cm	1.497	-	1.610	-
Optimum M.C.	-	21.70%	22.82	-	20.00	-
	-					
C by uu.Test	-	-	7.8 t/sq.m	-	-	-
ϕ by uu.Test	-	-	7.5 deg.	-	-	-
C by cu.Test	-	-	3.9 t/sq.m	-	-	-
ϕ by cu.Test	-	-	15.0 deg.	-	-	-
Permeability	-	-	7.1×10^{-6} cm/sec	-	-	-
Void Ratio	-	-	0.724	-	-	-
Degree of Saturation	-	-	81.51%	-	-	-
Compression Index	-	-	0.149	-	-	-
Consolidation Coefficient	-	-	$8.4 \times 10^{-3} \sim 3.4 \times 10^{-3}$ sq.cm/sec	-	-	-

TABLE C5-7 RISULT OF LABORATORY TESTS AT CAPAYAS DAM (1/2)

Sample No. / Physical Properties	CTP-1	CTP-2	CTP-3	CTP-4	CTP-5	CTP-6
Depth	0.6∿1.25m	0.6∿1.65	0.0∿1.2	0.3∿1.2	0.3∿1.25	0.3∿1.2
Classification	SC	CH	MH	CH	CH	-
Specific Gravity	2.635	2.536	2.586	2.581	2.755	2.642
N. Moisture C.	23.1%	33.2	33.2	29.0	31.7	27.1
Gravel Content	34%	1	2	0	8	1
Sand Content	28%	19	18	8	29	3
Silt Content	) 38%	55	65	60	50	)96
Clay Content		25	15	32	13	
Liquid Limit	-	76.1 %	75.5	69.1	72.4	-
Plastic Limit	-	30.45%	43.05	31.5	31.55	-
Plastic Index	-	45.65%	32.45	37.6	40.85	-

TABLE C5-8 RISULT OF LABORATORY TESTS AT CAPAYAS DAM

Date	Location & Sample No.	Geology	Specific Gravity; Gr 1/	Gradation Gravel 4.76 (%)	Sand 0.074 (%)	Silt 0.005 (%)	Clay (%)	Sound-ness (%)	Remark
1985	Capayas Q S.N.-1	Andesite (Sheer Zone)	2.665 2.75	67	26	7		46.21	Rock M. (Semi-Pervious)
1985	Ilaya River S.N.-2	Alluvial Deposit	2.60 2.64	87	12	1		27.54	Sand and Gravel
	Guinsularan River S.N.-3	"	2.32 2.465	71	28	1		38.65	"

Note ; 1/ : Upper Column is Fine Aggregate
Lower Column in Coarse Aggregate

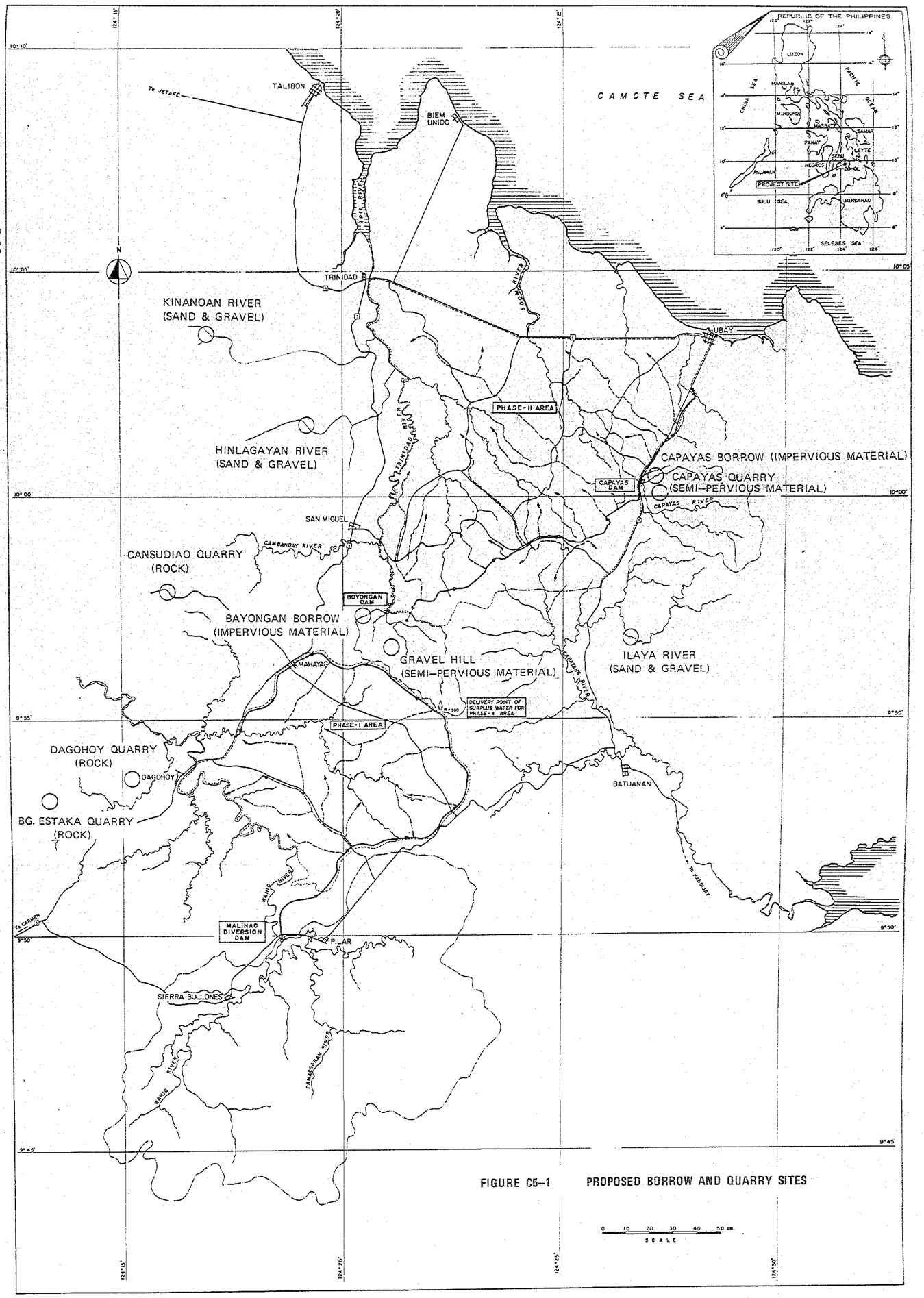


FIGURE C5-1 PROPOSED BORROW AND QUARRY SITES

CHAPTER VI RECOMMENDATIONS

6.1 Bayongan Dam

The study has been presently prepared on feasibility level. In accordance with this study there are few problems in fill-type dam construction of which height is about 30 meters from an engineering geological point of view. Some remaining questionable points concerning geological conditions are as follows;

(1) The removal of soft layers underlying the dam body has been proposed, and it is recommended to study this in detail before the construction stage in-situ.

(2) As the sedimentary rock such as siltstone, mudstone and sandstone composing the foundation of the damsite cause slaking and weathering very early when exposed to water and atmosphere, the cut off of the core trench should be performed with the best attention before the dam embankment works.

(3) The embankment materials for the dam body are available near the damsite and the reservoir area. There are no problems concerning quantity to be required because of extensive distribution.

(4) The material in the borrow area presents the high field moisture content, so that the field moisture should be controlled during the dam embankment works so as to decrease the moisture content in the borrow area.

(5) The gravel materials are found in the borrow area located at the right upstream hilly area in the reservoir area. In this study the laboratory tests have not been carried out, so that the laboratory tests will be required in future for the detailed design of dam.

(6) An assumed fault and/or sheared zone is situated along the direction connecting BD-2, DA-4, BU-3 and DC-1 borehole, and extends from northwest to southeast. During the cut off works this assumed fault should be paid any attention to.

6.2 CAPAYAS DAM

According to this study there are few problems in homogeneous dam type construction of which height is 17 m. Some remaining questionable points concerning geological conditions are as follows;

(1) Same as 6.1 (1)

(2) Same as 6.1 (2)

(3) The additional boring investigation to confirm the permeability of the base rock will be required for the foundation treatment.

(4) Same as 6.1 (3)

(5) Earth material itself belongs to class CH and MH consisting of fine particle size of clay and silt, so that the dam embankment should be made by using the earth material mixed with weathered rock and gravel as much as possible in order to obtain good compaction effort.

ANNEX D. SOILS AND LAND USE

ANNEX D SOIL AND LAND USE

LIST OF TABLES

LIST OF FIGURES

CHAPTER I INTRODUCTION

Reclamation of the waste lands for increasing agricultural production under the systematic supply of irrigation water would be a prerequisites for successful growth and development of farm economy in the local region. The Project Area has been selected one of the good models which are urgently to be studied in Bohol Island following the Phase I Area.

The soil and land use survey in relation with its geological and topographical features will present scientific information useful for making the reasonable and necessary land development.

Objectives of the soil and land use survey conducted by the Feasibility Study Team are;

(1) to conduct soil profile observations for checking/confirming the results of the former soil surveys;

(2) especially to concentrate the survey to find availability of the grass lands which will be expanded under the irrigation system; and

(3) to investigate suitability and problems of soils and water quality for improving agricultural managements aimed at increasing farm production.

(4) to survey the agricultural status from viewpoints of land use for establishing future land development plan.

The survey was carried out for one month from January to February in 1985 in cooperation with Planning and Development Department of NIA and its Office of Region VII at Tagbilaran.

CHAPTER II TOPOGRAPHY AND GEOLOGY

2.1 General

The project area (Phase II) lies mostly in the northeast basin area of Bohol Island, which borders on Phase I area beyond hilly areas on the south. The project area is bounded by the national road between Trinidad and Ubay on the north, also by the road from Ubay to Alicia on the east, and by Bayongan - Ipil river on the west. It is located at 124°21' - 28' East Longitude and at 9°58' - 10°5' North Latitude.

For topography survey as well as soil and land use survey, four topographical maps scaled at 1:10,000 were used. The maps were particularly compiled this time from the original maps made by JICA in 1984 at the scale of 1:4,000.

2.2 Topography

A greater part of the project area is gently sloping toward north coastal area, in elevation from 50 m to 2 m above sea level. The lands are largely composed of two distinct physiographic forms namely: Undulating terrain and Alluvial valley. FIGURE D2-1 is a partial map taken from the reports of Bohol Agricultural Land Resources Appraisal Project (1980). It illustrates that the project area belongs to Land System 13 having the above land feature. Only a few parts are tidal flats of Land System 1, which stretch at three locations across the northern national road.

The undulating terrains have been more or less dissected by many of the small streams, leaving the rolling hills on the south and east sides of the project area. Almost flat and very gently sloping lands are prevailing in higher extent from southern to eastern areas. The most finely dissected lands extend on north west side of the project area, where a complicated striped pattern is seen in topography as well as in land use.

The alluvial valleys, however, have only very narrow ways of streams. Flat alluvial lands spread below 5 m in elevation along three main rivers, Trinidad, Soon and Son. Oc, which finally empty to the Camotes Sea through the tidal flats. A general land grouping in topography is given in FIGURE D2-2.

If the land is simply divided by its slope gradient, about 60 percent of the whole area is flat to very gently sloping. The following result was obtained from the soil classification study in the next chapter:

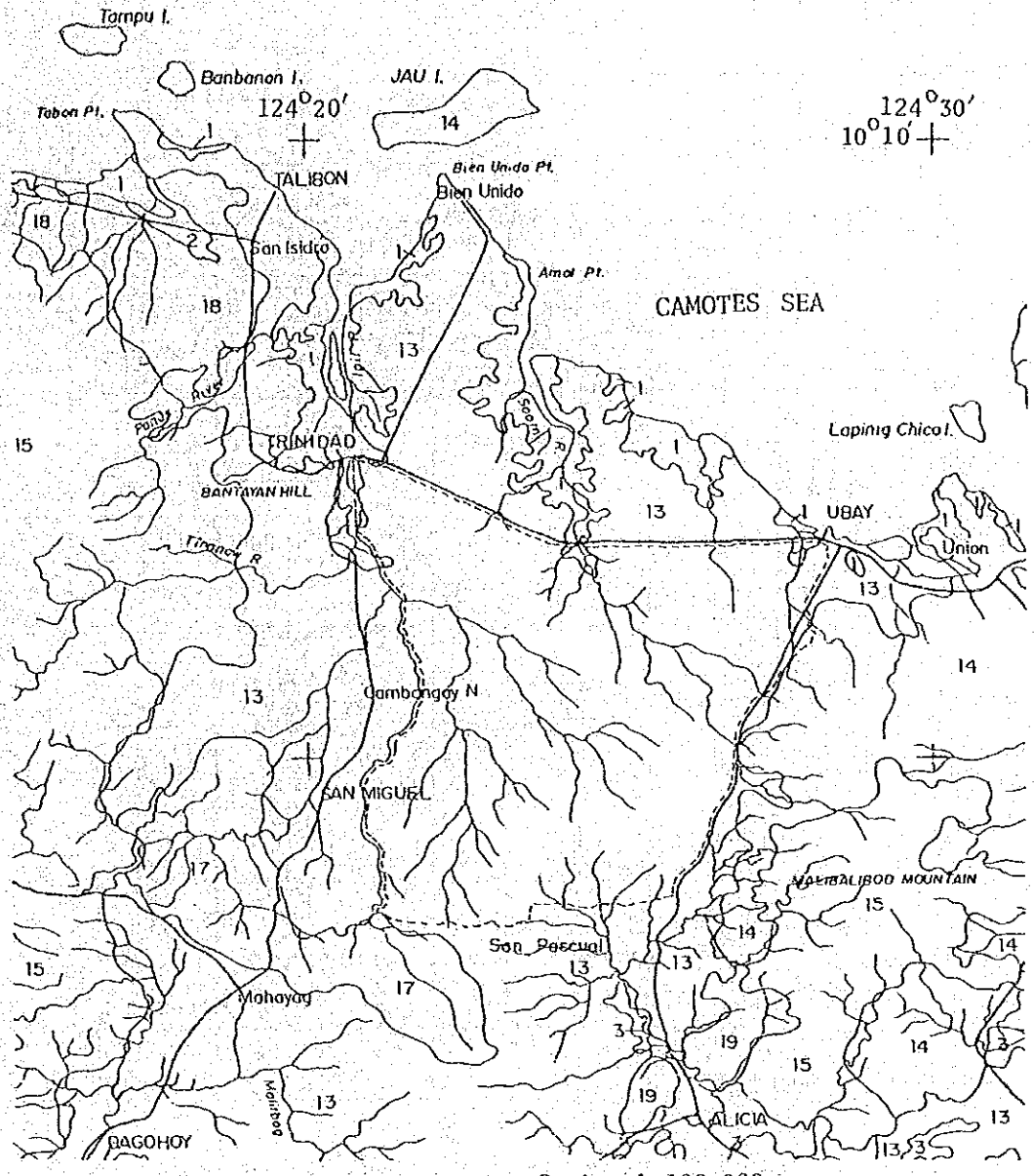
Land Slope Gradient (%)	Hectare	Percent
0 - 3	7,504	59
3 - 5	2,833	22
5 - 8	994	8
> 8	1,369	11
Total	12,700	100

2.3 Geology

FIGURE D2-3 is excerpted from the Bohol Project Report above mentioned. It presents general geological feature around the project area. The project area is entirely composed of Ilihan shale. Its constituent are shale, sandstone, slabby to karstic limestone beds, siltstone, mudston and marl. These sedimentary rocks are low dipping and interbedded with each other. The soils of the project area are developed mostly on dilluvial deposits of these parent materials. Dark brownish or black colored small gravels are abundantly contained in the subsoil and have been often mistaken for iron or manganese concretions. These seems to be secondary deposits because the same deposits which had been apparently transported first were observed in the test boring near the Bayongan damsite.

There has been found no evidence of limestone deposits during the present survey. This would be quite obvious in view of the soil properties which will be described later. Another soil material would be derived from the eastern area where igneous rocks consisting of basaltics and ultrabasics appear.

Alluvium spreads in a small extent at three locations. These flat lands had been partly formed with fluvio-marine deposits where saline peaty soils are observed.

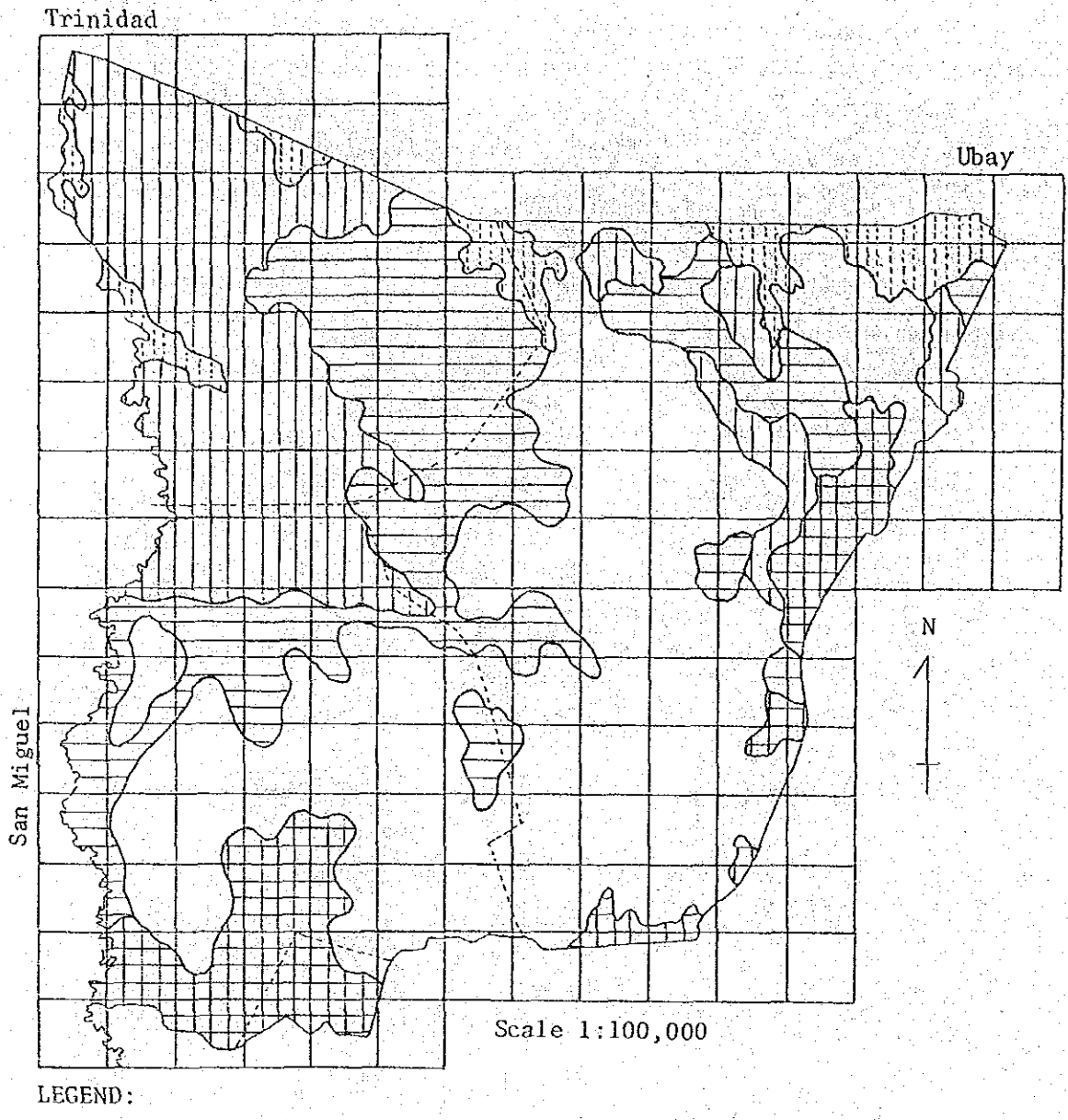


Scale 1:108,000

LAND SYSTEM NO.	LAND SYSTEM NAME	PHYSIOGRAPHIC DESCRIPTION
1	INABANGA	Active tidal flat with mangrove / fishpond
3	LOBOC	River terraces and floodplains
13	BUENAVISTA	Undulating terrain on shale/ sandstone
14	UBAY	Low rolling basic volcanic hills with alluvial valleys
15	MALIBALIBOO	Moderately dissected and rolling high basic volcanic hills
17	BABAG	Moderately to highly dissected and sharp ridge low shale/sandstone hills.
18	TANGHALIGUE	Low undulating to rolling diorite hills with alluvial valleys
19	DUAY	Moderately to highly dissected ultrabasic hills

----- Project Boundary

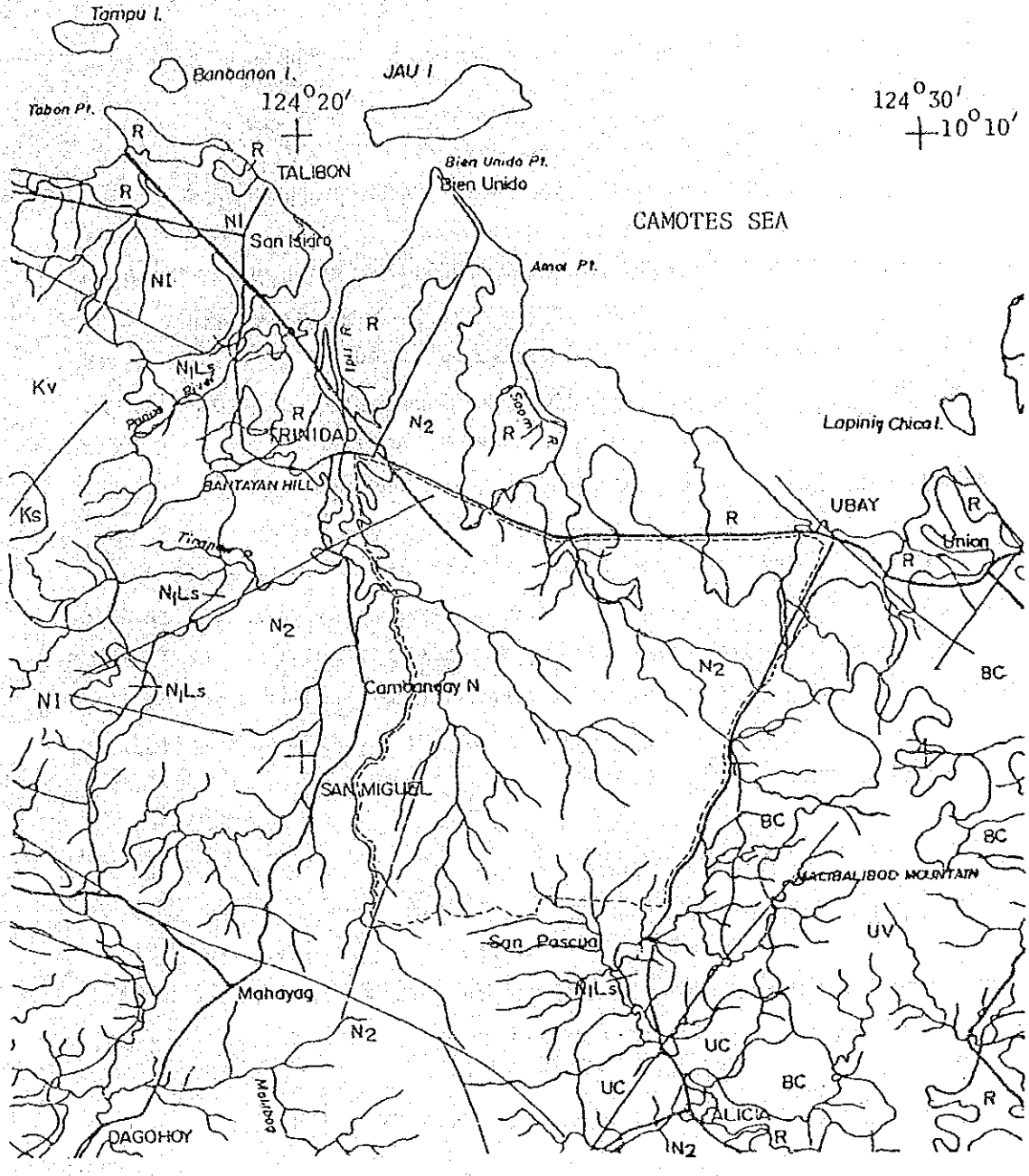
FIGURE D 2 - 1 LAND SYSTEMS AROUND THE PROJECT AREA



LEGEND:

Map Symbol	Topographical Feature
	Rolling terrain area of higher altitude
	Rolling terrain area of lower altitude
	Undulating terrain area of middle altitude
	Gently sloping terrain area
	Alluvial flat area

FIGURE D 2 - 2 GENERAL TOPOGRAPHICAL DIVISION OF THE PROJECT AREA



Scale 1:200,000

LEGEND: Sedimentary Rocks: Recent — R - Alluvium
Middle Miocene — N2 - Ilihan Shale
Lower Miocene — N1LS - Wahig Limestone
Cretaceous-Paleocene — Ks - Meta Sediments

Igneous Rocks: Upper Cretaceous-Paleocene
N1 - Diorite
UC - Ultrabasics
Cretaceous-Paleocene — UV - Malibalibad Volcanics
Kv - Metavolcanics
Pre-Jurassic — BC - Bacement Complex

----- Project boundary

(Source: Bohol Agricultural Land Resources Appraisal, 1980)

FIGURE D 2 - 3 GEOLOGICAL MAP AROUND THE PROJECT AREA

CHAPTER III SOIL SURVEY

3.1. General

The present survey period fell on the end of the rainy season when most of the paddy fields were transplanted and some were being prepared for dry season rice. Consequently, only a few paddy fields were observed by means of boring technique except for fallow fields. The weather was unsettled with occasional showers, causing traffic troubles. Its unseasonal status of the climate is referred to in ANNEX A.

Pit sites were selected on every land group topographically identified. The 1/10,000 topographical maps newly compiled for the present study have been very useful practically not only to find the sites but to inspect the land use status there. Since most of the lands are more or less sloping, the pits were made on the middle of the slope in spite of its length.

3.2 Soil Profile Observation

Because of the investigative nature of the study, detailed reconnaissance survey level was taken to decide the density of profile observation during the survey period. The density was one pit per 250 ha, and the pits totalled to 51 in the project area. Their locations are shown in TABLE D3-1 and FIGURE D3-1.

a) Pit

The pits were dug up to a depth of 80 to 120 cm from the surface with a width of 100 cm. To observe further the lower layers of the pit, boring was tried using a common posthole type auger.

b) Soil Hardness Test

Field test were conducted to determine soil hardness. A tester, a kind of cone penetrometer to measure soil compactness, was used since it is handy and portable for the field survey. Compactness of the soil layer is of much importance to determine workability of a land for potentiality classification as well as to distinguish genetic differences in the soil classification process.

Values resulting from the use of the Soil Hardness Tester are categorized as follows;

Criteria of Soil Hardness Evaluation

Hardness Category	Tester Index* (mm)	Resistance (kg/cm^3)	Easiness in Tilth Work
Soft	< 8	≤ 0.98	Very easy
Slightly hard	8 - 12	0.98 - 1.93	Easy
Hard	12 - 17	1.93 - 4.04	Slightly difficult
Very Hard	17 - 23	4.04 - 10.0	Difficult
Extremely hard	> 23	> 10.0	Very difficult

* Dr. Yamanaka's Soil Hardness Tester. Index (mm) is a reading of the cone when it penetrates into the solum.

c) Chemical Tests

In addition, quick chemical reagent tests were tried with every soil profile. These are;

a) Dilute hydrochloric acid solution (1N) for detecting carbonates (effervescence)

b) Benzidin (pp' -diamino-diphenyl salt) solution (one percent in 10 percent acetic acid solution) for detecting active manganese (dark blue color development)

c) αα'-dipyridyl solution (0.05 percent in 10 percent acetic acid solution) for detecting ferrous iron (Fe++) (pnk-red color development)

The soil profile descriptions followed the method defined in the FAO Guidelines for Soil Profile Description which are now of wider use in the world.

3.3 Sampling and Analysis

3.3.1. Sampling and Field Analysis

Soil horizons of the profile were sampled and air-dried. Fine soil samples were then prepared through a 2 mm sieve, when content of gravels (> 2 mm) was measured.

As noted in TABLE D3-1, 40 samples of the fine soil were analyzed for pH and electrical conductivity (EC) at the temporary laboratory in the Chocolate Hill Hotel by means of portable electrode meters.

In the course of the soil survey, water samples from various sources were collected and analyzed similarly as the soil samples. These results are given in TABLE D3-2 and D3-3.

3.3.2. Laboratory Analysis

Out of 81 soil samples, the other 41 samples (fine soil) were subjected to further physical and chemical analysis at Soil and Water Laboratory Service, NIA, Muñoz, Nueva Ecija. The data are presented in TABLE D3-4 and D3-5.

TABLE D3-1 SITES OF SOIL PITS AND SAMPLES COLLECTED IN THE PROJECT AREA (1)

Pit No.	Site	Land Use[1/] (Slope %)	No. of Soil Samples	Groundwater Depth (cm)
P 1	San Miguel Poblacion	GL (5)	3	95
P 2	San Vicentev Ferrer, Trin.	GL (2)	3	85
P 3	Guinobatan, Trinidad	Co (2)	4*	80
P 4	Bugang, San Miguel	Pr (0)	2	20
P 5	Mahagbu, San Miguel	GL (3)	4*	--
P 6	Soom, Trinidad	GL (3)	3	--
P 7	Casate, Ubay	GL (0)	3*	--
P 8	Humay-Humay, Ubay	Mr (0)	2*	50
P 9	Hambabauran, Ubay	GL (2)	3	--
P10	Gabi, Ubay	GL (2)	3	90
P11	Bulilis, San Miguel	GL (3)	4	--
P12	Corazon, San Miguel	GL (2)	2	60
P13	Cambangay Note, S. Miguel	GL (2)	3*	--
P14	Soom, Trinidad	GL (2)	3	--
P15	Mahagbu, Trinidad	GL (8)	4	--
P16	Ubay Poblation	Mr (0)	2*	18
P17	Tuburan, Ubay	GL (2)	3*	--
P18	Guinobatan, Trinidad	Mr (0)	2	25
P19	Bayongan, San Miguel	GL (1)	--	--
P20	Cambangay, San Miguel	GL (1)	3*	68
P21	Bulilis, San Miguel	GL (2)	--	--
P22	Corazon, San Miguel	GL (1)	--	--
P23	San Vicente, San Miguel	GL (2)	2*	--
P24	Bulilis, San Miguel	GL (3)	--	--
P25	Tagum Sur, Trinidad	UL (2)	3	--
P26	Tuburan, Ubay	UL (0)	--	--
P27	Mahagbu, Trinidad	GL (3)	--	(95)
P28	Launion, Trinidad	GL (3)	--	(70)
P29	Mahagbu, Trinidad	GL (0)	--	(85)
P30	Camanbugan, Ubay	GL (2)	3*	86
P31	Tuburan, Ubay	GL (2)	--	--
P32A	Camanbugan, Ubay	GL (0)	--	--
P33	Gabi, Ubay	GL (1)	--	--
P34	Hambabauran, Ubay	GL (2)	--	--
P35	Lumangog, Ubay	GL (2)	--	--
P36	Copayas, Ubay	GL (4)	--	--
P37	Son-Oc, Ubay	UL (2)	--	--
P38	Tubog, Ubay	GL (0)	3	60
P39	Bayang, Ubay	GL (2)	--	--
P40	Camalian, Ubay	GL (1)	4	--

Note: A, B and C show the pit situation on the top, middle and lower part of the land slope, respectively. Soil samples marked with* were subjected to the field analysis. The other samples were sent to NIA Soil Laboratory at Muñoz, Nueva Echiha for physical and chemical analysis. Groundwater in parenthesis was not collected.

1/ Land Use: Pr--Paddy field, UL--Upland field, Co--Coconut field, GL--Grass Land, Mr--Mangrove or nipa area

TABLE D3-1 SITES OF SOIL PITS AND SAMPLES COLLECTED IN THE PROJECT AREA (2)

Pit No.	Site	Land Use[1/] (Slope %)	No. of Soil Samples	Groundwater Depth (cm)
P41	Camalian, Ubay	GL (1)	--	60
P42C	Lumangog, Ubay	Pr (0)	3*	30
P43B	Camanbugan, Ubay	GL (4)	3*	--
P44	Catoogan, Trinidad	GL (1)	2*	64
P45	BPI Expt. Sta., Gabi, Ubay	UL (1)	3	(82)
P46B	Kalangganan, Ubay	GL(10)	--	--
P47	Casate, Ubay	GL (3)	2*	--
P48	Bayongan, San Miguel	GL (2)	--	--
P49	Bugang, San Miguel	GL(15)	--	--
P50C	Mahagbu, Trinidad	Pr (0)	--	--
P51	Bulilis, San Miguel	GL (1)	--	(83)

Note: A, B and C show the pit situation on the top, middle and lower part of the land slope, respectively. Soil samples marked with* were subjected to the field analysis. The other samples were sent to NIA Soil Laboratory at Muñoz, Nueva Echiha for physical and chemical analysis. Groundwater in parenthesis was not collected.

1/ Land Use: Pr--Paddy field, UL--Upland field, Co--Coconut field, GL--Grass Land, Mr--Mangrove or nipa area

TABLE D3-2 RESULTS OF FIELD ANALYSIS OF THE SOIL SAMPLES COLLECTED IN THE PROJECT AREA

Sample No. 1/	Soil Hardness 2/	Gravel Content 3/ %	pH (H_2O) 1:2.5	pH (1N·KCl) 1:2.5	Difference	EC (1:2.5) mmhos, 25°C
P 3-1	18	4.2	5.10	3.84	1.26	0.038
2	21	3.9	5.09	3.63	1.46	0.021
3	20	47.9*	5.30	3.68	1.62	0.019
4	17	22.1	5.94	3.75	2.19	0.015
P 5-1	20	30.6*	5.71	3.97	1.74	0.033
2	20	2.9	5.54	3.85	1.69	0.035
3	18	2.2	5.87	4.36	1.51	0.047
4	20	1.4	6.25	4.40	1.85	0.053
P 7-1	20	0.2	5.72	4.02	1.70	0.028
2	16	2.7	5.57	3.85	1.72	0.028
3	20	56.6*	5.59	3.93	1.66	0.031
P 8-1	5	5.6**	6.65	6.32	0.33	7.42
2	7	4.4**	6.95	6.60	0.35	11.20
P13-1	21	22.5*	5.51	3.81	1.70	0.014
2	21	28.8*	5.49	3.75	1.74	0.013
3	22	55.6*	5.26	3.81	1.45	0.015
P15-5	24	59.6*	7.00	4.86	2.14	0.030
P16-1	5	2.3	6.91	6.64	0.27	23.90
2	5	0.2	7.04	6.78	0.26	23.80
P17-1	18	25.9	5.28	3.94	1.34	0.037
2	22	18.5	5.10	3.84	1.26	0.016
3	24	0.7	5.15	3.86	1.29	0.018
P20-1	18	0.1	5.60	3.98	1.62	0.020
2	18	3.5	5.26	3.76	1.50	0.016
3	17	65.9*	5.37	3.80	1.57	0.014
P23-1	19	0.3	5.58	3.94	1.64	0.021
2	19	6.5	5.60	3.80	1.80	0.013
P30-1	18	1.4	6.48	5.06	1.42	0.023
2	16	0.2	5.65	4.09	1.56	0.016
3	16	11.4	5.60	4.03	1.57	0.016
P42-1	--	1.7	5.60	4.01	1.59	0.021
(C) 2	--	14.9	5.78	4.08	1.70	0.013
3	--	19.6	6.04	4.39	1.65	0.014
P43-1	19	11.1	5.46	4.27	1.19	0.051
(B) 2	22	67.1	5.74	4.06	1.68	0.021
3	20	52.9*	5.55	3.89	1.66	0.018
P44-1	16	0.5	5.73	4.18	1.55	0.032
2	18	0.4	5.77	4.07	1.70	0.023
P47-1	17	29.5	5.78	4.28	1.50	0.037
4	23	50.3*	5.82	4.20	1.62	0.017

Note: 1/: Alphabet in the parenthesis under pit No. shows the place of observation in the sampling survey on soil-topography relationships. Refer to Table D3-1.
2/: Readings of soil hardness tester as tested on the profile.
3/: On air-dried soil basis.

* Including fairly amounts of clayey particles which easily become dispersed in water.
** Mixed with some decayed timber or peat.

TABLE D3-3 pH AND ELECTRICAL CONDUCTIVITY OF THE WATER SAMPLES COLLECTED IN THE PROJECT AREA

Sample No.	Water Group	Site Where Collected	pH	EC mmho, 25°C
1	G	P1	6.90	0.083
2	S	Nearby P1	7.64	0.187
3	G	P2	6.34	0.024
4	G	P3	5.76	0.026
5	G	P4	5.86	0.026
6	R	Soom River	7.30	18.65
7	G	P10	6.26	0.034
8	W (1.2)	Gabi, Ubay	6.66	0.115
9	G	P12	6.04	0.053
10	W (2.5)	Ubay	7.14	0.223
11	G	P16	7.19	36.96
12	W (0.1)	Casate, Ubay	7.61	0.562
13	G	P18	6.74	32.00
14	W (0.8)	Bayongan, S.M.	6.94	0.756
15	G	P20	5.92	0.035
16	R	Cambangay Creek	7.42	0.165
17	R	San Pascual R.*	7.96	0.155
18	R	Ontaga River*	8.47	0.317
19	R	Bagasio River*	8.21	0.339
20	R	Wahig River*	8.14	0.315
21	R	Cambangay Cr.	8.31	0.239
22	R	Bayongan R.	7.83	0.305
23	R	Ipil River	7.57	9.23
24	S	Marsh, Soom, Tr.	7.27	0.091
25	W (1.3)	Mahagbu, Trinidad	6.85	0.195
26	G	P30	6.70	0.165
27	R	Tuburan River	7.77	0.172
28	R	BPI Expt. Sta.	7.60	0.072
29	R	Bayang River	8.20	0.190
30	R	Son-Oc River	7.64	0.133
31	R	Dita Creek	7.33	0.178
32	G	P38	6.74	0.100
33	G	P41	5.95	0.036
34	G	P42	5.91	0.090
35	G	P44	6.17	0.074
36	W (0.5)	Casate, Ubay	7.03	0.277
37	R	Nearby P48	7.05	0.225

Note: Water group: G--Ground water
R--River water
S--Swamp water
W--Well water (Distance from soil surface in meter)
*--These belong to the Phase 1 Area located north of the Project Area

TABLE D3-4 RESULTS OF LABORATORY ANALYSIS OF THE SOIL SAMPLES COLLECTED IN THE PROJECT AREA (I)-(1)

Pit No.	Layer No.	Depth cm	Gravel %	Particle Size Distribution Sand %	Silt %	Clay %	Texture	Soil Hardness	pH (H_2O) 1:2.5	pH (1N·KCl) 1:2.5	Difference	Exchange Acidity me/100g
P 1	1	0-20	52.0*	49	33	18	L	13	5.8	4.1	1.7	10.6
	2	20-61	61.5	54	16	30	SCL	21	5.5	4.0	1.5	13.1
	3	61-90	39.3*	33	30	37	CL	20	5.7	4.6	1.1	9.6
P 2	1	0-22	7.8	46	41	13	L	17	5.3	3.9	1.4	8.0
	2	22-40	26.7	46	34	20	L	18	5.3	4.1	1.2	9.1
	3	40-73	65.5*	47	23	30	SCL	17	5.3	4.2	1.1	9.1
P 4	1	0-20	2.1	76	18	6	LS	20	5.6	4.5	1.1	4.0
	2	20-65	52.9	84	10	6	LS	23	5.7	4.2	1.5	2.0
P 6	1	0-22	10.5	59	31	10	SL	20	5.4	4.0	1.4	6.5
	2	22-40	56.3	64	23	13	SL	20	5.3	3.9	1.4	6.5
	3	40-65	57.1*	55	22	23	SCL	21	5.3	3.8	1.5	10.1
P 9	1	0-15	30.3*	58	32	10	SL	20	5.3	3.8	1.5	7.0
	2	15-34	48.5	57	27	16	SL	23	5.1	3.7	1.4	8.5
	3	34-65	39.2*	49	24	27	SCL	22	5.0	3.7	1.3	13.1
P10	1	0-25	5.1	56	34	10	SL	17	5.2	3.8	1.4	7.0
	2	25-52	61.0	58	26	16	SL	20	5.2	3.8	1.4	8.0
	3	52-70	54.5*	46	26	28	SCL	22	5.4	4.6	0.8	7.0
P11	1	0-17	26.2	64	28	8	SL	18	5.5	4.6	0.9	4.5
	2	17-32	70.3	64	25	11	SL	20	5.4	4.0	1.4	4.5
	3	32-55	66.5	60	25	15	SL	21	5.4	4.0	1.4	7.0
P12	1	0-20	6.1	44	45	11	L	18	5.2	4.0	1.2	7.0

Note: Gravel content was measured at the time of soil preparation in the Project Area. The other items were analysed by Soils and Water Laboratory Services, NIA, Muñoz, Nueva Ecija.

* Containing clayey particles which become dispersed with water.

** Mainly composed of decayed wood pieces or peat.

TABLE D3-4 RESULTS OF LABORATORY ANALYSIS OF THE SOIL SAMPLES COLLECTED IN THE PROJECT AREA (I)-(2)

Pit No.	Layer No.	Depth cm	Gravel %	Particle Size Distribution Sand %	Silt %	Clay %	Texture	Soil Hardness	pH (H_2O) 1:2.5	pH (1N·KCl) 1:2.5	Difference	Exchange Acidity me/100g
P14	1	0-15	22.5*	49	35	16	L	18	5.1	4.2	0.9	8.5
	2	15-33	28.8*	58	21	21	SCL	24	4.9	3.9	1.0	9.6
	3	33-55	55.6*	51	24	25	SCL	21	5.1	4.0	1.1	11.1
P15	1	0-10	59.4*	46	34	20	L	16	5.5	4.7	0.8	10.1
	3	23-35	59.5*	39	26	35	CL	18	5.9	5.0	0.9	9.6
P18	1	0-12	50.7**	37	17	46	C	5	6.4	5.9	0.5	12.6
	2	12-45	41.6**	34	12	54	C	8	6.5	6.1	0.4	12.1
P25	1	0-12	5.0	68	24	8	SL	16	5.6	4.6	1.0	7.0
	2	12-32	1.4	68	18	14	SL	18	5.2	4.4	0.8	7.0
	3	32-56	21.0*	71	13	16	SL	21	5.5	3.9	1.6	5.5
P38	1	0- 7	0	48	44	8	L	17	5.3	4.8	1.4	5.5
	2	7-34	34.6*	48	31	21	L	19	5.3	4.7	0.6	7.0
	3	34-52	1.2	49	41	10	L	21	5.4	3.9	0.5	4.0
P40	1	0-18	24.3*	60	31	9	SL	18	5.2	4.1	1.1	5.5
	2	18-32	65.6	50	32	18	L	22	5.0	4.4	0.6	8.0
	3	32-70	58.1	57	21	22	SCL	22	5.2	4.5	0.7	8.0
	4	70-90	28.1*	44	29	28	CL	20	5.2	4.5	0.7	8.0
P45	1	0-19	0.5	54	34	12	SL	17	5.5	5.1	0.4	7.0
	2	19-43	4.8	44	34	22	L	18	5.1	4.5	0.7	7.0
	3	43-68	73.9	50	24	26	SCL	21	5.2	4.5	0.7	8.5

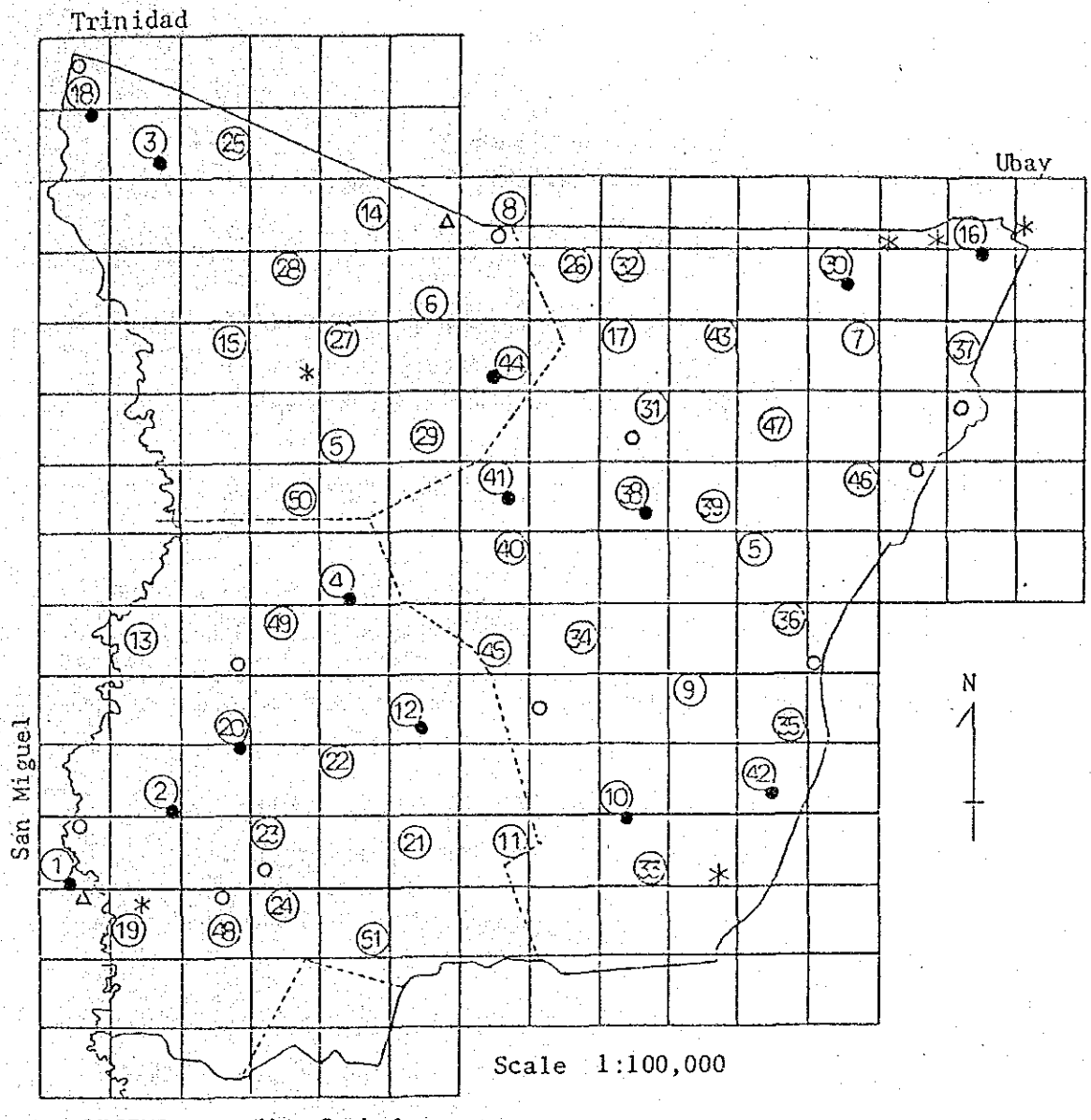
Note: Gravel content was measured at the time of soil preparation in the Project area. The other items were analysed by Soils and Water Laboratory Services, NIA, Muñoz, Nueva Ecija.
* Containing clayey particles which become dispersed with water.
** Mainly composed of decayed wood pieces or peat.

TABLE D3-5 RESULTS OF LABORATORY ANALYSIS OF THE SOIL SAMPLES COLLECTED IN THE PROJECT AREA (II)-(1)

Pit No.	Layer No.	Depth cm	Organic Matter %	Available Phosphorus ppm (Olsen)	Exchangeable Cations, me/100g					CEC me/100g	Base Saturation %
					K^+	Na^+	Ca^{++}	Mg^{++}	Total		
P 1	1	0-20	4.56	10.5	0.18	0.50	4.5	6.2	11.4	21.9	52
	2	20-61	2.84	6.5	0.19	0.49	9.0	13.1	22.8	35.8	64
	3	61-90	2.37	6.5	0.26	0.53	11.2	9.8	21.8	31.3	70
P 2	1	0-22	5.15	11.0	0.06	0.26	2.7	2.2	5.2	13.2	40
	2	22-40	3.96	7.0	0.03	0.26	3.4	2.6	6.3	15.4	41
	3	40-73	2.68	7.0	0.12	0.49	6.6	6.2	13.4	22.5	60
P 4	1	0-20	3.31	11.0	0.01	0.25	0.8	1.0	2.1	6.1	34
	2	20-65	2.76	9.5	0	0.28	1.3	1.0	2.6	4.5	57
P 6	1	0-22	3.39	7.0	0.05	0.28	2.7	2.3	5.3	11.9	45
	2	22-40	3.02	7.0	0.05	0.26	2.7	2.3	5.3	11.9	45
	3	40-65	2.55	7.0	0.08	0.30	4.3	5.7	10.4	20.4	51
P 9	1	0-15	4.53	11.5	0.03	0.20	1.6	1.2	3.0	10.0	30
	2	15-34	3.67	9.5	0.03	0.28	2.7	2.1	5.1	13.6	38
	3	34-65	3.52	6.5	0.15	0.42	7.5	8.4	16.5	29.5	56
P10	1	0-25	5.03	9.5	0.17	0.26	2.0	1.5	4.0	11.0	36
	2	25-52	4.58	9.5	0.02	0.27	1.9	0.8	3.0	11.1	27
	3	52-70	3.28	8.0	0.13	0.46	6.1	10.8	17.5	24.6	71
P11	1	0-17	5.52	10.5	0.05	0.20	1.3	2.0	3.6	8.1	44
	2	17-32	4.22	9.5	0.02	0.26	1.6	1.1	3.0	7.5	40
	3	32-55	4.19	7.0	0.03	0.28	4.4	3.6	8.3	15.3	54
P12	1	0-20	3.67	11.5	0.03	0.26	2.2	1.9	4.4	11.3	39

TABLE D3-5 RESULTS OF LABORATORY ANALYSIS OF THE SOIL SAMPLES COLLECTED IN THE PROJECT AREA (II)-(2)

Pit No.	Layer No.	Depth cm	Organic Matter %	Available Phosphorus ppm (Olsen)	Exchangeable Cations, me/100g					CEC me/100g	Base Saturation %
					K^+	Na^+	Ca^{++}	Mg^{++}	Total		
P14	1	0-15	5.13	10.5	0.14	0.30	4.3	4.4	9.1	17.8	51
	2	15-33	3.96	9.5	0.07	0.33	5.7	6.1	12.2	21.7	56
	3	33-55	3.90	8.5	0.11	0.31	6.9	7.5	14.8	25.9	57
P15	1	0-10	3.75	10.5	0.22	0.30	4.8	7.6	12.9	22.9	56
	3	23-35	3.26	9.0	0.18	0.51	7.6	16.8	25.1	34.7	72
P18	1	0-12	5.78	19.5	3.96	38.1	9.9	25.5	77.5	90.0	86
	2	12-45	5.78	13.0	4.35	44.3	9.3	27.4	85.4	97.4	88
P25	1	0-12	5.52	8.5	0.03	0.30	1.1	1.4	2.5	9.8	26
	2	12-32	5.34	7.5	0.01	0.28	1.0	0.8	2.1	9.2	23
	3	32-56	3.20	6.5	0	0.28	1.4	0.7	2.4	7.9	30
P38	1	0-7	3.91	12.5	0.02	0.29	1.6	1.0	2.9	8.4	35
	2	7-34	3.96	11.0	0.05	0.51	3.8	3.0	7.4	14.4	51
	3	34-52	3.02	8.5	0	0.31	1.8	0.9	3.0	7.1	42
P40	1	0-18	5.05	10.8	0.09	0.29	1.7	0.6	2.7	8.2	33
	2	18-32	4.92	9.0	0.02	0.47	2.6	1.5	4.6	12.6	37
	3	32-70	4.53	8.8	0.03	0.66	4.8	3.4	8.9	17.0	52
	4	70-90	3.02	8.8	0.08	0.68	8.9	6.4	16.1	24.1	67
P45	1	0-19	5.23	14.0	0.08	0.46	3.8	1.3	5.6	12.7	44
	2	19-43	4.50	11.0	0.06	0.52	4.6	3.5	8.7	15.6	56
	3	43-68	4.37	8.5	0.11	0.53	8.1	7.3	16.0	24.5	65



LEGEND: Map Symbols

(5) Soil Pit Number

● Groundwater
○ River Water
△ Pond or Marsh Water
✳ Well Water

FIGURE D3-1 SITES OF SOIL PIT EXAMINATION AND WATER SAMPLING IN THE PROJECT AREA

CHAPTER IV SOIL CHARACTERISTICS

General soil characteristics presented in this chapter are mainly described on the dominant soil types of Ubay Series. Because of its very small extent, the properties of the saline soil re referred to the following chapter. Some analytical data of the former soil surveys could be cited to compare with the results obtained by the present survey. Those data pertaining to the project area are summarized in TABLE D4-1 (1-3) and D4-2.

4.1 Soil Horizons and Structure Development

Soil horizons give in general a sequence of A, B and C tough the differentiation is not so distinct. In most cases C horizons consist of two or three deposits different in gravel content and texture.

Structure is weak to moderate, and medium to course blocky in A and B horizon; C horizons are mostly massive and very compact.

4.2 Soil Color, Texture and Gravel Content

Surface soil color (A) is gray to yellowish brown (10 YR when dry with almost no mottles except for the lowland or paddy field. Subsoil color (B) mostly becomes lighter but is endowed with common to abundant brownish mottles.

Substrate layers (C) have pale brown to yellowish brown basic color with abundant brownish to reddish brown mottles, assuming color mosaics. The covering wild grasses have supplied organic matter to the upper layers; The content ranges 1 to 5 percent.

Texture of the surface soil is sandy loam to loam. It becomes finer with the depth of subsoils but is not finer than clay loam or silty clay.

High gravel content is observed of almost all subsoils. It ranges 20 to 60 percent on air-dry weight basis of the soil. This is one of the soil deficiencies not only in reducing available soil depth but in causing soil compactness. In fact, majority of the subsoils are very hard, more than 20 in tester index. Some of the profiles have an extremely compact layer as hard as 24. The root growth is entirely impossible in such conditions since the index value more than 23 (10 kg/cm^2) was reported to check elongation of the rice roots (Takijima, Y., 1969) (Refer to TABLE D3-2 and D3-4).

4.3 Soil Reaction (pH) and Base Status

pH is an important indicator representing soil acidity in relation to base status of the soil. The results of present and recent analyses uniformly gave acidic reactions as low as pH 5.5 or so. TABLE D3-2 and D4-2 realize remarkably low pH as 4.0 or so when measured with 1N KCl solution. The average difference between these two measurements is about 1.6 excluding the saline soils. Considering together with high exchange acidity, the strong acidic reaction may suggest high percentage of exchangeable aluminum which will be harmful for plant growth.

Laboratory analysis (TABLE D3-5) clearly shows low contents of exchangeable bases other than hydrogen and aluminum, resulting in a low base saturation percentage. The shallower are the layers, the lower are the both values in a similar tendency as change in pH. Such base status can illustrate that a remarkable base elution has occurred through water percolation as well as water erosion under the rainy season. Very weak reaction of active manganese was observed while no visible effervescence of carbonate was detected throughout all the profiles.

4.4 Electrical Conductivity (EC)

Electrical conductivity of water extract of the soil reflects its content of soluble salts. Determination of EC is indispensable

in case of saline soils. So far as the field analysis is concerned, no questionable value of EC was found in view of salinity damage among the soils in the project area with the exception of those in the tidal flat areas. On the contrary, EC values seem too low to sustain the crop growth. These range 0.01 - 0.05 mmho at 25°C with 1:2.5 soil water ratio (TABLE D3-2).

4.5 Soil Fertility

Together with physical and chemical properties of the soil above mentioned, available nutrients such as nitrogen, phosphorus and potassium are related to the soil fertility.

As shown in the analytical results, nitrogen expressed as organic matter content appears not so deficient in the upper soil layers. Origin of the organic matter would be the thriving wild grass covers.

Available potassium and phosphorus are generally deficient or marginal according to the guidelines for fertility rating of soils (TABLE D4-3). In many of the paddy fields, rice plants assumed dark green color without any initiation of tillering after transplanted, indicating a typical phenomenon of phosphorus deficiency.

Zinc was also reported to be marginal by Bohol Agricultural Land Resources Appraisal Project (1980). Special care must be taken to this deficiency upon lime application to the fields.

4.6 Water Quality

TABLE D3-3 presents pH and EC of water samples collected from various sources. Salt concentrations expressed as EC are very low not only in groundwater but also river water excluding those from the tidal flat areas. Therefore, contrary to no trouble due to the salinity damage, there will be scarce possibility of receiving

nutrient bases from the irrigation water. Comparing with rivers in Phase I Area, these running into the project area are much lower in EC values ranging from 0.1 to 0.2 mmho, probably due to their origins in the non calcareous mountains.

TABLE D4-1 RECENT ANALYTICAL DATA OF THE SOIL SAMPLES IN THE PROJECT AREA (1)

1. Bureau of Soils, Region No. 7 (Fertilizer and Lime Recommendations for Rice, 1980)

Municipality	Barangay	Soil Type	pH (1:1)	OM,%	P,ppm	K,ppm	Rice Crop
San Miguel	Poblacion	Ubay Clay	6.2	2.1	16.7	79.7	HY∇
	San Isidro	"	5.4	2.0	8.1	89.7	"
	Bayongan	Ubay Sandy Loam	4.8	2.0	6.0	32.5	Local
	Bugang	Ubay Clay	5.1	1.7	6.2	56.2	HY∇
Ubay	Bayang	Ubay Clay Loam	5.0	1.4	9.4	61.5	HY∇
	"	"	5.3	1.7	12.6	68.1	Local
	Calangganan	"	5.6	1.2	2.3	39.0	HY∇
	Camalian	"	5.3	1.8	14.0	113.7	"
	Camambugan	"	5.0	1.5	7.2	39.4	"
	"	"	4.8	2.0	7.2	62.5	Local
	Gabi	Ubay Clay	5.4	1.4	11.4	52.4	HY ∇
	"	"	5.7	1.7	22.5	97.6	Local
	Lumangog	Ubay Sandy Loam	5.8	1.2	10.5	27.3	HY ∇
	Poblacion	"	5.3	2.0	7.4	37.5	"
	San Pascual	Ubay Clay	5.8	1.2	9.8	55.8	"
	"	"	5.9	1.2	5.1	125.3	Local
	Average:	Ubay Sandy Loam	5.3	1.7	8.0	32.4	
		Ubay Clay Loam	5.2	1.6	8.8	47.4	
		Ubay Clay	5.6	1.6	11.4	79.5	

Note: Figures indicate average values in each barangay samples

TABLE D4-1 RECENT ANALYTICAL DATA OF THE SOIL SAMPLES IN THE PROJECT AREA (2)

2. Bureau of Soils, Tagbilaran City, Region 7 (Fertilizer Recommendation, 1982-83)

Municipality	Barangay	Soil Type	pH (1:1)	OM,%	P,ppm	K,ppm	Lime ton/ha	kg/ha N	P	K
San Miguel	Bayongan	Ubay Sandy Loam	5.9	1.6	6.0	134.4	--	100	40	0
	Corazon	Ubay Clay	5.3	1.4	6.6	55.4	1	100	40	0
	Hagbuyo	"	5.0	1.7	6.2	72.0	1	100	40	0
Trinidad	Catoogan	Hydrosol	6.0	1.3	2.9	133.3	--	100	40	0
	Poblacion	Ubay Sandy Loam	5.6	2.7	7.6	193.3	--	80	20	0
	Soom	Ubay Clay	5.8	1.3	8.1	34.8	--	100	20	30
Ubay	Tubog	Ubay Sandy Loam	5.9	1.0	5.6	73.5	--	100	40	0
	Lumangog	"	5.9	1.0	8.0	29.5	--	100	20	45
	San Pascual	Ubay Clay	6.0	1.5	27.0	66.0	--	100	0	0
	Camambugan	Ubay Sandy Loam	5.2	1.8	8.0	36.6	1	100	20	30
	Gabi	Ubay Clay	5.3	2.6	5.9	86.0	1	80	40	0
	Calangganan	Ubay Sandy Loam	5.8	1.4	6.8	55.3	--	100	20	0
	Bayang	"	6.0	1.4	8.8	53.1	--	100	20	0
	Average:	Ubay Sandy Loam	5.8	1.5	7.3	82.2				
		Ubay Clay	5.6	1.6	9.5	74.5				

Note: Average soil test values in each barangay samples. Lime requirement and recommended nutrients are cited for dry season rice.

TABLE D4-1 RECENT ANALYTICAL DATA OF THE SOIL SAMPLES IN THE PROJECT AREA (3)

3. Bureau of Soils/UNDP/FAO (Technical Report 12, Bohol Agricultural Land Resources Appraisal Project, Philippines, 1980)

Soil Family	Pit No.	pH (1:1)	OM,%	P,ppm	Exch. K,meq	CEC meq	BSP %	Deficient Factors**	General Fertility Level
Typic Hydraquent	33*	6.8	10	21	2.6	100	87	--	Moderate
(Land System 1)	59*	6.6	8	53	1.2	79	91	--	High
	134*	5.8	5	19	1.6	78	91	--	High
	Average	6.4	8	31	1.8	86	90		
Ultic Tropudalf	137	5.4	3.3	Trace	0.16	19.2	52	pH,P,K,CEC	Moderate
Aeric "	139	4.8	0.43	Trace	0.12	14.8	38	pH,OM,P,K,CEC	Low
Typic Tropudult	147	5.8	2.5	Trace	0.07	10.6	52	OM,P,K,CEC	Low
(Land System 13)	176	5.3	2.4	Trace	0.06	10.9	50	pH,OM,P,K,CEC	Low
	Average	5.3	2.2	Trace	0.10	13.9	48		

Note: * Outside of the Project Area.
** Specific factors for upland crops are underlined.

TABLE D4-2 SOIL ACIDITY OF THE PROJECT AREA PRELIMENARILY TESTED BY AGRICULTURAL PROMOTION CENTER[1/]

Sample No.	Location (Land Use)	Layer No.	Depth cm	Texture	pH (H_2O) 1:2.5	pH (N·KCl) 1:2.5	Difference
7	S. Vecente, Trinidad* (UL)	1	0-11	SL	5.1	3.8	1.3
		2	11-23	SL	5.0	4.0	1.0
		3	23-	SL	5.3	4.6	0.7
9	Camanbugan, Ubay* (UL)	1	0-10	SL	5.9	5.0	0.9
		2	10-16	SL	5.7	4.2	1.5
10	Ilabod, Trinidad* (GL)	1	0-10	CL	5.4	3.8	1.6
		2	10-16	LiC	5.3	3.9	1.4
		3	16-	LiC	5.5	3.8	1.9
20	S. Vicente, San Miguel (UL)	1	0-20	SiCL	6.2	3.9	2.3
		2	20-	SiCL	5.4	3.8	1.6
21	" (Pr)	1	0-20	CL	5.4	4.5	0.9
22	Corazon, San Miguel (GL)	1	0-20	SiCL	6.0	4.1	1.9
		2	20-	SiCL	5.8	3.9	1.9
23	Bulilis, Ubay (Co)	1	0-20	SCL	5.8	4.1	1.7
24	APC Field (New PrI)	1	0-20	SCL	5.6	3.8	1.8
32	Mahayag, San Miguel (GL)*	1	0-13	SL	5.6	4.0	1.6
		2	13-24	CL	5.7	3.8	1.9
33	Camanaga, San Miguel (GL)*	1	0- 5	SL	5.6	4.0	1.6
		2	5-11	SL	5.4	3.9	1.5
34	Garcia, San Miguel (GL)*	1	0- 8	SL	5.3	3.7	1.6
		2	8-18	L	5.0	3.7	1.3
35	La Union, Trinidad (GL)	1	0-10	L	5.1	3.8	1.3
		2	10-16	L	5.3	3.8	1.5
36	Mahagbu, Trinidad (GL)	1	0-12	L	6.1	4.1	2.0
		2	12-24	CL	6.1	4.1	2.0
	Average in Texture			SL-L	5.4	3.8	1.6
				SCL-Lie	5.7	4.0	1.7

Note: 1/ Private letter from Dr. K. Shiraishi, Japanese Expert at APC.
* Outside of the Project Area.

TABLE D4-3 GENERAL GUIDELINES FOR THE FERTILITY RATING OF SOILS

Soil Fertility Factor	Soil Fertility Rating	Adequate (favorable)	Marginal (moderately unfavorable)	Deficient (unfavorable)
pH (H_2O 1:1)		5.5 - 8.5	5.0 - 5.5	<5.0 - >8.5
Base saturation percentage	(%)	>35	20 - 35	< 20
Cation exchange capacity	(meq/100 g soil)	>20	10 - 20	< 10
Organic matter content	(%)	>1 - >3[1/]	--	< 1 - <3[1/]
Exchangeable potassium	(meq/100 g soil)	>0.25	0.15 - 0.25	< 0.15
Available phosphorus	(ppm)	>10 - 20[1/]	6 - 10 6 - 20[1/]	<6
Zinc	(ppm)	>1.5 - 1.00[1/]	0.5 - 1.5 0.5 - 1.0[1/]	< 0.5

Note:

Rating: High--four factors are high or adequate, one is marginal
Medium--two or more factors are marginal, one or none is low
Low--two or more factors are low

1/: Limits applicable for dryland crops

CHAPTER V SOIL CLASSIFICATION

5.1 Classification in Higher Categories

In 1972, Bureau of Soils published for the first time a nation-wide soil map by adopting the USDA-Soil Conservation Service System (1970). FIGURE D5-1 is a copy from the original map showing the soils of Bohol province together with those of adjacent islands.

Five soil orders in the highest categories are identified in the map. Among them three orders are included in Bohol island. Majors are ALFISOLS and ULTISOLS; both have subsurface horizons of clay accumulation but are different in base supply and moisture conditions. ULTISOLS to which soils of the project area belong are much lower in base saturation and less humid. VERTISOLS developed in a small extent on the northwest side are characterized by high content of swelling clays and deep wide cracks.

Meanwhile, Soil Map of the World has been published by FAO/UNESCO (1978) compiling great soil groups of each country into the universal soil units under newly united soil taxonomy. Although the soil boundaries of both maps are almost same, correlations between the soil group and unit are arranged as follows:

USDA System			FAO/UNESCO System	
Order	Sub-order	Great Group	Soil Unit	Map Symbol
ALFISOLS	Udalfs	Tropudalfs	Orthic Luvisols	Lo 68-2/3a
INCEPTISOLS	Tropepts	Eutropepts	Gleyic Cambisols	Bg 8-2/3a
ULTISOLS	Udults	Tropudults	Dystric Nitosols	Nd 66-2/3b
VERTISOLS	Usterts	Pellusterts	Pellic Vertisols	Vp 65-3a

5.2 Classification in Lower Categories

5.2.1 Results of the Former Soil Survey

Back to 1947, the first soil survey report for Bohol province was issued by Bureau of Soils. This report described the soils on

the level of soil series and type. Two soil series, Hydrosol (1) and Ubay, and two types of Ubay Series, Sandy Loam (224) and Clay (173) were identified as shown in FIGURE D5-2.

Lately in 1980, Bohol Agricultural Land Resources Appraisal Project conducted the soil survey on the semi-detailed level. The report illustrated up to the level of great soil group expressed as Land System without further division of the soils.

5.2.2 Results of Present Soil Survey

a) Soil Series and Types

In the present survey, two soil series and four soil types were identified.

Hydrosol name of which was taken from the original report is not a soil series but miscellaneous land type. The soils have AC horizons formed on the alluvium of three rivers draining to Camotes Sea. C horizon contains abundant mangrove or nipa peats. EC is extremely high as 10 to 23 mmhos with water extracts (1:2.5). Therefore, this type can be classified into Solontchaks in the universal system. The lands of this type are quite inadequate for any agricultural purpose unless soluble salts are removed by leaching. While, Ubay series is the largest group of soils, covering about one third of Bohol Island and almost 98 percent of the project area, too.

As mentioned in the foregoing chapters, Ubay series is characterized by slightly coarse-textured surface soil underlaid by loamy or clayey but gravelly subsoils. The soils have been developed on the dilluvial deposits and undergone long period of leaching and erosion, resulting in different types of ABC horizon sequence. These were thus classified into two soil types, Ubay Sandy Loam and Ubay Loam according to the dominant texture of the

top soil. Ubay Loam is a soil type newly established this time because Ubay Clay type has not been detected during the present survey. Ubay Loam was further divided into two groups, type 1 and type 2. Type 1 is considered an intermediate type between Ubay Sandy Loam and Loam. The columnar diagram of FIGURE D5-3 illustrates the typical profile of each soil type. The other profiles are arranged typewise in FIGURE D5-4.

b) Profile Descriptions

Four soil type profiles illustrated in FIGURE D5-3 are formally described as follows:

PROFILE No. P18

I. Information on the Site

a.	Profile No.	: P18
b.	Soil Name	: Hydrosol (Solontchaks)
c.	Date of Examination	: Feb. 4, 1985
d.	Location	: Guinobatan, Trinidad, about 1 km south of the national road from Ubay
e.	Elevation	: 1.4 m
f.	Land Form and Slope	: Flat and wet alluvial land
g.	Vegetation and Land-use	: Nipa palms, moderately growing

II. General Information on the Soil

a.	Parent Material	: Coastal alluvium
b.	Drainage	: Very poor
c.	Depth of Groundwater	: 25 cm but at the time of low tide
d.	Presence of Surface Stones, Others	: No stone but many of decayed wood and and peat pieces
e.	Evidence of Erosion	: Almost none

III. Profile Description

A1 0 - 12 cm : Very dark brown (7.5YR 2/1) moist, very dark grayish brown (2.5Y 2/1) dry, clay; structureless; non-sticky, slightly plastic, friable (5) moist; no distinct mottle; abundant peat or decayed timber pieces common nipa roots; abrupt smooth boundary; pH 6.4 (Sample No. P18-1)

B2g 12 - 45 cm : Black (10YR 2/1) wet, very dark grayish brown (2.5Y 3/1) dry, clay; almost massive structure; slightly sticky, slightly plastic, friable (8) wet; no mottle but distinct reaction of ferrous iron with chemical reagent; many peat and decayed timber pieces dark in color; few nipa roots; abrupt smooth boundary; pH 6.5 (Sample No. P18-2)

Cp 45 - 140 cm+: Black (10YR 2/1) wet, sandy clay loam; structureless (peaty layer); non-sticky, non-plastic, loose (4) wet; extremely abundant nipa peats with ferrou iron reaction; almost no root (Not sampled)

Groundwater: 25 cm from the soil surface; pH 6.74; EC 32.0 mmhos/cm, 25°C

PROFILE No. P10

I. Information on the Site

a. Profile No.	:	P10
b. Soil Name	:	Ubay Sandy Loam
c. Date of Examination	:	Jan. 31, 1985
d. Location	:	Gabi, Ubay, middle of the hill slope, the right side of the road to BPI Experimental Station, about 2.7 km northwest of the national road from Ubay to Pilar.
e. Elevation	:	35 m
f. Land Form and Slope	:	Terrain, very gently sloping (2%) towards northeast.
g. Vegetation and Land-use	:	Tropical grassland (common Amorsilco-- acidity-tolerant graminaceous plant)

II. General Information on the Soil

a. Parent Material	:	Coarse dilluvium derived from sedimentary and igneous rocks
b. Drainage	:	Moderately well
c. Depth of Groundwater	:	90 cm
d. Presence of Surface Stones, Others	:	Very few small gravels
e. Evidence of Erosion	:	Slight under heavy rainfall

III. Profile Description

A 0 - 25 cm : Dark brown (7.5YR 3/3) moist, light gray (10YR 7/2) dry, sandy loam; weak medium angular blocky; non-sticky, non-plastic, friable but hard (17) moist; no mottle; few small round hard gravels; many fine roots; abrupt smooth boundary; pH 5.2 (Sample No. P10-1)

B 25 - 52 cm : Dark brown (7.5YR 4/4) moist, pale brown (10YR 6/3) dry, sandy loam; very wek coarse blocky; non-sticky, non-plastic, very hard (20) moist; common brownish yellow mottles; very frequent small round hard gravels (0.2 - 1.0 cm in diameter); few fine roots; abrupt smooth boundary; pH 5.2 (Sample No. P10-2)

C1 52 - 70 cm : Yellowish brown (10YR 5/4) moist, grayish brown (2.5Y 5/2) dry, sandy clay loam; almost massive structure; slightly sticky, slightly plastic, hard (15) moist; common brownish yellow mottles; very frequent small round hard and soft gravels (0.2 - 3.0 cm); no root; abrupt smooth boundary; pH 5.4 (Sample No. P10-3)

C2 70 - 95 cm+: Light yellowish brown (10YR 6/4) wet, clay loam; massive structure; very sticky, plastic, very hard (22) moist; many strong brown (7.5YR 5/6) mottles; few small hard gravels (Not sampled)

Groundwater: 90 cm from the soil surface; pH 6.26; EC 0.034 mmhos/cm, 25°C

PROFILE No. P40

I. Information on the Site

a. Profile No. : P40

b. Soil Name : Ubay Loam (Type 1)

c. Date of Examination : Feb. 12, 1985

d. Location : Camalian, Ubay, middle of the hill slope, about 4.5 km south of the Soom River bridge on Ubay-Trinidad national road

e. Elevation : 25 m

f. Land Form and Slope : Terrain, very gently sloping (1%) towards northeast

g. Vegetation and Land-use: Tropical grassland dominated by Cogon in moderately good growth

II. General Information on the Soil

a. Parent Material : Coarse and medium dilluvium derived from sedimentary and igneous rocks

b. Drainage : Well

c. Depth of Groundwater : Below profile at the time

d. Presence of Surface Stones, Others: Almost none

e. Evidence of Erosion : Slight under heavy rainfall

III. Profile Description

A 0 - 18 cm: Dark yellowish brown (10YR 3/4) moist, yellowish brown (10YR 5/4) dry, sandy loam; weak coarse angular blocky; non-sticky, non-plastic, very hard (18) moist; few mottles; few small round soft and hard gravels; many fine roots; abrupt smooth boundary; pH 5.2 (Sample No. P40-1)

B2 18 - 32 cm: Dark yellowish brown (10YR 4/6) moist, brown (10YR 5/3) dry, loam; very weak very coarse granular; sticky, plastic, very hard (22) moist; common brownish yellow filmy mottles; very frequent small round hard gravels (0.2 - 1.0 cm); few fine roots; clear smooth boundary; pH 5.0 (Sample No. P40-2)

C1 32 - 70 cm: Yellowish brown (10YR 5/6) moist, very pale brown (10YR 7/4) dry, Sandy Clay Loam; almost massive structure; very sticky, very plastic, very hard (22) moist; many strong brown filmy mottles (7.5YR 5/6); very frequent small round, irregular soft and hard gravels; no root; clear smooth boundary; pH 5.2 (Sample No. P40-3)

C2 70 - 90 cm+: Light yellowish brown (10YR 6/4) moist, brownish yellow (10YR 6/6) dry, clay loam; massive structure; very sticky, very plastic, very hard (20) moist; many strong brown filmy mottles; frequent round, irregular soft gravels including weathered shale or sand stone gravels; pH 5.2 (Sample No. P40-4)

PROFILE No. P2

I. Information on the Site

a. Profile No.	:	P2
b. Soil Name	:	Ubay Loam (Type 2)
c. Date of Examination	:	Jan. 29, 1985
d. Location	:	San Vicente, San Miguel, middle of the terrain slope, about 2.5 km east of San Miguel Municipality
e. Elevation	:	27 m
f. Land Form and Slope	:	Undulating dilluvial terrain, sloping (3%) towards east
g. Vegetation and Land-use	:	Tropical grassland dominated by Cogon in moderately good growth.

II. General Information on the Soil

a. Parent Material	:	Medium dilluvium derived from sedimentary rocks
b. Drainage	:	Well
c. Depth of Groundwater	:	>85 cm, just below profile
d. Presence of Surface Stones, Others	:	Almost nil
e. Evidence of Erosion	:	Slight under heavy rainfall

III. Profile Description

A 0 - 22 cm: Dark brown (10YR 3/3) moist, light gray (10YR 7/2) dry, loam; weak medium blocky; slightly sticky, slightly plastic, hard (17) moist; almost no mottle; few small round gravels; many fine roots; clear smooth boundary; pH 5.3 (Sample No. P2-1)

22 - 40 cm: Dark yellowish brown (10YR 4/5) moist, pale brown (10YR 6/3) dry, loam; weak coarse blocky; sticky, plastic, hard (17) moist; few brownish yellow mottles; frequent small round soft and hard gravels (0.2 - 1.0 cm); few fine roots; abrupt smooth boundary; pH 5.3 (Sample No. P2-2)

40 - 73 cm: Yellowish brown (10YR 5/6) moist and dry, sandy clay loam; massive structure; sticky, plastic, very hard (18); many yellowish red (5YR 5/8) filmy mottles; very frequent small round soft and hard gravels; no root; clear smooth boundary; pH 5.3 (Sample No. P2-3)

73 - 85 cm+: Yellowish brown (10YR 5/6) moist, clay loam; massive structure; very sticky, very plastic, very hard (18); many yellowish red filmy mottles; few weathered shale and sand stone gravels (Not sampled)