ON JAPAN'S GRANT AID PROGRAM

1.Japan's Grant Aid Procedures

(1) The Japan's Grant Aid Program is executed by the following procedures.
- Application (request made by a recipient country)
- Study (Preliminary Study / Basic Design Study conducted by JICA)
- Appraisal & Approval (Appraisal by the Government of Japan and Approval by the Cabinet of Japan)
- Determination of Implementation (Exchange of Notes between both Governments)
- Implementation (Implementation of the Project)

(2) Firstly, an application or a request for a project made by the recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to see whether or not it is suitable for Japan's grant Aid. If the request is deemed suitable, the Government of Japan entrusts a study on the request to JICA (Japan International Cooperation Agency).

Secondly, JICA conducts the Study (Basic Design Study), using a Japanese consulting firm. If the background and objective of the requested project are not clear, a Preliminary Study is conducted prior to a Basic design Study.

Thirdly, the Government of Japan appraises to see whether or not the Project is suitable for Japan's Grant Aid Program, based on the Basic Design Study report prepared by JICA and the results are then submitted for approval by the Cabinet.

Fourthly, the Project approved by the Cabinet becomes official when pledged by the Exchange of Notes signed by both Governments.

Finally, for the implementation of the Project, JICA assists the recipient country in preparing contracts and so on.

2. Contents of the Study

(1) Contents of the Study

The purpose of the Study (preliminary Study / Basic Design Study) conducted on a project requested by JICA is to provide a basic document necessary for appraisal of the project by the Japanese Government. The contents of the Study are as follows:

a) to confirm background, objectives, benefits of the project and also institutional capacity of agencies concerned of the recipient country necessary for project implementation.
b) to evaluate appropriateness of the Project for the Grant Aid Scheme from a technical, social and economical point of view,
c) to confirm items agreed on by both parties concerning a basic concept of the project,
d) to prepare a basic design of the project,
e) to estimate cost involved in the project.

Final project components are subject to approval by the Government of Japan and therefore may differ from an original request.

Implementing the project, the Government of Japan requests the recipient country to take necessary measures involved which are itemized on Exchange of Notes.

(2) Selecting (a) Consulting Firm(s)

For smooth implementation of the study, JICA uses (a) consulting firm(s) registered. JICA selects (a) firm(s) through proposals submitted by firms which are interested. The firm(s) selected carry(its) out a Basic Design Study and write(s) a report, based upon terms of reference made by JICA.

The consulting firm(s) used for the study is(are) recommended by JICA to a recipient country after Exchange of Notes, in order to maintain technical consistency and also to avoid possible undue delay in implementation caused if a new selection process is repeated.

(3) Status of a Preliminary Study in the grant Aid Program

A Preliminary Study is conducted during the second step of a project formulation & preparation as mentioned above.

A result of the study will be utilized in Japan to decide if the Project is to be suitable for a Basic Design Study.

Based on the result of the Basic Design Study, the Government would proceed to the stage of decision making process (appraisal and approval).

It is important to notice that at the stage of Preliminary Study, no commitment is made by the Japanese side concerning the realization of the Project in the scheme of Grant Aid Program.

3. Japan's Grant Aid Scheme

(1) What is Grant Aid?

The Grant Aid Program provides a recipient country with non reimbursable funds needed to procure facilities, equipment and services for economic and social development of the country under the following principles in accordance with relevant laws and regulations of Japan. The Grant Aid is not in a form of donation or such.

(2) Exchange of Notes (E/N)

The Japan's Grant Aid is extended in accordance with the Exchange of Notes by both Governments, in which the objectives of the Project, period of execution, conditions and amount of the Grant, etc. are confirmed.

(3) "The period of the Grant Aid" means one Japanese fiscal year which the Cabinet approves the Project for. Within the fiscal year, all procedure such as Exchange of Notes, concluding a contract with (a) consulting firm(s) and (a) contractor(s) and a final payment to them must be completed.

(4) Under the Grant, in principle, products and services of origins of Japan or the recipient country are to be purchased.
When the two Governments deem it necessary, the Grant may be used for the purchase of products or services of a third country origin.
However the prime contractors, namely, consulting, contractor and procurement firms, are limited to "Japanese nationals". (The term "Japanese nationals" means Japanese physical persons or Japanese juridical persons controlled by Japanese physical persons.)

(5) Necessity of the "Verification"

The Government of the recipient country or its designated authority will conclude into contracts in Japanese yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. The "Verification" is deemed necessary to secure accountability to Japanese tax payers.

(6) Undertakings required to the Government of the recipient country

In the implementation of the Grant Aid, the recipient country is required to undertake necessary measures such as the following'

a) to secure land necessary for the sites of the project and to clear and level the land prior to commencement of the construction work,

b) to provide facilities for distribution of electricity, water supply and drainage and other incidental facilities in and around the sites,

c) to secure buildings prior to the installation work in case the Project is providing equipment,

d) to ensure all expenses and prompt execution for unloading, customs clearance at the port disembarkation and internal transportation of the products purchased under the Grant Aid,

e) to exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts,

f) to accord Japanese nationals whose services may be required in connection with the supply of the products and services under the Verified Contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.

(7) Proper Use

The recipient country is required to maintain and use facilities constructed and equipment purchased under the Grant Aid properly and effectively and to assign staff necessary for their operation and maintenance as well as to bear all expenses other than those to be borne by the Grant Aid.

(8) Re-export

The products purchased under the Grant Aid shall not be re-exported from the recipient country.

(9) Banking Arrangement (B/A)

a)The Government of the recipient country or its designated authority shall open an account in the name of the Government of the recipient country in an authorized foreign exchange bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by Government of the recipient country or its designated authority under the contracts verified.

b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an Authorization to pay issued by the Government of the recipient country or its designated authority.

d.
A

ANNEX-II

NECESSARY MEASURES TO BE TAKEN BY THE GOVERNMENT OF VIETNAM IN CASE JAPAN'S GRANT AID IS EXTENDED.

1.To provide data and information necessary for the Project.

2.To secure the site for the Project.

3.To bear two kinds of commissions to the Japanese foreign exchange bank for its banking services based upon the Banking Arrangement (B/A) namely,
- the advising commission of the "Authorization to Pay (A/P)" and
- the payment commission.

4.To ensure prompt unloading, tax exemption, and customs clearance at the port of disembarkation in Vietnam and prompt internal transportation therein of the materials and equipment for the project purchased under the Grant Aid.

5.To exempt Japanese nationals or a staff from a third country engaged in the project from customs duties, internal taxes and other fiscal levies which may be imposed in Vietnam with respect to the supply of the products and services under the verified contracts.

6.To accord Japanese nationals or a staff from a third country whose services may be required in connection with supply of the products and services under the verified contracts, such facilities as may be necessary for their entry into Vietnam and stay therein for the performance of their work.

7.To provide necessary permissions,licenses, and other authorization for implementing the Project, if necessary.

8.To assign appropriate budget and staff members for proper and effective operation and maintenance of the facilities constructed under the Project.

9.To maintain and use properly and effectively the facilities constructed and equipment provided under the Project;

10.To bear all the expenses other than those to be borne by the Grant Aid within the scope of the Project.

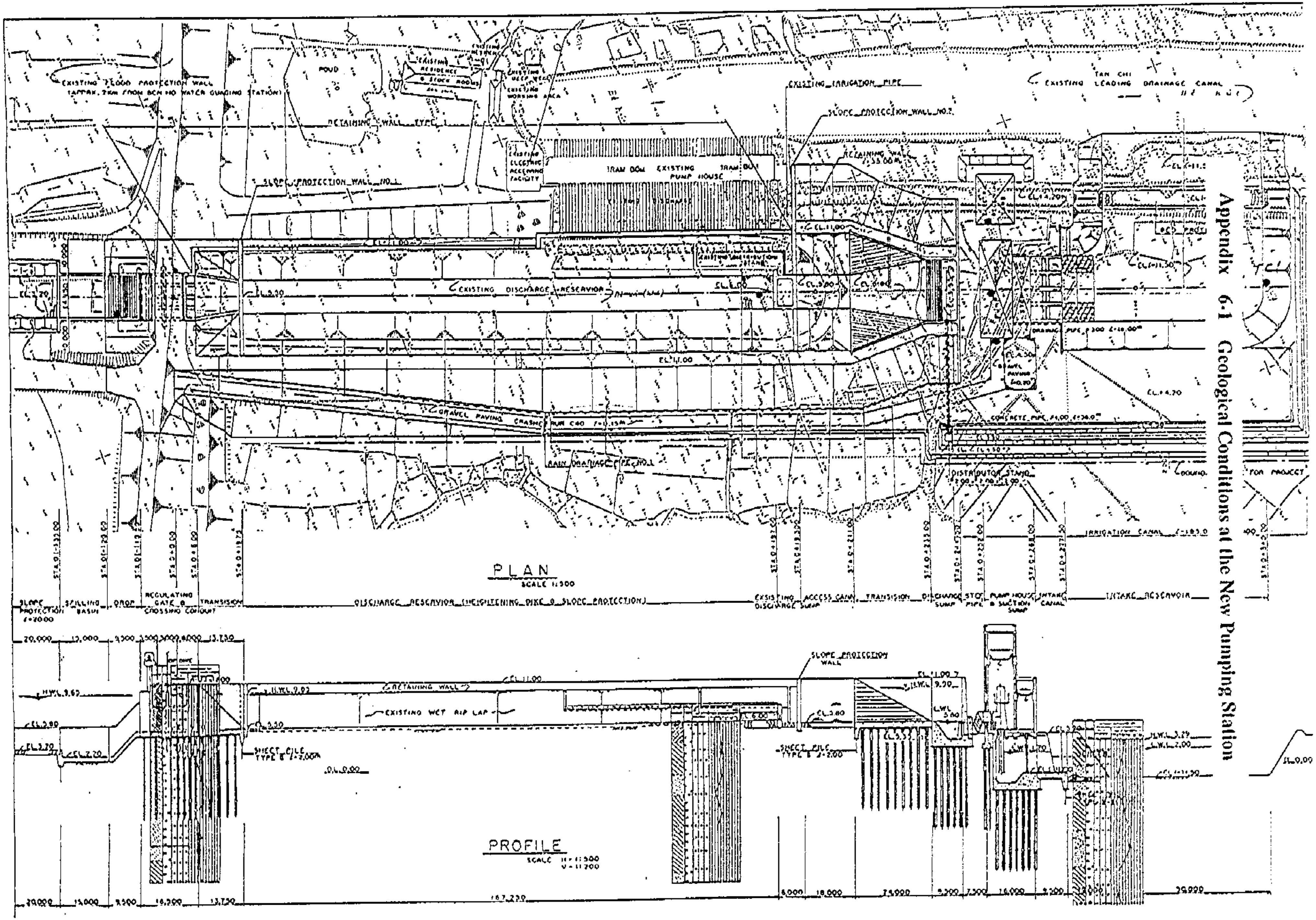
Appendix 5 Cost Estimation Borne by the Receipt Country

(Unit : million dong)

Item	Without the Scope of G.A. Project				Within the Scope of G.A. Project				Grand Total
	Qnt.	Unit	Unit Price	Price.	Qnt	Unit	Unit price	Price	
1. Construction Cost									
1)Direct Construction Cost	1	L.S.	33,724	33,730	0	L.S.	0	0	33,730
2)Common Temporary Work	1	L.S.	3,620	3,620	0	L.S.	0	0	3,620
3)Site Expenditure	1	L.S.	13,541	13,550	0	L.S.	0	0	13,550
4)Over Head	1	L.S.	3,372	3,380	0	L.S.	0	0	3,380
Sub Total				54,280					54,280
2. Association Cost									
1)Land Acquisition Cost	7.5	Ha	153	1,150	2.5	Ha	153	390	1,540
2)Banking Commission	0	L.S.		0	1	L.S.		120	120
3)Rehabilitation of Electric line to New P.S	0	L.S.		0	1	L.S.		1,410	1,410
4)Electric Receiving Facilities	0	L.S.		0	1	L.S.		50	4,000
5)Access Road to New Pumping Station	0	L.S.		0	1	L.S.		240	240
6)Custom Clearance and Inland Transportation	0	L.S.		0	1	L.S.		50	50
Sub Total				1,150				2,260	3,410
3.Grand Total				55,430				2,260	57,690

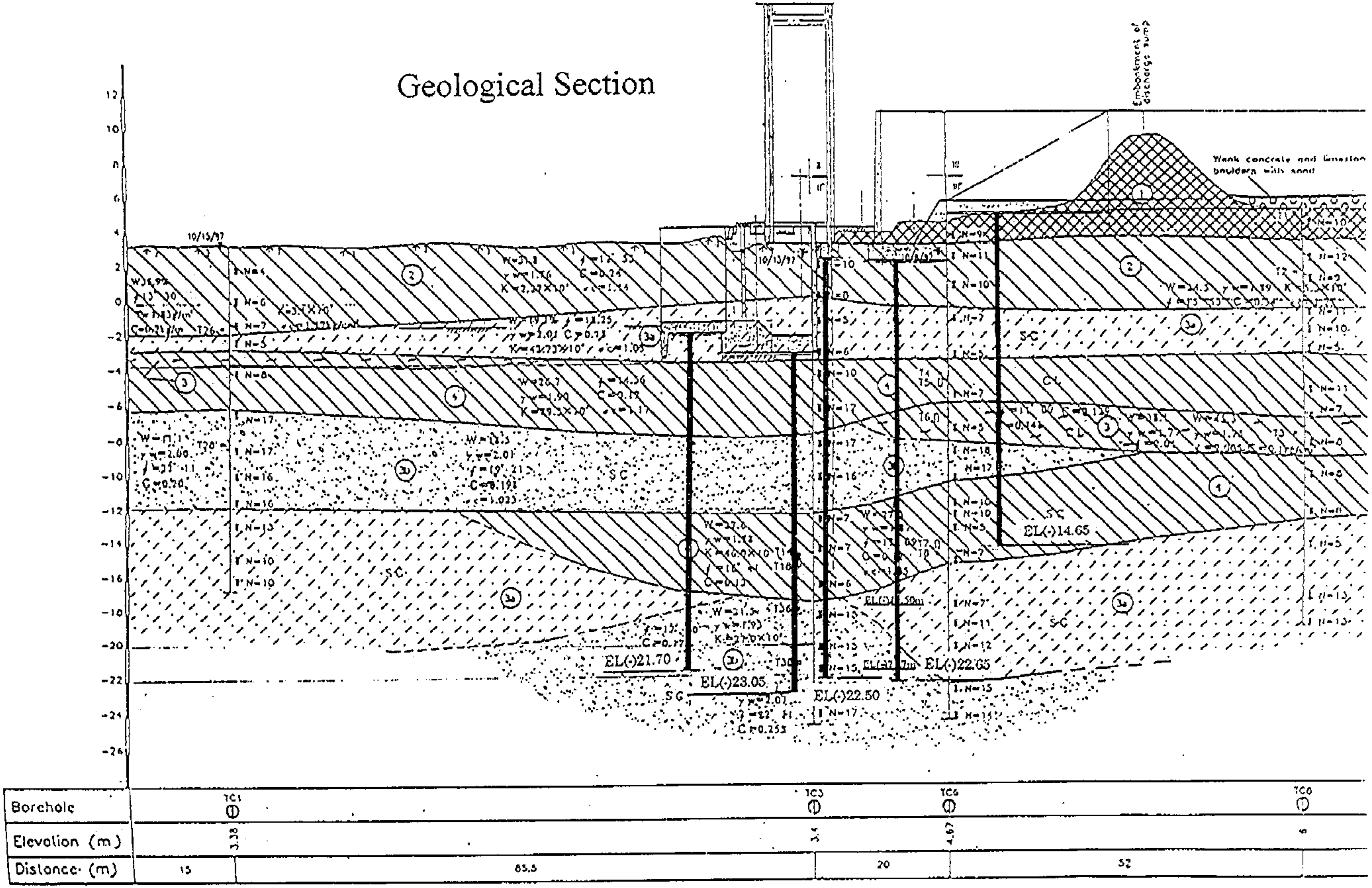
Direct Construction Cost (Unit :million dong)

1. Direct Construction Cost	
(1) Crossing Structures of Main Drainage Canal	
①Tram Bridge	5,407
②No.6 Elevated Flume	0
③Dong Mai Bridge	2,388
Sub Total	7,795
(2) Crossing Structures of Secondary Canal	
(3) Rehabilitation of Drainage Canal	
①Main Drainage Canal	11,445
②Secondary Canal	13,947
Sub Total	25,392
Total	33,187
2. Direct Temporary Construction Cost	
(1) Crossing Structures of Main Drainage Canal	240
(2) Crossing Structures of Secondary canal	0
(2) Rehabilitation of Drainage Canal	297
Sub Total	537
3. Grand Total	33,724



Appendix 6-1 Geological Conditions at the New Pumping Station

Geological Section



HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1(HEC-1)

BOREHOLE LOG

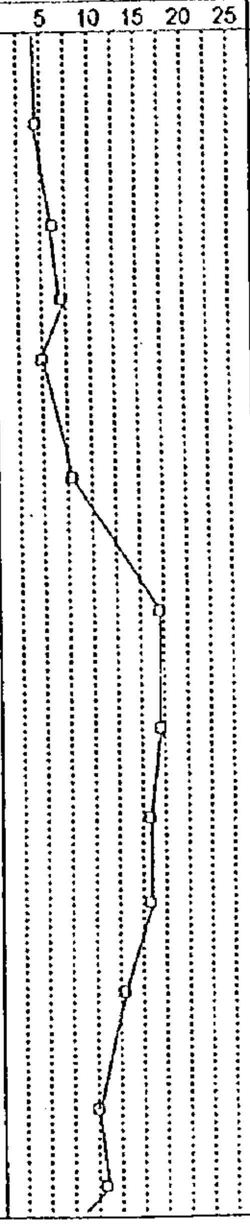
HEC

Project :	IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM	Coordinate X =	33 209.355
Location :	SUCTION SUMP	Y =	11 920.507
Borehole :	TC 1	GWL /date :	
Depth (m) :	20.00	Appeared :	
Elevation :	3.38	Stabilized :	3.48 / 10/15/97

Commenced : Oct 13th, 97
Completed : Oct 13th, 97
Logged by TRAN HOANG LAN
Checked : GIAP DUC TINH
Sheet .1. .of .1. .

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Legend 1:100	Depth (m)	Standard Penetration Test – Nos of blows/10cm			Core recovery percentage (%)	Sample type	Drilling method
Top cultivation soil (0.0 - 0.30 m) Lean CLAY (CL): Brownish and yellowish to whitish grey; moist, firm, plastic.			1	1	2	100		Φ 110
Fat CLAY (CH): Brownish to whitish grey, wet, soft - firm, highly plastic.			2	2	2			Drilling with alloy bit Φ 91 mm
		5.1	2	1	1		T 26	
Clayey SAND (SC): Fine grained, grey to blackish grey; saturated, loose.		6	2	1	2			
Fat CLAY (CH): Blackish grey to grey, rarely organic matters; moist, soft, plastic.		6.9						
Lean CLAY with sands (CL): Reddish brown to yellowish and bluish grey; moist, firm - stiff, plastic.		9.4	2	3	3			
Clayey SAND (SC): Fine to medium grained with some small gravels, brown and yellowish to brownish grey; saturated, medium dense.			5	6	6		T 28	
			5	6	6			
			5	5	6	60		
		15.1	5	5	6			
Clayey SAND (SC): Grey and brownish grey, with some thin clay lenses; saturated, medium dense.			4	4	5	100		
			3	3	4			
Bottom at 20 m		20	3	4	4			

Nos of blows/30cm



Remark :

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°II (HEC II)

BOREHOLE LOG

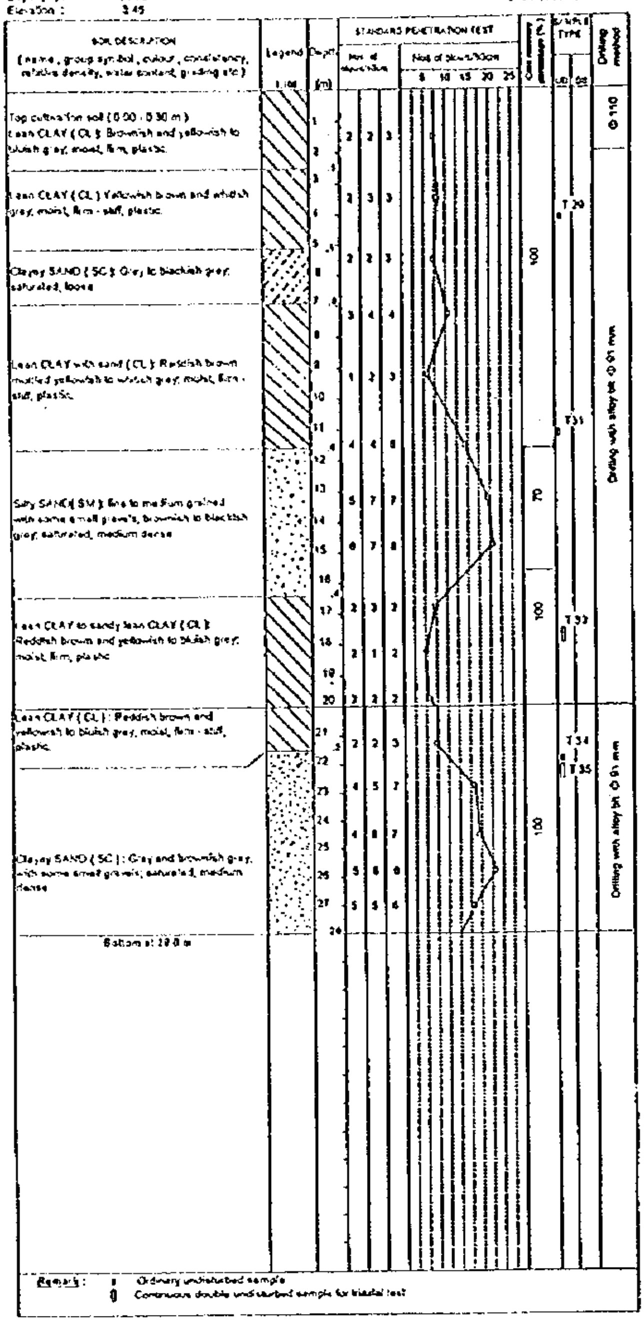
HEC

Project : IMPROVEMENT OF TAN OH DRAINAGE SYSTEM
Location : PUMPING STATION
Borehole : TC 2
Depth (m) : 28.00
Elevation : 3.45

Coordinate X = 33 118 750 Y = 11 838 053
GWL Date :
Appeared :
Stabilized : 2.95 (10/15/07)

Commenced : Oct. 11th, 07
Completed : Oct. 12th, 07
Logged by : TRAN HOANG LAM
Checked : BUI DUC THAI

Sheet 1 of 2



HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°II (HEC II)

BOREHOLE LOG

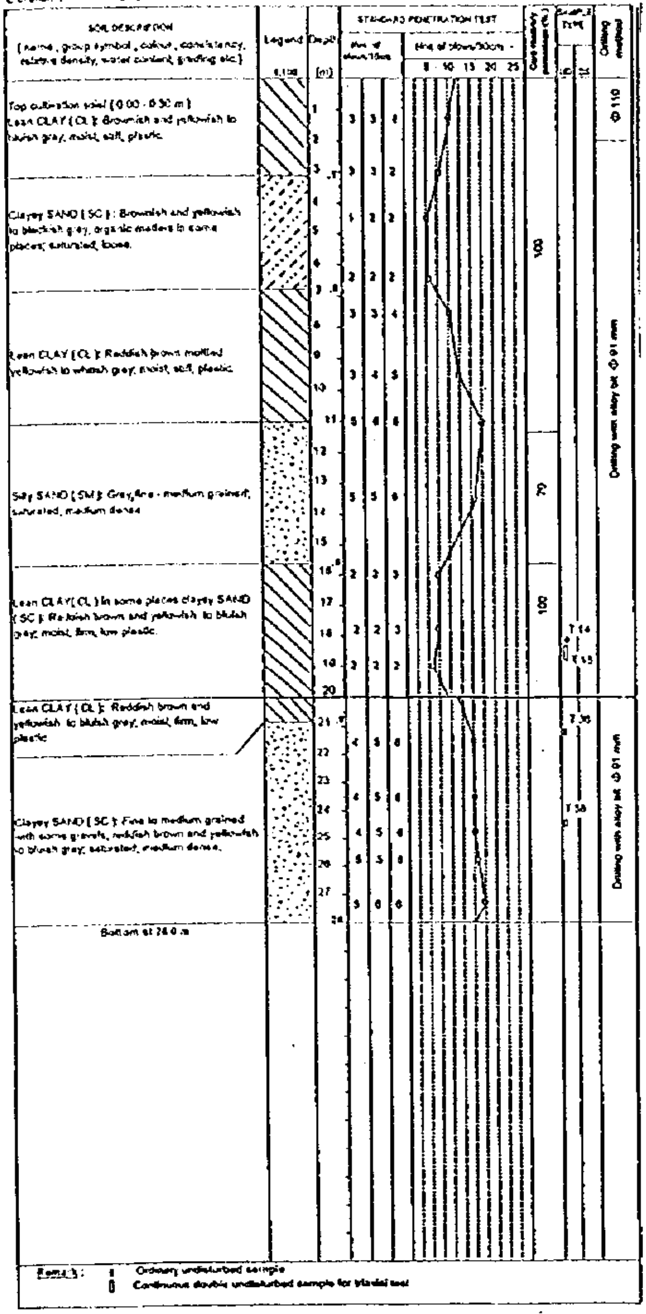
HEC

Project : IMPROVEMENT OF TAN OH DRAINAGE SYSTEM
Location : PUMPING STATION
Borehole : TC 3
Depth (m) : 28.00
Elevation : 3.40

Coordinate X = 33 127 532 Y = 11 846 127
GWL Date :
Appeared :
Stabilized : 3.80 (10/13/07)

Commenced : Oct. 8th, 07
Completed : Oct. 10th, 07
Logged by : TRAN HOANG LAM
Checked : BUI DUC THAI

Sheet 1 of 2



HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1 (HEC-1)

BOREHOLE LOG

HEC

Project : IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM
Location : PUMPING STATION
Borehole : TC 4
Depth (m) : 28.00
Elevation : 3.15

Coordinate X = 35 134 320
Y = 11 877 682
GWL Water :
Appeared :
Stabilized : 2.88 /10/ 11/97

Commenced : Oct. 7th, 97
Completed : Oct. 8th, 97
Logged by : TRAN HOANG LAN
Checked : QUY DUC THI

Sheet 1 of 2.

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc)	Depth to base (m)
Top cultivation soil (0.00 - 0.30 m). Lean CLAY (CL): Brownish and yellowish to bluish grey, moist, stiff, plastic.	4.4
Clayey SAND (SC): Brownish and yellowish bluish grey, saturated, loose.	7.8
Lean CLAY (CL): Reddish brown mottled yellowish to whitish grey, rare laterite; moist, stiff - firm, plastic.	10.7
Lean CLAY (CL): Blackish grey to grey with a little organic matter, moist, soft, plastic.	12.8
Silty SAND (SM): Fine to medium grained, grey to brownish grey, saturated, medium dense.	16
Lean CLAY (CL) to CLAY with sand: Reddish brown, yellowish to bluish grey, moist, firm, plastic.	20
Lean CLAY (CL) to CLAY with sand: Reddish brown, yellowish to bluish grey, moist, firm, plastic.	21.4
Clayey SAND (SC): Brownish and whitish grey to grey; saturated, loose.	28
Bottom at 28.0 m	

Standard Penetration Test – Nos of blows/15cm:

3	3	3
4	3	4
3	3	3
1	2	2
4	5	5
4	3	3
2	2	3
3	3	4
4	4	5
4	4	5
2	2	3
1	2	2
2	2	2
2	2	3
2	2	3
2	2	3
3	2	3

Core recovery (%): 100, 80, 100, 100

Sample type: T16, T17

Drilling method: Φ 110; Drilling with alloy bit Φ 91 mm; Drilling with alloy bit Φ 91 mm

Remark :

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1 (HEC-1)

BOREHOLE LOG

HEC

Project : IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM
Location : PUMPING STATION
Borehole : TC 5
Depth (m) : 27.00
Elevation : 3.89

Coordinate X = 35 103 000
Y = 11 817 500
GWL Water :
Appeared :
Stabilized : 2.56 10/5/97

Commenced : Oct. 4th, 97
Completed : Oct. 5th, 97
Logged by : TRAN HOANG LAN
Checked : QUY DUC THI

Sheet 1 of 2.

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc)	Depth to base (m)
Top cultivation soil (0.00 - 0.30 m). Lean CLAY (CL): Greyish brown and yellowish to bluish grey, moist, firm - stiff, plastic.	4.0
Clayey SAND (SC): Brownish and yellowish to yellowish grey, saturated, loose.	7.3
Lean CLAY (CL): Reddish brownish mottled yellowish to bluish grey, moist, stiff, plastic.	10.1
Lean CLAY to lean CLAY with sand (CL): Blackish grey to black, with a little organic matters; moist, soft - firm, plastic.	15.0
Silty SAND with gravel (SM): Medium - coarse grained, grey to brownish grey, saturated, loose.	15.4
Lean CLAY (CL) in place clayey SAND (SC): Bluish to yellowish grey mottled reddish brown; moist, firm - stiff, plastic.	20
Clayey SAND (SC): Yellowish and brownish grey to grey, saturated, loose - medium dense.	27
Bottom at 27 m.	

Standard Penetration Test – Nos of blows/15cm:

3	4	4
2	3	2
3	2	2
3	3	3
5	4	5
3	3	4
2	1	1
1	1	1
1	2	1
1	3	4
3	4	3
3	3	3
3	2	3
3	3	3
3	3	2
3	4	4
3	4	4
4	3	5

Sample type: T19, T20, T21, T22, T23, T24, T25

Remark : ı Ordinary undisturbed sample
[Continuous double undisturbed sample for triaxial test

BOREHOLE LOG

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION No 1 (HEC-1)

HEC

Project : IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM
Location : PUMPING STATION
Borehole : TC 6
Depth (m) : 29.00
Elevation : 4.87

Coordinate X = 33 108 773
Y = 11 840 330
GWL date :
Appeared :
Stabilized : 2.07 /10/6/97

Commenced : Oct 2nd, 97
Completed : Oct 5th, 97
Logged by : TRAN HOANG LAN
Checked : BUI DUC THAI
Sheet 1 of 2.

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc)	Nos of blows/15cm			Core recovery (%)	Sample type	Drilling method
Top cultivation soil (0.00 - 0.30 m) BACKFILL - Lean CLAY : Yellowish to whitish grey; moist, stiff, plastic.	3	3	3			
	3	4	4			
Lean CLAY (CL): Brownish and yellowish to bluish grey; moist, stiff, plastic.	3	3	4	100		
Clayey SAND (SC) : yellowish and bluish to blackish grey, saturated, loose	2	2	3			Drilling with alloy bit Φ 91 mm
	1	2	2		T4	
Lean CLAY (CL) : Reddish brown mottled yellowish and bluish to whitish grey ; moist, firm, plastic.	2	2	3		T5	
Lean CLAY (CL): Grey to blackish grey, rarely organic matters; moist, firm, plastic.	1	2	2		T6	
Silty SAND with gravel (SM): medium to coarse grained, grey to brownish grey; saturated, medium dense	6	4	4	60		
	4	5	6			
Lean CLAY (CL), in place clayey SAND (SC): Bluish grey mottled reddish brown; moist, firm - stiff, plastic.	3	3	4	100		
	3	4	5			
	1	2	2		T7	
	2	2	3		T8	
Clayey SAND (SC): Brownish to yellowish grey; saturated, loose - medium dense.	2	3	2	100		Drilling with alloy bit Φ 91 mm
	3	4	4			
	4	4	4			
	3	4	3			
Silty SAND with gravel (SM): Brownish to blackish grey, saturated, medium dense.	4	5	6	60		
	5	4	5	100		

Bottom at 29.0 m

Remark :

BOREHOLE LOG

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION No 1 (HEC-1)

HEC

Project : IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM
Location : PUMPING STATION
Borehole : TC 7
Depth (m) : 28.00
Elevation (m) : 4.95

Coordinate X = 33 111 577
Y = 11 860 214
GWL date :
Appeared :
Stabilized : 2.85 /10/10/97

Commenced : Sep 30th, 97
Completed : Oct 1st, 97
Logged by : TRAN HOANG LAN
Checked : BUI DUC THAI
Sheet 1 of 2.

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc)	Nos of blows/15cm			Core recovery (%)	Sample type	Drilling method
Top cultivation soil (0.00 - 0.30 m) BACKFILL - Lean CLAY (CL): Yellowish to whitish grey; moist, firm, plastic.	2	2	3			
Lean CLAY (CL): Brownish and yellowish to bluish grey; moist, firm, plastic.	2	2	3	100		
	2	3	2			
Clayey SAND (SC) : yellowish and bluish to blackish grey, saturated, loose.	2	2	2			Drilling with alloy bit Φ 91 mm
	1	2	2	60		
Lean CLAY to lean CLAY with sand (CL): Reddish brown mottled yellowish to whitish grey; moist, firm, plastic.	2	2	3		T9	
	2	2	3		T10	
Clayey SAND (SC): Grey to blackish grey, saturated, loose.	2	2	2	100		
	1	2	2			
Silty SAND (SM): Grey, medium grained, with some small gravels; saturated, loose.	1	1	2		T11	
	3	4	4		T12	
Sandy lean CLAY (CL): Bluish grey mottled reddish brown, moist, firm, plastic.	2	2	2			
	2	2	3			
Clayey SAND (SC): Brownish to yellowish grey, saturated, loose.	3	2	3	100	T13	Drilling with alloy bit Φ 91 mm
	2	3	2			
Silty SAND (SM): Brownish to blackish grey, medium dense.	3	3	4			
	4	4	4			
Silty SAND with gravel (SM): medium - coarse grained, grey to brownish grey, saturated, medium dense.	4	4	5	60		

Bottom at 28.0 m

Remark : ▮ Ordinary undisturbed sample
▯ Continuous double undisturbed sample for triaxial test

BOREHOLE LOG

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION (HEC-II)

HEC

Project :	IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM
Location :	DISCHARGE SUMP
Borehole :	TC 8
Depth (m) :	25.00
Elevation (m) :	6.00
Coordinate X =	33 050 318
Y =	11 873 349
GWL date :	:
Appeared :	
Stabilized :	
Commenced :	Sep 28th, 97
Completed :	Sep 29th, 97
Logged by	TRAN HOANG LAM
Checked :	GIAP DUC THAI

Sheet 1 of 2.

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Legend 1:100	Depth (m)	No. of blows/15cm			No. of blows/30cm (5 10 15 20 25)	Core recovery percentage (%)	Sample type (UD / TN)	Drilling method
The bottom of discharge sump : 0-0.1 m : Wash concrete, 0.1-0.7 m : Limestone boulders and sand.		1.5	3	3	4		100	T1	Drilling with alloy bit Ø 110 mm
BACKFILL - Lean CLAY (CL): Brownish and yellowish bluish grey; moist, stiff, plastic.		3.5	4	4	4				
Lean CLAY (CL): Brownish and yellowish to bluish grey; moist, stiff, plastic.		5	3	3	3			T2	
Clayey SAND (SC): Yellowish and bluish to blackish grey; saturated, medium dense. (Rarely organic maters at 8.60 - 9.10 m)		7	3	4	4		60		Drilling with alloy bit Ø 91 mm
		9	2	2	1				
Lean CLAY (CL): Brownish and yellowish to whitish grey; rare laterite; moist, stiff, plastic.		11.5	3	4	4				
		13	2	3	2		100	T3	
Elastic SILT (MH): Black to blackish grey with some organic materials, wet, soft - very soft, highly plastic.		14.5	3	3	2				
Lean CLAY to lean CLAY with sand (CL): Bluish and yellowish grey mottled reddish brown; moist, firm, plastic.		16	3	3	2				
		18.5	3	2	3				
Clayey SAND (SC): Reddish brown and yellowish grey; saturated, loose.		20	2	2	1		60		Ø 91 mm
Clayey SAND (SC): Reddish brown and yellowish grey; saturated, loose - medium dense.		23	3	5	5		100		
		25	4	4	5				
Bottom at 25.0 m									

Remark :

BOREHOLE LOG

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION (HEC-II)

HEC

Project :	IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM
Location :	EMBANKMENT - DISCHARGE SUMP
Borehole :	TC 9
Depth (m) :	22.00
Elevation (m) :	5.55
Coordinate X =	32 830 870
Y =	11 877 250
GWL date :	:
Appeared :	
Stabilized :	
Commenced :	Oct 15th, 97
Completed :	Oct 15th, 97
Logged by	TRAN HOANG LAM
Checked :	GIAP DUC THAI

Sheet 1 of 2.

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Legend 1:100	Depth (m)	No. of blows/15cm			No. of blows/30cm (5 10 15 20 25)	Core recovery percentage (%)	Sample type (UD / TN)	Drilling method
The bottom of discharge sump : 0-0 - 0.2m : Accumulative soil, 0.2 - 0.3 m : Wash concrete		1.5	2	2	2				Ø 110
BACKFILL - Fat CLAY (CH): Brownish to yellowish grey; moist, firm, plastic.		3	1	2	1			T 39	
Lean CLAY (CL): Brownish grey to brown; moist, soft, plastic.		4.5	1	1	1		100		Drilling with alloy bit Ø 91 mm
Lean CLAY (CL): Reddish brown mottled whitish to yellowish grey, rare laterite; moist, firm - stiff, plastic.		6	4	5	5				
		8	5	4	5				
		10	3	3	3				
Lean CLAY to lean CLAY with SAND (CL): Brownish yellown and whitish grey; moist, firm, plastic.		11.5	2	2	3				
Clayey SAND (SC): Brownish grey to grey; saturated, loose.		12.5	2	3	3		80	T 40	
Silty SAND (SM): Fine grained. Grey to yellowish grey; saturated, medium dense.		15	4	4	5				
Lean CLAY to lean CLAY with sand (CL): Reddish brown and yellowish to whitish grey; moist, firm - stiff, plastic.		17	4	5	5		100		
		18	2	2	3				
		20	2	2	2				
Lean CLAY with sand (CL): Reddish brown and yellowish to whitish grey; moist, firm, plastic.		21.5	2	2	2		100		Ø91
Bottom at 22.0 m									

Remark :

BOREHOLE LOG

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1 (HEC-1)

HEC

Project : IMPROVEMENT OF [illegible] DRAINAGE SYSTEM	Coordinate X = 32 478.50	Commenced :	Oct 20th, 97
Location : EMBANKMENT	Y = 11 628.150	Completed :	Oct 21st, 97
Borehole : TC 10	GWL Rate :	Logged by :	[illegible]
Depth (m) : 25.00	Appeared :	Checked :	[illegible]
Elevation (m) : 11.30	Stabilized : 5.30, 10/22/97	Sheet 1 of 2	

Soil description (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Depth (m)	Nos of blows/15cm			Core recovery (%)	Sample type	Drilling method
BACKFILL - Lean CLAY (CL) to fat CLAY (CH): Brownish to bluish grey, moist, stiff - firm, plastic.	1	2	2	3			Φ 110
	2	4	4	5			
	3	3	3	4		T 41	Drilling with alloy bit Φ 91 mm
	4	3	3	4			
	6	2	3	3			
Lean CLAY (CL): Brown and brownish to bluish grey, moist, firm - stiff, plastic.	7	2	3	3			
	8	3	4	4	100		
Lean CLAY (CL): Grey to blackish grey, with a little organic matters, wet, soft, highly plastic.	11	3	3	4			
Lean CLAY (CL): Reddish brown mottled yellowish and bluish grey, rare laterite, moist, stiff, plastic.	13	3	3	3			
	14	3	3	4			
Lean CLAY with sand (SC): Yellowish to brownish grey, moist, firm - soft, plastic.	16	1	2	2		T 42	
	17	1	1	2			
Clayey SAND (SC): Fine grained, brownish to yellowish grey, saturated, very loose - loose.	18	1	1	1			
	20	2	3	3			
Clayey SAND (SC): Fine grained, brownish to yellowish grey, saturated, loose.	21				100		Φ 91 mm
Silty SAND (SM): Medium grained with some small gravels, yellowish grey to grey, loose - medium dense.	22	4	3	3	70		
	23	6	7	8			
Lean CLAY to lean CLAY with sand (CL): Reddish brown mottled yellowish to whitish grey, moist, firm - stiff, plastic.	25	3	3	4	100		

Bottom at 25.0 m

Remark :

BOREHOLE LOG

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1 (HEC-1)

HEC

Project : IMPROVEMENT OF [illegible] DRAINAGE SYSTEM	Coordinate X = 32 864.250	Commenced :	Oct 18th, 97
Location : EMBANKMENT	Y = 11 817.050	Completed :	Oct 18th, 97
Borehole : TC 11	GWL Rate :	Logged by :	[illegible]
Depth (m) : 25.00	Appeared :	Checked :	[illegible]
Elevation : 11.08	Stabilized : 5.25, 10/21/97	Sheet 1 of 2	

Soil description (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Depth (m)	Nos of blows/15cm			Core recovery (%)	Sample type	Drilling method
BACKFILL - Lean CLAY (CL): Brownish to yellowish grey, moist, firm - stiff, plastic.	1	2	3	3			Φ 110
	2	3	3	3			
	4	3	4	3			
	6	3	3	4			Drilling with alloy bit Φ 91 mm
Lean CLAY (CL) to fat CLAY (CH): Brown and brownish to bluish grey, moist, firm - stiff, plastic.	7	3	3	4		T 43	
	9	2	2	3			
Lean CLAY (CL): Gray to blackish grey, with a little organic matters, moist, soft, plastic.	10	2	3	4	100		
Lean CLAY to lean CLAY with sand (CL): Reddish brown mottled yellowish and bluish grey, rare laterite, moist, firm - stiff, plastic.	12	3	4	4		T 44	
	13	5	6	6			
	14	5	6	6			
	16	2	2	2			
Clayey SAND (SC): Yellowish to brownish grey, saturated, loose - medium dense.	17	2	4	4			
	19	3	4	4			
Clayey SAND (SC): Yellowish to brownish grey, saturated, loose.	21	2	3	2	70		Φ 91 mm
Lean CLAY (CL): Reddish brown mottled yellowish to whitish grey, moist, stiff, plastic.	22	3	3	4			
	24	3	4	4	100		
	25	3	4	4			

Bottom at 25.0 m

Remark :

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1 (HEC-1)

BOREHOLE LOG

HEC

Project : IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM
Location : EMBANKMENT
Borehole : TC 12
Depth (m) : 25.00
Elevation (m) : 10.82

Coordinate X = 32 892 000
Y = 11 801.350
GWL /date : :
Appeared :
Stabilized : 5.12, 10/19/97

Commenced : Oct 17th, 97
Completed : Oct 18th, 97
Logged by TRAN HOANG LAN
Checked : GIAP DUC TINH

Sheet 1 of 2.

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Legend 1:100 / Depth (m) of layer bottom	Core recovery percentage (%)	Sample type	Drilling method
BACKFILL - Lean CLAY (CL) to fat CLAY (CH): Brownish to yellowish grey, moist, stiff, plastic.	6.2		T 45, T 46	Φ 110 / Drilling with alloy bit Φ 91 mm
Lean CLAY (CL) to fat CLAY (CH): Brown to brownish grey, moist, stiff, plastic.	.5	100	T 47	Drilling with alloy bit Φ 91 mm
Lean CLAY (CL), in place clayey SAND with laterite; reddish brown mottled yellowish and bluish grey, moist, stiff - firm, plastic.	16		T 48	Drilling with alloy bit Φ 91 mm
Clayey SAND (SC): Fine grained, Grey, yellowish grey, saturated, loose - medium dense.	20			Drilling with alloy bit Φ 91 mm
Clayey SAND (SC): Fine grained, Grey, yellowish grey, saturated, loose - medium dense.	22.5	60		Φ 91 mm
Lean CLAY to lean CLAY with sand (CL): Reddish brown mottled yellowish to whitish grey, moist, firm - stiff, plastic.	25	100		Φ 91 mm

STANDARD PENETRATION TEST

Depth (m)	Nos of blows/10cm			Nos of blows/30cm (5 10 15 20 25)
2	2	2	4	
4	3	4	4	
5	3	4	3	
6.2	3	4	3	
8	4	5	5	
9	4	4	5	
11	4	5	5	
12	4	5	5	
15	2	2	2	
16	2	2	2	
18	2	3	3	
20	4	5	4	
21	4	3	4	
22	3	3	3	
22.5	2	3	3	
25	2	3	2	

Sample type: UD | DS

Remark : ....

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1(HEC-1)

BOREHOLE LOG

HEC

Project : IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM	Coordinate X = 32 869.950 Y = 11 813.000	Commenced : Oct. 21th, 97	
Location : EMBANKMENT	GWL /date :	Completed : Oct. 22th, 97	
Borehole : TC 13	Appeared :	Logged by : TRAN HOANG LAN	
Depth (m) : 20.00	Stabilized : 5.32 / 10/23/97	Checked : GIAP DUC TINH	
Elevation (m) : 5.92		Sheet .1. .of. 1. .	

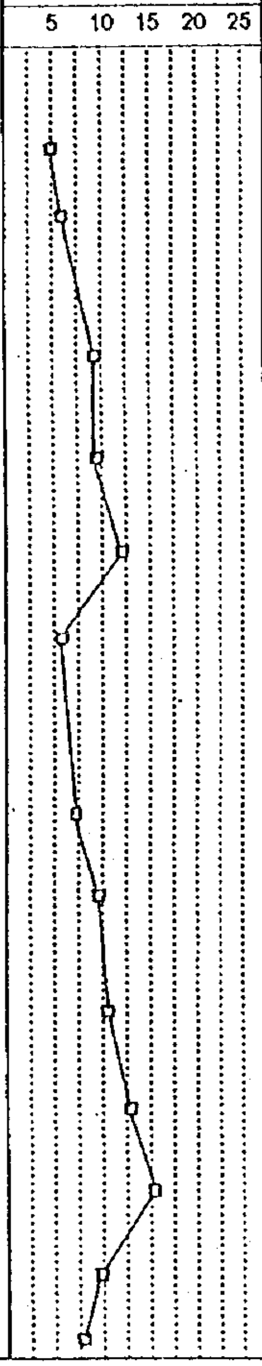
SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Depth (m)
Stones separated by very weak mortar.	.4
Lean CLAY(CL): brownish and yellowish grey; moist, firm, plastic.	2.9
Fat CLAY (CH): Grey to blackish grey; wet, soft, highly plastic.	3.5
Lean CLAY (CL): Brownish grey to brown; moist, soft - firm, plastic.	4.4
Lean CLAY to lean CLAY with sand (CL): Reddish brown mottled yellowish to bluish grey; moist, stiff, plastic.	9.8
Clayey SAND (SC): Fine grained, Brownish and yellowish grey; saturated, loose - medium dense.	15
Silty SAND (SM): Fine to medium grained, yellowish and brownish grey; saturated, medium dense.	17.5
Lean CLAY with sand (SC): Reddish brown mottled bluish grey; moist, firm - stiff, plastic.	20
Bottom at 20 m	

Legend 1:100

STANDARD PENETRATION TEST

Depth (m)	Nos of blows/10cm		
~1.5	1	2	2
~2.5	2	2	2
~4.5	2	3	4
~6.5	2	3	4
~8	3	4	5
9	2	2	2
12	2	2	3
13	2	3	4
15	3	4	4
~16.5	4	4	5
~17.5	4	7	5
19	3	3	4
20	2	3	3

Nos of blows/30cm



Core recovery percentage (%): 70 (0 – 0.4 m); 100

SAMPLE TYPE (UD, DS): T 49, T 50, T 51, T 52

Drilling method: Φ110; Drilling with alloy bit Φ 91 mm

Remark : ▪ . Ordinary undisturbed sample
▯ Continuous double undisturbed sample for triaxial test

HYDRAULIC ENGINEERING CONSULTANTS CORPORATION N°1(HEC-1)

BOREHOLE LOG

HEC

Project : IMPROVEMENT OF TAN CHI DRAINAGE SYSTEM

Location : EMBANKMENT

Borehole : TC 14

Depth (m) : 20.00

Elevation : 7.07

Coordinate X = 32 877.000, Y = 11 797.050

GWL /date : Appeared : ; Stabilized : 6.07 , 10/18/97

Commenced : Oct. 16th, 97

Completed : Oct. 16th, 97

Logged by : TRAN HOANG LAN

Checked : GIAP DUC TINH

Sheet 1 of 1

SOIL DESCRIPTION (name, group symbol, colour, consistency, relative density, water content, grading etc.)	Legend 1:100	Depth (m)	Core recovery percentage (%)	Sample type	Drilling method
Lean CLAY - accumulative soil: Brown; mois, soft.		0 – .8	100		Φ110
Separated by very weak mortar		.8 – 2	60		Φ110
Lean CLAY (CL): Brownish and yellowish, moist, soft, plastic.		2 – 3	100	T 53 (UD)	Drilling with alloy bit Φ 91 mm
Lean CLAY (CL) to fat CLAY (CH): Grey to blackish grey; wet, firm, highly plastic.		3 – 5	100		Drilling with alloy bit Φ 91 mm
Lean CLAY (CL): Reddish brown mottled yellowish to bluish grey; moist, stiff - firm, plastic.		5 – 10.5	100		Drilling with alloy bit Φ 91 mm
Clayey SAND (SC): Yellowish to brownish grey; saturated, loose.		10.5 – 13.5	60 / 100	T 54 (UD)	Drilling with alloy bit Φ 91 mm
Clayey SAND (SC): Fine grained. Grey and brownish grey; saturated, loose.		13.5 – 17.8	60		Drilling with alloy bit Φ 91 mm
Silty SAND (SM): Medium grained with some small gravels, grey to yellowish grey; saturated, loose.		17.8 – 19.4	60		Drilling with alloy bit Φ 91 mm
Bottom at 20 m		19.4 – 20	60		Drilling with alloy bit Φ 91 mm

STANDARD PENETRATION TEST

Depth (m)	Nos of blows/10cm			Nos of blows/30cm
3	1	1	1	2
4.5	2	2	1	3
5.5	3	4	5	9
7	3	4	4	8
8.5	4	4	5	9
10.5	3	4	4	8
11	2	2	3	5
13.5	2	2	2	4
14.5	1	2	2	4
16	2	2	3	5
17.5	2	3	2	5
20	3	3	3	6

Remark : ....

Table 3 - 1/6

SOIL PROPERTIES

LAYER 1: BACKFILL - Lean to fat CLAY

				T1	T39	T41	T45	T46	SUM	AVERAGE
Lab. No				T1	T39	T41	T45	T46		
Sample No										
Bore hole No				TC8	TC9	TC10	TC12	TC12		
Depth (m)		from...		0.80	2.33	3.55	2.78	3.10		
		to...		1.00	2.55	4.00	3.00	3.60		
PARTICLE SIZE DISTRIBUTION % - mm		BS	ASTM							
	Clay	<0.002	<0.005	32.0	55.0	31.0	41.0	37.0	196.0	39.2
	Silt	.002-.063	.005 - .020	14.0	16.0	28.0	26.0	29.0	113.0	22.6
			.050 - .075	42.0	27.0	36.0	28.0	27.0	160.0	32.0
	Sand	.063-2.0	.075 - .425	10.0	1.0	4.0	3.0	3.0	21.0	4.2
			.425 - 2.0	1.0	1.0	1.0	2.0	4.0	9.0	1.8
			2.0 - 4.75	1.0					1.0	0.2
	Gravel	2.0-63.0	4.75-20.0							
			20.0-75.0							
	Cobble	>63.0	75.0-300.0							
ATTERB LIMITS	Liquid Limit (%)			41.5	64.7	54.1	66.3	63.5	290.1	58.0
	Plastic Limit (%)			22.5	32.7	28.1	32.4	30.5	146.2	29.2
	Plasticity Index (%)			19.0	32.0	26.0	33.9	33.0	143.9	28.8
	Liquidity Index			0.326	0.075	0.019	0.006	-0.018	0.408	0.082
PHYSICAL PROPERTIES	Water Content (%)		W	28.7	35.1	28.6	32.6	29.9	154.9	31.0
	Wet Density (g/cm³)		γ_w	1.91	1.83	1.85	1.80	1.88	9.27	1.85
	Dry Density (g/cm³)		γ_c	1.48	1.35	1.44	1.36	1.45	7.08	1.42
	Specific Gravity		Δ	2.74	2.73	2.76	2.74	2.76	13.73	2.75
	Void Ratio		ε	0.846	1.015	0.919	1.018	0.907	4.705	0.941
	Porosity (%)		n	45.8	50.4	47.9	50.5	47.6	242.2	48.4
	Degree of Saturation (%)		G	92.7	94.4	86.0	87.9	91.1	452.1	90.4
	Coeff. of Permeab. (cm/s) $\times 10^{-7}$				0.35		3.50		3.85	1.93
DS	SHEARING	φ (Deg)		13°26	11°18		13°29		38°13	12°44
	STRENGTH	C (KG/cm²)		0.270	0.210		0.27		0.75	0.25
UU	PARAMETERS	φ' (Deg)				12°55		12°44	25°39	12°49
		C' (KG/cm²)				0.333		0.362	0.695	0.348
UN. COM. STRENGTH		Strain (%)								
		(KG / cm²)								
PROCTOR COMPACTION		Optimum Moisture %								
		Max Dry Dens. g/cm³								
ONE-DIMENS.CONS.										
Coefficent of Compressibility a_v (cm²/KG)		σn = 0 - 0.125								
		-0.250								
		-0.500		0.043	0.048		0.087		0.178	0.059
		-1.000		0.032	0.037		0.045		0.114	0.038
		-2.000		0.030	0.030		0.028		0.088	0.029
		-4.000		0.021	0.019		0.015		0.055	0.018
		-8.000								
Precons. Press.		σc	KG/cm²	1.19	1.25		0.98		3.42	1.14
SOIL CLASSIFICATION (ASTM)				CL	CH	CH	CH	CH		

Table 3 - 2/6

SOIL PROPERTIES

LAYER 2: Lean to fat CLAY

				T2	T26	T29	T43	T47	T50	SUM	AVERAGE
Lab. No				T2	T26	T29	T43	T47	T50		
Sample No											
Bore hole No				TC8	TC1	TC2	TC11	TC12	TC13		
Depth (m)		from...		4.30	4.70	4.00	8.50	8.50	3.50		
		to...		4.52	4.92	4.22	8.70	9.00	3.72		
PARTICLE SIZE DISTRIBUTION % -mm		BS	ASTM								
	Clay	<0.002	<0.005	34.0	32.0	30.0	48.0	51.0	50.0	245.0	40.8
	Silt	.002-.063	.005 - .020	11.0	18.0	17.0	20.0	18.0	19.0	103.0	17.2
			.050 - .075	31.0	43.0	46.0	29.0	30.0	30.0	209.0	34.8
	Sand	.063-2.0	.075 - .425	24.0	5.0	7.0	2.0	1.0	1.0	40.0	6.7
			.425 - 2.0		1.0		1.0			2.0	0.3
			2.0 - 4.75		1.0					1.0	0.2
	Gravel	2.0-63.0	4.75-20.0								
			20.0-75.0								
	Cobble	>63.0	75.0-300.0								
ATTERB LIMITS	Liquid Limit (%)			43.5	52.9	45.6	63.7	65.7	41.3	312.7	52.1
	Plastic Limit (%)			23.0	29.1	25.0	30.6	30.8	24.1	162.6	27.1
	Plasticity Index (%)			20.5	23.8	20.6	33.1	35.0	17.2	150.2	25.0
	Liquidity Index			0.073	0.286	0.515	-0.027	0.026	0.535	1.408	0.235
PHYSICAL PROPERTIES	Water Content (%)	W		24.5	35.9	35.6	29.7	31.7	33.3	190.7	31.8
	Wet Density (g/cm^3)	Yw		1.89	1.83	1.83	1.88	1.88	1.84	11.15	1.86
	Dry Density (g/cm^3)	Yc		1.52	1.35	1.35	1.45	1.43	1.38	8.48	1.41
	Specific Gravity	Δ		2.73	2.74	2.74	2.75	2.75	2.69	16.40	2.73
	Void Ratio	ε		0.798	1.035	1.030	0.897	0.926	0.949	5.635	0.939
	Porosity (%)	n		44.4	50.9	50.7	47.3	48.1	48.7	290.1	48.4
	Degree of Saturation (%)	G		83.9	95.1	94.7	91.1	94.3	94.4	553.5	92.3
	Coeff. of Permeab. (cm/s) x 10^{-7}			5.3	3.10	1.90	0.42	0.63		11.35	2.27
DS	SHEARING STRENGTH	φ (Deg)		15°53	13°30	15°16	11°08		9°16	64°37	12°55
		C (KG/cm^2)		0.340	0.200	0.160	0.38		0.14	1.22	0.24
UU	PARAMETERS	φ' (Deg)						11°38		11°38	11°38
		C' (KG/cm^2)						0.381		0.381	0.381
UN. COM. STRENGTH		Strain (%)									
		(KG/cm^2)									
PROCTOR COMPACTION		Optimum Moisture %									
		Max Dry Dens. g/cm^3									
ONE-DIMENS.CONS.											
Coefficent of Compressibility a_v (cm^2/KG)		σn = 0 - 0.125									
		-0.250									
		-0.500		0.050	0.115	0.094	0.048		0.089	0.396	0.06
		-1.000		0.037	0.058	0.060	0.031		0.059	0.245	0.05
		-2.000		0.031	0.044	0.045	0.024		0.038	0.182	0.04
		-4.000		0.020	0.028	0.028	0.015		0.023	0.114	0.02
		-8.000									
Precons. Press.		σc	KG/cm^2	1.25	1.17	1.21	1.10		0.99	5.72	1.14
SOIL CLASSIFICATION (ASTM)				CL	CH	CL	CH	CH	CL		

Table 3 - 3/6

SOIL PROPERTIES

LAYER 3: Lean to fat CLAY

Lab. No				T16	T17	T20	T21	T6	T3	T49	T53	SUM	AVERAGE
Sample No													
Bore hole No				TC4	TC4	TC5	TC5	TC6	TC8	TC13	TC14		
Depth (m)		from...		11.10	11.60	11.28	11.50	11.10	13.60	3.0	3.58		
		to...		11.55	11.80	11.50	12.00	11.60	13.82	3.5	3.8		
PARTICLE SIZE DISTRIBUTION % -mm		BS	ASTM										
	Clay	<0.002	<0.005	27.0	21.0	17.0	18.0	23.0	51.0	47.0	36.0	240.0	30.0
	Silt	.002-.063	.005 - .020	24.0	24.0	23.0	20.0	22.0	24.0	17.0	33.0	187.0	23.4
			.050 - .075	47.0	50.0	55.0	55.0	50.0	24.0	35.0	30.0	346.0	43.2
	Sand	.063-2.0	.075 - .425	2.0	5.0	5.0	7.0	5.0	1.0	1.0	1.0	27.0	3.4
			.425 - 2.0										
			2.0 - 4.75										
	Gravel	2.0-63.0	4.75-20.0										
			20.0-75.0										
	Cobble	>63.0	75.0-300.0										
ATTERB LIMITS	Liquid Limit (%)			48.1	36.2	42.5	42.2	42.6	62.4	55.0	52.8	381.8	47.7
	Plastic Limit (%)			26.3	21.1	24.8	24.3	24.1	32.7	28.3	27.8	209.4	26.2
	Plasticity Index (%)			21.8	15.1	17.7	17.9	18.5	29.7	26.7	25.0	172.4	21.6
	Liquidity Index			0.560	0.887	0.633	0.631		0.424	0.345	0.560	4.040	0.577
PHYSICAL PROPERTIES	Water Content (%)		W	38.5	34.5	36.0	35.6	35.2	45.3	37.5	41.8	304.4	38.1
	Wet Density (g/cm³)		Yw	1.74	1.82	1.75	1.78	1.76	1.75	1.79	1.76	14.15	1.77
	Dry Density (g/cm³)		Yc	1.26	1.35	1.29	1.31	1.30	1.20	1.30	1.24	10.25	1.28
	Specific Gravity		Δ	2.70	2.67	2.68	2.69	2.68	2.65	2.71	2.74	21.52	2.69
	Void Ratio		ε	1.149	0.973	1.083	1.049	1.059	1.200	1.062	1.208	8.603	1.100
	Porosity (%)		n	53.5	49.3	52.0	51.2	51.4	54.6	52.0	54.7	366.7	52.4
	Degree of Saturation (%)		G	90.5	94.7	89.1	91.3	89.1	99.6	93.8	94.7	742.8	92.9
	Coeff. of Permeab. (cm/s) × 10^{-7}				8.6						5.62	14.22	7.11
DS	SHEARING	φ(Deg)			9°22	10°12			9°05		6°20	36°59	9°14
	STRENGTH	C(KG/cm²)			0.110	0.120			0.100		0.09	0.42	0.11
UU	PARAMETERS	φ(Deg)		8°19			8°30	11°00		8°17		36°06	9°01
		C(KG/cm²)		0.101			0.101	0.148		0.165		0.515	0.129
UN. COM. STRENGTH		Strain (%)											
		(KG / cm²)											
PROCTOR COMPACTION		Optimum Moisture %											
		Max Dry Dens. g/cm³											
ONE-DIMENS.CONS.													
Coefficent of Compressibility a_v (cm²/KG)		σn = 0 - 0.125											
		-0.250			0.136	0.144						0.280	0.140
		-0.500			0.112	0.115			0.060		0.132	0.419	0.105
		-1.000			0.076	0.076			0.060		0.078	0.290	0.073
		-2.000			0.050	0.040			0.046		0.055	0.191	0.048
		-4.000							0.034		0.036	0.070	0.035
		-8.000											
Precons. Press.		σc	KG/cm²		0.84	0.8			1.06		0.91	3.61	0.90
SOIL CLASSIFICATION (ASTM)				CL	CL	CL	CL	CL	MH	CH	CH		

Table 3 -4/6

SOIL PROPERTIES

LAYER 3a: Clayey SAND

				T24	T25	T13	T54	SUM	AVERAGE
Lab. No				T24	T25	T13	T54		
Sample No									
Bore hole No				TC5	TC5	TC7	TC14		
Depth (m)	from...			22.50	24.00	22.40	12.78		
	to...			23.00	24.22	22.90	13.00		
PARTICLE SIZE DISTRIBUTION % -mm		BS	ASTM						
	Clay	<0.002	<0.005	10.0	10.0	12.0	10.0	42.0	10.5
	Silt	.002-.063	.005 - .020	7.0	8.0	9.0	6.0	30.0	7.5
			.050 - .075	13.0	13.0	12.0	31.0	69.0	17.2
	Sand	.063-2.0	.075 - .425	66.0	65.0	66.0	49.0	246.0	61.5
			.425 - 2.0	4.0	4.0	1.0	4.0	13.0	3.3
			2.0 - 4.75						
	Gravel	2.0-63.0	4.75-20.0						
			20.0-75.0						
	Cobble	>63.0	75.0-300.0						
ATTERB LIMITS	Liquid Limit (%)			25.6	25.5	29.4	26.2	106.7	26.7
	Plastic Limit (%)			15.8	16.0	16.5	14.2	62.5	15.6
	Plasticity Index (%)			9.8	9.3	12.9	10.5	42.5	10.6
	Liquidity Index			0.429	0.074	0.419	0.333	1.255	0.314
PHYSICAL PROPERTIES	Water Content (%)	W		20.0	16.7	21.9	17.7	76.3	19.1
	Wet Density (g/cm³)	γ_w		2.03	1.94	1.95	2.10	8.02	2.01
	Dry Density (g/cm³)	γ_c		1.69	1.66	1.60	1.78	6.73	1.68
	Specific Gravity	Δ		2.67	2.68	2.72	2.67	10.74	2.69
	Void Ratio	ε		0.578	0.612	0.700	0.496	2.386	0.597
	Porosity (%)	n		36.6	38.0	41.2	33.2	149.0	37.3
	Degree of Saturation (%)	G		92.3	73.1	85.1	95.0	345.5	86.4
	Coeff. of Permeab. (cm/s)$\times 10^{-7}$				56.00	26.0	46.20	128.20	42.73
DS SHEARING STRENGTH		φ (Deg)			18.25			18.25	18.25
		C (KG/cm²)			0.180			0.180	0.180
UU PARAMETERS		φ' (Deg)		19°15		19°59		39°14	19°37
		C' (KG/cm²)		0.210		0.107		0.317	0.159
UN. COM. STRENGTH		Strain (%)							
		(KG / cm²)							
PROCTOR COMPACTION		Optimum Moisture %							
		Max Dry Dens. g/cm³							
ONE-DIMENS.CONS.									
Coefficent of Compressibility a_v (cm²/KG)		σn = 0 - 0.125							
		-0.250							
		-0.500			0.069			0.069	0.07
		-1.000			0.030			0.030	0.03
		-2.000			0.017			0.017	0.02
		-4.000			0.009			0.009	0.01
		-8.000							
Precons. Press.		σc	KG/cm²		1.03			1.03	1.03
SOIL CLASSIFICATION (ASTM)				SC	SC	SC	SC		

Table 3 - 5/6

SOIL PROPERTIES

LAYER 3b: Clayey to Silty SAND

Lab. No				T28	T34	T35	T36	T38	T40	SUM	AVERAGE
Sample No											
Bore hole No				TC1	TC2	TC2	TC3	TC3	TC9		
Depth (m)	from...			11.30	21.78	22.00	21.10	24.33	14.20		
	to...			11.52	22.00	22.50	21.32	24.55	14.42		
PARTICLE SIZE DISTRIBUTION % -mm		BS	ASTM								
	Clay	<0.002	<0.005	7.0	10.0	10.0	12.0	13.0	8.0	60.0	10.0
	Silt	.002-.063	.005 - .020	4.0	7.0	9.0	8.0	5.0	6.0	39.0	6.5
			.050 - .075	13.0	12.0	20.0	21.0	9.0	14.0	89.0	14.8
	Sand	.063-2.0	.075 - .425	34.0	60.0	56.0	55.0	60.0	71.0	336.0	55.0
			.425 - 2.0	31.0	10.0	5.0	4.0	10.0	1.0	61.0	10.2
			2.0 - 4.75	8.0	1.0			2.0		11.0	1.8
	Gravel	2.0-63.0	4.75-20.0	3.0				1.0		4.0	0.7
			20.0-75.0								
	Cobble	>63.0	75.0-300.0								
ATTERB LIMITS	Liquid Limit (%)			24.3	25.5	26.0	31.4	25.4	25.8	158.4	26.4
	Plastic Limit (%)			15.3	15.8	15.9	17.8	16.0	15.8	96.6	16.1
	Plasticity Index (%)			9.0	9.7	10.1	13.6	9.4	10.0	61.8	10.3
	Liquidity Index			-0.457	0.505	0.554	0.272	0.117	0.330	1.311	0.219
PHYSICAL PROPERTIES	Water Content (%)		W	11.1	20.7	21.5	21.5	17.1	19.1	111.0	18.5
	Wet Density (g/cm³)		γ_w	2.00	1.96	2.00	1.93	2.07	2.08	12.04	2.01
	Dry Density (g/cm³)		γ_c	1.80	1.62	1.65	1.59	1.77	1,75	10.18	1.70
	Specific Gravity		Δ	2.68	2.67	2.68	2.69	2.69	2.68	16.09	2.68
	Void Ratio		ε	0.489	0.644	0.628	0.693	0.522	0.535	3.511	0.585
	Porosity (%)		n	32.8	39.2	38.6	40.9	34.3	34.8	220.6	36.8
	Degree of Saturation (%)		G	60.9	85.8	91.7	83.4	88.2	95.8	505.8	84.3
	Coeff. of Permeab. (cm/s) $\times 10^{-7}$					78.00	27.0		2.10	107.1	35.7
DS	SHEARING STRENGTH	φ (Deg)		22°11	17°29		17°10		20°36	77°26	19°21
		C (KG/cm²)		0.200	0.160		0.170		0.260	0.790	0.193
UU	PARAMETERS	φ' (Deg)				16°31		22°11		40°42	20°21
		C' (KG/cm²)				0.181		0.225		0.406	0.203
UN. COM. STRENGTH		Strain (%)									
		(KG / cm²)									
PROCTOR COMPACTION		Optimum Moisture %									
		Max Dry Dens. g/cm³									
ONE-DIMENS.CONS.											
Coefficent of Compressibility a_v (cm²/KG)		σn = 0 -0.125									
		-0.250									
		-0.500			0.072		0.056		0.038	0.166	0.055
		-1.000			0.032		0.030		0.019	0.081	0.027
		-2.000			0.022		0.018		0.010	0.050	0.017
		-4.000			0.012		0.011		0.006	0.029	0.010
		-8.000									
Precons. Press.		σc	KG/cm²		1.00		1.02		1.05	3.07	1.023
SOIL CLASSIFICATION (ASTM)				SC	SC	SC	SC	SC	SC		

Table 3 -6/6

SOIL PROPERTIES

LAYER 4: Lean CLAY, in place clayey sand

	T31	T32	T14	T18	T19	T22	T23	T4	T5	T7	T8	T9	T10	T11	T12	T42	T44	T48	T51	T52	SUM	AVERAGE
Lab. No	T31	T32	T14	T18	T19	T22	T23	T4	T5	T7	T8	T9	T10	T11	T12	T42	T44	T48	T51	T52		
Sample No / Bore hole No	TC2	TC2	TC3	TC3	TC5	TC5	TC5	TC6	TC6	TC6	TC6	TC7	TC7	TC7	TC7	TC10	TC11	TC12	TC13	TC13		
Depth (m) from...	11.00	17.50	18.00	18.30	7.25	18.15	18.50	8.78	9.30	18.50	19.20	8.50	9.50	15.78	16.50	16.80	12.10	13.0	5.80	6.50		
to...	11.22	18.00	18.22	18.80	7.47	18.37	19.00	9.00	9.80	19.00	19.42	8.72	10.00	16.00	17.00	17.0	12.6	13.2	6.00	7.0		
PARTICLE SIZE DISTRIBUTION % -mm: Clay, BS <0.002, ASTM <0.005	16.0	21.0	19.0	16.0	33.0	20.0	22.0	38.0	24.0	19.0	21.0	33.0	33.0	30.0	30.0	22.0	28.0	19.0	20.0	33.0	497.0	24.9
Silt, BS .002-.063, ASTM .005-.020	12.0	10.0	8.0	8.0	15.0	10.0	9.0	14.0	17.0	10.0	8.0	11.0	21.0	7.0	5.0	10.0	15.0	8.0	10.0	22.0	230.0	11.5
ASTM .050-.075	49.0	22.0	18.0	14.0	43.0	18.0	20.0	43.0	50.0	17.0	18.0	37.0	41.0	24.0	24.0	24.0	41.0	20.0	49.0	39.0	611.0	30
Sand, BS .063-2.0, ASTM .075-.425	22.0	47.0	55.0	62.0	9.0	52.0	49.0	4.0	8.0	54.0	53.0	16.0	5.0	29.0	38.0	42.0	13.0	17.0	20.0	6.0	601.0	30.0
ASTM .425-2.0	1.0							1.0	1.0			3.0		10.0	3.0	1.0	2.0	0.0	1.0		23.0	1.2
ASTM 2.0-4.75																1.0	1.0	14.0			16.0	0.8
Gravel, BS 2.0-63.0, ASTM 4.75-20.0																		22.0			22.0	1.1
ASTM 20.0-75.0																						
Cobble, BS >63.0, ASTM 75.0-300.0																						
ATTERB. LIMITS: Liquid Limit (%)	32.2	31.8	28.8	27.9	48.0	32.2	32.9	43.7	39.8	31.7	32.0	43.5	45.1	38.3	32.6	36.3	37.8	44.3	31.1	44.2	732.2	36.6
Plastic Limit (%)	17.7	18.4	17.3	16.3	25.0	18.4	18.4	23.3	21.8	18.4	18.7	23.1	25.0	20.0	18.7	20.3	20.6	24.0	18.1	25.3	408.8	20.4
Plasticity Index (%)	14.5	13.4	11.5	11.6	23.0	13.8	14.5	20.4	18.0	13.3	13.3	20.4	20.1	16.3	13.9	16.0	17.2	20.3	13.0	18.9	323.4	16.2
Liquidity Index	0.678	0.552	0.898	0.784	0.209	0.514	0.593	0.196	0.389	0.669	0.647	0.216	0.164	0.442	0.640	0.294	-0.099	0.128	0.600	0.164	8.674	0.434
PHYSICAL PROPERTIES: Water Content (%) W	27.5	25.8	27.8	25.4	29.8	25.5	27.0	27.3	28.8	27.3	27.3	27.5	28.3	27.2	27.6	25.0	18.9	26.6	25.9	28.4	534.7	26.7
Wet Density (g/cm³) γw	1.86	1.92	1.88	1.92	1.90	1.89	1.90	1.90	1.81	1.87	1.86	1.93	1.91	1.98	1.88	1.90	2.03	1.92	1.91	1.91	38.08	1.90
Dry Density (g/cm³) γc	1.46	1.53	1.47	1.53	1.46	1.51	1.50	1.49	1.41	1.47	1.46	1.51	1.49	1.55	1.47	1.52	1.71	1.52	1.52	1.49	30.07	1.50
Specific Gravity Δ	2.71	2.74	2.73	2.73	2.71	2.73	2.74	2.74	2.72	2.74	2.74	2.76	2.72	2.70	2.69	2.70	2.75	2.76	2.71	2.72	54.54	2.73
Void Ratio ε	0.858	0.795	0.853	0.783	0.851	0.813	0.831	0.836	0.936	0.865	0.875	0.823	0.827	0.742	0.826	0.778	0.811	0.820	0.786	0.829	16.336	0.817
Porosity (%) n	46.2	44.3	46.0	43.9	46.0	44.8	45.4	45.5	48.3	46.4	46.7	45.2	45.3	42.6	45.2	43.7	37.9	45.1	44.0	45.3	897.8	44.9
Degree of Saturation (%) G	86.9	88.9	88.3	88.6	94.9	85.7	89.0	89.5	83.7	88.5	85.5	92.2	93.1	99.5	89.9	86.9	85.2	89.7	89.4	93.4	1786.8	89.3
Coeff. of Permeab. (cm/s)·10^{-7}	56.00		46.0		7.95	26.00		9.6		25.0		1.6	4.2	1.0					37.1		214.5	21.4
DS SHEARING STRENGTH: φ (Deg)			16°41		14°15	14°44		12°34			17°44	13°03		14°08		16°11					119°30	14°56
C (KG/cm²)			0.130		0.180	0.090		0.240			0.110	0.300		0.220		0.25					1.52	0.19
UU PARAMETERS: φ' (Deg)	12°57	16°20		16°20			15°51		13°12	17°09			14°02		13°24		18°35			14°30	152°20	15°14
C' (KG/cm²)	0.139	0.130		0.120			0.119		0.210	0.110			0.315		0.131		0.352			0.32	1.95	0.19
UN. COM. STRENGTH: Strain (%)																						
(KG / cm²)																						
PROCTOR COMPACTION: Optimum Moisture %																						
Max Dry Dens. g/cm³																						
ONE-DIMENS.CONS.																						
Coefficient of Compressibility a_v (cm²/KG): σn = 0 - 0.125																						
-0.250																						
-0.500					0.124			0.048			0.142	0.000		0.057		0.044					0.505	0.034
-1.000					0.086			0.036			0.065	0.046		0.032		0.029					0.274	0.046
-2.000					0.047			0.029			0.039	0.033		0.027		0.024					0.199	0.033
-4.000					0.020			0.018			0.023	0.022		0.023		0.015					0.130	0.022
-8.000																						
Precons. Press. σc KG/cm²					1.05			1.11			1.05	1.23		1.41		1.14					6.99	1.17
SOIL CLASSIFICATION (ASTM)	CL	CL	SC	SC	CL	SC	CL	CL	CL	SC	SC	CL	CL	CL	CL	CL	CL	SC	CL	CL		

Pump Check List (1/5)

Appendix 4 Checklist of Existing Pump and Motor

Pump	Used age		Hand	Centerring	Seal space	Pump bearing	Motor	Vibration (water none) (μ mm)				Vibration (water in) (μ mm)				Motor electric		Switch	Note	Judgement
No.	Age	Judge	roll		Water Leak	noise	noise	Pump		Motor		Pump		Motor		current (A)		board		
								H	V	H	V	H	V	H	V	water none	water in	type		
1	6																	F	none	×
2	6		○	○	△	○	△					36	60	40	28		52.3	F		
3	6		×			×												F		×
4	6		○	○	○	○	△					42	50	76	20		49.5	F		
5	31		○	○	△	△	△					80	80	90	30		46.3	F		
6	31																	F	Elelctric trouble	?
7	31		○	○	○	○	○					38	80	270	74		53.5	F		
8	31																	F	Elelctric trouble	?
9	31		○	○	△	×	○					95	80	120	50		51.7	F		×
10	31		○	○	○	○	○					72	72	120	40		51.3	F		
11	31		○	○	△	○	○					140	125	300	100		50.3	F		
12	31		○	○	△	○	○					205	260	850	280		52.3	F		
13	31		×			×												F		×
14	31																49.3	F	Elelctric trouble	?
15	31		○	○	○	○	×					150	100	125	26		54.0	F		×

Pump Check List (2/5)

Pump	Used age		Hand	Centerrring	Seal space	Pump bearing	Motor	Vibration (water none) (μ mm)				Vibration (water in) (μ mm)				Motor electric		Switch	Note	Judgement
								Pump		Motor		Pump		Motor		current (A)		board		
No.	Age	Judge	roll		Water Leak	noise	noise	H	V	H	V	H	V	H	V	water none	water in	type		
16	31		○	○	○	○	○					70	105	300	110		43.3	F	air	
17	31		○	○	○	○	×					50	42	75	37		53.3	F		×
18	31		○	○	×	△	○					60	60	180	30			F		×
19	31		○	○	△	△	○					170	55	45	32		47.0	F		
20	31		○	○	△	△	○					100	170	32	46		42.3	F		
21	31		○	○	○	○	○					24	28	.84	35		55.0	F		
22	31		○	○	×	○	○					80	80	105	27		51.7	A		×
23	31		○	○	○	○	○					26	120	420	100		50.3	B		
24	31		○	○	○	○	○					34	70	105	37		54.0	B		
25	31		○	○	○	○	△					26	20	40	18		51.3	B		
26	31		○	○	○	○	○					210	165	135	38		46.0	B		
27	31		○	○	×	○	○					90	160	180	50	33.0	49.3	A		×
28	31		○	○	△	○	○					90	55	65	10		55.3	B		
29	31		○	○	×→○	○	○					18	18	16	10		51.0	A		
30	31		○	○	○	○	○					65	70	220	35		45.8	B		

Pump Check List (3/5)

Pump No.	Used age: Age	Used age: Judge	Hand roll	Centerring	Seal space Water Leak	Pump bearing noise	Motor noise	Vibration (water none) (μ mm) Pump H	Pump V	Motor H	Motor V	Vibration (water in) (μ mm) Pump H	Pump V	Motor H	Motor V	Motor electric current (A) water none	water in	Switch board type	Note	Judgement
31	31		○	○	△	△	○					180	60	200	120		47.0	A	air	
32	31		○	○	○	○	○					50	90	500	35		53.0	F		
33	31		○	○	○	○	○					120	100	700	250		53.5	F		
34	31		○	○	○	○	○					24	12	110	34		42.5	F	フランジ	
35	31		○	○	△	△	○					500	240	1000	300		46.0	F		
36	31		○	○	△	×	○					200	250	700	170		46.3	F		×
37	31		○	○	○	○	○					85	35	150	55		49.8	B		
38	31		○	○	△	△	○					210	110	280	50		50.2	A		
39	31		△	○	△	△	○					20	20	40	12		45.3	B		
40	31		○	○	×	○	○					60	65	170	52		47.3	A		×
41	31		○	○	△	△	○					170	280	260	170		51.3	B		
42	31		△	○	×	△	○					560	160	900	600		46.7	A		×
43	31		○	○	×	×											49.7	B		×
44	31		○	○	△	△	○					65	35	40	30		43.7	A		
45	31		○	○	×	△	○					60	110	250	45		42.3	B		×

Pump Check List (4/5)

Pump	Used age		Hand	Centerring	Seal space	Pump bearing	Motor	Vibration (water none) (μ mm)				Vibration (water in) (μ mm)				Motor electric current (A)		Switch	Note	Judgement
								Pump		Motor		Pump		Motor				board		
No.	Age	Judge	roll		Water Leak	noise	noise	H	V	H	V	H	V	H	V	water none	water in	type		
46	31		Δ	×	Δ	Δ	○					250	150	340	210		48.3	F		
47	31																	A	Electrical trouble	?
48	31		○	×	○	○	○					160	160	700	110		49.2	A		
49	31		○	○	Δ	×	×	90	160	500	90					32.8	51.7	B		×
50	31		○	○	×	Δ	○	34	16	18	10	94	96	45	38	31.3	52.0	A		×
51	31		○	○	○	○	○	18	40	110	85	52	38	34	20	30.2	46.0	B	Common base → FC	
52	31		○	○	○	○	○	50	10	50	28	48	52	38	46	29.9	50.0	A		
53	31		○	○	○	○	○	10	68	28	92	145	135	580	180	32.2	52.3	B		
54	31		○	○	Δ	Δ	Δ	6	10	26	10	130	110	210	58	25.0	45.7	A		
55	31		○	○	○	○	○	240	360	500	340					35.5	52.3	B		
56	31		Δ	○	○	×	○	150	140	160	50					31.8	53.7	A		×
57	31		○	○	○	×	○	220	120	460	150						49.3	A	F	×
58	31		Δ	○	Δ	×	○	55	60	70	35	52	36	84	38	31.3	41.0	A		×
59	31		×															B	Electrical trouble	×
60	31		○	×	Δ	Δ	○	40	180	100	500					26.3	44.3	A		×

Pump Check List (5/5)

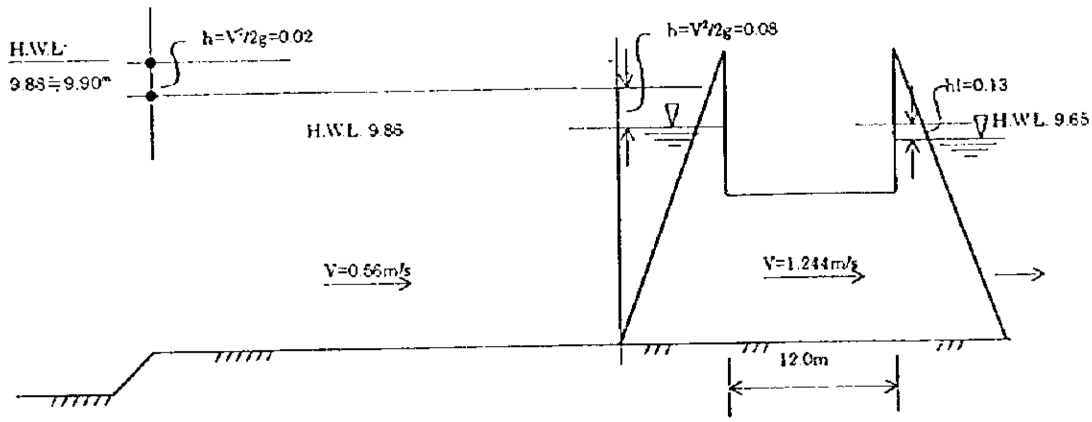
Pump	Used age		Hand	Centerring	Seal space	Pump bearing	Motor	Vibration (water none) (μ mm)				Vibration (water in) (μ mm)				Motor electric current (A)		Switch board	Note	Judgement
No.	Age	Judge	roll		Water Leak	noise	noise	Pump		Motor		Pump		Motor				type		
								H	V	H	V	H	V	H	V	water none	water in			
61	10		○	○	○	△	○	160	150	60	100						48.0	B		
62	10		○	×	△	△	△	30	30	70	86	180	190	140	250		51.3	A		
63	10		○	○	○	△	○	50	65	30	130						55.3	B		
64	10		○	×	○	×	○	42	170	30	59	140	130	119	138			A		×
65	6		○	○	○	△	○	40	38	28	70					30.3	54.8	A		
66	6		○	○	×	△	○					72	430	580	700		41.3	F		
67	6		○	○	○	○	○	12	28	20	40					26.3	45.3	F		
68	6		△	×	○	○	○	38	68	260	160					28.7	51.7	F		

Appendix 6-2 Study on Pump Type and Pump Combination Planning

(1) Delivery Water Level in the Discharge Reservoir

High water level of the Duong river at the Tan Chi pumping station is estimated at EL(+)9.65m with 10 year-probability. The delivery water level in the discharge reservoir is set up by the following calculation of head losses.

Size of sluiceway	B×H×No.	2.50(m)×2.5(m)×4(No.)
Discharge	Q	$31.1m^3/s$
Velocity	V=Q/A	1.244m/s
Velocity head	$h=V^2/2g$	0.08m
Outlet losses	$hl=f\cdot V^2/2g$ f=1.0	0.08m
Inlet losses	$hl=f\cdot V^2/2g$ f=0.5	0.04m
Friction losses	$hl=\dfrac{n^2\cdot V^2}{R^{3/4}}\cdot L$	0.01m
	L=12.0	
	n=0.018	
	$R=\dfrac{BH}{2(B+H)}=0.625$	
	$R^{4/3}=0.534$	



Total losses 0.08+0.08+0.04+0.01=0.21m

The highest delivery water level in the discharge reservoir is

9.65+0.21=9.86≒9.9m

The lowest delivery water level in the discharge reservoir is set up at El.(+)5.80m being equivalent to the bottom elevation of the discharge reservoir in the beginning point of upstream side, although the sill elevation of sluiceway is El.(+)5.2m.

(2) Actual Head

The actual head = highest delivery water level-lowest suction water level
= 9.9 - 1.7 =8.2m

(3) Pump Type

1) In Case of Axial Flow Pump

Required NPSH(Hsvo)= $\left(\frac{H\sqrt{Q}}{S}\right)^{4/3}$ ---------------------------- (1)

Number of pump rotation(N)= Ns × $\frac{H^{4/3}}{\sqrt{Q}}$ -------------------- (2)

It follow that

$$Hsvo = \left(Hs \times \frac{H^{4/3}}{\sqrt{Q}} \times \sqrt{Q} \times \frac{1}{S}\right)^{4/3} = \left(\frac{Ns}{S}\right)^{4/3} \times H \quad \text{---------------------------- (3)}$$

where H=Total pump head ------------------- 9.0m
Ns=Specific speed in case axial flow 1500
S=Suction specific speed

①Checking Cavitation under Design Conditions

Friction loss by pipe	hlo=0.58 m
Actual head	ha=8.2 m
Total pump head	H=9.0 m

$$\frac{ha}{H}=\frac{8.2}{9.0}=0.911 \qquad \frac{hlo}{H}=\frac{0.58}{9.0}=0.064$$

From Figure and Table, q=1.03 α=1.1 s=1270

Then

$$Hsvo=\left(\frac{1500}{1270}\right)^{4/3}\times 9.0=1.248\times 9.0=11.24m$$

$$Hsv=\alpha \times Hsvo=1.1\times 11.24m=12.4m$$

$$Hsvo=Da+hso-Ba-hlso-\beta$$

where	Da: Atmospheric pressure	10.3 m
	hso: Suction actual head	2.0 m
	Ba: Saturated vapor pressure	0.3 m
	hlso: Friction loss by pipe(suction)	0.0 m
	β : Surplus head	0.5 m

Hsvo=Da+hs-Ba-hlso-β

hs: Suction actual head except design point	2.0 m
hls: Friction loss by pipe (suction)	0.0 m

Hsvo=10.3+2.0-0.3-0-0.5=11.5 m

Hsvo=11.5 m<Hsv=12.4 m

From the above calculation, cavitation occurs in case of axial flow pump.

②Checking Cavitation under other Conditions

Friction loss by pipe line	hlo=0.58m
Actual head	ha=5.8m-1.7m=4.1m
Total pump head	H=9.0 m

$$\frac{ha}{H}=\frac{4.1}{9.0}=0.455 \qquad \frac{hlo}{H}=\frac{0.58}{9.0}=0.064$$

From the Table q=1.22 α=2.0 s=980

$$Hsvo=\left(\frac{1500}{980}\right)^{4/3}\times 9.0=15.87m$$

$$Hsv=15.87\times 2.0=31.78m$$

$$Hsvo=11.5m<Hsv=31.78m$$

From the above calculation, cavitation occurs, therfore, axial flow pump can not be used.

2) In Case of Mixed Flow Pump

H: Total pump head	9.0m
Hs: Specific speed	900
S: Suction specific speed	

①Checking Cavitation under Design

Friction loss	hlo=0.58m
Actual head	ha=8.2m
Total pump head	H=9.0m

$$\frac{ha}{H}=\frac{8.2}{9.0}=0.911 \qquad \frac{hlo}{H}=\frac{0.58}{9.0}=0.064$$

From the figure q=1.02 α=1.05 s=1280

$$Hsvo=\left(\frac{900}{1280}\right)^{4/3}\times 9.0=5.63$$

$$Hsv=1.05\times 5.63=5.91m$$

$$Hsvo=11.5m>Hsv=5.91m$$

From the above result, cavitation will not occur.

②Checking Caviation under other Conditions

Friction loss by pipe	hlo=0.58m
Actual head	ha=5.8m-1.7m=4.1m
Total pump head	H=9.0m

$\frac{ha}{H} = \frac{4.1}{9.0} = 0.455$ $\frac{hlo}{H} = \frac{0.58}{9.0} = 0.064$

From the figure $q=1.26$ $\alpha=1.6$ $s=880$

$$Hsvo = \left(\frac{900}{880}\right)^{4/3} \times 9.0 = 9.27$$

$$Hsv = 1.6 \times 9.27 = 14.8m$$

$$Hsv = 11.5m < Hsv = 14.8m$$

In this case, cavitation occurs. It is necessary to control discharge by discharge valves at the time of the low head.

Based on the study on cavitation, vertical axial mixed flow pump is suitable as pump type.

(4) Pump Combination Planning

1) Basic Conditions

Design Dischrage	16 m^3/s=960 m^3/min	
Design Head	Actual head	9.9m-1.7m=8.2m
	Head loss	0.58m
	Surplus	0.22m
	Total	9.0m

Under the above conditions, the following five types of pump sets have been studied.

Table 2-1 Pump Specification for Each Alternative

Number of Pump			2 sets	3 sets	4 sets	5 sets
Pump	Capacity (m3/min)		480	320	240	92
	Head (m)		9	9	9	9
	Bore (mm φ)		1800	1500	1350	1200
	Velocity (m/s)		3.15	3	2.8	2.83
	Length (m)		5.8	5.4	5.2	4.9
	Efficiency (%)		85	84	83.5	83
	Rotation	Ns=700(rpm)	166	203	235	263
		Ns=900(rpm)	213	261	302	338
		Ns=1300(rpm)	308	377	436	487
Motor	Specified Output (kw)		1000	630	500	400
	Rotation (rpm)		220	240	290	325
	Pole (P)		26	24	20	18
	Calculated Output (kw)		911.3	614.8	463.8	372.3
Auxiliary Device	Discharge Valve	Bore (mm φ)	1800	1500	350	1200
		Velocity (m/s)	3.15	3	2.4	2.83
	Flap Valve	Bore (mm φ)	2200	1800	1650	1500
		Velocity (m/s)	2.1	2.1	1.87	1.81
	Capacity of Overhead Crane (T)		32	20	20	13

2) Monthly Operation Hours

Monthly operation hours are estimated from the daily report of the existing pumping station, because hourly rainfall patterns are not available. The following table shows pump operation hours for each set of pump.

Table 2-2 Pump Operation Hour

Month	Operation Hour (hour·set)	Estimation Discharge (m^3/month)	Pump Operation Hours per One Set			
			2 sets	3 sets	4 sets	5 sets
1	2,470	1,482,000	51	77	103	129
2	1,608	964,800	34	50	67	84
3	867	520,200	18	27	36	45
4	635	381,000	13	20	26	33
5	6,124	3,674,400	128	191	255	319
6	1,096	657,600	23	34	46	57
7	4,316	2,589,600	90	135	180	225
8	8,507	5,104,200	177	266	354	443
9	6,234	3,740,400	130	195	260	325
10	3,455	2,073,000	72	108	144	180
11	369	221,400	8	12	15	19
12	380	228,000	8	12	16	20
Total	36,061	21,636,600	751	1,127	1,502	1,878

Note: Operation Hours are based on the 1993 year's record at Tan Chi Pumping Station.

In the above table, estimated discharge and pump operation hours are obtained by the following calculation.

①Estimated Discharge

The existing pump capacity per one set is 600 m^3/h, so the discharge is estimated as follows:

Estimated discharge = operation hours ×600 m^3/h·set

In case of January,

2,470m^3/h·set×600m^3/h·set=1,482,000m^3/month

②Pump Operation Hours

Operation Hours = Estimated Discharge ÷ Capacity of One Pump

In case of pump operation hours per one set of pump in January for option-1 (two sets of pump) is calculated as follows:

1,482,000 m^3/month ÷480m^3/min = 3,087 min=51 hour

Minimum operation hours are estimated as follows, if pump is operated 6 hours per week.

6 hours ×4~5 weeks/ month =24~30 hours/month

③Operation Hours for Storage Capacity of Suction Side

The area of suction side including intake reservoir and Tan Chi leading canal is about 26m(W) ×1000m(L)

Available water depth for pump operation:

LWL-LLWL = 1.7 m- 1.4 m= 0.3 m

The storage capacity at the suction side:

26 m× 1000m ×0.3 m=7,800 m^3

The amount of natural inflow to suction sump

LWL=1.7 m Inflow = about 3 m^3/s

The pump operation hours from LWL to pump stopping water level is calculated as follows:

$$\text{Operation hours} = \frac{\text{strage capacity at the suction side}}{\text{pump capacity per one set inflow}}$$

In case of option-1 (2 sets of pump)

$$\text{Operation hours} = \frac{7800m^3}{480m^3/min - 180m^3/min} = 26min$$

Operation hours for each option are calculated according to the same process as option-1 and summarized as follows:

	Operation Hours for the Storage Capacity of the Suction Side (minute)			
Number of Pump(set)	2 sets	3 sets	4 sets	5 sets
Operation Hours(min)	26	56	130	650

From a view point of stable pump operation, it requires around 2 hours to operate pumps, therefore, option -4 (4 sets of pump) is recommendable.

④Cost Study

The cost study for each option is shown in Table 2-3.

Table 2-3 Comparison of Cost

Numbef of Pump			2 Sets		3 Sets		4 Sets		5 Sets	
Cost	Pump			275,040		305,280		314,240		316,400
	Motor			189,920		219,120		197,120		189,600
	Discharge valve			23,600		26,100		29,600		31,000
	Flap valve			7,200		8,700		10,000		11,000
	Overhead Crane		(1unit)	18,600	(1unit)	16,600	(1unit)	16,600	(1unit)	12,100
	Screen		(4unit)	7,200	(3unit)	8,700	(4unit)	12,000	(5unit)	13,000
	Step pipe			16,200		18,900		20,800		23,000
	Sub-total			537,760		603,400		600,360		596,100
	Electric reciving facilities	35kv Primary panel		19,300		19,300		19,300		19,300
		35kv Metering PT&CT panel		26,000		26,000		26,000		26,000
		35kv Incoming panel		16,300		16,300		16,300		16,300
	Sub-total			61,600		61,600		61,600		61,600
	Distribution	6kv Incoming panel	1set	8,100	1set	8,100	1set	8,100	1set	8,100
		6kv Reactor panel	2sets	18,600	3sets	21,300	4sets	25,600	5sets	29,500
		6kv Motor starter	2sets	19,200	3sets	23,100	4sets	28,400	5sets	32,000
		500kva Aixliary feeder transformer	1set	9,800	1set	9,800	1set	9,800	1set	9,800
		Auxiliary transformer panel	1set	2,600	1set	2,600	1set	2,600	1set	2,600
		Low valtage panel	2sets	6,200	2sets	6,200	2sets	6,200	3sets	9,300
		Battery&charger panel	2sets	11,000	2sets	11,000	2sets	11,000	2sets	11,000
		Local pump control plant	2sets	3,800	3sets	5,700	4sets	7,600	5sets	9,500
		Auxiliary relay panel	2sets	10,400	2sets	10,400	3sets	10,400	3sets	15,600
		Cables	LS	17,500	LS	18,500	LS	19,500	LS	21,500
	Sub-total			107,200		116,700		129,200		148,900
	Facilities Total			706,560		781,700		791,160		806,600
	Packing and transport			49,460		54,720		55,380		56,460
	Installation Cost			113,080		125,080		126,560		129,040
	Total			869,100		961,500		973,100		992,100

Table 2-4 Summary of Comparison Study on Pump Combination

Option	1	2	3	4
Number of Pump (set)	2	3	4	5
Pump Bore (mm)	1800	1500	1350	1200
Pump Capacity (m^3/min)	480	320	240	192
Pump Load (t)	65	50	39	19.8
Motor Spec.	vertical shaft opened type dip proof 1000kwx26Px6kv	vertical shaft opened type dip proof 630kwx24Px6kv	vertical shaft opened type dip proof 500kwx20Px6kv	vertical shaft opened type dip proof 400kwx18Px6kv
Motor Weight(t)	25	20	15	10
Operational flexibility	low	low	medium	medium
for discharge fluctuation	26 min	56 min	130 min	650 min
		(Operation hour for minimum discharge)		
Risk of incidental failures(%)	50	33	25	20
Exchangeability for spare part	low	low	medium	high
Suction sump(m^2)	91.5	165.4	163.4	143.4
Depth of suction sump(m)	6.9	5.6	5.25	4.5
Weight of suction sump(t)	1,580	2,500	2,352	1,860
Pump house(m^2)	104	202	219	174
-do- weight(t)	720	1,255	1,265	904
Suction sump load(t)	2,470	3,965	3,833	2,913
Number of pile	21	32	36	33
Load per one pile(t/pcs)	117.6	123.9	106.5	88.3
Bearing capacity (t/pcs)	130.7	130.7	130.7	130.7
Safety factor	1.1	1.05	1.23	1.48
Cost of pump equipment(1000yen)	869,100	961,500	973,100	992,100
Cost of pump facilities(1000yen)	206,100	302,300	280,000	211,000
Pump house (1000yen)	15,100	34,400	35,200	30,500
Total cost of pumping station	1,090,300	1,298,200	1,288,300	1,233,600
Operation Cost for 30 years	112,650	106,500	96,870	112,650
Renewal of motor(1000yen)	118,700	91,300	61,600	47,400
Total Cost	1,321,650	1,496,000	1,446,770	1,393,650
9 Ratio	100	113	100	105

⑤Conclusion

Based on the above studies, the following issues are justified.

* Cost of pump equipment becomes cheaper coping with the decrease of pump sets. The area of a suction sump becomes smaller following the decrease of

pump sets. On the other hand, when pump bore becomes larger, load per unit area is larger because the depth of suction sump is more deeper.

* When the number of pump increases, the following merits can be listed. Discharge to be secured at the time of pump failure, Exchangeability of spare parts Stability of structures
* Operation cost for 30 years consisting of electrical charge and renewal of motor becomes more economical in case the size of motor is smaller. Regarding the total cost including construction and operation, option 1 (2 sets) is the most economical. However, from a view point of operation and maintenance option 3 (4 sets) have more advantages in terms of operational cost, safety, risk of incidental failure, exchangeability of spare parts.

Therefore, 4 sets of pump combination with 1350 mm of pump bore is selected for the Tan Chi new pumping station.

JICA