Geologic Logs of Pits

GEOLOGIC LOG OF PIT

Puna Tsang Chhu Hydropower Project F/S   PIT No. QP-1   (SHEET 1 OF 1)

LOCATION	Quarry	DEPTH OF PIT	1.5 m		
ELEVATION	m	EXCAVATION METHOD	HAND DIGGING		
COORDINATE		EXCAVATED BY	Mr.Penjore Dendhup DOR	COMMENCED	99/10/28
		LOGGED BY	Mr.Seiji Hongo EPDC	COMPLETED	99/10/28

ELEVATION	DEPTH	MATERIAL TYPE	LOG	OBSERVATION OF WALL: COLOR	OBSERVATION OF WALL: DESCRIPTION	SAMPLING	TESTING	G.W.L. (Dpt.H)	DEPTH
	0m								0m
	0–1.5	Alluvium		dark gray, grayish white	0.0–1.5 Alluvium Sand and Gravel including cobbles and boulders 50cm dia. in maximum rock type: gneiss (dominant) pegmatite, metasedimentary rock	0.5–1.0m, QP-1-01	no test		1
	1.5–4				1.5m, bottom of pit				2, 3, 4

GEOLOGIC LOG OF PIT

Puna Tsang Chhu Hydropower Project F/S   PIT No. QP-2   (SHEET 1 OF 1)

LOCATION	Quarry	DEPTH OF PIT	1.5 m
ELEVATION	m	EXCAVATION METHOD	HAND DIGGING
COORDINATE		EXCAVATED BY	Mr.Penjore Dendhup DOR
		LOGGED BY	Mr.Seiji Hongo EPDC
COMMENCED	99/10/28	COMPLETED	99/10/28

ELEVATION	DEPTH	MATERIAL TYPE	LOG	OBSERVATION OF WALL: COLOR	OBSERVATION OF WALL: DESCRIPTION	SAMPLING	TESTING	G.W.L. (Dpt.H)	DEPTH
	0m								0m
	0–1.5	Alluvium		dark gray, grayish white	0.0–1.5 Alluvium Sand and Gravel including cobbles and boulders 60cm dia. in maximum rock type: gneiss (dominant) pegmatite, metasedimentary rock	0.5–1.1m, QP-2-01	no test		
	1.5				1.5m, bottom of pit				
	1, 2, 3, 4								1, 2, 3, 4

GEOLOGIC LOG OF PIT

Puna Tsang Chhu Hydropower Project F/S   PIT No. QP-3   (SHEET 1 OF 1)

LOCATION	Quarry	DEPTH OF PIT	1.5 m
ELEVATION	m	EXCAVATION METHOD	HAND DIGGING
COORDINATE		EXCAVATED BY	Mr.Penjore Dendhup DOR
		LOGGED BY	Mr.Seiji Hongo EPDC

COMMENCED 99/10/28
COMPLETED 99/10/28

ELEVATION	DEPTH	MATERIAL TYPE	LOG	OBSERVATION OF WALL: COLOR	OBSERVATION OF WALL: DESCRIPTION	SAMPLING	TESTING	G.W.L. (Dpt.H)	DEPTH
	0m								0m
	0–1.5	Alluvium		dark gray, grayish white	0.0–1.5 Alluvium Sand and Gravel including cobbles and boulders 45cm dia. in maximum rock type: gneiss (dominant) pegmatite, metasedimentary rock	0.4–0.9m, QP-3-01	no test		1
	1.5				1.5m, bottom of pit				
	2								2
	3								3
	4								4

GEOLOGIC LOG OF PIT

Puna Tsang Chhu Hydropower Project F/S   PIT No. QP-4   (SHEET 1 OF 1)

LOCATION	Quarry	DEPTH OF PIT	1.5 m		
ELEVATION	m	EXCAVATION METHOD	HAND DIGGING		
COORDINATE		EXCAVATED BY	Mr.Penjore Dendhup DOR	COMMENCED	99/10/28
		LOGGED BY	Mr.Seiji Hongo EPDC	COMPLETED	99/10/28

ELEVATION	DEPTH	MATERIAL TYPE	LOG	OBSERVATION OF WALL: COLOR	OBSERVATION OF WALL: DESCRIPTION	SAMPLING	TESTING	G.W.L. (Dpt.H)	DEPTH
	0m								0m
	0–1.5	Alluvium		dark gray, grayish white	0.0–1.5 Alluvium Sand and Gravel including cobbles and boulders 70cm dia. in maximum rock type: gneiss (dominant) pegmatite, metasedimentary rock	0.4–1.1m, QP-4-01	no test		
	1.5				1.5m, bottom of pit				
	2								2
	3								3
	4								4

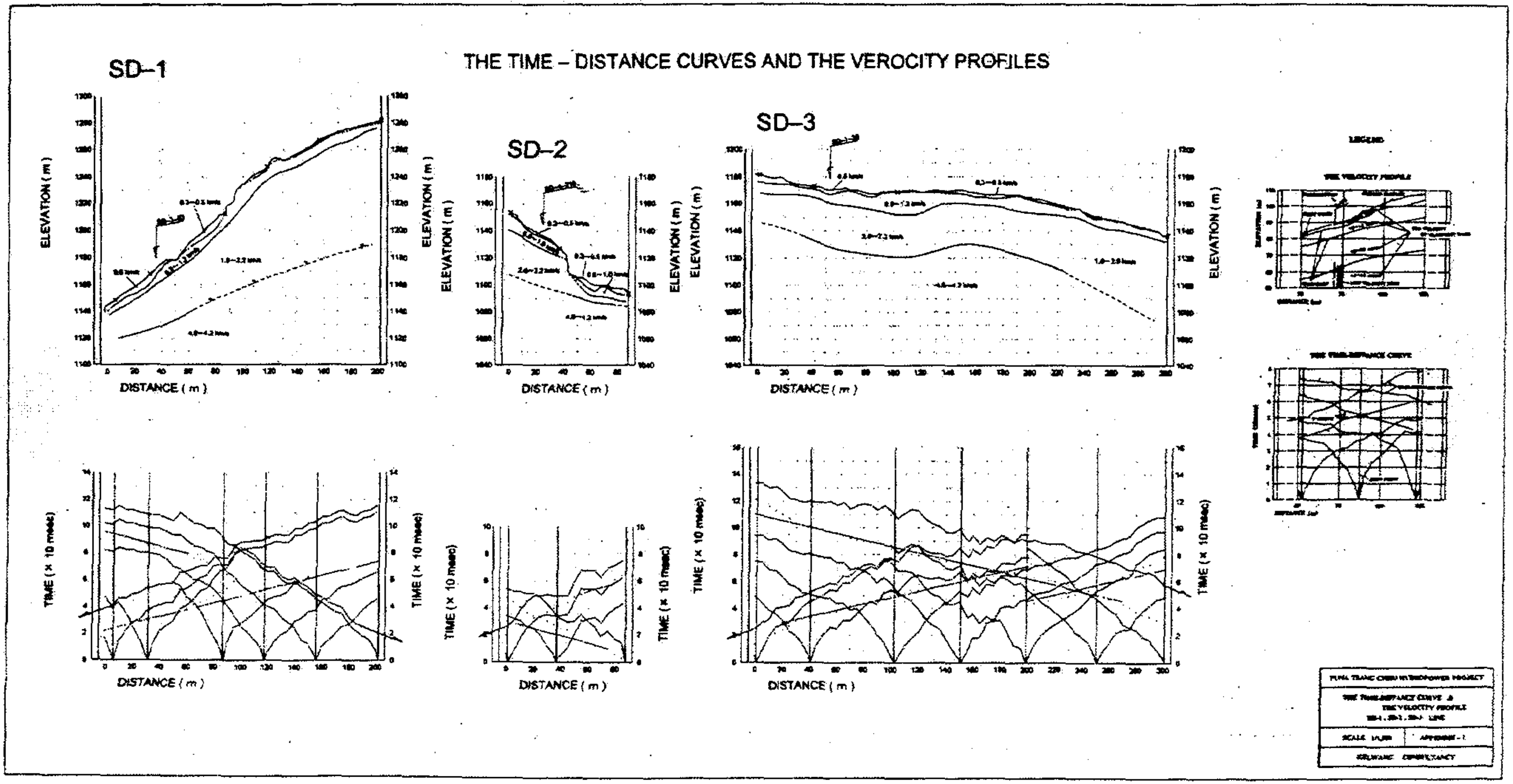
GEOLOGIC LOG OF PIT

Puna Tsang Chhu Hydropower Project F/S   PIT No. QP-5   (SHEET 1 OF 1)

LOCATION	Quarry	DEPTH OF PIT	1.5 m		
ELEVATION	m	EXCAVATION METHOD	HAND DIGGING		
COORDINATE		EXCAVATED BY	Mr.Penjore Dendhup DOR	COMMENCED	99/10/28
		LOGGED BY	Mr.Seiji Hongo EPDC	COMPLETED	99/10/28

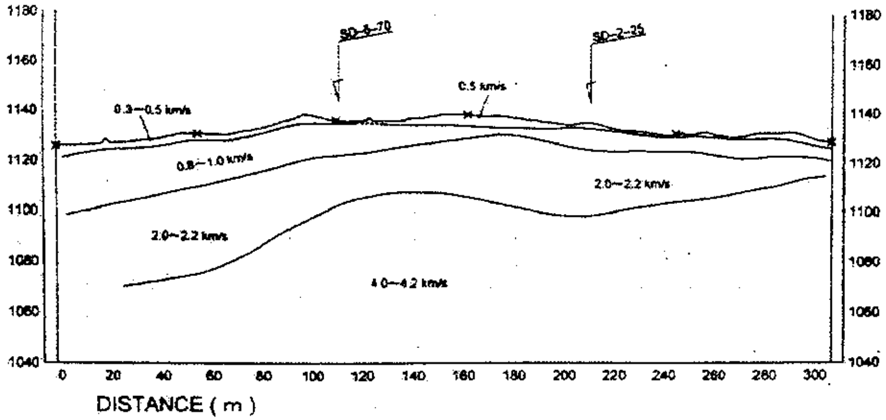
ELEVATION	DEPTH	MATERIAL TYPE	LOG	OBSERVATION OF WALL: COLOR	OBSERVATION OF WALL: DESCRIPTION	SAMPLING	TESTING	G.W.L. (Dpt.H)	DEPTH
	0m								0m
	0.0–1.5	Alluvium		dark gray, grayish white	0.0–1.5 Alluvium Sand and Gravel including cobbles and boulders 32cm dia. in maximum rock type: gneiss (dominant) pegmatite, metasedimentary rock	0.4–1.0m, QP-5-01	no test		
	1.5				1.5m, bottom of pit				
	2								2
	3								3
	4								4

Result of Seismic Prospecting

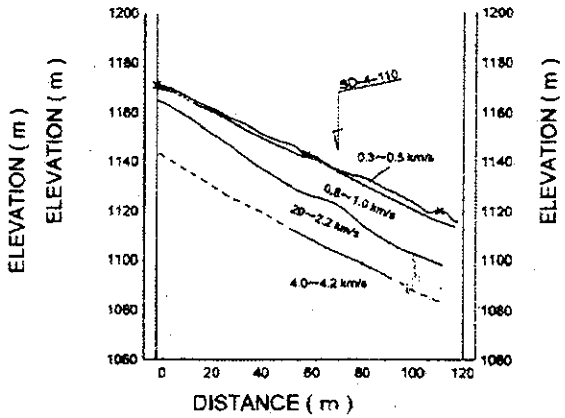


THE TIME – DISTANCE CURVES AND THE VEROCITY PROFILES
SD–1
SD–2
SD–3
ELEVATION (m)
DISTANCE (m)
TIME (× 10 msec)

SD–4

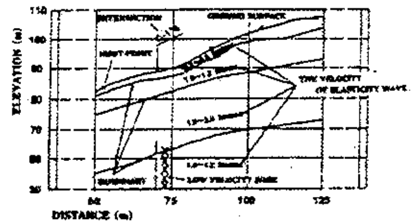


SD–5

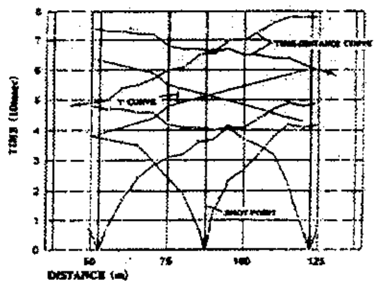


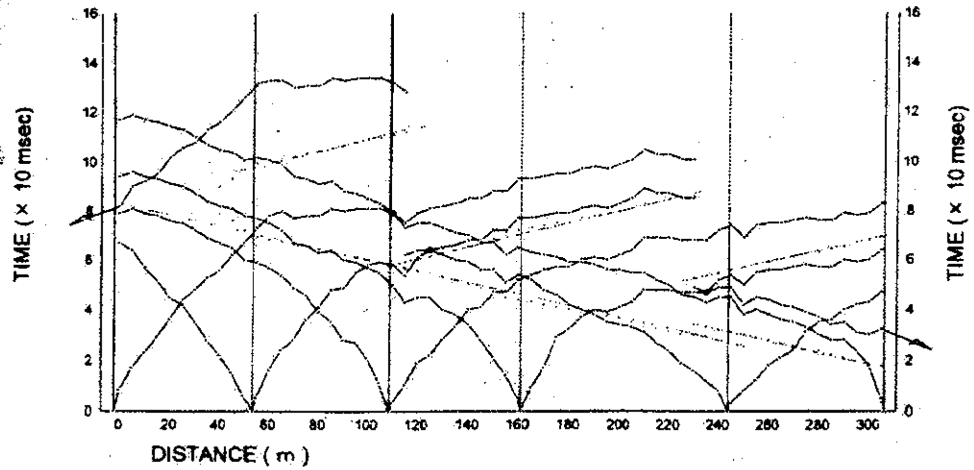
LEGEND

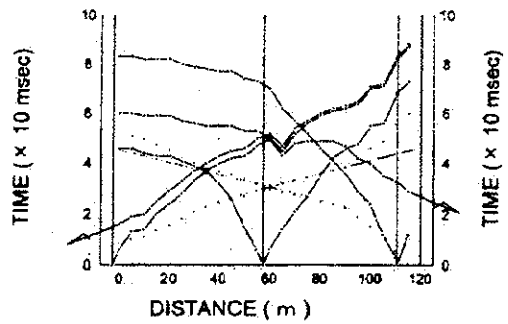
THE VELOCITY PROFILE



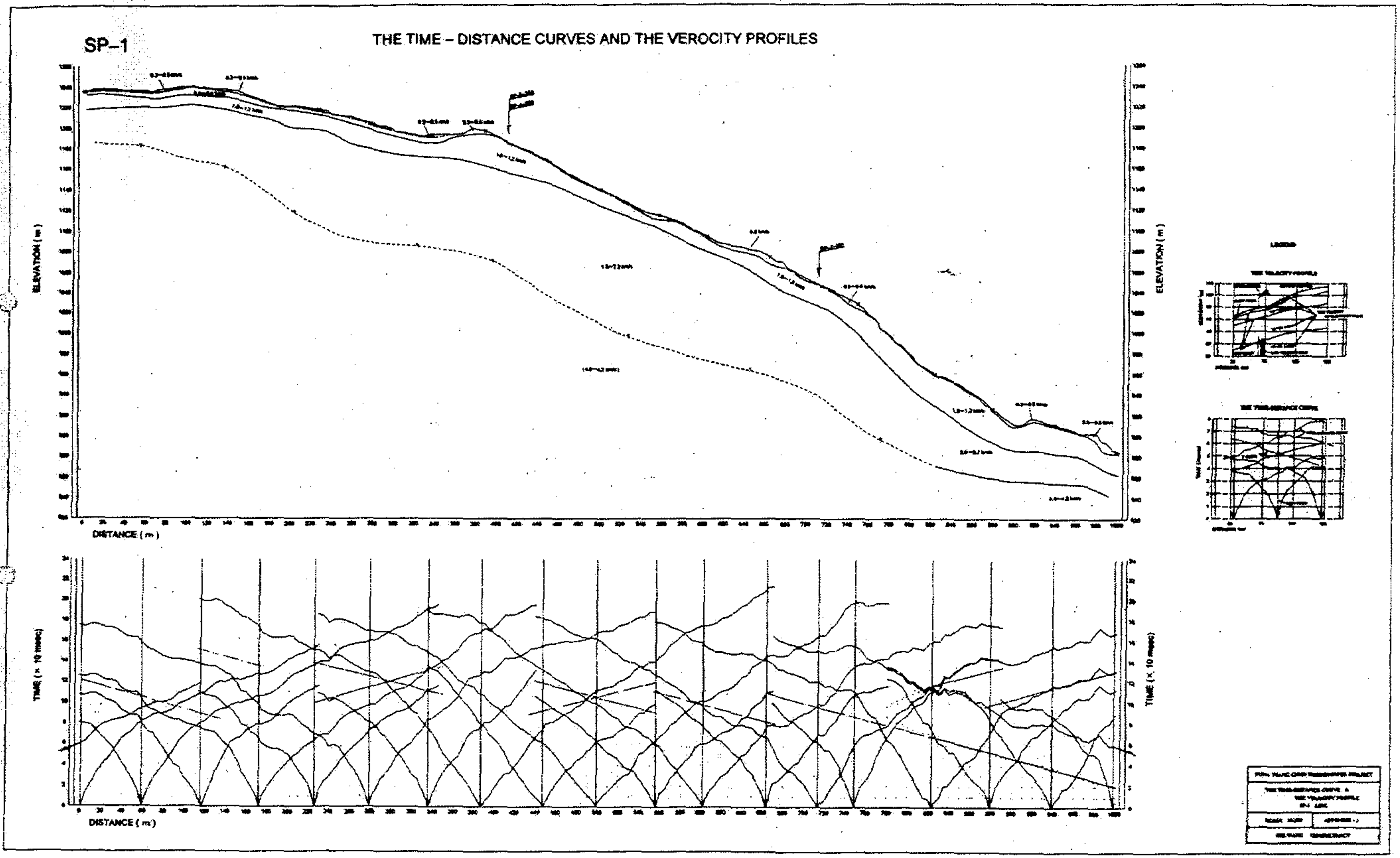
THE TIME-DISTANCE CURVE

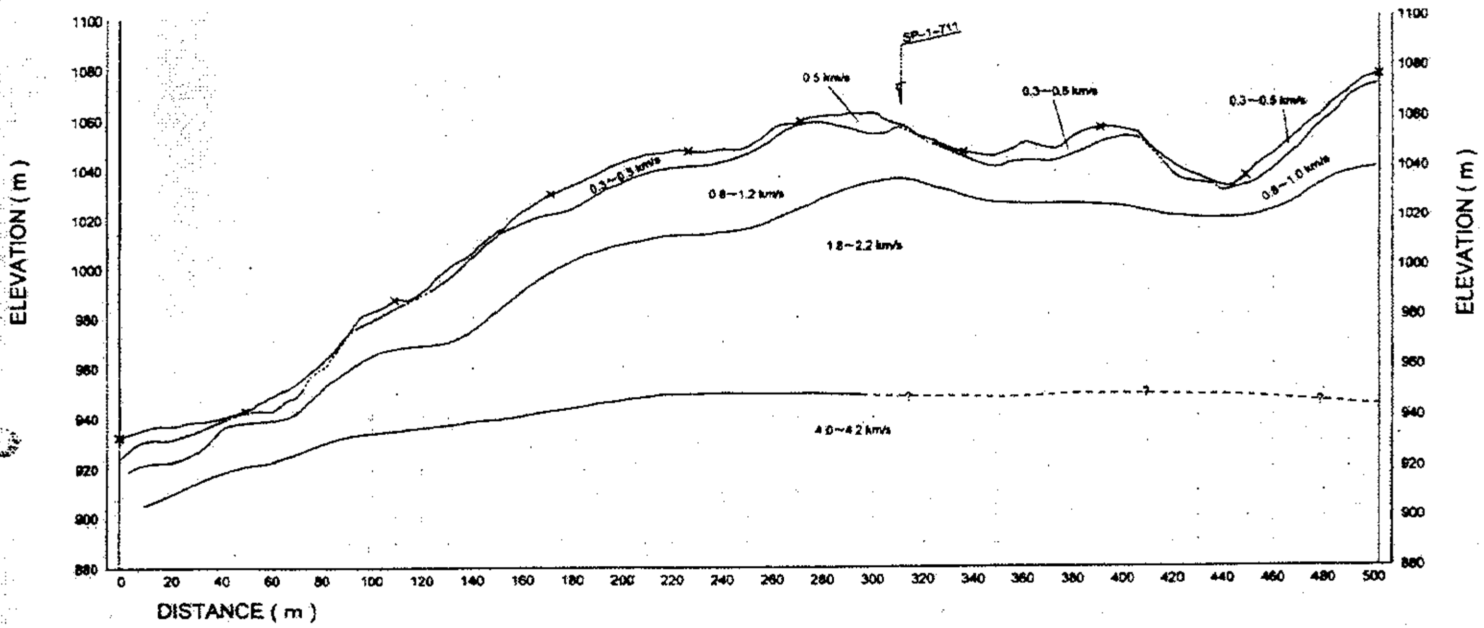


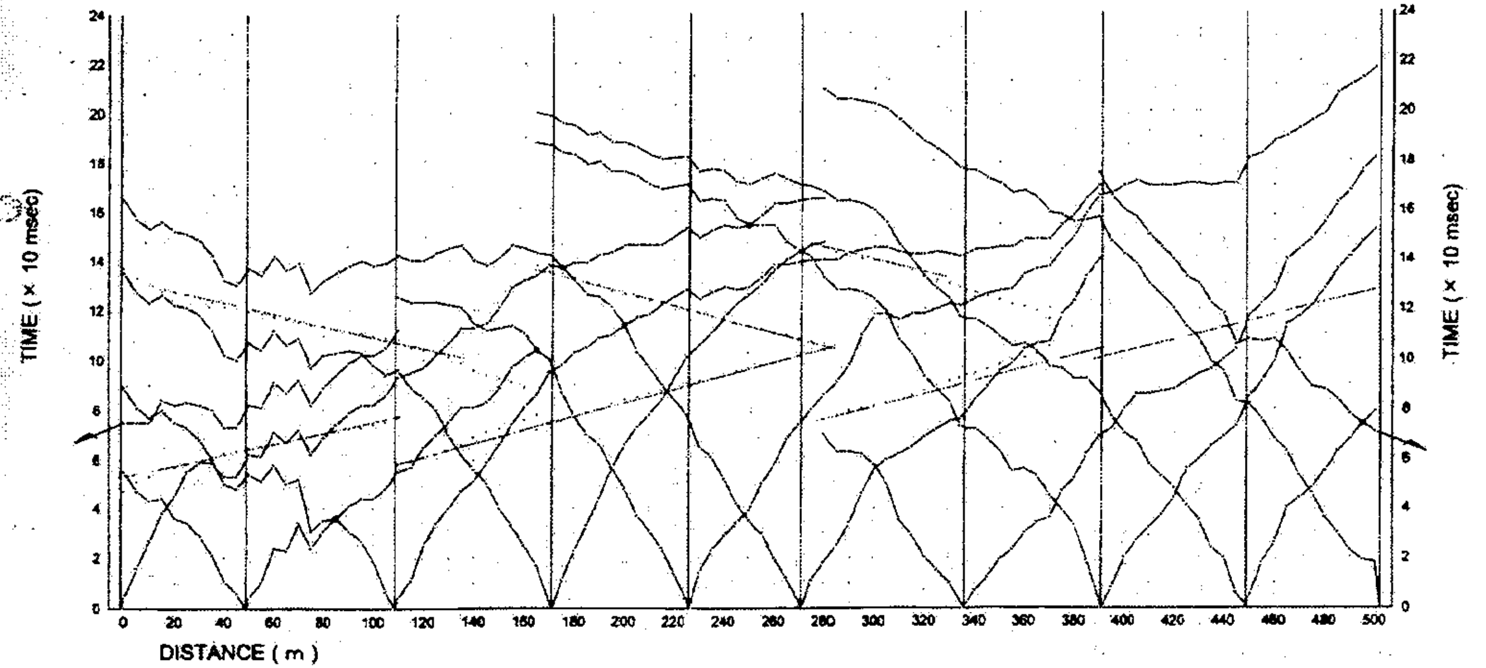




PUNA TSANG CHHU HYDROPOWER PROJECT	
THE TIME-DISTANCE CURVE & THE VELOCITY PROFILE SD-4 , SD-5 LINE	
SCALE 1/1,000	APPENDIX - 2
KELWANG CONSULTANCY	

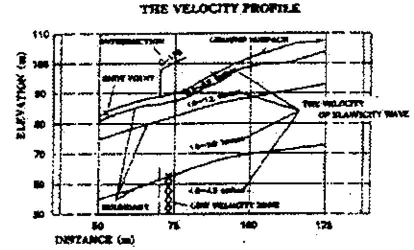

SP–1
THE TIME – DISTANCE CURVES AND THE VEROCITY PROFILES
ELEVATION (m)
DISTANCE (m)
TIME (× 10 msec)



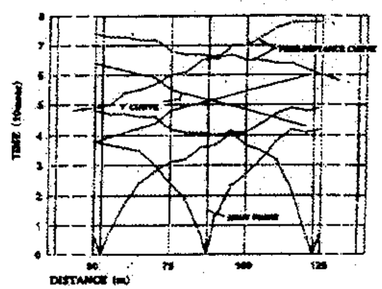


LEGEND

THE VELOCITY PROFILE

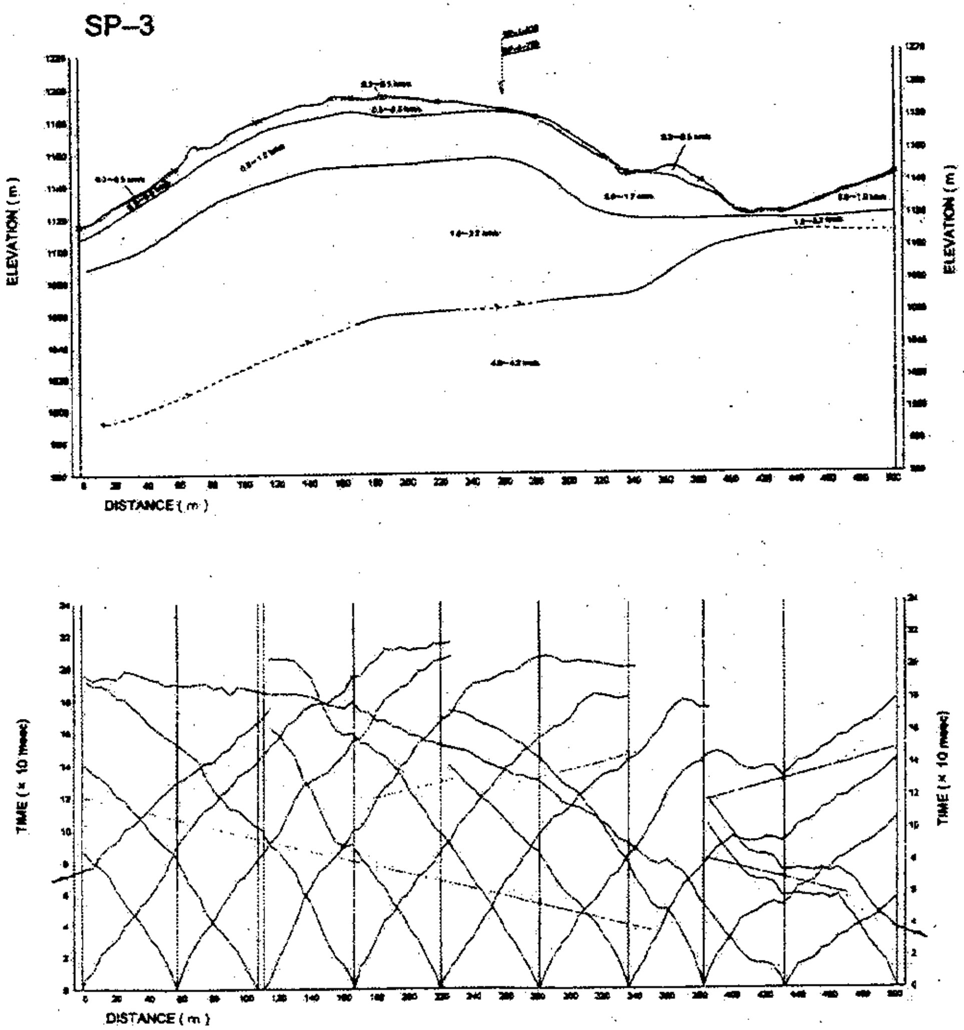


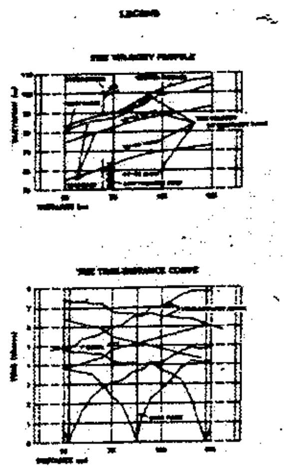
THE TIME-DISTANCE CURVE



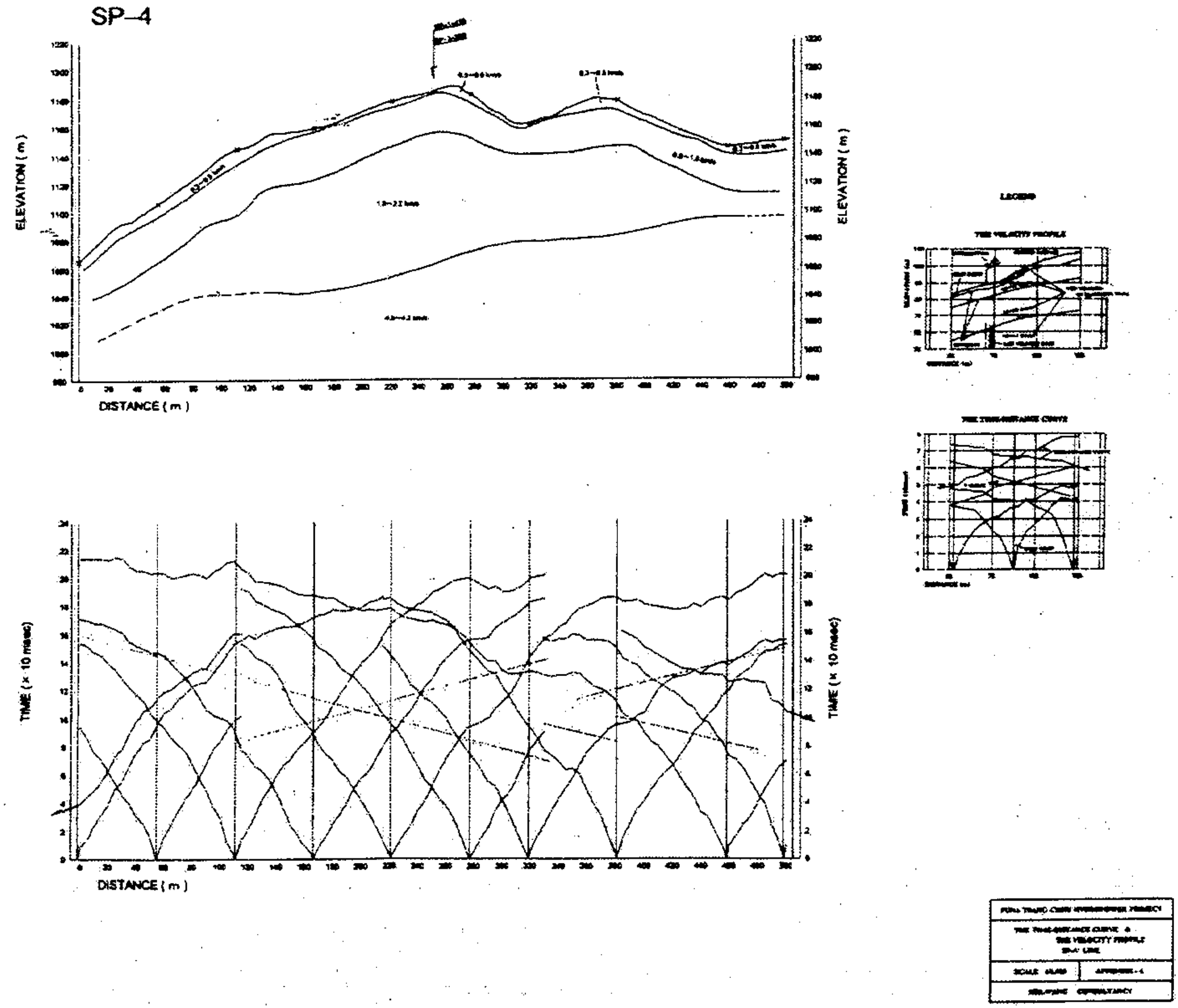
PUNA TSANG CHHU HYDROPOWER PROJECT	
THE TIME-DISTANCE CURVE & THE VELOCITY PROFILE SP-2 LINE	
SCALE 1/1,000	APPENDIX - 4
KELWANG CONSULTANCY	

THE TIME – DISTANCE CURVES AND THE VEROCITY PROFILES

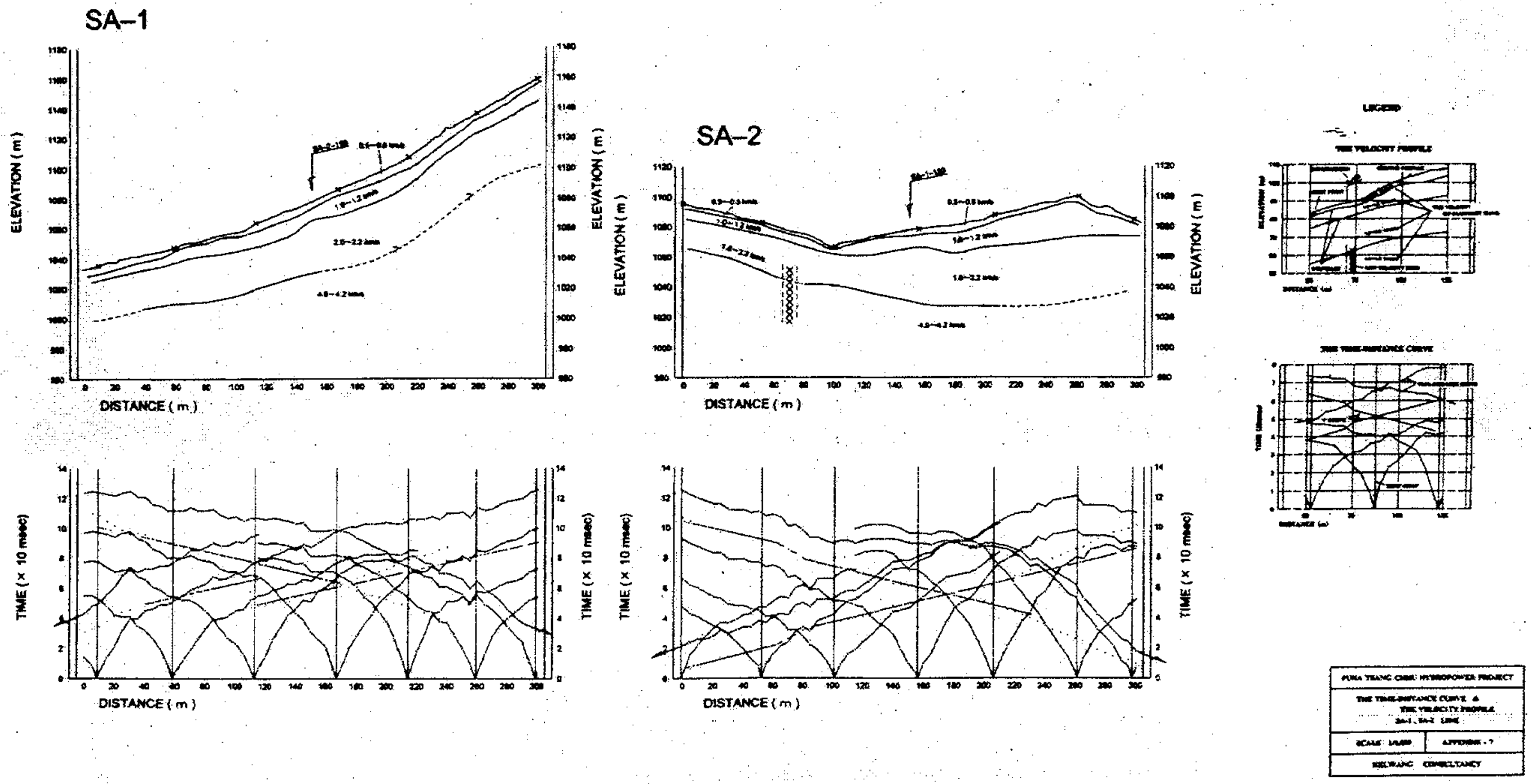




THE TIME – DISTANCE CURVES AND THE VEROCITY PROFILES

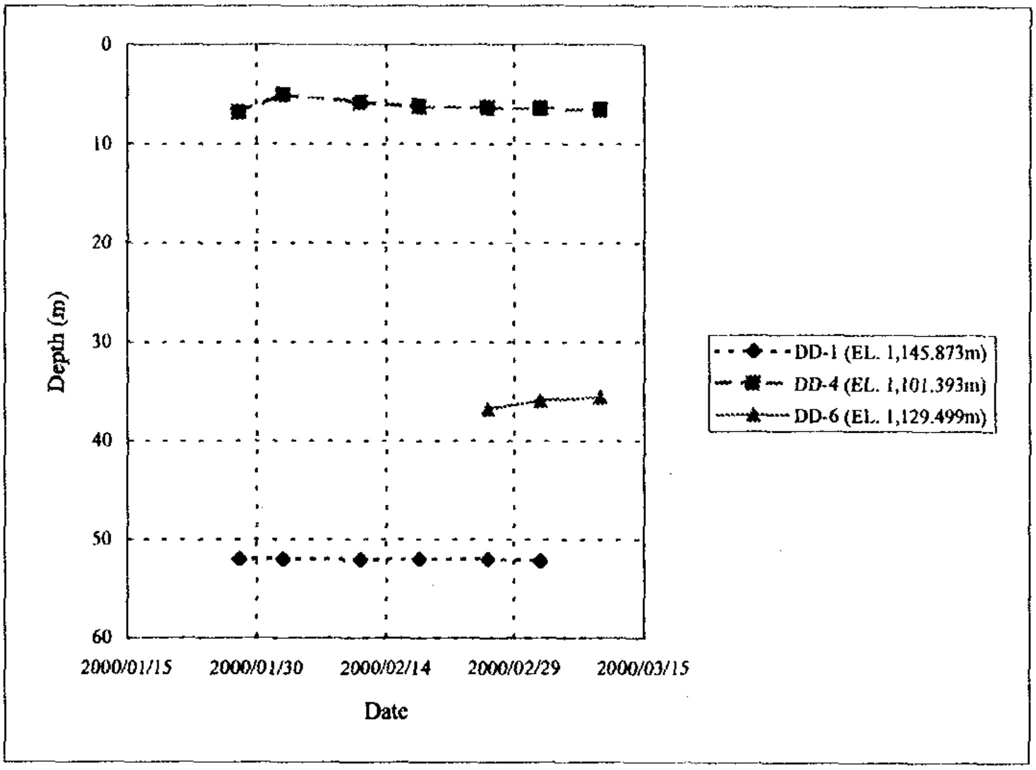


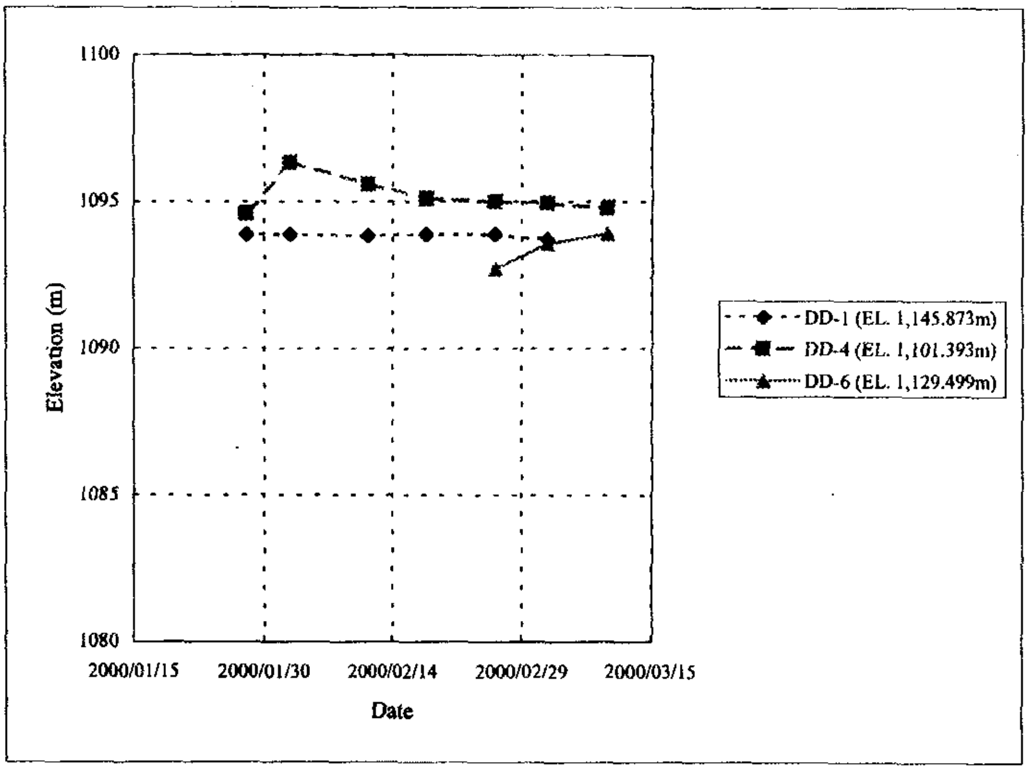
THE TIME – DISTANCE CURVES AND THE VEROCITY PROFILES



Result of Water Level Measurement
In Drill Holes

Result of Ground Water Level Measurement





Result of Laboratory Tests

Summary of Laboratory Test Results on Rock Cores

	Location	Dam		Powerhouse		
	Rock Type	Gneiss	Pegmatite	Gneiss	Pegmatite	Migmatite
Dry Density (g/cm3)	Average	2.80	2.74	2.70	2.53	2.64
	Minimum	2.72	-	2.58	2.29	2.62
	Maximum	2.89	-	2.82	2.70	2.65
	Number of Data	8	1	7	3	2
Saturated Density (g/cm3)	Average	2.81	2.74	2.73	2.54	2.66
	Minimum	2.74	-	2.62	2.30	2.64
	Maximum	2.90	-	2.87	2.70	2.67
	Number of Data	8	1	7	3	2
Specific Gravity	Average	2.67	2.51	2.47	2.61	2.75
	Minimum	2.58	-	1.90	2.55	2.70
	Maximum	2.75	-	2.70	2.71	2.79
	Number of Data	8	1	7	3	2
Water Absorption (%)	Average	1.56	2.64	1.37	1.68	0.90
	Minimum	1.00	-	0.60	1.61	0.80
	Maximum	2.22	-	2.21	1.81	1.00
	Number of Data	8	1	7	3	2
Water Content (%)	Average	0.43	0.27	1.06	0.33	0.67
	Minimum	0.14	-	0.13	0.11	0.56
	Maximum	0.61	-	1.82	0.76	0.77
	Number of Data	8	1	7	3	2
Compressive Strength (kgf/cm2)	Average	322	351	411	914	1,080
	Minimum	217	-	264	686	1,008
	Maximum	577	-	589	1,239	1,152
	Number of Data	8	1	6	3	2

List of Core Sample

Location	Sample No.	Hole No.	Sampling Depth (m)		Remarks
			from	to	
Dam	DD-1-01	DD-1	16.40	16.60	
	DD-1-02	DD-1	16.60	16.85	
	DD-1-03	DD-1	18.50	18.80	
	DD-1-04	DD-1	32.20	32.50	
	DD-1-05	DD-1	50.10	50.50	
	DD-5-01	DD-5	16.05	16.35	
	DD-5-02	DD-5	21.00	21.30	
	DD-5-03	DD-5	21.30	21.70	
	DD-5-04	DD-5	21.70	22.00	
	DD-5-05	DD-5	36.00	36.30	
Powerhouse	DP-1-01	DP-1	39.60	39.90	
	DP-1-02	DP-1	44.25	44.50	
	DP-1-03	DP-1	55.20	55.50	
	DP-1-04	DP-1	62.30	62.50	
	DP-1-05	DP-1	68.40	68.70	
	DP-1-06	DP-1	74.70	74.90	
	DP-1-07	DP-1	77.50	77.80	
	DP-1-08	DP-1	96.40	96.60	
	DP-1-09	DP-1	118.30	118.50	
	DP-1-10	DP-1	154.70	155.00	
	DP-1-11	DP-1	158.50	158.80	
	DP-1-12	DP-1	168.60	168.85	
					total 22 samples

Result of Laboratory Tests on Rock Cores

Sample No.	Hole No.	Sampling Depth (m)		Rock Type	Petrographic Examination	Dry Density (g/cm3)	Saturated Density (g/cm3)	Water Content (%)	Compressive Strength		Specific Gravity	Water Absorption
		from	to						(kgf/cm2)	(MPa)		
DD-1-01	DD-1	16.40	16.60	Gneiss	Garnet-Sillimanite-Biotite	2.72	2.74	0.60	250	24.6	2.58	1.61
DD-1-02		16.60	16.85	Gneiss	Garnet-Sillimanite-Biotite	2.73	2.74	0.45	238	23.3	2.64	1.60
DD-1-03		18.50	18.80	Pegmatite	Quartz-Potasium Feldspar Rock	2.74	2.74	0.27	351	34.4	2.51	2.64
DD-1-04		32.20	32.50	Gneiss	Garnet-Sillimanite-Biotite							
DD-1-05		50.10	50.50	Gneiss	Garnet-Sillimanite-Biotite	2.89	2.90	0.61	577	56.6	2.74	1.41
DD-5-01	DD-5	16.05	16.35	Gneiss		2.89	2.89	0.14	298	29.2	2.61	2.22
DD-5-02		21.00	21.30	Gneiss		2.79	2.81	0.51	217	21.3	2.71	1.00
DD-5-03		21.30	21.70	Gneiss		2.75	2.76	0.30	260	25.5	2.62	1.81
DD-5-04		21.70	22.00	Gneiss		2.79	2.79	0.29	275	26.9	2.71	1.20
DD-5-05		36.00	36.30	Gneiss		2.82	2.84	0.53	462	45.3	2.75	1.61
DP-1-01	DP-1	39.60	39.90	Gneiss		2.70	2.71	0.13	501	49.1	2.56	1.40
DP-1-02		44.25	44.50	Pegmatite		2.29	2.30	0.11	686	67.2	2.57	1.81
DP-1-03		55.20	55.50	Pegmatite		2.70	2.70	0.11	1,239	121.5	2.55	1.61
DP-1-04		62.30	62.50	Pegmatite	Biotite Gneiss	2.61	2.63	0.76	816	80.0	2.71	1.61
DP-1-05		68.40	68.70	Migmatite		2.62	2.64	0.77	1,008	98.9	2.79	0.80
DP-1-06		74.70	74.90	Migmatite	Biotite Gneiss	2.65	2.67	0.56	1,152	113.0	2.70	1.00
DP-1-07		77.50	77.80	Gneiss	Biotite Gneiss	2.69	2.72	1.10	456	44.7	2.58	1.61
DP-1-08		96.40	96.60	Gneiss		2.76	2.78	0.73	349	34.3	2.59	0.60
DP-1-09		118.30	118.50	Gneiss		2.66	2.70	1.29	264	25.9	2.70	1.20
DP-1-10		154.70	155.00	Gneiss		2.58	2.62	1.82	74	7.2	1.90	0.60
DP-1-11		158.50	158.80	Gneiss	Biotite Gneiss	2.82	2.87	1.70	309	30.3	2.23	1.95
DP-1-12		168.60	168.85	Gneiss	Biotite Gneiss	2.72	2.74	0.67	589	57.7	2.70	2.21

Summary of Laboratory Test Results on Concrete Aggreg

Item		Result	Remarks
Specific Gravity (coarse aggregate)	Average	2.45	
	Minimum	2.01	
	Maximum	2.64	
	Number of Data	4	
Specific Gravity (fine aggregate)	Average	2.54	
	Minimum	2.47	
	Maximum	2.61	
	Number of Data	5	
Water Absorption (%)	Average	1.5	
	Minimum	1.4	
	Maximum	1.6	
	Number of Data	4	
Abrasion Loss (%)	Average	36.5	
	Minimum	33.0	
	Maximum	41.0	
	Number of Data	4	
Soundness (%)	Average	2.0	
	Minimum	1.4	
	Maximum	3.0	
	Number of Data	4	
Fineness Modulus	Average	3.79	
	Minimum	2.80	
	Maximum	4.16	
	Number of Data	5	
Alkali-aggregate Reactivity	Result	Innocuous	
	Number of Data	4	

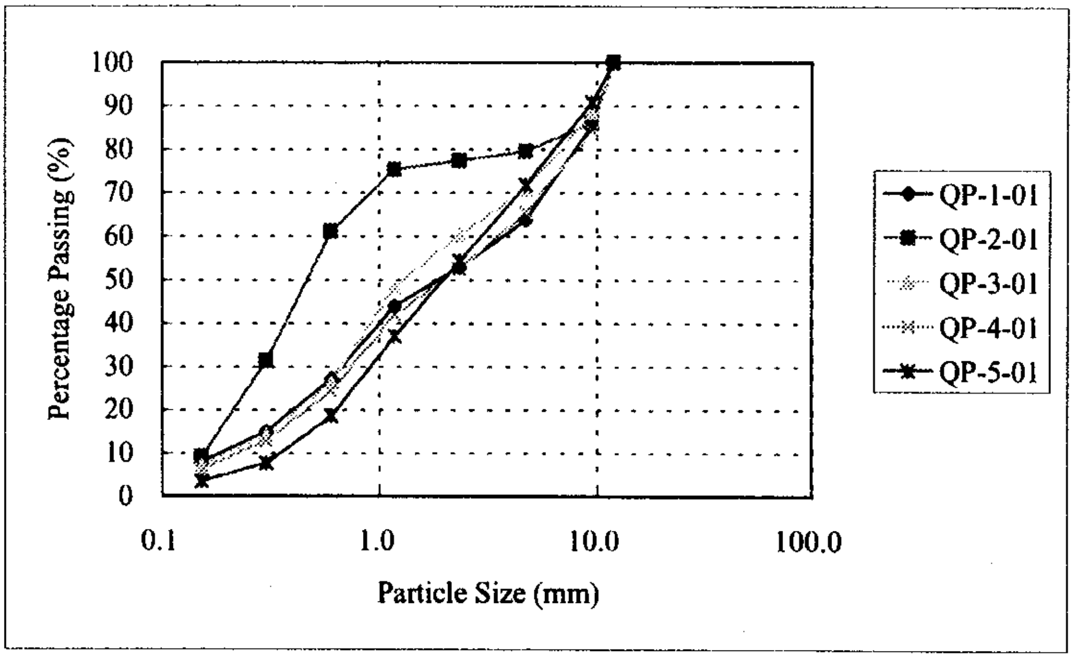
Laboratory Test Result: Coarse Aggregate

Sample No.	Pit No.	Specific Gravity	Absorption Ratio (%)	Abrasion Loss (%)	Soundness (%)	Fineness Modulus	Alkali-Aggregate Reactivity	Petrographic Examination	Remarks
QP-2-01	PQ-2	2.60	1.41	38.0	3.0	N/A	Innocuous		
QP-3-01	PQ-3	2.64	1.40	33.0	1.7	N/A	Innocuous		
QP-4-01	PQ-4	2.56	1.60	34.0	2.0	N/A	Innocuous		
QP-5-01	PQ-5	2.01	1.41	41.0	1.4	N/A	Innocuous		
average		2.45	1.46	36.5	2.0				
minimum		2.01	1.40	33.0	1.4				
maximum		2.64	1.60	41.0	3.0				
nuber of data		4	4	4	4				

Laboratory Test Result: Fine Aggregate

Sample No.	Pit No.	Specific Gravity	Absorption Ratio (%)	Abrasion Loss (%)	Soundness (%)	Fineness Modulus	Alkali-Aggregate Reactivity	Petrographic Examination	Remarks
QP-1-01	PQ-1	2.61	N/A	N/A	N/A	4.04	N/A	N/A	
QP-2-01	PQ-2	2.47	N/A	N/A	N/A	2.80	N/A	N/A	
QP-3-01	PQ-3	2.51	N/A	N/A	N/A	3.84	N/A	N/A	
QP-4-01	PQ-4	2.52	N/A	N/A	N/A	4.12	N/A	N/A	
QP-5-01	PQ-5	2.57	N/A	N/A	N/A	4.16	N/A	N/A	
average		2.54				3.79			
minimum		2.47				2.80			
maximum		2.61				4.16			
nuber of data		5				5			

Result of Sieve Analysis



Sieve (mm)	Percentage Passing (%)				
	QP-1-01	QP-2-01	QP-3-01	QP-4-01	QP-5-01
12.00	100.0	100.0	100.0	100.0	100.0
9.50	85.7	86.2	88.4	84.4	91.0
4.75	63.8	79.6	70.9	65.6	71.9
2.36	52.9	77.4	60.5	52.5	54.3
1.18	44.0	75.3	48.3	42.0	37.0
0.60	27.2	61.2	26.5	24.5	18.6
0.30	14.9	31.4	14.4	13.0	7.6
0.15	7.9	9.1	7.3	6.2	3.4

Result of Alkali-reactivity Test

Project Name: Puna Tsang Chhu Hydropower Project
Applied Method: Chemical Method (Liquid Bath)
Particle Size of Sample (mm: 2.36 - 4.75
Soaked Time in Solution (h): 2.0
Solution Temperature (°C): 83.6
Proportion of Solution (for 100g of Reagent Water):
Sodium Hydroxide (g): 2.42
Potassium Hydroxide (g): 4.86
Calcium Hydroxide (g): 66.67
Purity of Reagents:
Sodium Hydroxide (%): 97.5
Potassium Hydroxide (%): 84.0
Calcium Hydroxide (%): 100.0

Tested by: Seiji Hongo
JICA Study Team
Date of Test: 2000/1/6
Checked by:
Date of Check:

Sample No.	Pit No.	Weight (g)		Gravimetric Change	Volume (ml)		Volumetric Change (%)	Alkali Reactivity	Remarks
		Before	After		Before	After			
QP-2-1	QP-2	391.0	395.9	1.3%	160.2	166.4	3.9%	innocuous	
QP-3-1	QP-3	392.5	394.3	0.5%	152.4	159.7	4.8%	innocuous	
QP-4-1	QP-4	374.4	375.9	0.4%	145.4	147.0	1.1%	innocuous	
QP-5-1	QP-5	315.2	316.3	0.3%	129.3	130.2	0.7%	innocuous	

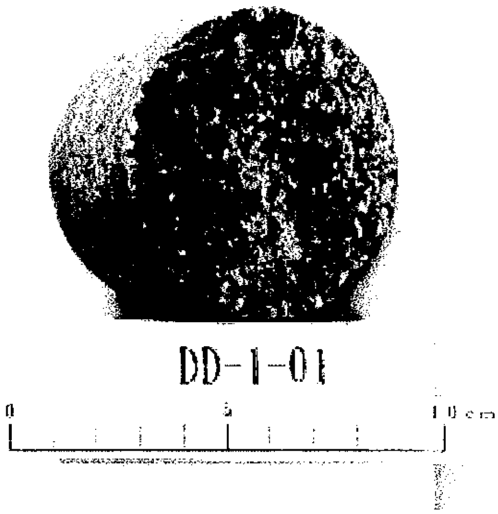
Evaluation Criterion of Potential Alkali-reactivity

Volumetric Change	Determination
5% or less	Innocuous
5 to 10%	Potentially Deleterious
10% or more	Deleterious

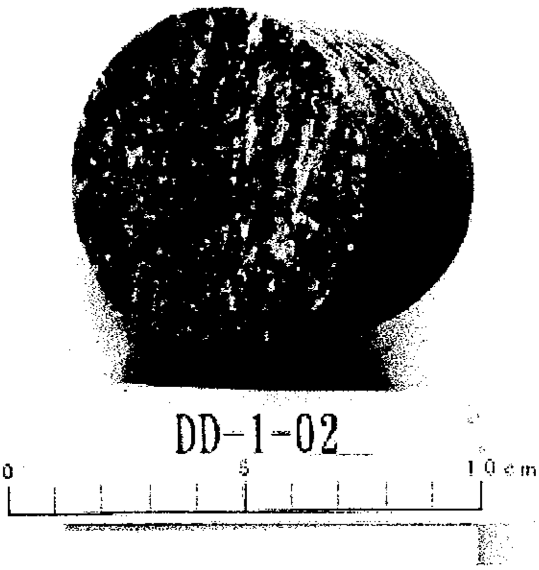
Photographs of Rock Core Samples

Photographs of Rock Core Samples (for Thin Section)

Sample No.: DD-1-01
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Location: Dam Site, Drill Hole DD-1, 16.40 to 16.60m

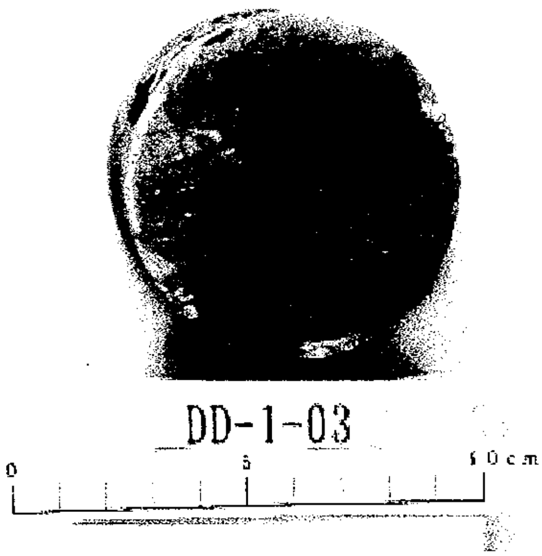


Sample No.: DD-1-02
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Location: Dam Site, Drill Hole DD-1, 16.60 to 16.85m

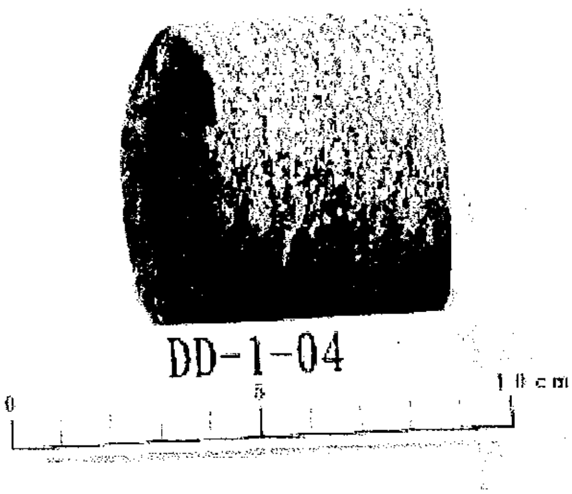


Photographs of Rock Core Samples (for Thin Section)

Sample No.: DD-1-03
Rock Type: Quartz-Potasium Feldspar Rock
Location: Dam Site, Drill Hole DD-1, 18.50 to 18.80m

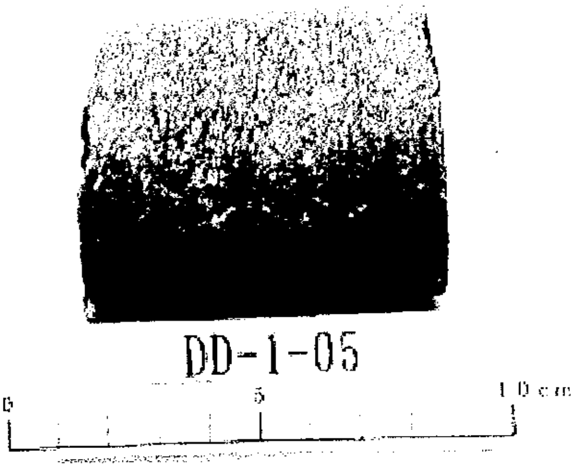


Sample No.: DD-1-04
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Location: Dam Site, Drill Hole DD-1, 32.20 to 32.50m

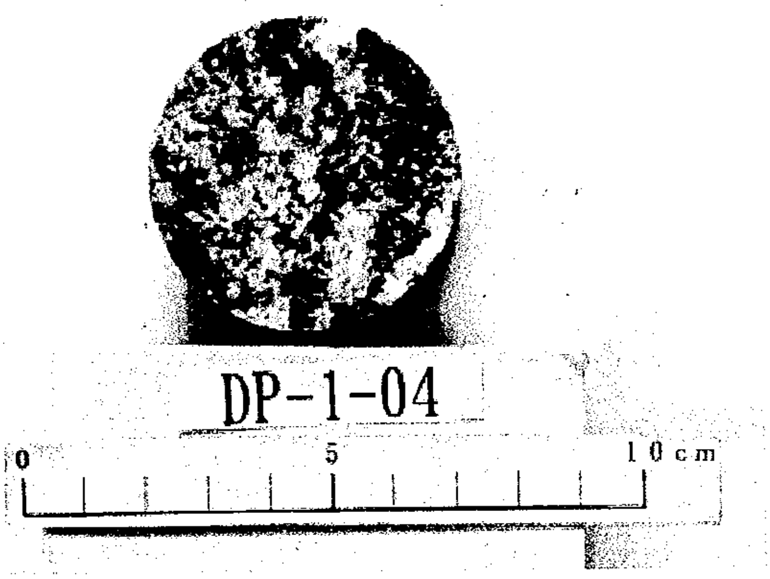


Photographs of Rock Core Samples (for Thin Section)

Sample No.: DD-1-05
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Location: Dam Site, Drill Hole DD-1, 50.10 to 50.50m

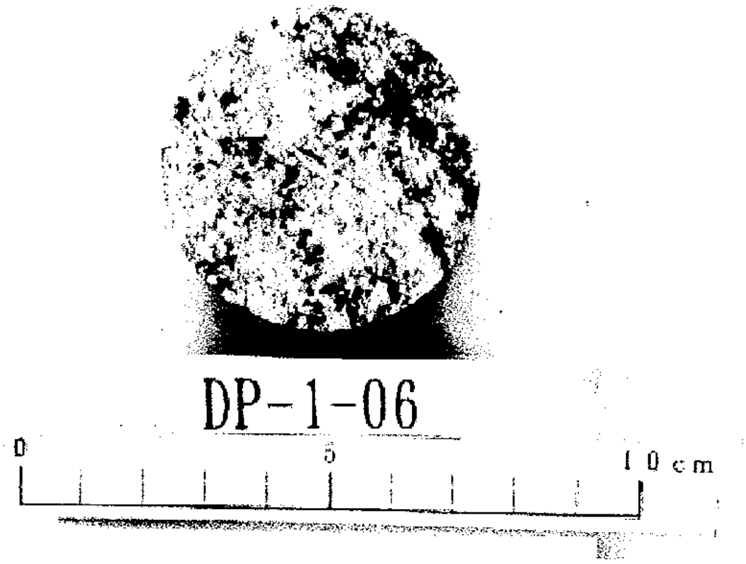


Sample No.: DP-1-04
Rock Type: Biotite Gneiss
Location: Powerhouse Site, Drill Hole DP-1, 62.30 to 62.50m

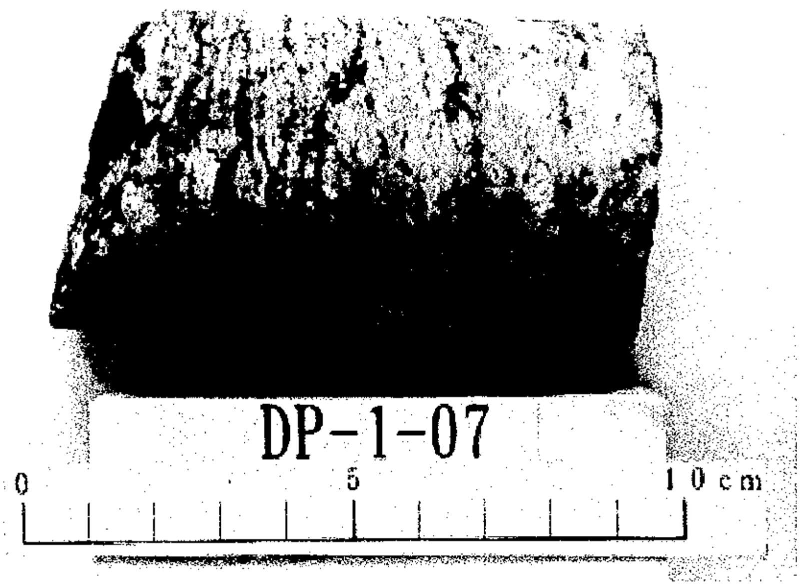


Photographs of Rock Core Samples (for Thin Section)

Sample No.: DP-1-06
Rock Type: Biotite Gneiss
Location: Powerhouse Site, Drill Hole DP-1, 74.70 to 74.90m

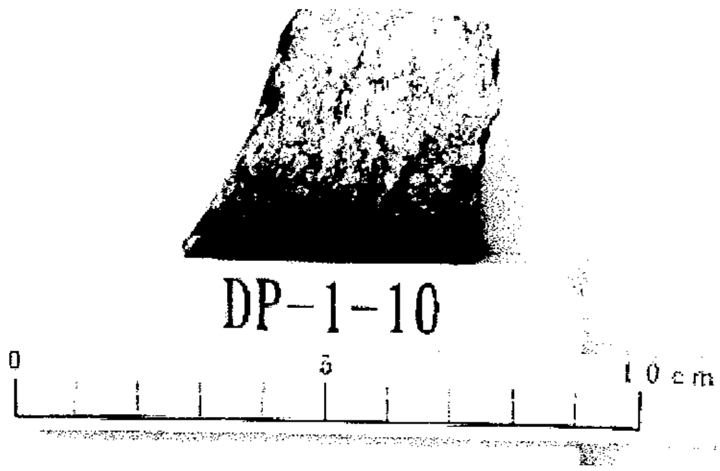


Sample No.: DP-1-07
Rock Type: Biotite Gneiss
Location: Powerhouse Site, Drill Hole DP-1, 77.50 to 77.80m

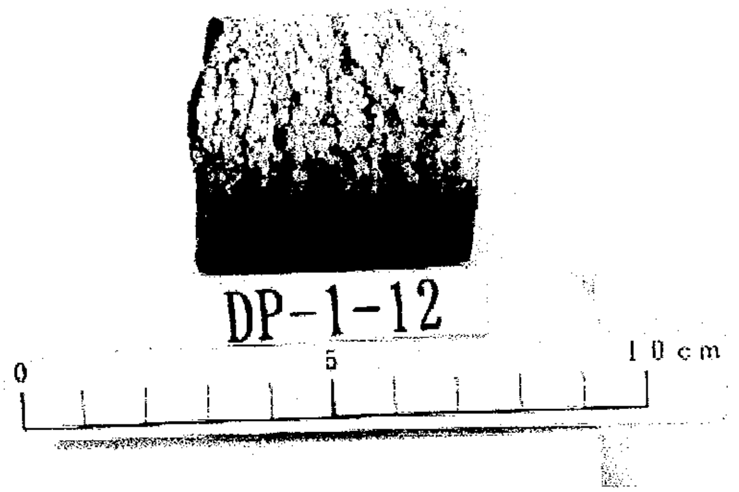


Photographs of Rock Core Samples (for Thin Section)

Sample No.: DP-1-10
Rock Type: Biotite Gneiss
Location: Powerhouse Site, Drill Hole DP-1, 154.70 to 155.00m



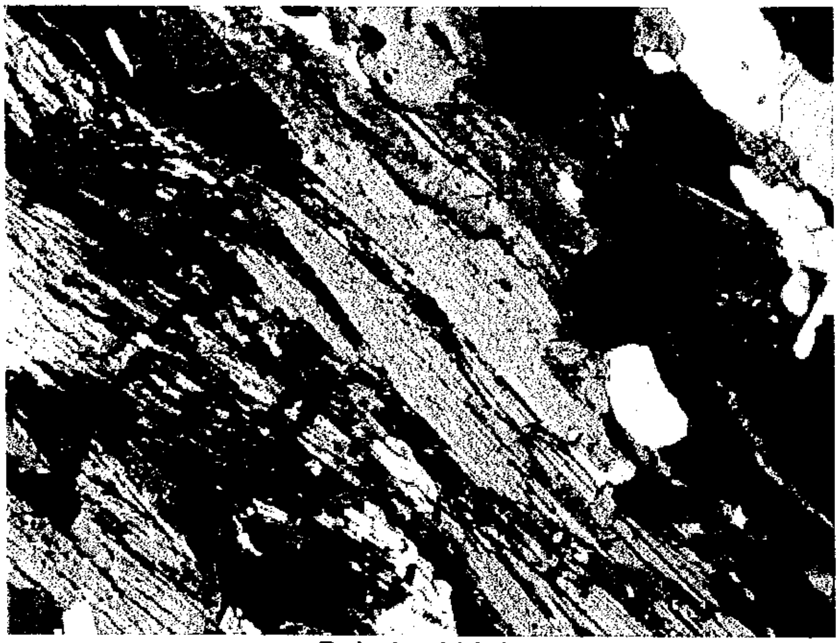
Sample No.: DP-1-12
Rock Type: Biotite Gneiss
Location: Powerhouse Site, Drill Hole DP-1, 168.60 to 168.85m



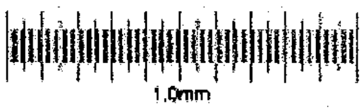
Photomicrographs of Rock Core Sample

Sample No.: DD-1-01
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Texture: Banded gneissose texture

Non-polarized Light

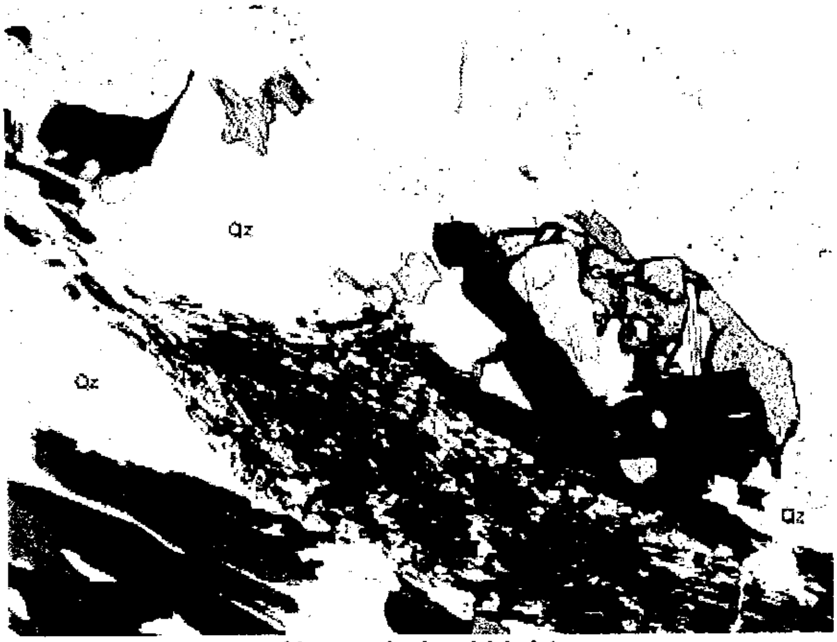


Polarized Light



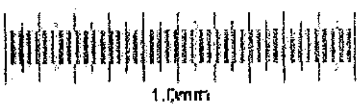
Photomicrographs of Rock Core Sample

Sample No.: DD-1-02
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Texture: Banded gneissose texture



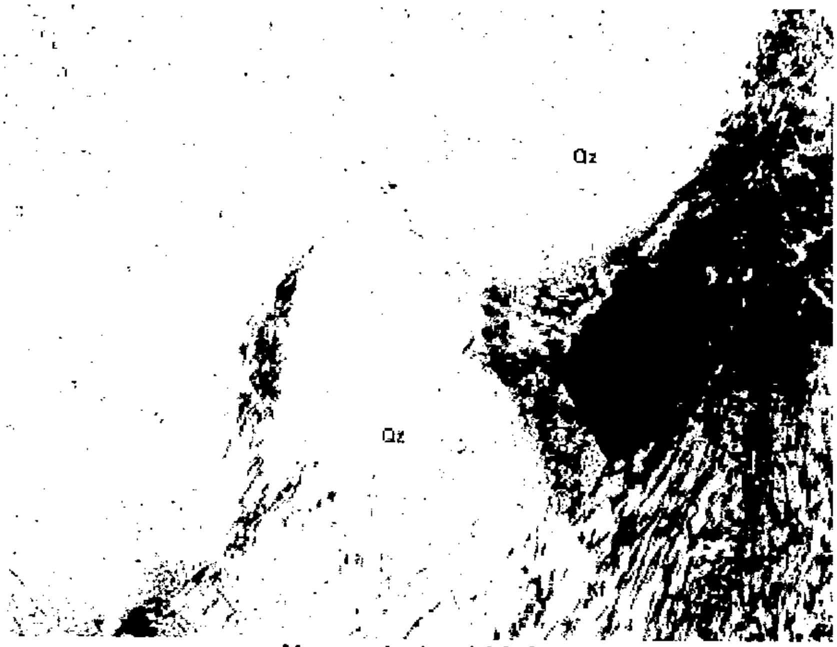
Non-polarized Light

Polarized Light

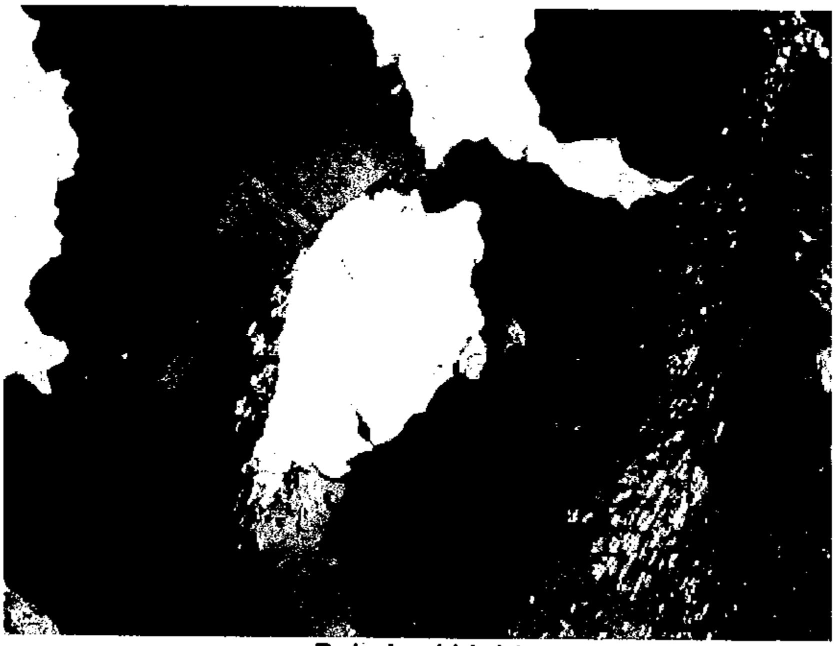


Photomicrographs of Rock Core Sample

Sample No.: DD-1-03
Rock Type: Quartz-Potasium Feldspar Rock
Texture: Equiglanular texture



Non-polarized Light



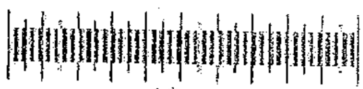
Polarized Light

Photomicrographs of Rock Core Sample

Sample No.: DD-1-04
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Texture: Banded gneissose texture

Non-polarized Light

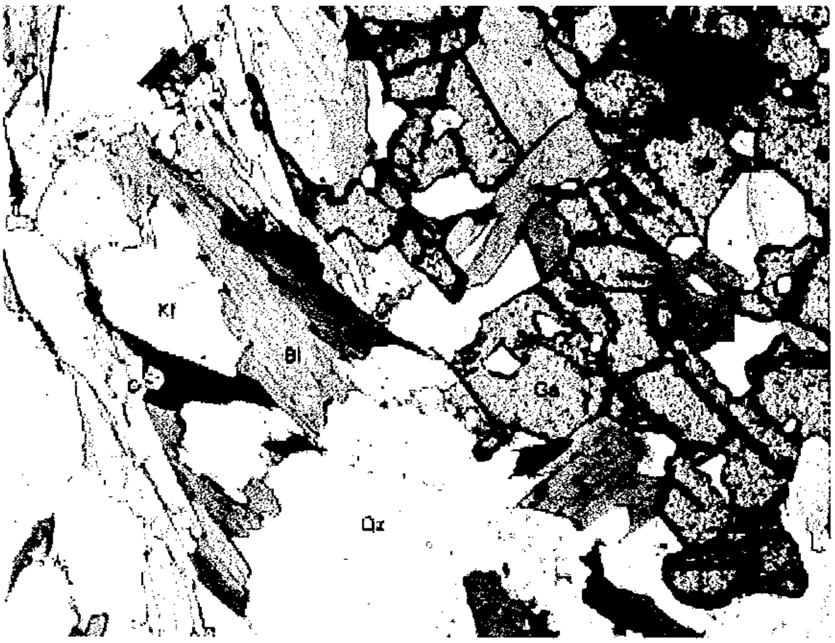
Polarized Light



1.0mm

Photomicrographs of Rock Core Sample

Sample No.: DD-1-05
Rock Type: Garnet-Sillimanite-Biotite Gneiss
Texture: Banded gneissose texture



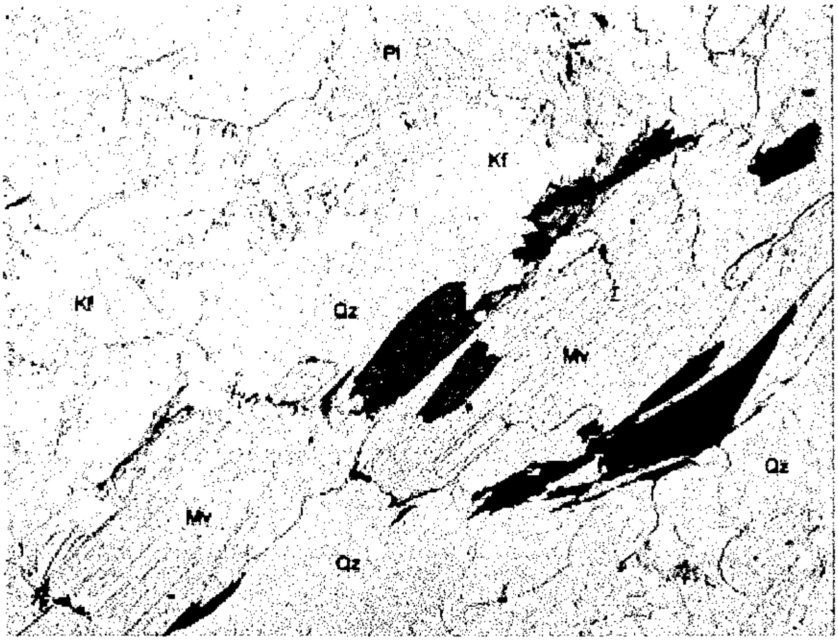
Non-polarized Light

Polarized Light

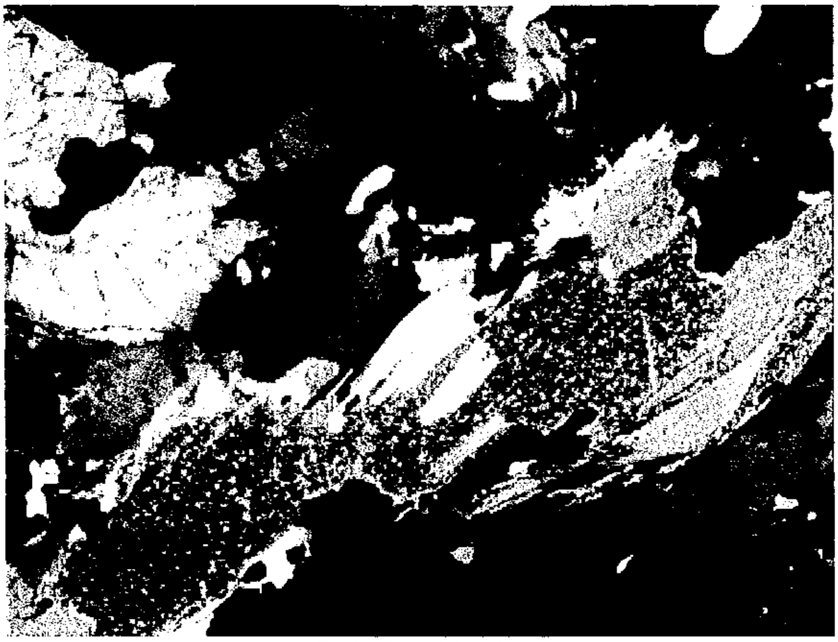
1.0mm

Photomicrographs of Rock Core Sample

Sample No.: DP-1-04
Rock Type: Biotite Gneiss
Texture: Banded gneissose texture



Non-polarized Light

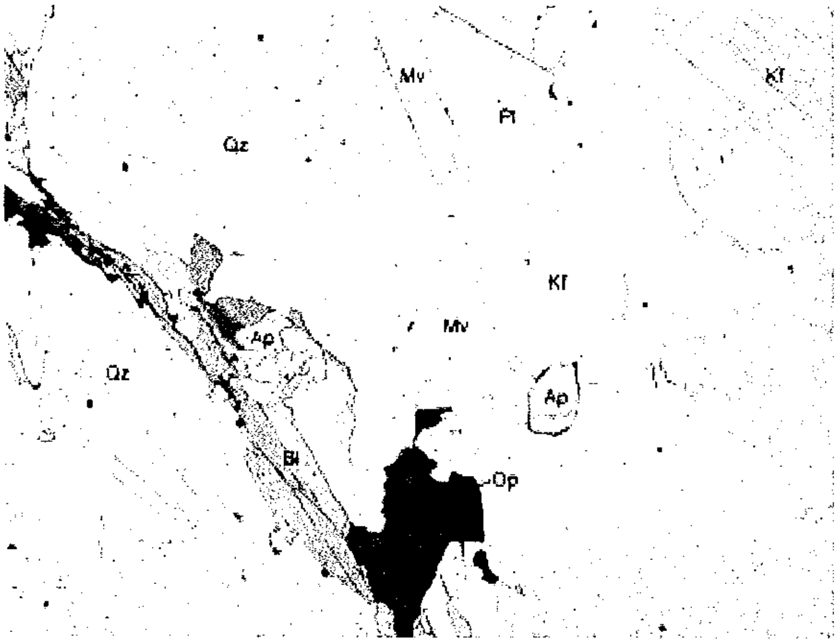


Polarized Light

1.0mm

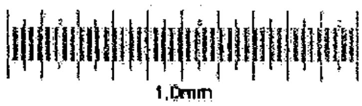
Photomicrographs of Rock Core Sample

Sample No.: DP-1-06
Rock Type: Biotite Gneiss
Texture: Banded gneissose texture



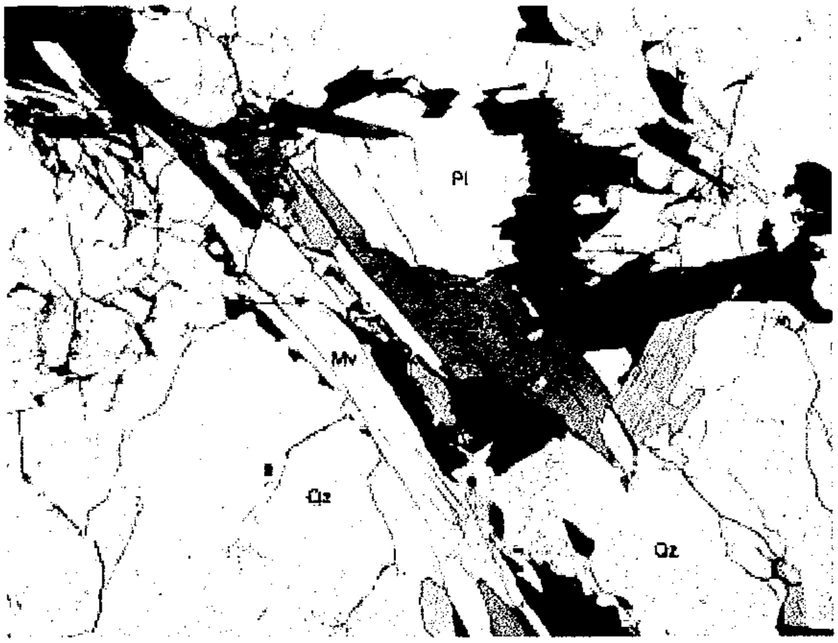
Non-polarized Light

Polarized Light

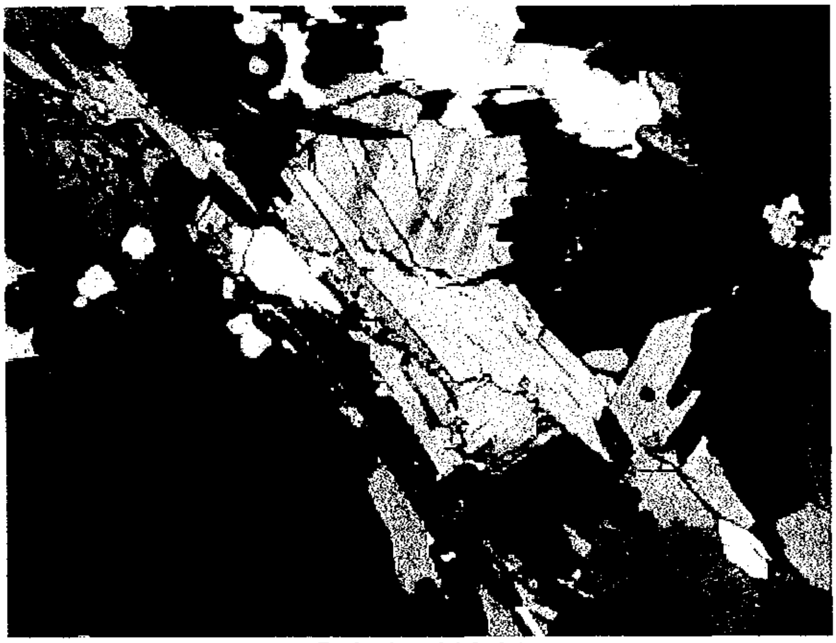


Photomicrographs of Rock Core Sample

Sample No.: DP-1-07
Rock Type: Biotite Gneiss
Texture: Banded gneissose texture



Non-polarized Light

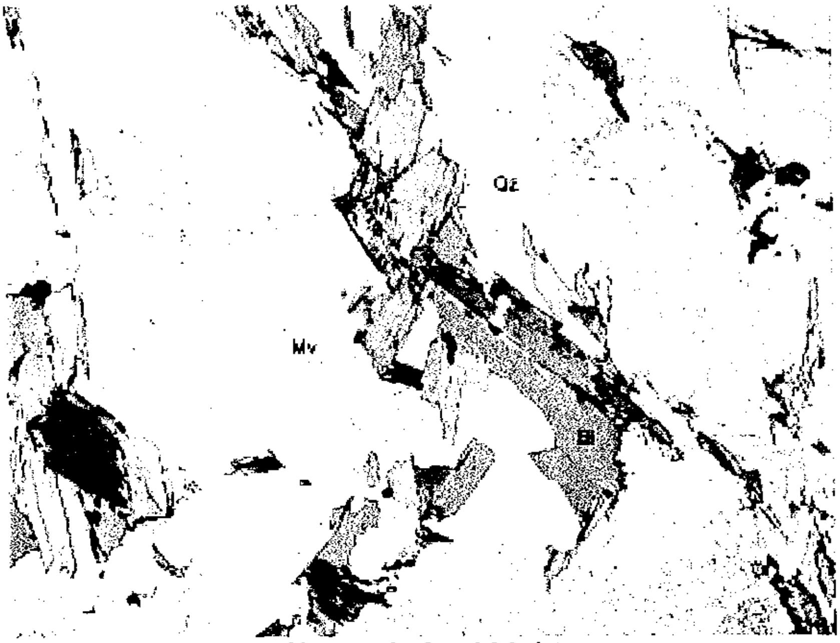


Polarized Light

1.0mm

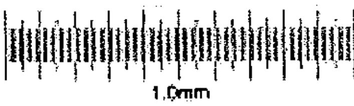
Photomicrographs of Rock Core Sample

Sample No.: DP-1-10
Rock Type: Biotite Gneiss
Texture: Banded gneissose texture



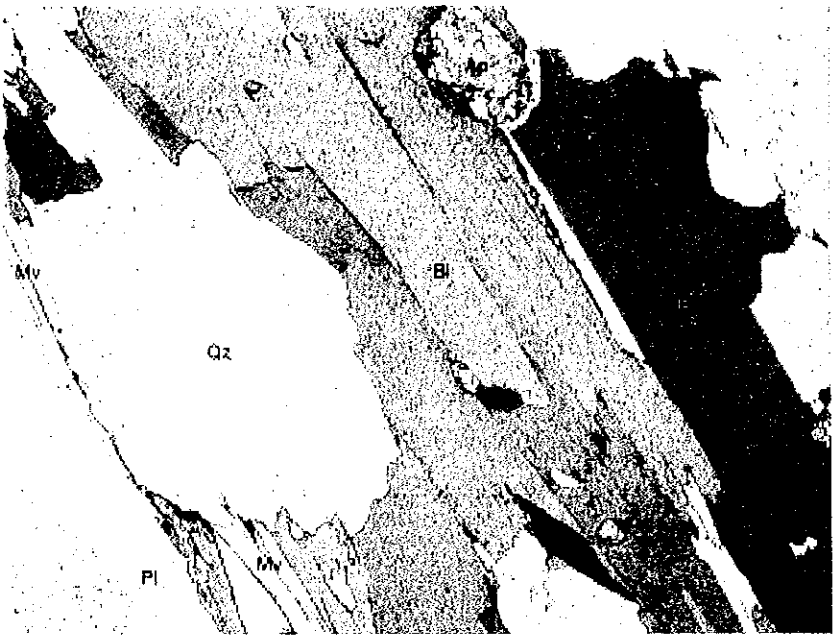
Non-polarized Light

Polarized Light



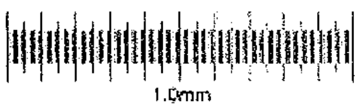
Photomicrographs of Rock Core Sample

Sample No.: DP-1-12
Rock Type: Biotite Gneiss
Texture: Banded gneissose texture



Non-polarized Light

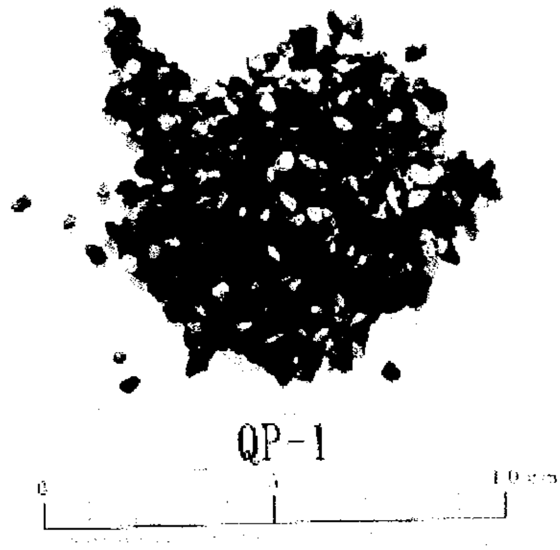
Polarized Light



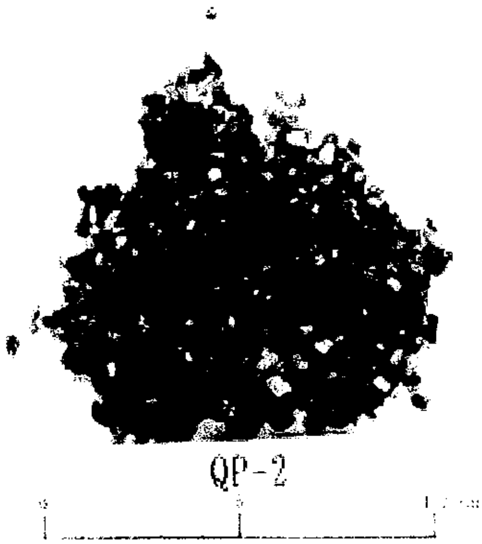
Photographs of Soil Samples

Photographs of Soil Samples (for X-ray Diffraction Method)

Sample No.: QP-1-01
Location: Quarry Site, Pit QP-1

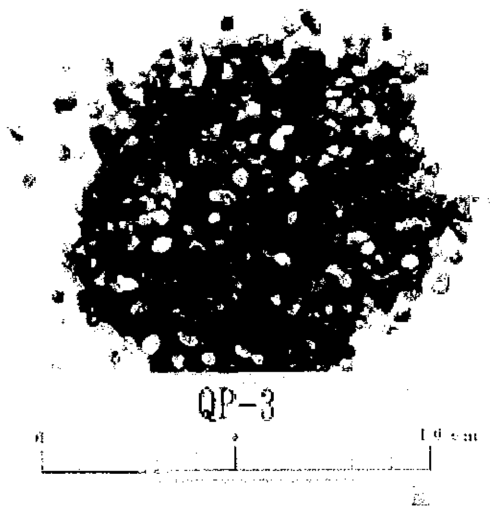


Sample No.: QP-2-01
Location: Quarry Site, Pit QP-2

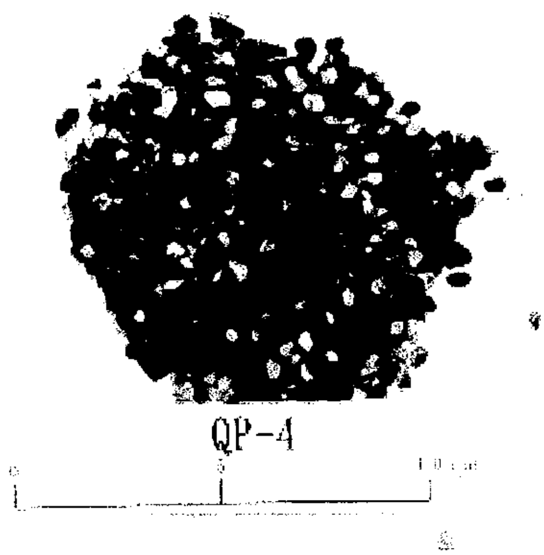


Photographs of Soil Samples (for X-ray Diffraction Method)

Sample No.: QP-3-01
Location: Quarry Site, Pit QP-3

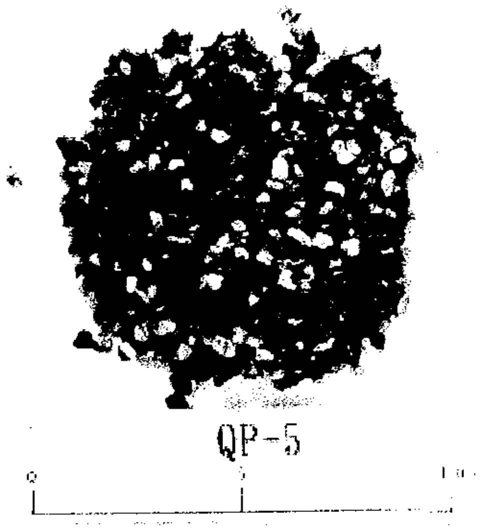


Sample No.: QP-4-01
Location: Quarry Site, Pit QP-4



Photographs of Soil Samples (for X-ray Diffraction Method)

Sample No.: QP-5-01
Location: Quarry Site, Pit QP-5



Results of Petrographic Examination

Results of Petrographic Examination

Type	Sample No.	Method	Result							
			Qz	Kf	Ab	Mi	Ho	Sil	Cc	Ch
Alluvium	QP-1-1	X-ray Diffraction	++++	++	++	+	+-±	+	+	±
Alluvium	QP-2-1	X-ray Diffraction	++++	++	++	++	±	++-+	+	±
Alluvium	QP-3-1	X-ray Diffraction	++++	++	++	+	±	+	+	±
Alluvium	QP-4-1	X-ray Diffraction	++++	++	++	++	±	++	+	±
Alluvium	QP-5-1	X-ray Diffraction	++++	++	++	++	-	+	+	±
Total	5	samples								

Rock Forming Mineral:

Qz	Quartz	Ho	Hornblende
Kf	Potasium Feldspar	Sil	Sillimanite
Ab	Albite	Cc	Calcite
Mi	Mica	Ch	Chlorite

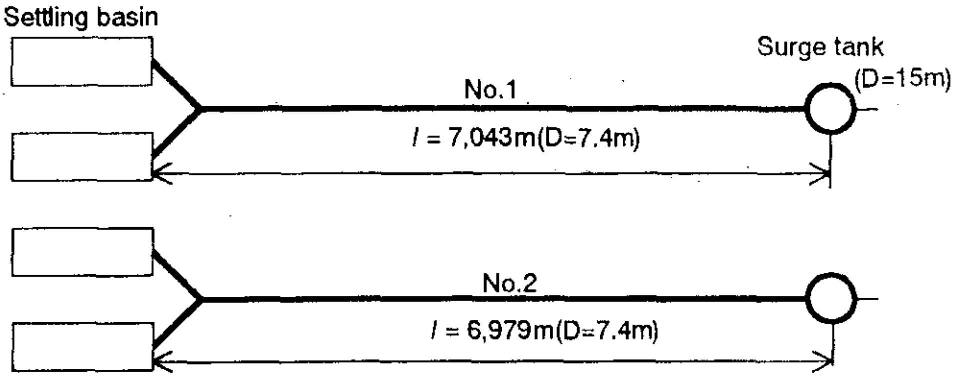
CHAPTER 11

FEASIBILITY DESIGN

FEASIBILITY DESIGN

Calculation of Surging

CALCULATION OF SURGING



(Condition of Calculation)

Type of surge tank : Orifice type surge tank (D=15m)
Headrace tunnel : Twin tunnel , L=7,043m(No1 tunnel)
D=7.4m , n=0.013

Maximum discharge : Q=348m^3/s／2 (for one tunnel)

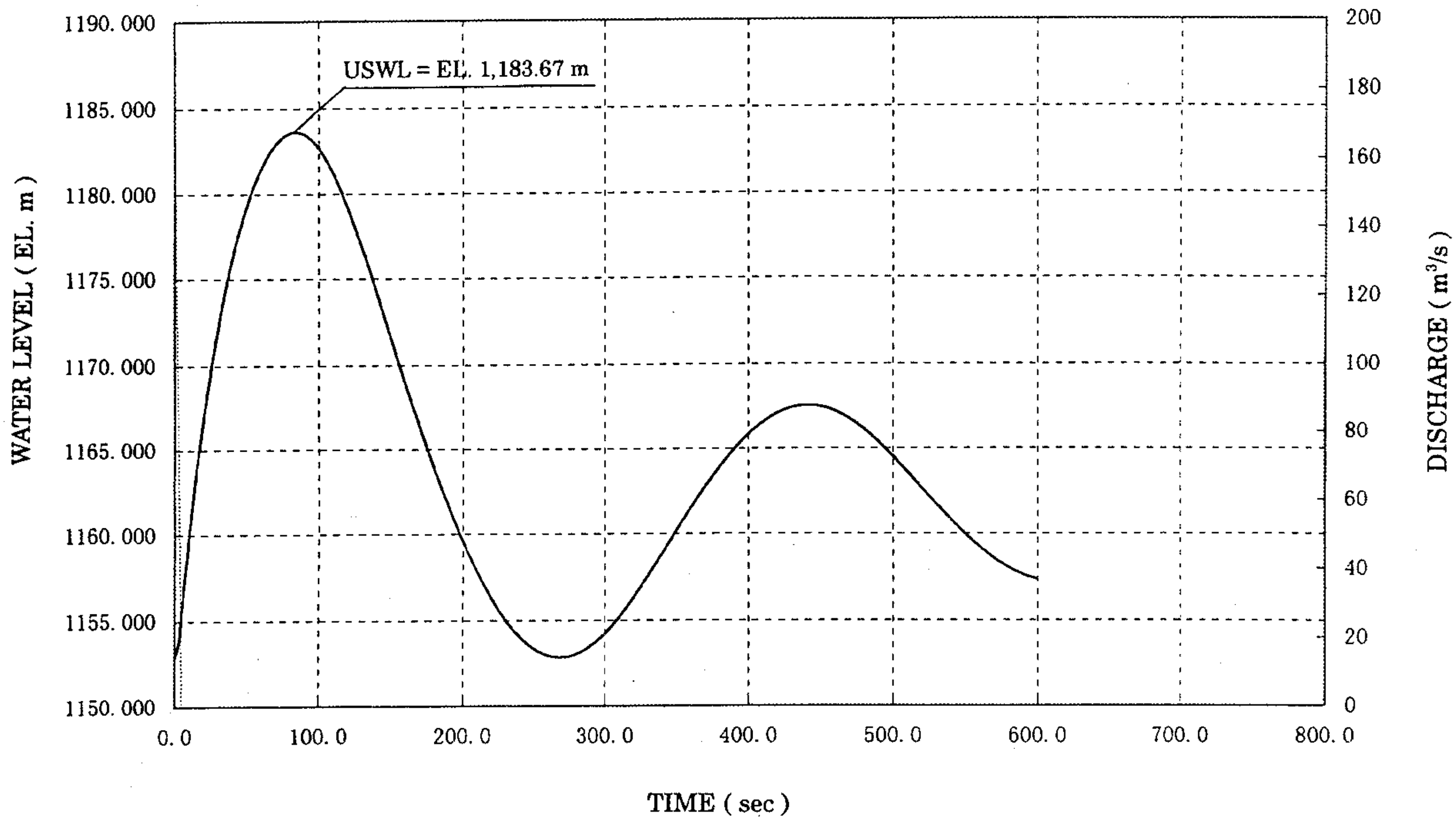
Load rejection : Q (348m^3/s／2→ 0m^3/s) , Δt=5 sec

Load increase : Q (348m^3/s／2×50%→348m^3/s／2) , Δt=90 sec

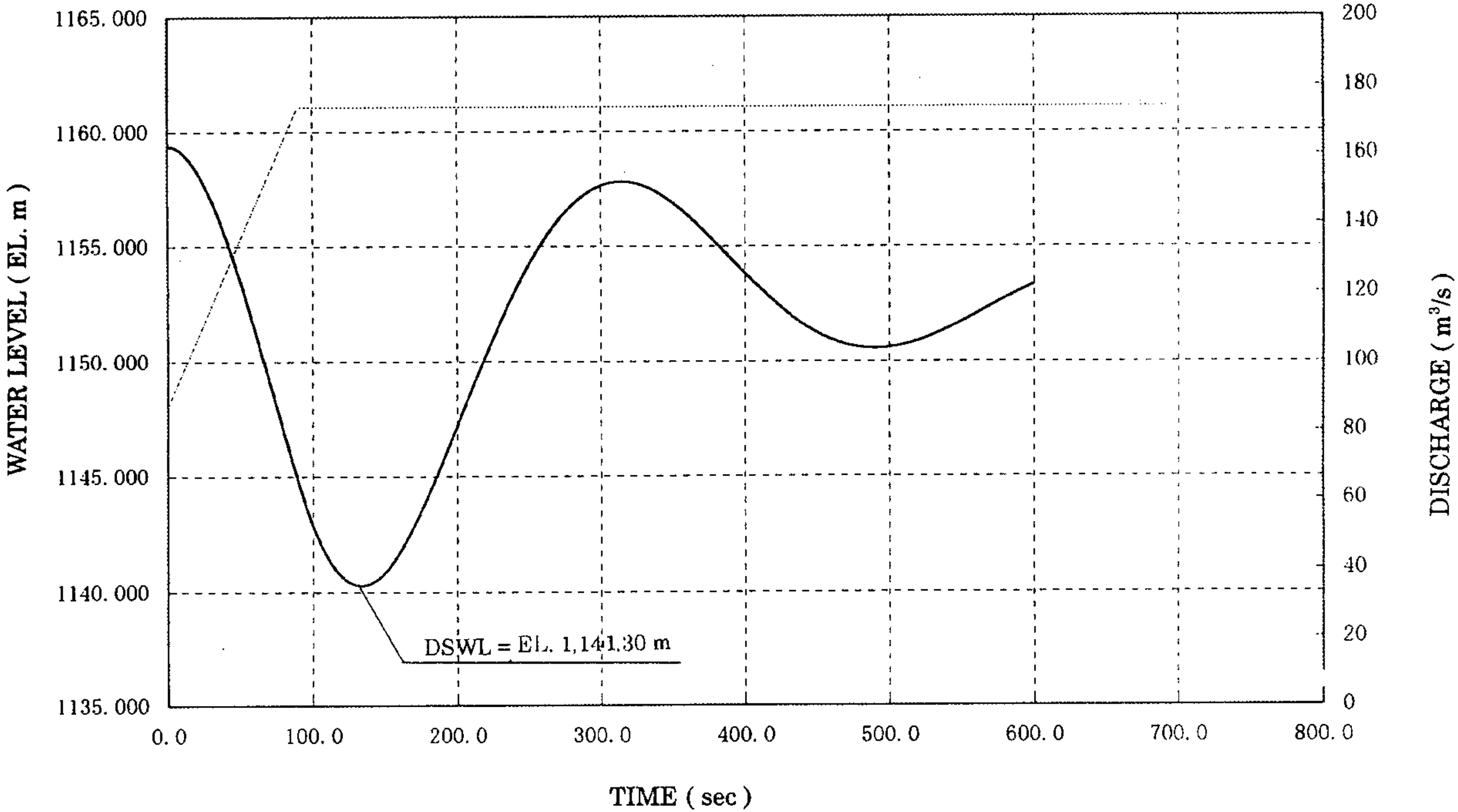
(Result of Calculation)

USWL : EL. 1,183.67 m by load rejection
DSWL : EL. 1,140.30 m by load increase

Up Surging Curve by Load Rejection



Down Surging Curve by Load Increase



CHAPTER 12

CONSTRUCTION PLAN AND CONSTRUCTION COST ESTIMATE

CONSTRUCTION PLAN AND CONSTRUCTION SCHEDULE

Figures:

CONSTRUCTION PLAN AND CONSTRUCTION SCHEDULE

1 River Diversion Work

1.1 Basic Conception

The river diversion work consists of the following structures.

- Diversion Tunnel No.1 L= 822.40 m D= 7.80 m
- Diversion Tunnel No.2 L= 932.47 m D= 7.80 m
- Upstream Cofferdam
- Downstream Cofferdam

A 5 years return period flood is applied as design discharge of cofferdams and diversion tunnels. The upstream cofferdam is expected to remain as long as possible reinforced by CGS and wire mesh system even as overtopping during the rainy season may occur.

1.2 Diversion Tunnel

(1) Excavation

Tunnel excavation of total length of 822.40m for No.1 tunnel and 932.47m for No.2 tunnel will be executed by NATM from the upstream and downstream portals. The drilling will be carried out by 3-boom drill jumbos. The width of the excavated tunnel invert will be 6.3m, to which the loaders and the dump track are to be dimensioned.

The shotcrete and rock bolts if required will be executed immediately after blasting. The rockbolting will place by the drill jumbo or a rock bolt placing machine.

- Average advance: 100 m/month per face

(2) Concrete lining and Contact Grouting

After the completion of the tunnel excavation, the concrete lining is to executed using a removal steel form length of 9.00m. Concrete is transported by truck mixers (5.0 m^3) and placed by a concrete pump (80 m^3/hr).

- Average advance per month
  9 m/span x 1 span/2days x 25 days/month = 112.5 m/month

The sections in which the concrete lining has been placed are to be grouted with mortar after the curing of about one month. Pressure of mortar injection is 3 - 5 kg/cm^2.

The contact grouting is to be performed through grout hole.

The consolidation and curtain grouting will be executed at the section of concrete plug after the completion of the mortar injection. The consolidation grouting around the inlet portal is planed additionally, if required.

(3) Concrete Plug

Before placement of plug concrete in diversion tunnel, tunnel will be closed using stop gate provided at the upstream end of the tunnels. Then the river flow will be transferred from diversion tunnel to the Punatsangchhu River.

The concrete plug has been designed at the location of the dam axis to stop seepage of water from the reservoir.

Prior to the concrete placing of plug section, drainage pipes (8 inches in diameter) with upstream coffering will be provided to drain leaking water from the inlet portal.

The surface of all invert and side walls (half of tunnel height) of the concrete plug section shall be chipped to provide bond of fresh concrete to the lining concrete.

The plug concrete will be placed by concrete pump in 4 layers. After completion of plug concrete, curtain grouting and consolidation grouting will be executed 1 - 2 weeks after the concrete placing using injection pressure of 5 - 15 kg/cm^2.

1.3 Cofferdams

(1) Construction Method

The construction of cofferdams should be constructed in the dry season after the diversion tunnels are available for river water flowing.

A temporary closure is to be constructed upstream of the main coffer dam. After the flow of the river is diverted in to the diversion tunnels, the main cofferdam is to be carefully constructed.

The upstream cofferdam is designed to be constructed mainly by filling rock with water-tight layer of impervious materials. The curtain grouting will be executed using a sleeve grout method, if required.

The downstream cofferdam is to be constructed generally according to the construction procedure of the upstream cofferdam.

1.4 Construction Schedule

River diversion works (diversion tunnel and cofferdam) will control the construction schedule of the entire project and thus it will be necessary to be completed as early as possible. Therefore, preparation works for the diversion tunnel should be started in early time after the Award of Contract of main civil work.

The main cofferdams are to be constructed immediately after the completion of the diversion tunnel, and completed before the start of the open excavation of dam foundation below the national highway level (EL. 1,171 m).

2 Dam

2.1 Excavation

(1) Excavation Volume

The excavation volume of dam is indicated below.

Location	Elevation	Volume (m^3)
Left Bank	Above EL.1,090 m	107,000
Right Bank	Above EL.1,090 m	834,000
Riverbed	Below EL.1,090 m	1,379,000
Total		2,320,000

(2) Excavation Method

Both banks will be excavated by bench cut method from up to down. The benches would be 2.5m – 5.0m high, and 65 mm diameter of holes to be drilled by crawler drills. Each bench will be excavated up to 0.5 m out of the design excavation line by blasting and the remaining part (0.5 m approx.) will be excavated by Jack hammer.

For slope protection, rock bolting, wire mesh and shotcrete will be placed on the excavated slope. At weathered zone, the shotcrete will be executed depending on the geological condition.

Excavated muck and loose rock are collected by both man-power and 0.4 m^3 backhoe at upper benches. Consequently, 1.2 m^3 backhoe and heavy duty bulldozers will be used around excavation at the lower benches. For riverbed excavation, backhoe with minimum capacity 1.2 m^3 and heavy duty bulldozers will be used.

Transportation of the excavated muck will be done by dump trucks with capacity 11 ton to 20 ton, crawler loaders with 3.2 m^3 and backhoes.

(3). Construction Schedule

After relocation of national highway located at the right bank of damsite, dam foundation excavation will start from the end of first year. However, right bank excavation below elevation of national highway will be carried out after diverting the Punatsangchhu river discharge into the diversion tunnel. Dam foundation excavation will be completed in the third year.

2.2 Dam Concrete

Dam concrete volume of dam is shown below.

Description	Volume (m^3)
Dam Concrete above riverbed (EL.1090 m)	411,200
Dam Concrete below riverbed (EL.1090 m)	416,200
Pier and Wall Concrete	86,300
Total	913,700

Estimated dam concreting volume is approximately 910,000 m^3. In order to shorten the dam concreting period, the riverbed portion below EL 1090 (height: 60m) is to be carried out by the RCC method. Concreting of the portion above EL 1090 m is to be performed using two units of tower crane, lifting capacity of 20 tons each. A 180 m^3/hr concrete batching plant is to be installed on the right bank downstream of the damsite. Dam concreting will start from the beginning of the third year and is completed in the middle of the fifth year. The diversion tunnels will be plugged during the dry season of the fifth year, with river discharge at that time being diverted by the sluiceways within the dam structure.

As sufficient quantity of suitable aggregates for concrete are not available around the site. The fresh rock generated from underground excavation will be used for concrete aggregate. A 350 ton/hr crashing plant for aggregate is to be constructed adjacent to the batching plant located just downstream of the damsite.

The workable days per month and daily working hours for concrete placement are assumed as follows.

Daily working hours:	20 hrs.
Monthly workable days:	22 days from June to September, and 25 days for all other month

(1). Roller Compacted Concrete (RCC)

The RCC concrete placement method will be applied for dam construction bellow EL.1,090 m. The height of lift for dam concrete is 1.0 m and each lift is divided into 3 layers. Dump trucks will be used for transportation of concrete from batching plant to the site. The thickness of each layer of concrete is selected at 33 cm, and bulldozer and vibrating roller will be used for concrete placement. Expected average daily progress of concrete placement is estimated at 2,100 m^3/day.

To avoid cracks in dam concrete the following measures should be applied.

- The temperature of placing concrete should be kept in low

- The quantity of cement should be minimized to avoid raising temperature from hydration of cement. Moderate heat cement with fly ash for dam concrete would be recommended.

- Aggregate temperature in summer season should be kept in low by covering storage bins and/or sprinkling cool water.

(2). Concrete Placement by Tower Crane

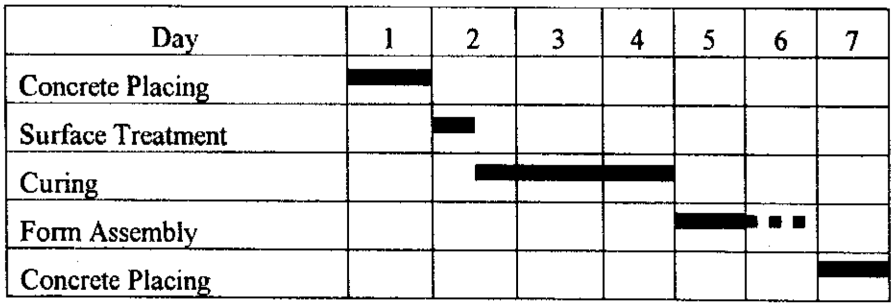
For dam construction above EL.1,090 m, it is assumed to use the block system. The dam concrete is placed by 6.0 m^3 bucket to be operated by tower crane. The height of lift for dam concrete placement is 1.5 m, and each lift is divided into 3 layers. Each layer of concrete will be vibrated by vibrators mounted on bulldozer.

The rates of concrete placement are assumed as follows.

Average progress

Hourly progress:	70 m^3/hr
Daily progress:	1,150 m^3/day
Monthly Progress:	19,000 m^3/month

Standard cycle time of concrete placement by tower crane is as shown bellow.



2.3 Grouting Work

The consolidation grouting is executed in 5 m grid with 5 m drill depth in the foundation rock. An additional grouting will be executed depend on the geological condition of bedrock.

Injection holes will be drilled by drill rigs vertical at the riverbed, and vertical and inclined at the both abutments. Additional grouting will be executed depend on the permeability test results or injection results.

The curtain grouting is executed in two rows and 1.5 m interval.

The bore holes are drilled by rotary drilling machines

- 66 mm hole: test and drainage holes
- 46 mm hole: injection holes

The test holes are required to recover cores to get reference data for the injection results.

The curtain grouting shall be performed after completion of the consolidation grouting within 5 m around the hole. The injection from the dam gallery shall be done after placing concrete 15 m in height from the foundation rock. The injection will be carried out in sequence from the test holes to the general holes. Portland cement is mainly adopted for the curtain grouting.

Detailed construction schedule of dam construction is shown in Fig A.12.2.

3. Underground Settling Basin

Four (4) settling basins (20 m width × 39m height × 130m length) will be established at a point approximately 300m downstream from the intake structure. The access tunnel to settling basins will be aligned from EL 1171 m just above the power intake and used to excavate the settling basin arch portion. Excavation volume is roughly 104,000 m^3 per each settling basin, requiring approximately 18 months. Excavation method to be applied for settling basins are a combination of presplit blasting and bench cutting, with wall reinforcement by rockbolt and shotcreting as excavation progresses. Excavated muck will be removed via the flushing tunnel, access tunnel and work adit of headrace tunnel. Upon completion of excavation, walls will be reinforced by concreting.

3.1 List of Equipment for Cavern Excavation

Following equipment will be used for each underground settling basin excavation.

		Equipment	Specifications	No. of set
Excavation	1	3 boom hydraulic wheel jumbo	170 kg	1
	2	Hydraulic crawler drill	150 kg	1
	3	Hydraulic breaker	130 kg (0.6 m^3 backhoe)	1
Mucking	4	Wheel loader (Side dump type)	3.4 m^3	1
	5	Backhoe	0.4 m^3	1
	6	Dump tracks	11 - 20 ton	
Shotcrete	7	Shotcrete machine (wheel type)	6 - 20 m^3 Robot	1
	8	Compressor	12m^3/min x 2	1
	9	Truck mixer	4.4 m^3	1

Excavation method for underground settling basin is indicated in Fig A.12.1.

4. Headrace Tunnel

The tunnel construction consists of three (3) work adits and two (2) headrace tunnels. The work will be conducted simultaneously from thee work adits namely upstream work adit (L= 455m) midstream work adit (L= 600 m) and downstream work adit (L= 250 m). Access to the respective working faces will be via an adit.

Two circular shaped headrace tunnels of 7,053 m and 6,989 m in length and inner diameter of 7.40 m are planned to be driven along the left bank of the Punatsangchhu River.

The excavation work of the tunnel will be made by conventional blasting method with rail type equipment. The excavation works will be undertaken by two shifts operating each day. The concrete lining work will be carried out after the completion of tunnel excavation.

The following equipment and manpower are foreseen for tunnel construction work (for each face).

(1). Tunnel excavation

3 booms hydraulic jumbo	1 unit
Battery locomotive	3 units

6 m^3 muck car	18 units
2.3 m^3 wheel loader	1 unit
150 t/hr train loader	1 unit
11 ton dump track	2 units
21 ton bulldozer	1 unit
Breaker	1 unit
Ventilation fan	
Manpower, 2 shifts of 30 men	60 men

Average excavation advance per month is planed at 150 m requiring around one year for completion.

(2). Lining concrete

Lining concrete will be carried out 12 m sliding form mounted on the needle beam. The concrete lining works will be undertaken by one shift operating with a two days per cycle.

The following equipment and manpower will be applied for concrete lining works.

12 m long steel sliding form (needle beam type)		1 unit
30 m^3/hr concrete pump		1 unit
6 m^3 agitator car		4units
12 ton battery locomotive		4 units
4.4 m^3 track mixer		3 units
Manpower (for each face)	1 shift of 40 men	40 men

Monthly advance of concrete lining is estimated at 120 m. The grouting works will begin at least two (2) months after commencing the concrete lining. The grouting works consist of mortar grouting and consolidation grouting. Mortar grouting is to be injected using grout pipes embedded at arch portion of lining concrete. Consolidation grout is to be done by drilling grout holes by crawler drill.

5. Surge Tank

A restricted type surge tank will be constructed between each headrace tunnel and penstock tunnel. The diameter and height of surge tank shaft are 15.00 m and 54.60 m respectively. Upon completion of the tunnel portion just below the surge tank, a pilot heading of the surge shaft, 2.4 m x 2.4 m will be drilled upward by 2 leg hammers equipped on the raise climber. A blasting length of 1.0 m is assumed.

The enlargement of the surge shaft will be made from the top to the downward using crawler drill. A blasting length of 2 m for surge shaft is assumed. The muck will be discharged through the pilot heading. The excavated rock surface will be systematically protected with wire mesh, shotcrete and rockbolts where necessary.

The lining concrete for the surge shaft will proceed from the bottom upwards using a slip form with 3 m lift and 3 days cycle.

6. Penstock Tunnel *and* Powerhouse Complex

The construction methods of penstock tunnel, powerhouse complex, etc. are described in Chapter 12 of the Main Report. Detailed construction schedule of penstock tunnel and powerhouse cavern are shown in Figs. A.12.2 and A.12.3 respectively.

7. Detailed Construction Schedule

A detailed construction schedule of Punatsangchhu Hydropower Project is indicated in Figs. A.12.2 and A.12.3 in Appendix.

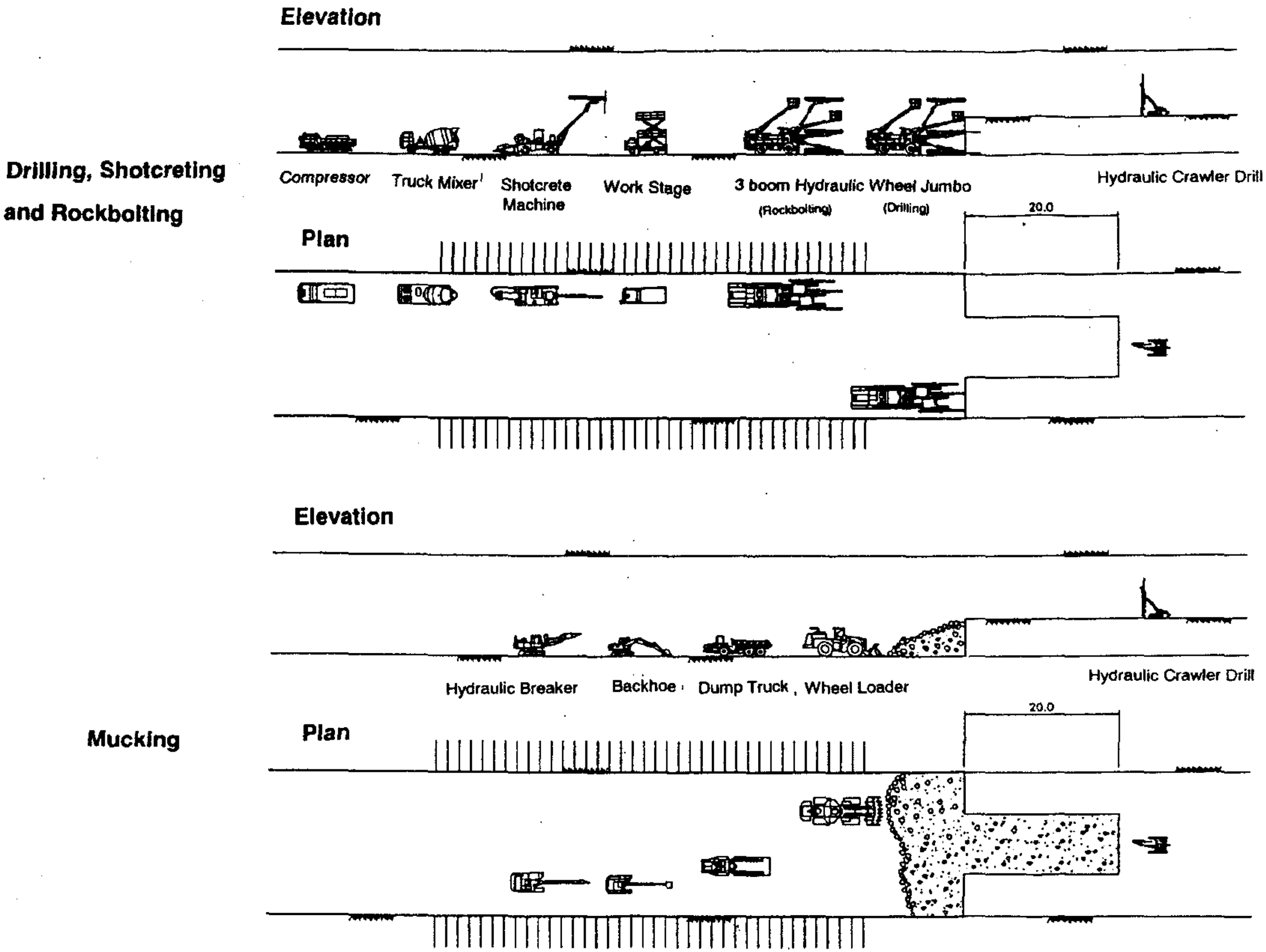


Fig. A.12.1 Cavern Excavation Method (Settling Bashine and Powerhouse)

Fig. A.12.2 CONSTRUCTION SCHEDULE, DAM AND WATERWAY, PUNATSANGCHHU PROJECT

Description	Quantity	Unit
Award of Contract (Main Civil Works)		
Impounding of Reservoirs		
Filling Water in Waterway		
Mobilization		LS
< Preparatory Works >		
Road Improvements	1	LS
Road Relocation (Damsite Area)	361	m
Construction Power Supply System	1	LS
Camp Facilities	1	LS
< Care of River >		
Coffer Dam		
Diversion Tunnel	933+822	m
Excavation		
Concrete		
< Temporary Access Road >		
Right Bank Upstream of Dam	1,815	m
Temporary Bridge (Upstream)	55	m
Left Bank, Upstream of Dam	1,280	m
Right Bank Downstream of Dam	300	m
Temporary Bridge (Downstream)	90	m
Left Bank, Downstream of Dam	200	m
< Dam >		
Excavation	2,320,000	cu.m
Dam Concrete (RCC)	412,000	cu.m
Dam Concrete	416,200	cu.m
Concrete, Pier and Wall	87,000	cu.m
Consolidation Grouting	27,800	m
Curtain Grouting	16,000	cu.m
Sluiceway	2	sets
Spillway Gate	7+4	sets
Crest Road	1	LS
< Power Intake >		
Open Excavation	98,000	cu.m

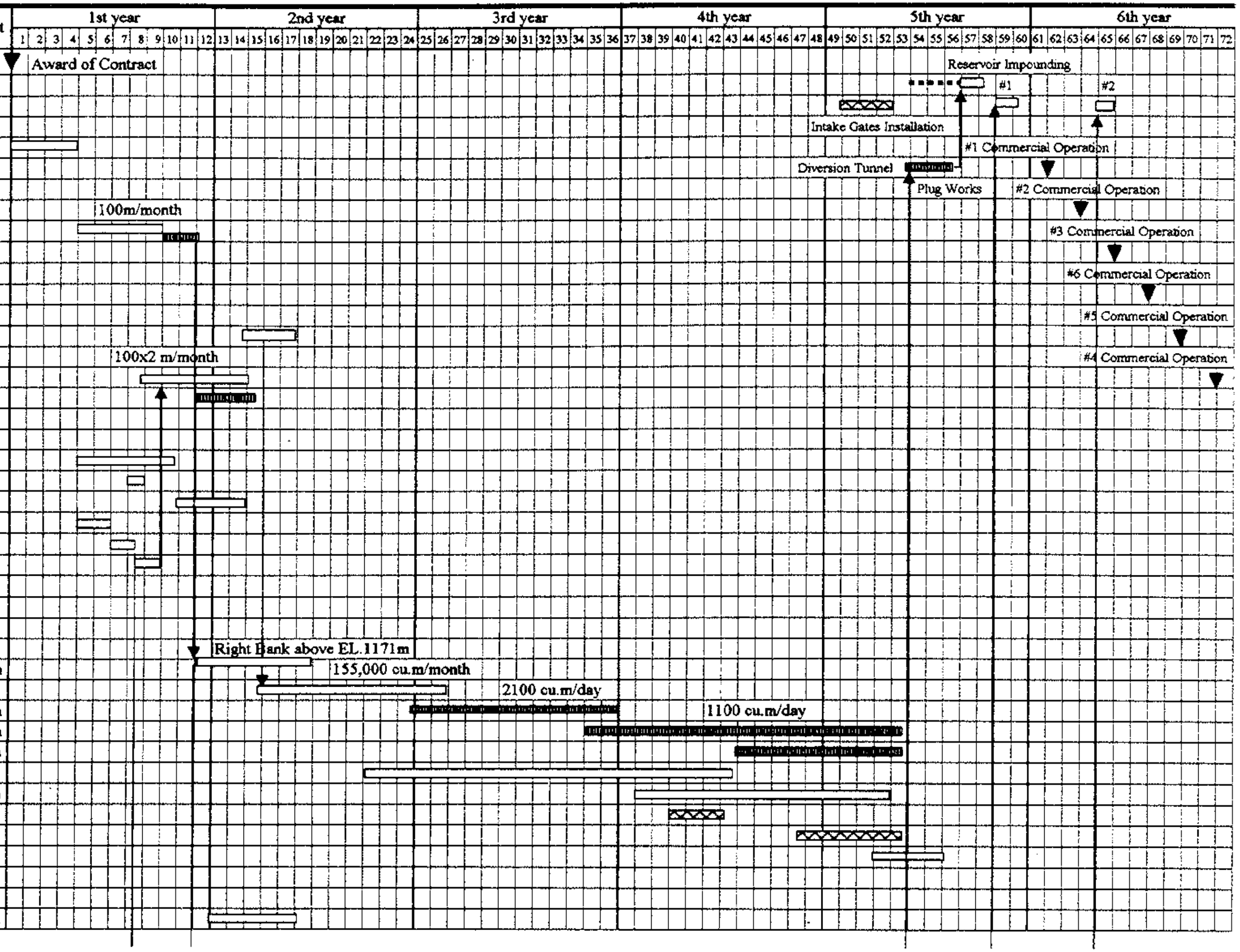


Fig. A.12.2 CONSTRUCTION SCHEDULE, DAM AND WATERWAY, PUNATSANGCHHU PROJECT

Description	Quantity	Unit
Intake Concrete	24,900	cu.m
Tunnel Excavation	52,000	cu.m
# 1	379	m
# 2	326	m
# 3	273	
# 4	227	
Lining Concrete	17,900	cu.m
# 1	379	m
# 2	326	m
# 3	273	
# 4	227	
Gate Shaft	29 m x 4	m
Intake Gate	4	sets
Trashracks	4	LS
< Settling Basin >		
Access Tunnel EL. 1,171 m	391	m
Access Tunnel EL. 1,163 m	326+146	m
Settling Basin No.1	130	m
Cavern Excavation	103,900	cu.m
Arch Portion	130	m
Glory Hole	27m x 3	m
Bottom Heading	130	m
Concrete	15,425	cu.m
Control Gates	3	sets
Settling Basin No.2	130	m
Cavern Excavation	103,900	cu.m
Arch Portion	130	m
Glory Hole	27m x 3	m
Bottom Heading	130	m
Concrete	15,425	cu.m
Control Gates	3	sets
Settling Basin No.3	130	m
Cavern Excavation	103,900	cu.m
Arch Portion	130	m
Glory Hole	27m x 3	m
Bottom Heading	130	m
Concrete	15,425	cu.m
Control Gates	3	sets
Settling Basin No.4	130	m
Cavern Excavation	103,900	cu.m
Arch Portion	130	m

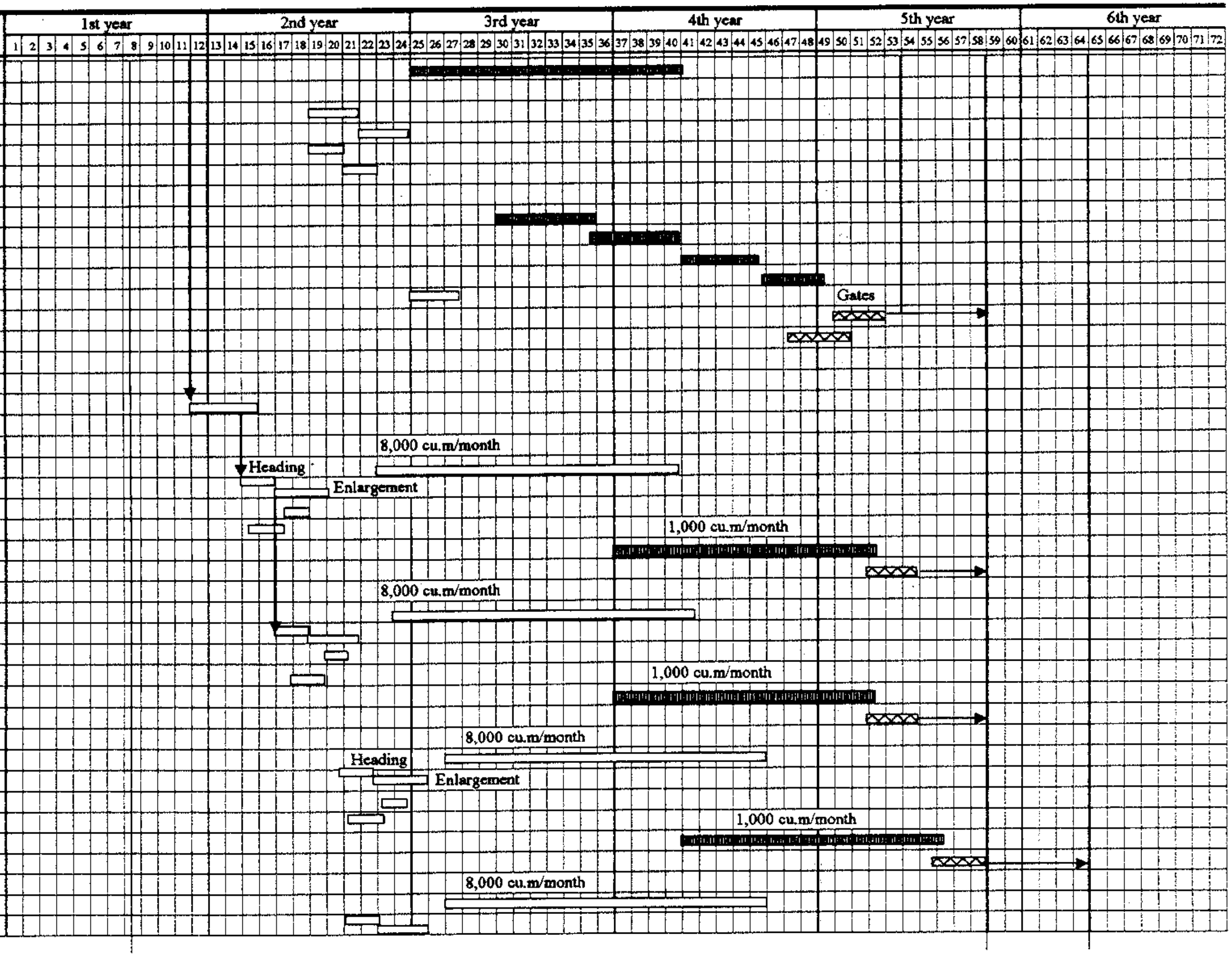


Fig. A.12.2 CONSTRUCTION SCHEDULE, DAM AND WATERWAY, PUNATSANGCHHU PROJECT

Description	Quantity	Unit
Glory Hole	27m x 3	m
Bottom Heading	130	m
Concrete	15,425	cu.m
Control Gates	3	sets
Flushing Tunnel	414+341	m
< Headrace Tunnel >		
Access Road to Midstream Adit	300+1,520	m
Temporary Bridge	97	m
Access Road to Downstream Adit	3,210+104 -550	m
Work Adit (Upstream)	455	m
Work Adit (Midstream)	600	m
Work Adit (Downstream)	190+60	m
Tunnel No.1		
Tunnel Excavation		
From Upstream Adit		
Upstream	220	m
Downstream	1,764	m
From Midstream Adit		
Upstream	1,900	m
Downstream	1,900	m
From Downstream Adit		
Upstream	1,328	m
Lining Concrete		
From Upstream Adit		
Upstream	220	m
Downstream	1,764	m
From Midstream Adit		
Upstream	1,900	m
Downstream	1,900	m
From Downstream Adit		
Upstream	1,328	m
Consolidation Grouting		
Plug of Work Adits		
Tunnel No.2		
Tunnel Excavation		
Upstream	220	m

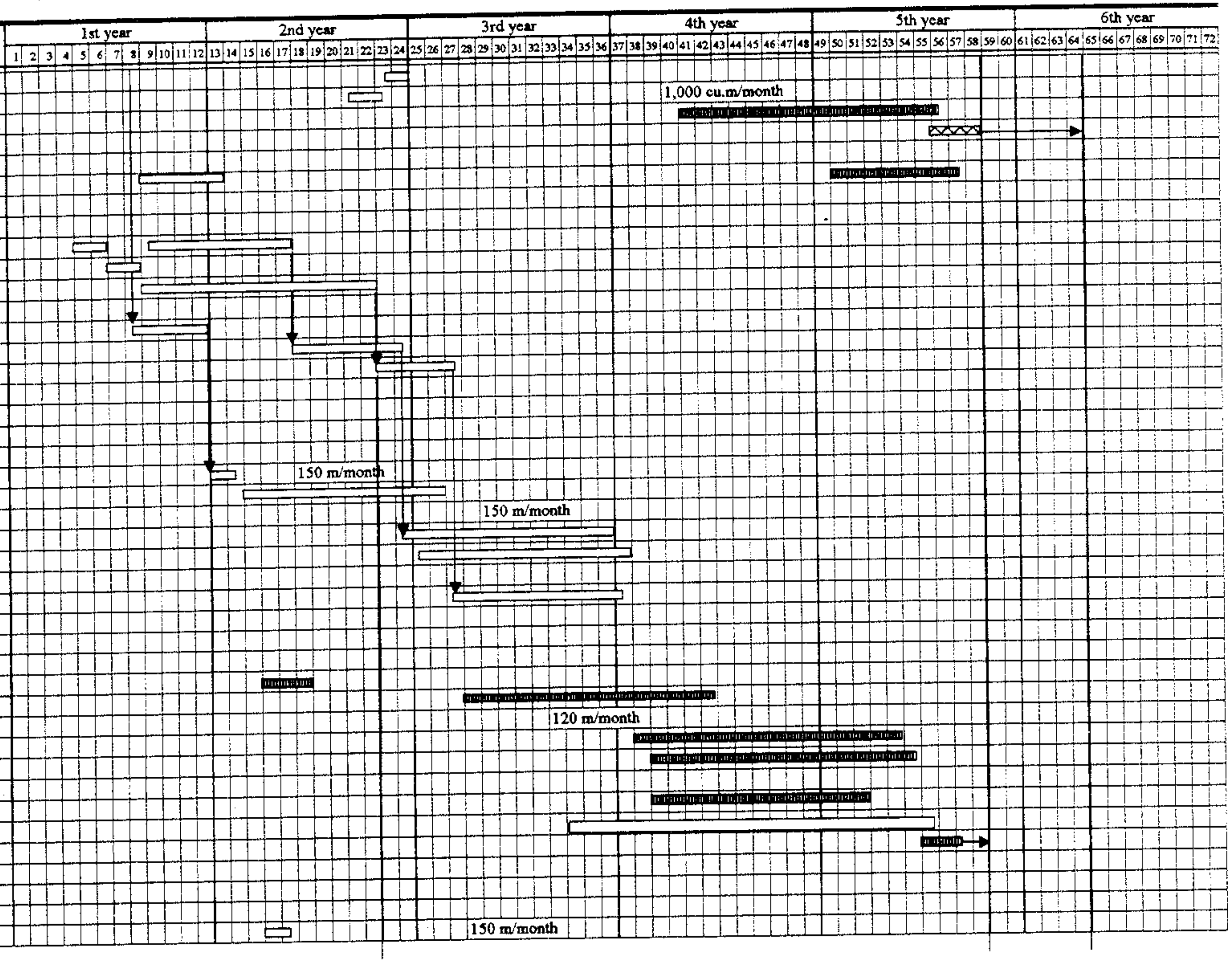


Fig. A.12.2 CONSTRUCTION SCHEDULE, DAM AND WATERWAY, PUNATSANGCHHU PROJECT

Description	Quantity	Unit
Downstream	1,764	m
From Midstream Adit		
Upstream	1,900	m
Downstream	1,900	m
From Downstream Adit		
Upstream	1,264	m
Lining Concrete		
From Upstream Adit		
Upstream	220	m
Downstream	1,764	m
From Midstream Adit		
Upstream	1,900	m
Downstream	1,900	m
From Downstream Adit		
Upstream	1,264	m
Consolidation Grouting		
Plug of Work Adits		LS
< Surge Tank >		
Access Road to Surge Tank Top	550	m
Surge Tank No.1		
Open Excavation	15,700	cu.m
Shaft Excavation	55	m
Shaft Lining Concrete	2,600	cu.m
Tunnel Excavation	40	m
Steel Liner Installation	40+30	m
Filling Concrete	40+30	m
Consolidation Grouting	1	LS
Surge Tank No.2		
Open Excavation	15,700	cu.m
Shaft Excavation	55	m
Shaft Lining Concrete	2,600	cu.m
Tunnel Excavation	40	m
Steel Liner Installation	40+30	m
Filling Concrete	40+30	m
Consolidation Grouting	1	LS
< Penstock >		
Access Road to the Shafts	250	m

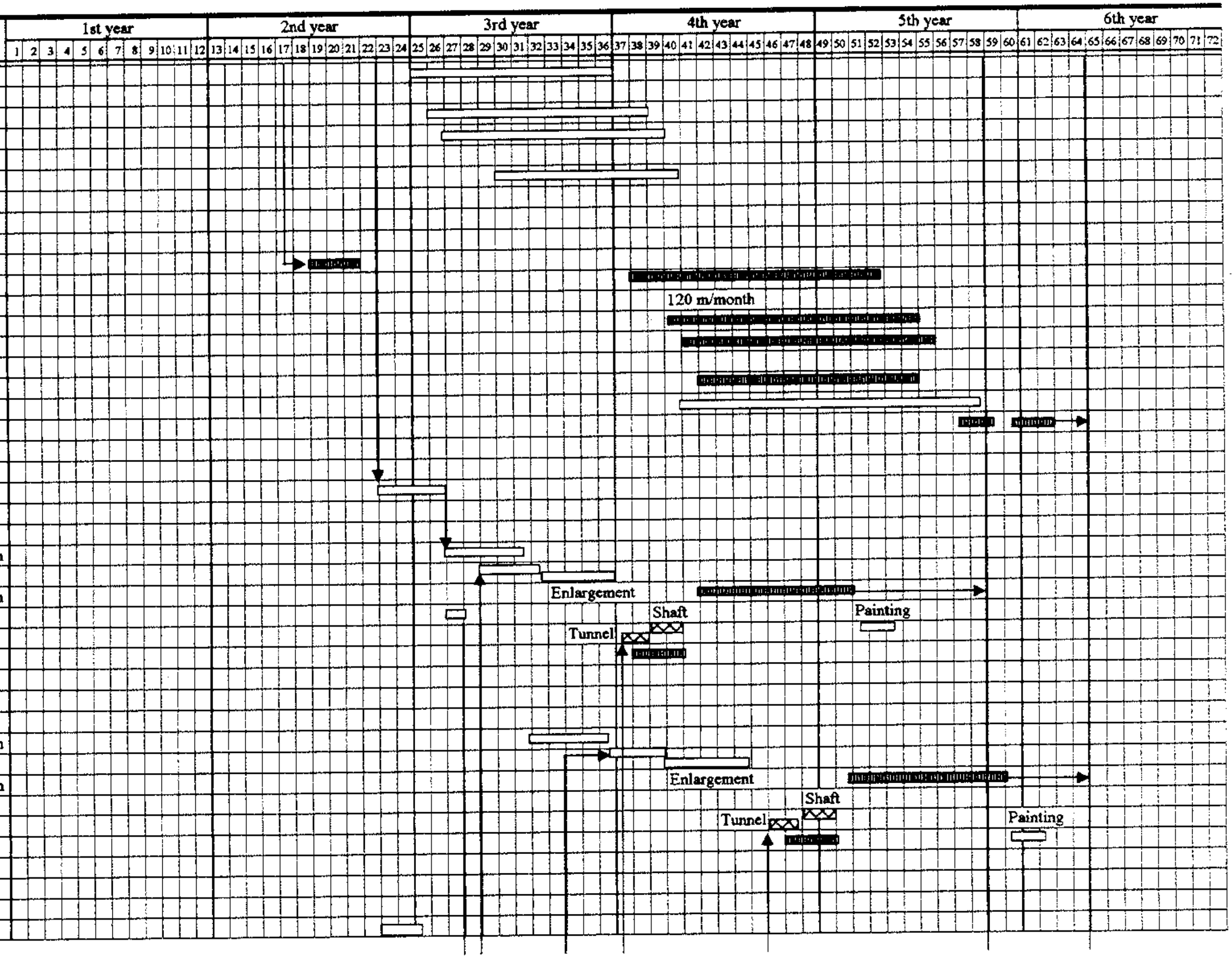


Fig. A.12.2 CONSTRUCTION SCHEDULE, DAM AND WATERWAY, PUNATSANGCHHU PROJECT

Description	Quantity	Unit
Shaft for Steel Liner Installation	60 + 60	m
Penstock Tunnel No.1		
Upper Horizontal Tunnel	40	m
Shaft Excavation	257	m
Steel Liner Installation		
Vertical Shaft	257	m
Upper Horizontal Portion	40	m
Concrete	297	m
Painting		
Penstock Tunnel No.2		
Upper Horizontal Tunnel	40	m
Shaft Excavation	257	m
Steel Liner Installation		
Vertical Shaft	257	m
Upper Horizontal Portion	40	m
Concrete	297	m
Painting		LS
Lower Horizontal Tunnel		
Adit to Penstock Tunnel	107+319	m
# 1 Tunnel		
Excavation	97+114	m
Steel Liner Installation	211	m
Concrete	211	m
# 2 Tunnel		
Excavation	97+114	m
Steel Liner Installation	211	m
Concrete	211	m
Trifurcation		
#1		
Excavation	1	LS
Liner Installation	1	LS
Concrete	1	LS
Connection with Turbine	1	LS
#2		
Excavation	1	LS
Liner Installation	1	LS
Concrete	1	LS

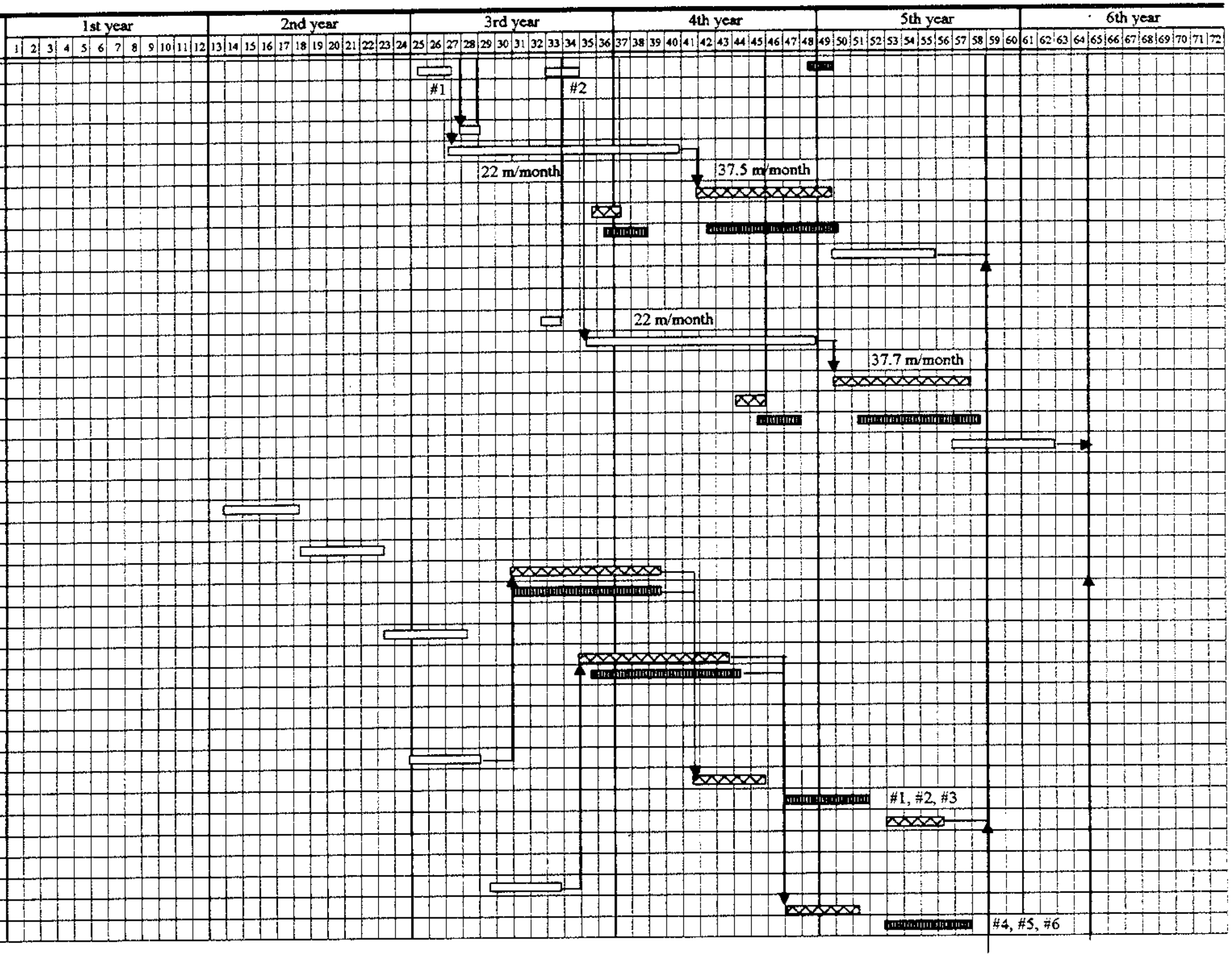


Fig. A.12.2 CONSTRUCTION SCHEDULE, DAM AND WATERWAY, PUNATSANGCHHU PROJECT

Description	Quantity	Unit
Connection with Turbine	1	LS
< Draft Tunnel >		
Tunnel Excavation #1,#2,#3	34m x 3	m
Tunnel Excavation #4,#5,#6	34m x 3	m
Steel Liner Installation	204	m
Concrete	204	m
< Tailrace Tunnel > D=7.4 m		
Work Adit	202	m
Tunnel Excavation #1	360	m
Lining Concrete #1	360	m
Tunnel Excavation #2	320	m
Lining Concrete #2	320	m
Grouting	1	LS
< Outlet >		
Access Road	200	m
Care of River	1	LS
Open Excavation	47,400	cu.m
Tunnel Excavation	10m x 2	m
Concrete	2,900	cu.m
Outlet Gate	2	sets
Trashracks	2	sets

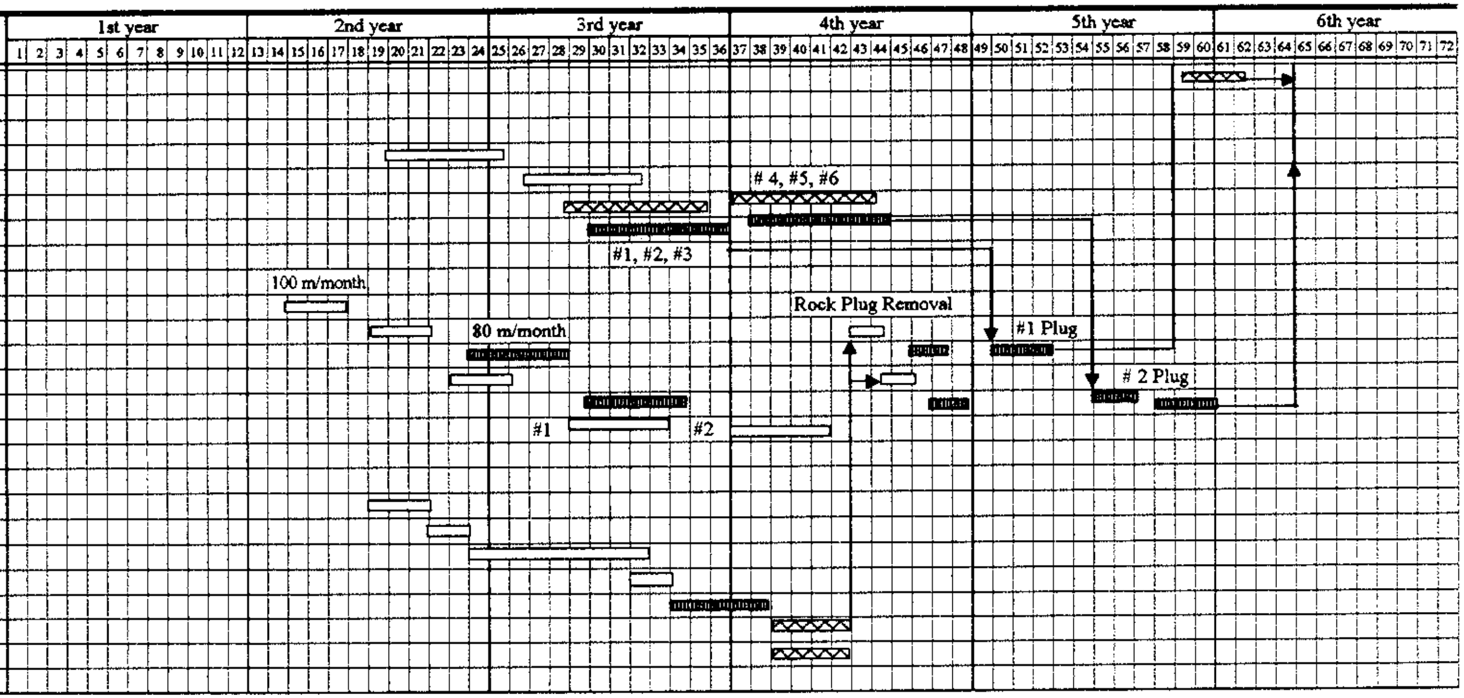


Fig. A.12.3 CONSTRUCTION SCHEDULE, POWERHOUSE COMPLEX, PUNATSANGCHHU PROJECT

Description	Quantity	Unit
Award of Contract (Main Civil Works)		
Impounding of Reservoirs		
Filling Water in Waterways		
< Powerhouse Complex >		
1. Civil Works		
Mobilization	1	LS
Temporary Access Road	1	LS
Permanent Access Bridge	104	m
Access Tunnel (6m x 6m)	476	m
Cable Tunnel (4m x 4m)	342	m
Transformer Room		
Excavation	13,900	cu.m
Rock Support	1	LS
Gate Shafts Excavation	1	LS
Draft Gate Installation	6	sets
Concreting	4,000	cu.m
Adit to the Powerhouse Top	100	m
Adit to the Powerhouse Bottom	242+56	m
Power Cavern Excavation	67,600	cu.m
Excavation		
Pilot Tunnel at EL. 863.50	83.0	m
Arch Excavation	(10,100)	cu.m
EL.863.50 - EL.847.00	16.5	m
EL.847.00 - EL.831.00	16.0	m
Around Draft Tube	6.0	m
Temporary Crane	1	LS
Concrete	29,900	cu.m
Erection Bay (Wall & Girder)		
Wall		

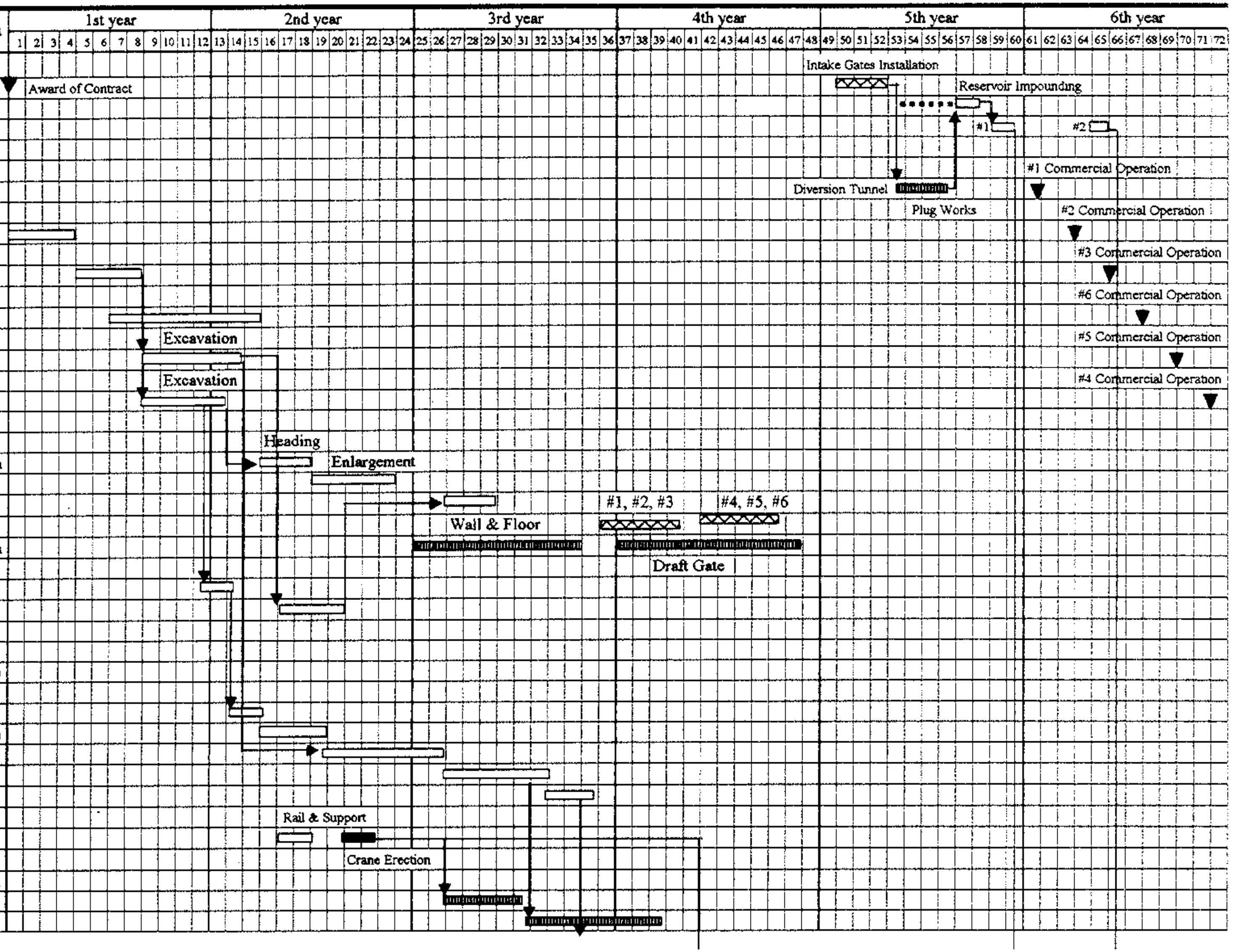


Fig. A.12.3 CONSTRUCTION SCHEDULE, POWERHOUSE COMPLEX, PUNATSANGCHHU PROJECT

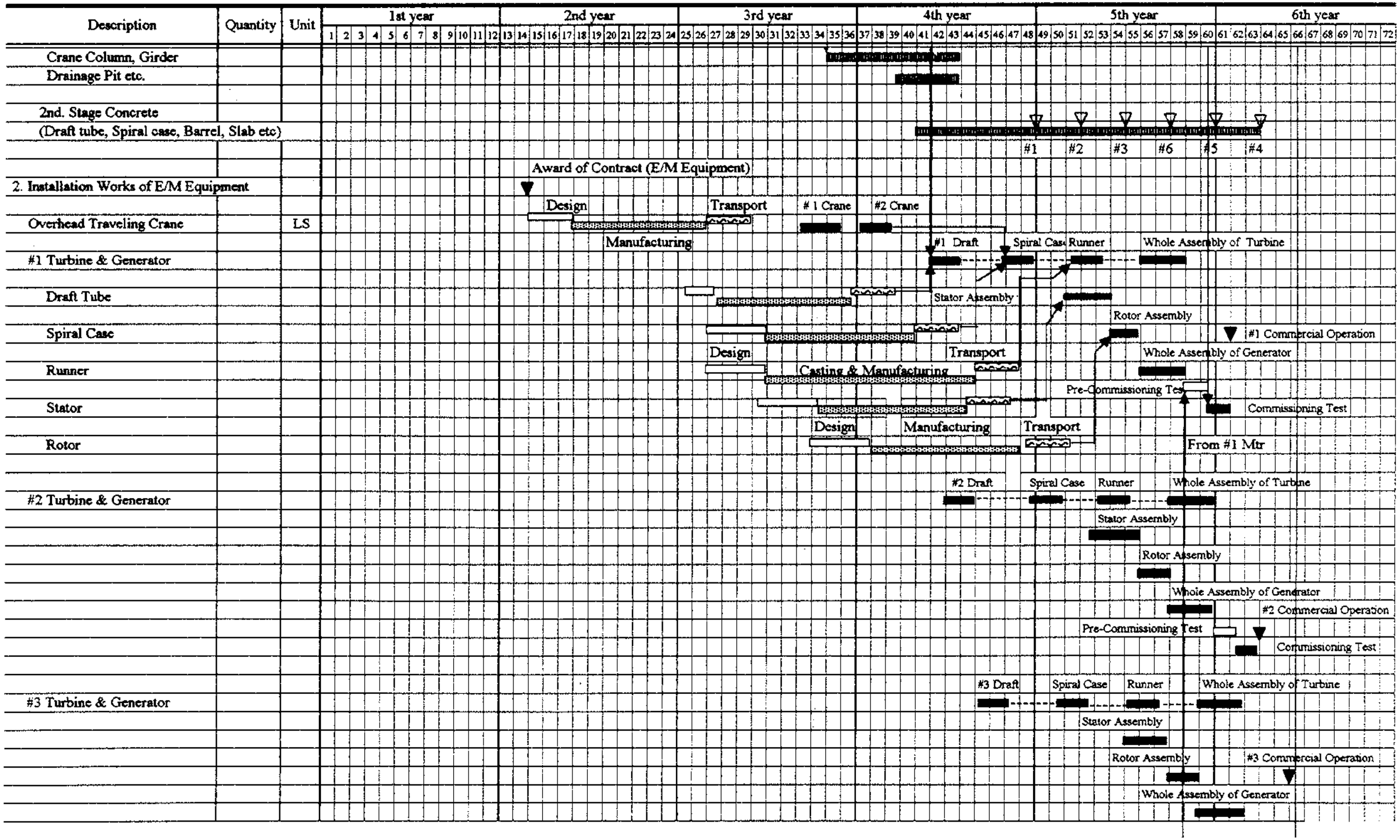
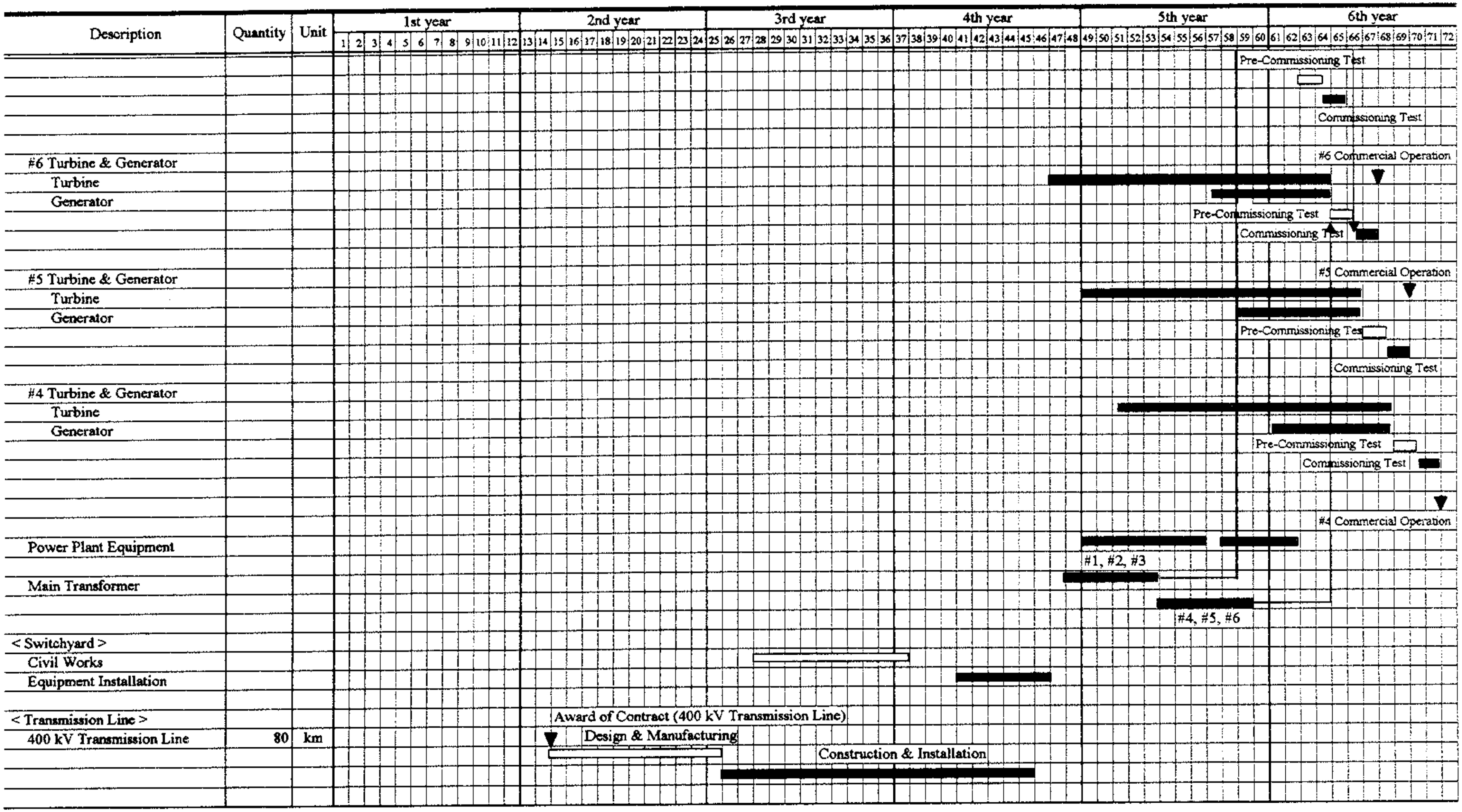


Fig. A.12.3 CONSTRUCTION SCHEDULE, POWERHOUSE COMPLEX, PUNATSANGCHHU PROJECT



PROJECT COST ESTIMATE

1. Permanent Facilities for Employer and Engineer

2. Road Improvement Cost

3. Construction Power Supply

4. Land Acquisition Compensation Cost

4.1 Compensation Costs

4.2 Cost for Implementing Environmental Management Plan

4.3 Cost for Implementing Environmental Monitoring Program

4.4 Land Acquisition and Compensation Costs

Fig. A.12.3 Detailed Disbursement Scheduel

CONSTRUCTION COST ESTIMATE

1. Permanent Facilities for Employer and Engineer

The permanent base camps to be used for overall project construction supervision will be constructed on the right bank upstream of the damsite and opposite bank of the power station. After commissioning of power plant, these base camp will be utilized as operation and maintenance facilities of the plant.

At the base camp a site office, guest house, social and medical care facilities, as well as the staff housing indicated below, will be constructed.

4 bed residence	10 units
3 bed residence (A)	15 units
3 bed residence (B)	20 units
2 bed residence	20 units
Dormitory (A)	1 unit
Dormitory (B)	2 units

The estimated construction cost for permanent camp facilities are as indicated bellow.

Description	Size (m^2)	Unit	Unit Price (US$)	Amount (US$)
Office	1160	1		250,000
4 bed residence	170	10	57,000	570,000
3 bed residence (A)	140	15	47,000	705,000
3 bed residence (B)	110	20	38,000	760,000
2 bed residence	72	20	26,000	520,000
Dormitory (A)	237	1		80,000
Dormitory (B)	250	2	80,000	160,000
Guest house	270	1		80,000
Maintenance & security office	170	1		40,000
Shopping complex	484	1		100,000
Club house	820	1		290,000
Land development		1		400,000
Access road		1		330,000
Water & power supply		1		600,000
Others		1		117,924
Total				5,002,924

2. Road Improvement Cost

(1). Road Improvement from Phuentsholing to the Site

Location (Distance from Phuentsholing km)	Length (km)	Improvement Cost (US$)
16 – 20	4	2,000,000
88	0.2	200,000
Others	250	2,500,000
Total		4,700,000

(2). Major Bridges Improvement / Reinforcement Cost (from Phuentsholing to the Site)

Bridge Name	Dzongkhag	Type	Length(m)	Width(m)	Load(ton)	Improvement Cost (US$)
	Chhukha	Composite	9	4.5	30	90,000
	Chhukha	RC T Beam	9	4.5	30	90,000
	Chhukha	RC T Beam	9	4.5	30	90,000
Wangchu	Chhukha	Pre-stressed Concrete	74	7.5	70	0
	Chhukha	RC T Beam	10	4.5	30	100,000
Tenalum	Thimphu	Pre-stressed Concrete	74	7.5	70	0
Horongchu	Thimphu	Composite	10	4.5	30	100,000
Babesa	Thimphu	Composite	12	4.5	30	120,000
Olaranachu	Thimphu	Composite	10.5	4.5	30	110,000
Hesothangka	Wangdue	SS Bailey	10	3.76	24	200,000
Lawakha	Wangdue	DSR Bailey	33	3.76	24	660,000
Basochu	Wangdue	SS Bailey	20	3.76	18	400,000
Rurichu	Wangdue	SS Bailey	17	3.76	18	340,000
Total						2,300,000

Total estimated road improvement cost will be as follows.

Road from Phuentsholing to the Site	4,700,000 US$
Major bridge from Phuentsoling to the Site	2,300,000
Other roads improvement/maintenance cost	500,000
Total	7,500,000 US$

3. Construction Power Supply

33 kV lines to the respective construction area : 15 km

Construction cost

33 kV line 15 km	US$ 450,000.-
Others	50,000.-
Total	US$ 500,000.-

4. Land Acquisition Compensation Cost

Area to be acquired for the project are as follows:

Structure	Area (ha)			
	Riverbed	Forest	Agricultural Land & Settlement	Total
Quarry Site	14.0			14.0
Reservoir Area	15.0	17.0	6.0	38.0
Structure	0.9	3.0	0.8	4.7
Temporary Facility	0.7	30.5	12.3	43.5
Muck Disposal Area		25.9	19.4	45.3
Road Construction		7.2	0.7	7.9
Total	30.6	83.6	39.2	153.4

4.1 Compensation Costs

(1). Estimated cost of compensation for affected homesteads

Items	No. of Household	Unit Cost (Nu.)	Total Cost (Nu.)
Housing Plot (housing land)	6	200 m^2 for each household @ Nu 40,000/plot	240,000
House Construction Assistance	6	Nu 100,000.- per household	600,000
Piped Drinking Wated	6	@ Nu 20,000.- per house	120,000
Electrification	6	@ Nu 30,000.- per house	180,000
Toilet Facilities	6	@ Nu 20,000.- per house	120,000
Total			1,260,000

(2). Horticultural crops

Fruit Trees	No. of Trees to be compensated	Unit Cost (Nu.) per tree	Total Cost (Nu.)
Orange	1,065	542	577,230
Mango	109	661	72,049
Guava	413	297	122,661
Banana	890	187	166,430
Total			940,000

Compensation cost for resettlement of affected household (in case of land for land option) is Nu.2.2 million (Nu. 1,260,000 + 940,000).

4.2 Cost for Implementing Environmental Management Plan

Item	Cost (Nu million)
Sanitary facilities in labour camps	5.25
Solid waste collection & disposal system	3.00
Environmental Management in road construction	10.00
Compensatory afforestation	20.35
Construction of settling tanks	0.50
Wildlife conservation	38.58
Control of water-related diseases	61.00
Control of air pollution	2.00
Stabilization of muck disposal sites	25.00
Sustenance of riverine fisheries	8.00
Maintenance of Environmental Cell	31.08
Area development activity (ADA)	4.60
Total	209.36

4.3 Cost for Implementing Environmental Monitoring Program

Item	Cost (Nu million/year)
Water quality	0.08
Soil quality	0.10
Ecology	0.50
Riverine fisheries and aquatic	0.50
Public health	0.50
Scholarship to students (as part of ADA)	0.24
Total	1.92

4.4 Land Acquisition and Compensation Costs

Resettlement of households	Nu. 2.20 million
Environmental management plan	209.36
Total	Nu. 211.56 million
	(US$ 4.735 million)

Environmental monitoring program	Nu. 1.92 million/year
For six years	Nu. 11.52 million
	(US$ 0.258 million)

Land acquisition and compensation cost: US$ 4.993 million → US$ 5 million

Table A.12.3 Detailed Disbursement Schedule

Unit : US$ thousand

Year	-3	-2	-1	1	2	3	4	5	6	7	Total
				▼ Award of Contract (Main Civil Works)							
Preparatory Works											
Road Improvement, Power Supply System & Camps			7,000	703	200	300	300				8,503
Others				25,996	2,981	130					29,107
Sub-total	0	0	7,000	26,699	3,181	430	300	0	0	0	37,610
LC	0	0	6,300	24,029	2,863	387	270	0	0	0	33,849
FC	0	0	700	2,670	318	43	30	0	0	0	3,761
Civil Works											
Care of River				7,600	11,300			629			19,529
Dam				300	13,200	39,400	42,300	24,241			119,441
Power Intake					3,800	7,400	3,172				14,372
Settling Basin				2,000	5,000	11,500	10,000	7,472			35,972
Headrace Tunnel				1,500	13,000	46,200	30,000	11,081	1,000		102,781
Surge Tank						2,000	2,400	975			5,375
Penstock Tunnel					1,600	3,300	1,800	799			7,499
Powerhouse				2,500	3,800	4,400	5,200	3,500	381		19,781
Tailrace Tunnel					2,000	1,800	1,500	505			5,805
Outlet					200	1,500	239				1,939
Switchyard						826	938				1,764
Disposal Area				800	800	500	400	300			2,800
Sub-total	0	0	0	45,466	43,760	95,061	78,359	39,601	1,105	33,706	337,058
LC	0	0	0	3,183	3,063	6,654	5,485	2,772	77	2,359	23,594
FC	0	0	0	42,283	40,697	88,407	72,874	36,829	1,028	31,346	313,464
Hydromechanical Equipment											
Intake											
Trash Racks					72			572		72	715

Table A.12.3 Detailed Disbursement Schedule

Unit : US$ thousand

Year	-3	-2	-1	1	2	3	4	5	6	7	Total
Intake Gates (2 sets)					85			676		85	845
Dam											
Spillway Gates					1,754			14,029		1,754	17,536
Sluiceway Gates					372		2,976			372	3,720
Sluiceway Steel Liner					415		3,322			415	4,152
Settling Basin											
Flushing Gates (6 sets)					296			2,368		296	2,960
Surge Tank											
Steel Liner (Tunnel)					150		1,200			150	1,500
Steel Liner (Shaft)					115		920			115	1,150
Penstock					0						
Steel Liner					6,216		12,432	18,648	18,648	6,216	62,160
Draft Gates					120	480	480			120	1,200
Outlet Gates (2 sets)					56		448			56	560
Sub-total	0	0	0	0	9,650	480	21,778	36,293	18,648	9,650	96,498
LC	0	0	0	0	965	48	2,178	3,629	1,865	965	9,650
FC	0	0	0	0	8,685	432	19,600	32,664	16,783	8,685	86,848
Electromechanical Equipment											
OHT Crane					360	900	900			240	2,400
Turbine and Generator											
# 1 Unit					3,055	2,037	6,110	6,110	1,018	2,037	20,367
# 2 Unit					3,055		3,055	9,165	3,055	2,037	20,367
# 3 Unit					3,055		3,055	8,147	4,073	2,037	20,367
# 4 Unit					3,055		2,037	7,128	6,110	2,037	20,367
# 5 Unit					3,055			8,147	7,128	2,037	20,367
# 6 Unit					3,055			7,128	8,147	2,037	20,367
Switchyard Equipment					4,425		22,125			2,950	29,500

Table A.12.3 Detailed Disbursement Schedule

Unit : US$ thousand

Year	-3	-2	-1	1	2	3	4	5	6	7	Total
Sub-total	0	0	0	0	23,115	2,937	37,282	45,825	29,532	15,410	154,100
LC	0	0	0	0	2,312	294	3,728	4,583	2,953	1,541	15,410
FC	0	0	0	0	20,804	2,643	33,554	41,243	26,579	13,869	138,690
400 kV Transmission Line	0	0	0	0	6,300	16,000	15,500			4,200	42,000
LC	0	0	0	0	630	1,600	1,550	0	0	420	4,200
FC	0	0	0	0	5,670	14,400	13,950	0	0	3,780	37,800
Total Direct Cost	0	0	7,000	72,165	86,006	114,907	153,218	121,719	49,285	62,966	667,266
LC	0	0	6,300	27,212	9,833	8,983	13,211	10,984	4,895	5,285	86,703
FC	0	0	700	44,953	76,173	105,925	140,007	110,735	44,389	57,680	580,563
Engineering & Administration Cost			700	8,007	10,009	12,678	16,682	13,345	5,305	0	66,727
LC			140	1,601	2,002	2,536	3,336	2,669	1,061	0	13,345
FC			560	6,406	8,007	10,142	13,345	10,676	4,245	0	53,382
Land Acquisition & Compensation (LC)	0	0	5,000								5,000
Contingency	0	0	1,270	8,017	9,601	12,759	16,990	13,506	5,459	6,297	73,899
LC	0	0	1,144	2,881	1,183	1,152	1,655	1,365	596	529	10,505
FC	0	0	126	5,136	8,418	11,607	15,335	12,141	4,863	5,768	63,394
Total Construction Cost	0	0	13,970	88,189	105,616	140,344	186,890	148,571	60,049	69,262	812,892
LC	0	0	12,584	31,694	13,018	12,670	18,202	15,018	6,552	5,814	115,553
FC	0	0	1,386	56,495	92,598	127,674	168,688	133,552	53,498	63,448	697,339

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