

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)  
WATER AND POWER DEVELOPMENT AUTHORITY (WAPDA)  
ISLAMIC REPUBLIC OF PAKISTAN

FEASIBILITY STUDY  
ON  
THE DEVELOPMENT  
OF  
MUNDA DAM MULTIPURPOSE PROJECT  
IN  
ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT

VOLUME IV  
DATA BOOK

MARCH 2000

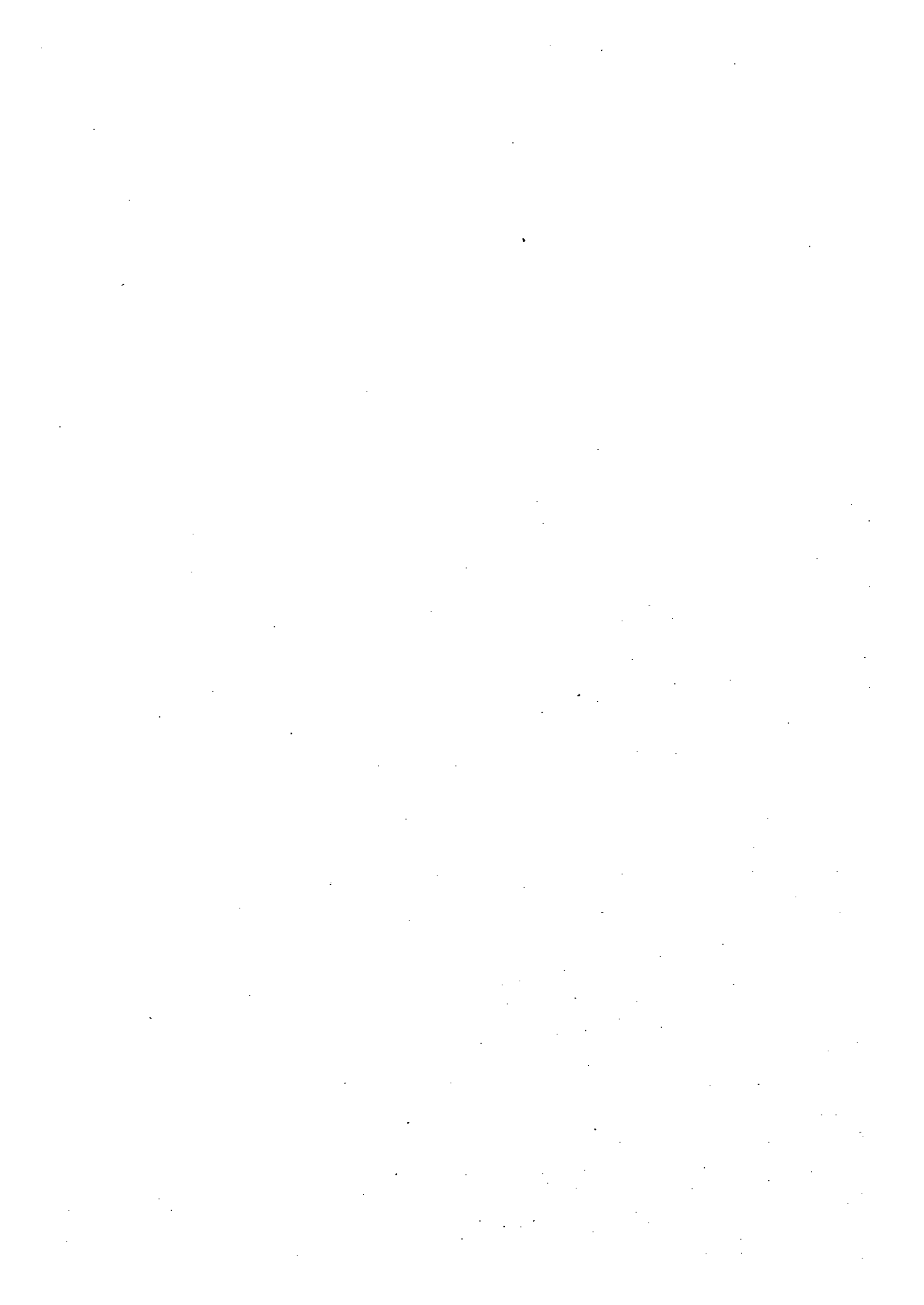
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WATER AND POWER DEVELOPMENT AUTHORITY (WAPDA)  
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	GE              Geological Investigation
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IN  
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VOLUME IV  
DATA BOOK**

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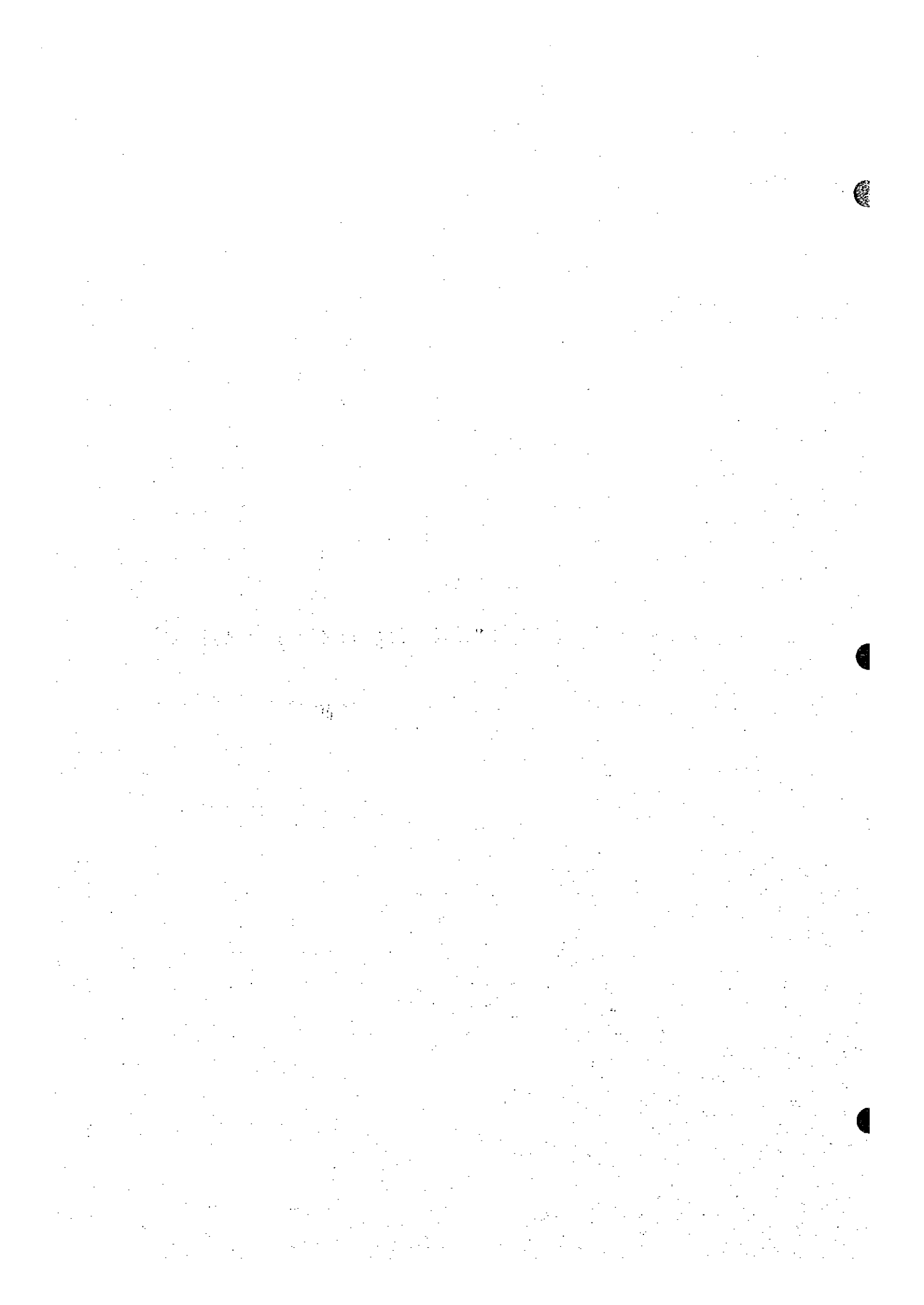
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***GE GEOLOGICAL INVESTIGATION***

**GE1.**

**GEOLOGICAL LOG OF DRILL HOLES**





### List of Drill Holes

No.	Depth (m)	Inclination (degree)	Location	Coordinate		Elevation (m)
				Northing	Easting	
<b>Dam site</b>						
M98-1	70.00	90	Dam axis; right bank	1,124,626.040	3,067,969.091	602.613
M98-2	100.00	90	Dam axis; right bank	1,124,807.933	3,067,915.867	508.620
M98-3	100.00	90	Dam axis, right bank	1,125,022.213	3,067,851.069	417.211
M98-4	70.00	60	Dam axis; riverbed	1,125,138.763	3,067,817.933	379.708
M98-5	30.00	90	Dam axis; riverbed	1,125,094.000	3,067,825.000	358.500
M98-6	70.00	90	Dam u/s end; left bank	1,125,140.165	3,067,562.789	395.089
M98-7	100.00	60	Dam u/s end; riverbed	1,125,018.645	3,067,584.851	370.389
M98-8	70.00	90	Dam u/s; right bank	1,124,881.850	3,067,610.461	417.032
M98-9	30.00	90	Tunnel intake	1,124,779.195	3,067,458.727	388.542
M98-10	30.00	90	Power station	1,125,230.008	3,068,226.471	384.106
M98-11	30.00	90	Tunnel outlet, right b.	1,125,236.704	3,068,380.158	375.300
M98-12	30.00	90	Spillway chute	1,125,479.286	3,068,221.870	401.918
M98-13	30.00	90	Right bank saddle	1,124,213.465	3,067,664.089	563.674
M98-14	180.00	90	Dam axis, left bank	1,125,167.569	3,067,834.841	382.011
M98-15	100.00	90	Dam axis, left bank	1,125,237.329	3,067,787.588	451.253
M98-16	70.00	90	Dam axis, left bank	1,125,411.839	3,067,732.004	546.269
M98-17	60.00	90	Dam axis, left bank	1,125,567.789	3,067,740.659	571.860
M98-18	30.00	90	Dam axis, left bank	1,125,811.380	3,067,632.113	560.337
M98-19	70.00	90	Dam u/s end, left bank	1,125,285.282	3,067,590.818	488.720
M98-20	30.00	90	Tunnel intake, left b.	1,125,104.856	3,067,375.848	418.234
Total	1,300.00					
<b>Quarry site</b>						
Qt-1	50.00	90	Todobo Banda	1,125,326.226	3,065,899.435	662.321
Qt-2	100.00	90	Todobo Banda	1,125,364.729	3,066,101.804	601.605
Qt-3	50.00	90	Todobo Banda	1,125,425.783	3,066,422.702	456.615
Qt-4	50.00	90	Todobo Banda	1,125,905.256	3,066,280.909	501.710
Qt-5	50.00	90	Todobo Banda	1,124,946.310	3,066,564.495	489.247
Qs-1	50.00	90	Sappare	1,126,172.176	3,070,357.495	528.236
Qs-2	100.00	90	Sappare	1,126,371.357	3,070,560.418	513.373
Total	450.00					

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-1, 1/3

Hole No.: **M98-1**  
 Ground EL.: **602.613 m**  
 Hole length: **70.00 m**

Location: **Dam Axis (Right Bank)**  
 Drilling period: **Dec. 1, 1998 - Feb. 1, 1999**  
 Hole inclination: **90 degrees (Vertical)**

Azimuth: **-**  
 Northing: **1,124,626.040**  
 Easting: **3,067,969.091**

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugeon value	Sample	Casing	Concentration	Depth (m)		
12/1	1	601.613		Fammitic Schist	95	62	0.40	Q	7	d	D	Residual Soil: Moderately to highly weathered rock fragments in earthy brown silty materials.						1		
	2				65	50	1.00	D	3	b-c	CM	Up to 1.0 m depth, highly weathered Quartzite. Folitic Schist. Joints are stained, deteriorated, and intercalated with soft material.						2		
	3				100	59	2.50	E	3-4	e-b	CL	Lower portion, with less intercalated soft material.						3		
12/2	4	595.613		Fammitic (Feldic) Schist	95	47		D-C	3-4	b-c	CM	From 1.0 to 60.4 m depth, rock is weathered moderately. Rock is usually a little deteriorated in brown color along joints and some of rock-forming minerals. Between 1.0 and 3.6 m, 4.3 and 7.2 m, Graphitic Schist. Dark gray to black, silty, luster, soft and smooth touch. Between 3.6 and 4.3 m, Fammitic Meta Schist. Joint planes angles from 5 to 10m along core axis, 30, 45, and 60 deg. to 70 deg. are common.						4		
	5				97	56	4.85	E	4-3	b-c	CL		CM						5	
	6				100	54	5.20													6
	7				100	37		D	3	b	CM		Some quartz veins or lenses found between 3.3 and 4.7 m (max. thickness 2 cm). Vertical fracture from 6.6 to 7.0 m.						7	
12/3	8	593.013		Fammitic Schist	94	35	7.45					From 7.2 to 9.1 m, Fammitic. Lower depth than 9.1 m, Fammitic Meta Schist is majority existence, but commonly altered with Graphitic Schist. Main Graphitic portions are between: 9.1-9.3m, 9.6-10.0m, 11.1-13.0m, 19.0-19.6m, 21.5-24.2m, 24.8-26.4m and 43.3-44.5m.						8		
	9				100	40		C-B	2-3	b-a	CH		Joints and irregular fracture planes are stained and intercalated thinly with earthy material. Vertical fracture from 4.9 to 5.4 m. Core develops cracks on exposure to air.	La's-110				9		
	10				98	54	9.95												10	
12/7	11	588.913		Fammitic (Feldic) Schist	95	32	11.10	D	3-2	b	CM	Joint planes angles between 60 and 70 deg. along core axis from 10 to 11m are commonly found.						11		
	12				98	60	12.40	C-D	2-3	b-a	CH		From 10.8 to 11.1 m, deteriorated to sandy soft material with brown limonite.					12		
	13				90	14	13.00	E-D	3-4	e-b	CL		CH	From 12.4 to 13.0 m and 14.3 to 14.6 m, highly weathered, deteriorated into silty soft.	La's-79				13	
12/8	14	581.113		Fammitic Schist	100	85	14.40	C	1-3	b-a	CH	Fractured zones are existing at 15-16m (fracture angle 60 deg.), 18.7-19.0m, 19.5-20.0m, 24.4-25.0, 25.0-26.4m, 27.0-27.7m, 29.2-29.5m, 32.0-33.5m, 40.0-43.1m, and 45.6.						14		
	15				100	0	14.40											15		
	16				97	13	16.40	D-C	2-3	b	CM							16		
12/17	17	576.113		Fammitic Schist	97	48						Vertical fractures are found at 12-13m, 15-16m, 17.0-17.6m, 20.4-22.0m, 23.5-25.0m, 31.4-32.0m, 38-40m, 43.0-43.1m, 45.6-46.5m, 50.0-50.5m, and 51.7-52.0m.						17		
	18				88	52		C	2-3	b-a	CH		Fractured zones are existing at 15-16m (fracture angle 60 deg.), 18.7-19.0m, 19.5-20.0m, 24.4-25.0, 25.0-26.4m, 27.0-27.7m, 29.2-29.5m, 32.0-33.5m, 40.0-43.1m, and 45.6.	La's-42				18		
	19				90	63	18.70	D-E	4	b-c	CL		Vertical fracture from 17.2 to 17.6 m, 20.4 to 21.0 m and 31.5 to 32.0 m.					19		
	20				90	32	19.40	D	3	b	CM		CL					20		
12/31	21	571.113		Fammitic (Feldic) Schist	94	32	19.70	E	4	b-c	CL	Vertical fractures are found at 12-13m, 15-16m, 17.0-17.6m, 20.4-22.0m, 23.5-25.0m, 31.4-32.0m, 38-40m, 43.0-43.1m, 45.6-46.5m, 50.0-50.5m, and 51.7-52.0m.						21		
	22				90	35		C-D	3	b	CM		CM	Joints are ranging from 60 to 70 deg. Limonite and bentonite is coating along joint planes.	La's-7.8	Pc=7.1		22		
	23				95	24	23.65											23		
1/1	24	576.113		Fammitic Schist	92	13						From 24.4 to 24.6 m, fracture zone intruded by quartz.						24		
	25				80	0		D-C	4	b-c	CL		CL					25		
	26				80	0	26.35											26		
1/2	27	576.113		Fammitic Schist	100	56						Quartz vein or lenses are observed at 9.5-10.5m, 18.6-19.5m, 20.3m and 20.8m (all is around 1 cm thickness, max. 2 cm).						27		
	28				90	21											28			
	29				92	60		C	3-4	b-c	CM		CM					29		
	30				90	42												30		

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-1, 2/3

Hole No.: **M98-1**  
 Ground FL.: **602.613 m**  
 Hole length: **70.00 m**

Location: **Dam Axis (Right Bank)**  
 Drilling period: **Dec. 1, 1993 to Feb. 1, 1999**  
 Hole Inclination: **90 degrees (Vertical)**

Azimuth: **-**  
 Northing: **1,124,626.040**  
 Easting: **3,067,969.091**

Date	Depth(m)	EL(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugron value	Sample	Casing	Cementation	Depth (m)
1/2	31	571.213		Paragneiss Schist	98	47	31.20	C	3	a	CM	Limstone and hematite is coating along joint planes.						31
	32			Paragneiss (Felsitic) Schist	58	28	32.00	D-E	4-5	b	CL	From 32.0 to 33.6 m, rock is fractured into small pieces and some of them deformed into soft material.		Lu=14 Pc=9.1				32
	33			Paragneiss Schist	80	0	33.50	C	3-2	b	CM							33
	34			Paragneiss Schist	80	10												34
	35			Paragneiss Schist	96	60												35
1/3	36	569.113		Paragneiss (Felsitic) Schist	90	48	35.65	E-D	4-3	e-b	D	From 36.1 to 36.9 m and 41.8 to 42.0 m, quartz intrusion is observed.						36
	37			Paragneiss Schist	90	50	36.00	C	3	b	CM							37
	38			Paragneiss Schist	100	45						From 35.6 to 41.5 m, vertical fracture develops well and this zone is bounded with fractured zone at 35.65-36.0 m and 41.5-41.65 m.		Lu=12				38
	39			Paragneiss Schist	86	30	38.95	C	2-3	b	CH	Quartz intrusion mentioned the above found at the both ends of this zone.						39
1/4	40	562.713		Paragneiss Schist	90	0												40
	41			Paragneiss (Felsitic) Schist	93	0	41.50	C	3	b	CM							41
	42			Paragneiss (Felsitic) Schist	97	28	42.90	D-C	3-5	b-c	CL	42.0-42.5 m, fractured zone accompanied with the quartz intrusion, partly deteriorated into soft material. Hematite is coating along joint planes.	1-10 43.0m		Lu=11			42
	43			Paragneiss Schist	96	0						After 43.1 m, recovered core is usually hard and well recovered, but joints and fractures is coated with limonite and hematite.						43
1/5	44	558.113		Paragneiss Schist	97	65												44
	45			Paragneiss Schist	100	45	45.30	C	2	b	CH	After 44.5 m, Quartz Chlorite Schist Schist - White to light gray with some greenish color, hard and massive, partly foliated.						45
1/6	46			Paragneiss Schist	90	23						45.3-45.4m, 10 cm thickness of Graphite Schist is intercalated in the Quartz Chlorite Schist Schist.						46
	47			Paragneiss Schist	93	12	46.75	C-D	3-5	b-c	CM	Quartz vein develops at 40.0-40.2 m, 45.0-45.02 m, 45.2-45.3 m, and 45.5 m (thickness 2 to 5 cm).						47
1/10	48			Paragneiss Schist	92	80						Tale decreases with increasing depth.						48
	49			Paragneiss Schist	59	85						Recovered cores of 45-47 m and 50.7-52.3 m are in soft and accompanied with soft material (limonite and hematite).						49
	50			Paragneiss Schist	94	69		C-D	1-3	b	CH	47.0-47.9 m, recovered core is very hard and massive. 50.2-50.7 m, recovered core is relatively fresh.	2-10 50.3m					50
	51			Paragneiss Schist	96	35						Deeper than 52 m, joints and fractures are almost accompanied with dense hematite coat.						51
1/11	52			Quartz vein Schist	90	33	51.50	D	3-5	b-c	CM	52.8-54.1, tabularitic. Quartz vein develops vertically.						52
	53			Quartz vein Schist	90	20	53.10											53
	54			Quartz vein Schist	86	60												54
1/13	55			Quartz vein Schist	100	72		C	1-2	b	CH							55
1/15	56			Quartz vein Schist	98	91	56.00											56
	57			Quartz vein Schist	60	10		E-C	3-5	b-c	CL	56.4-57.0 m, Pure Quartz intrusion with this biotite granitic head. 56.0-60.4 m, fractured zone.						57
1/26	58			Quartz vein Schist	58	0	57.60											58
1/27	59			Quartz vein Schist	45	0		D-E	4-6	e-d	D	At 56.5-57.0 m and 69.4-69.6 m, quartz vein found.						59
1/28	60			Quartz vein Schist	38	0												60

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-1, 3/3

Hole No.: M98-1  
 Ground EL.: 602.613 m  
 Hole length: 70.00 m

Location: Dam Axis (Right Bank)  
 Drilling period: Dec. 1, 1998 to Feb. 1, 1999  
 Hole Inclination: 90 degrees (Vertical)

Azimuth: \_\_\_\_\_  
 Northing: 1,124,626.040  
 Easting: 3,067,969.091

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Loggon value	Sample	Casing	Cementation	Depth (m)		
1/29	61	532.613		Quartz mica Schist	75	46	63.42	D	3	b-c	CM	From 60.4 to 66.8 m, slightly weathered and usually reddish brownish rust or intercession found along joints, fractures and cavities, however core is very hard and massive.							61	
	62				98	58		C	1-2	b	CH								62	
	63				91	90														63
1/30	64				80	30	63.50	E-D	4-5	c-d	D	Few pieces are over 5-cm in length. Some core between 20 and 30-cm length are observed, max. 60-cm.							64	
	65	58	97								65									
1/31	66				88	83	66.20	C	1-2	b	CH	After 66.8 m depth core is fresh and amphibole metacrust develops well partly.							66	
	67	90	64								67									
2/1	68				93	90							Ln=0.0 Fc=15.1						68	
	69	100	70				C	2-1	a	CH	69									
	70	70.00			100	70	70.00													70

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-2, 1/4

Hole No: **M198-2**  
 Ground EL: **508.620 m**  
 Hole length: **100.00 m**

Location: **Dam Axis (Right Bank)**  
 Drilling period: **Dec.16, 1993 - Jan.30, 1999**  
 Hole inclination: **90 degrees (Vertical)**

Azimuth: \_\_\_\_\_  
 Northing: **1,124,807.933**  
 Easting: **3,067,915.867**

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	C.W.L. S.P.T.	Lugon value	Sample	Casing	Cementation	Depth (m)
	1				60	0	0.50	F	5	a	D	Up to 1.1m depth, highly weathered rock and top soil zone. Assorted rock fragments mod. to highly weathered in earthy brown silty material and soft rocks.						1
	2				100	0	1.60	E	4	b	CL	Dolomite origin, massive to schistose; Greenish brown, soft to med. hard mod. weathered. Schistosity = 40 to 70 deg.						2
12/16	3				100	0						Joints are usually in concord with schistosity, dark gray in color coated with earthy material. Some vertical fractures are observed from 4.0 to 4.5 m. Some minerals weathered into soft materials and oxidized developing along schistosity.						3
	4				100	0						From 5.3 m, dark green, mod. to highly weathered, some minerals deteriorated into soft material forming relic.						4
	5				90	14						Remarkably deteriorated zones were observed at: 6.3-6.45m, 6.5-6.65m, 7.15-7.3m, 9.1-9.5m, 10.7-10.9m, and 11.0-12.4m.						5
	6				95	38		C-D	3	b	CM	From 8.5 m, recovered core is highly weathered and altered.						6
12/17	7			Green Schist	100	10						From 12.4, remarkably weathered and altered zone.						7
	8				100	18												8
12/18	9				100	26	8.50											9
	10				95	14	9.50	D	3-5	c	CL							10
	11				95	20	10.70	D-C	3	b	CM							11
	12				90	0												12
12/19	13				90	0		E-D	4	b-c	CL							13
	14	494.500			90	0	14.10											14
	15			Mixed rock of Quartz-mica Schist and Green Schist	50	0	15.20	F	5	c-d	D	Paragneiss Schist intruded with Dolomite from 14.1 to 17.3 m						15
	16				70	0						With increasing depth, dolomite decreases and schist increases.						16
	17				80	10						Generally highly weathered and altered.						17
12/21	18	491.300			95	0		D-E	3-4	b-c	CM	From 17.3 m depth, Paragneiss Schist:						18
	19				90	0						Up to 24.1 m, remarkably weathered and altered zone, earthy brown in color, some quartz veins at 18.1m, 19.1m, 20.2m, and 22.5m						19
	20				100	40	20.00					Joints and fractures are almost med. to argillaceous, usually deteriorated into earthy material.						20
	21				80	0												21
12/23	22				90	10		E-D	3-4	c	CL							22
	23			Quartz mica Schist	85	0												23
	24				80	10	24.10											24
	25				93	60						Below 24.1 m, recovered core is relatively fresh Schist composed of Sericite-Biotite-Quartz with paucy amphibole metacryst.						25
	26				90	50						Minerals along schistosity, slightly deteriorated.						26
12/24	27				90	25		C	3	a-b	CH	Quartz veins are observed at 26.4m (2cm), 27.9m (5cm), 28.0m (3-5cm), 28.5m (5cm), and 28.95m (5cm).						27
	28				98	22	28.35											28
	29				95	10												29
	30				75	0		C-D	3-4	b	CM	29.6-30.0m, fractured zone.						30

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-2, 2/4

Hole No.: M98-2  
 Ground EL.: 508.620 m  
 Hole length: 100.00 m

Location: Dam Axis (Right Bank)  
 Drilling period: Dec. 16, 1998 - Jan. 30, 1999  
 Hole inclination: 90 degrees (Vertical)

Arizuth: \_\_\_\_\_  
 Northing: 1,124,807.933  
 Easting: 3,067,915.867

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugon value	Sample	Casing	Cementation	Depth (m)
	31				85	0		C-D	3-4	b	CM							31
	32				90	0	32.70					Lower the depth, main composition becomes Biotite and Quartz, partly graphitic.	1/28 32.4m					32
12/25	33				85	10		D-C	4	b	CL	Joint planes angles along core axis between 30-31m = 30 to 60 deg.		Ln=8.5				33
	34				30	15	33.50					From 33.5 to 44.2m, fractured zone.						34
	35				80	0	35.00	E	5	c	D	Quartz veins are observed at 30.8-30.9m, 31.0-31.4m microfolded (1 to 2cm).						35
	36				60	0						Quartz veins and lenses are observed at 35.0-35.3m, 36.5-36.7m, and 37.9-38.0m.						36
	37				80	0					CL	Between 38.6 and 39.5, quartz veins solution zone.		Ln=1.4 Pc=8.4				37
12/26	38				80	0												38
	39				80	0		D	4-5	b	CL							39
	40				60	0						Joint planes angle from 40 to 45m are almost horizontal.						40
	41				70	0	41.50					Quartz veins and lenses are observed at 40.0-40.05m, 40.3-40.45m, 40.5-41.1m (vertical, microfolded), 41.3-43.35m, and thick pure quartz band (30cm) from 42.6 to 43.0m.						41
12/27	42				72	0												42
	43				80	22		C-D	3-4	b	CM			Ln=0.0 Pc=9.9				43
12/28	44				83	0	44.20											44
	45			Quartz-mica Schist	92	58						After 44.2 m, recovered core is few pieces between 7 and 5-cm in length. Some core between 10 and 30-cm length (max.50 cm) are observed.						45
	46				85	13						Joint planes in this section, smooth touch due to graphitic or bititic contents.						46
	47				100	41		C	3	a	CH	Quartz veins are observed so many, microfolded.		Ln=2.4 Pc=6.8				47
12/29	48				98	65						From 48.3 to 49.5m, a lot of garnet metacrysts are included.						48
	49				98	55												49
	50				97	25	50.20											50
	51				95	40						Three systems of joint group are recognized ranging from 60-70, 0-10 deg., and vertical.						51
	52				100	54												52
12/30	53				95	85					CH			Ln=0.1				53
	54				100	80												54
	55				100	60						Core is fresh and siliceous with many quartz veins. Some are Graphitic or Talcoic Schist.						55
	56				100	64		C	2-3	a	CH	56.4-56.5m, joint angle 30 deg, intercalated with soft material.						56
	57				95	47						Joint planes angle are mostly ranging 10-20 deg., 55-60 deg., and 45-50 deg.						57
12/31	58				100	77						Between 58-60.5m and 64.2-65.5m, quartz intrusive zone.		Ln=0.0				58
	59				100	47												59
	60				95	46												60

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-2, 3/4

Hole No: M198-2  
 Ground EL: 508.620 m  
 Hole length: 100.00 m

Location: Dam Axis (Right Bank)  
 Drilling period: Dec.16, 1998 - Jan.30, 1999  
 Hole Inclination: 90 degrees (Vertical)

Azimuth: \_\_\_\_\_  
 Northing: 1,124,807.933  
 Easting: 3,067,915.867

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock mass	Description	G.W.L. S.P.T.	Lugron value	Sample	Casing	Cementation	Depth (m)
	61				96	45							210 60.40a					61
	62				91	33												62
	63				55	50		C	2-3	a	CH			Lu=0.0				63
	64			Quartz mica Schist	95	93					CH	Joint angle is ranging from 45 to 70 deg.						64
	65				96	59						64.2-65.5m, joint and fracture planes slightly coated with limonite.						65
	66				68	10	65.50					65.5-66.1m, fractured zone, fragment covering to talc content fragment.						66
	67				80	30	67.00	D-C	3-4	a	CM							67
	68	68.50	443.100		50	0		E	3-4	c-b	CL	67.0 to 72.2m depth, Sheared Zone. Core is soft material assorted rock fragments. Joints and fractures are undulating at the top.		Lu=0.0				68
	69				50	0	68.50					Some of quartz veins are accompanied.						69
	70				42	0		E	5	d-e	D	69.2-69.6m, recovered core is deteriorated into brown in colour.						70
	71				20	0						70.0-70.5m, recovered core is deteriorated into brown in colour.						71
	72				69	0	71.35 72.00	E-D	3-5	c-d	CL							72
	73			Green Schist	80	10						71.8 - 72.2m, Graphitic.						73
	74				90	10		C-D	3-4	b-c	CM	Between 72.2 and 77.0m depth, gray to greenish chloritic schist caused probably by hydrothermal alteration of dolomite intrusion.		Lu=0.0 P=8.7				74
	75				98	21	75.25				CM	73.30 - 73.35m, intercalated with clayey soft material.						75
	76	76.20	432.400		90	0		C	4	b-c	CL	72.6-73.0 m, 73.6-74.0m, and 75.3-77.0m, Fractured zones.						76
	77				95	12	77.00											77
	78			Quartz mica Schist	95	42						After 77.0m, gray in colour, hard, and fresh Paragneiss Schist.		Lu=0.0 P=9.5				78
	79				90	10		C-D	3	a-b	CH							79
	80	80.90	428.600		90	40												80
	81	80.70	427.900	Green Schist	99	30	80.70					80.0-80.7m, intercalated with sandy soft material. At 80.7m, 82.7m, graphitic and talcose material is included.						81
	82			Quartz mica Schist	97	45		C	2	a	CH							82
	83	82.70	425.900		98	55	82.70							Lu=0.1 P=8.9				83
	84			Green Schist	98	0		E	3	c-d	CL	82.7 to 84.3m, Greenish clay associated rock fragments altered by hydrothermal solution.						84
	85	84.30	424.300		100	43	84.30					After 84.3m, greenish gray in colour, massive, chloritic, with some quartz veins.						85
	86				95	81		C-B	1-2	a	CH	Joint attitudes are ranging from 30-40 deg., 60-70 deg., and vertical.						86
	87			Quartz mica Schist	90	20						86.1 to 89.0m, fractured zone. Many quartz veins remarkably microfissled are observed.						87
	88				91	10		D-C	3-4	a	CM	Between 86.1 and 91.0 m, recovered core is Chlorite Mica Schist with some quartz vein with well developed schistosity. Fragment mostly 1 to 2-cm size broken along schistosity, some are fractured.		Lu=0.1 P=10.3				88
	89				90	11	89.00											89
	90				98	10		C-D	3	a	CH							90

## GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-2, 4/4

Hole No.: M98-2  
 Ground EL.: 508.620 m  
 Hole length: 100.00 m

Location: Dam Axis (Right Bank)  
 Drilling period: Dec. 16, 1998 - Jan. 30, 1999  
 Hole Inclination: 90 degrees (Vertical)

Azimuth: \_\_\_\_\_  
 Northing: 1,124,807.933  
 Easting: 3,067,915.867

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lu/gren value	Sample	Casing	Concentration	Depth (m)
1/28	91	416.900		Quartz-mica Schist	99	15	90.90	C-D	3	a	CH	91.8 - 94.0, dark green Chlorite Mica Schist with some quartz veins.  92.3 to 92.6m, blonze in colour copper mineral densely accumulated.  Joints angles are ranging from 45 to 50 deg.  94.0 to 94.1m, light green malachite mineral is associated with quartz vein.  After 94.0m, recovered core is highly sliced with many quartz veins.  At 95.5m, thin clay layer is intercalated (joint angle 50 - 40 deg).  From 97.0m, Fractured zone. Vertical fractures are commonly found in this zone.  Small pyrite minerals are observed a lot.						91
	92			98	46	C	2-1	a	CH	92								
	93	Green Schist		93	65					93								
	94	414.450		100	55					94								
	95	100		82	95													
1/29	96		Quartz-mica Schist	96	45	97.00	E-D	3-4	c	CL	CL	96						
	97			100	56							97						
	98			68	0							98						
1/30	99			99	12							99						
	100			100.00	408.600							90	0	100.00	100			



# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-3, 1/4

Hole No.: M98-3  
 Ground EL.: 417.211 m  
 Hole length: 100.00 m

Location: Dam Axis (Right Bank)  
 Drilling period: Nov. 23, 1988 - Jan. 6, 1989  
 Hole inclination: 90 degrees (Vertical)

Azimuth: \_\_\_\_\_  
 Northing: 1,125,022.212  
 Easting: 3,067,851.069

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock mass	Description	O.W.L. S.P.T.	Lugon value	Sample	Casing	Concentration	Depth (m)		
11/26	1	410.711	[Pattern]	Green Schist	75	0	3.70	F	5	d-c	D	D	Regional Soil & Highly Weathered Rock: Early brown to a more white, loose to some consolidated, or shaly between fingers. From 1 to 1.5m, mostly loose with few angular quartz fragments up to dia. 4 cm. Recovered core is highly weathered schist broken by fingers.  From 2.5m onwards, core is gradually harder with depth.					1		
	2				65	0													2	
	3				60	0													3	
	4				80	0													4	
11/27	5	410.711	[Pattern]	Mixed rock of Quartzitic Schist and Green Schist	90	20	5.50	D-E	3-5	c	CL	CL	Talcose Quartz Chlorite Schist: At 3.8 m, a more accumulated chlorite content schist appearing in the core, due to which core becomes more greenish (chlorite rich). Schistosity well developed with schistosity joints equal to 45 to 58 deg. Vertical fractures from 4.1 to 4.25m. Surface coated with argillaceous material. From 6.0m, fine grained Schist alternating with Chloritic Schist. Core is hard with coarse grains (sand) observed along schistosity planes. Joint planes show deep oxidation effect.	Lo-68			5			
	6				100	23												6		
	7				100	28												7		
11/28	8	408.211	[Pattern]	Mixed rock of Quartzitic Schist and Green Schist	100	55	11.00	C-D	3	b-c	CM	CM	At 8.00 m, the schist includes specks or microcrysts of garnet up to dia. 0.5cm reddish brown colour. Joint planes are mostly schistosity joint, mostly are coated with limonite or calcite. Quartz veins up to dia. 2cm observed in Talc-Chlorite Quartz Chlorite Schist up to 10 m depth. 5 to 10 m, schistosity joint angles 33 to 61 deg., other joint angles 25 to 52 deg. Rock of 9.0-10.7m has greenish metabasalts of sheet structured and granular. The rock is hard, fails to rock weathered, schistosity well developed. Band of quartz vein at 13.5m (dia. = 6cm). Garnet microcrysts are common.	Lo-11 Pc-5.8			8			
	9				100	22												9		
12/1	10	408.211	[Pattern]	Mixed rock of Quartzitic Schist and Green Schist	100	28	11.00												10	
	11				100	10														11
	12				100	80														12
	13				100	94														13
12/2	14	408.211	[Pattern]	Mixed rock of Quartzitic Schist and Green Schist	100	60	11.00												14	
	15				100	65														15
	16				100	90														16
12/3	17	408.211	[Pattern]	Mixed rock of Quartzitic Schist and Green Schist	100	85	21.30	C-B	1-2	b-a	CH	CH	15-20m, Core kept alternating Quartzitic Schist and Chlorite-Mica Schist.  Schistosity well developed. Schistosity and normal joints are coated with limonite.	Lo-4.3 Pc-8.8	C-36.7 C-31.2 C-33.7			17		
	18				100	50													18	
	19				100	52													19	
12/4	20	408.211	[Pattern]	Quartz mica Schist	100	77	21.30					Between 19.0 and 21.0m, Quartzitic Mica partly with Chlorite Schist:  Joint at 20.75m = 52 deg.					20			
	21				100	77												21		
12/5	22	408.211	[Pattern]	Quartz mica Schist	100	25	24.00	D-C	3-4	b	CM	CM	Vertical fracture at 24.6m.	Lo-5.8 Pc-9.2					22	
	23				100	10														23
	24				100	24														24
12/6	25	408.211	[Pattern]	Quartz mica Schist	100	52	24.00					Fracture observed in Quartz Mica Schist from 24.65 to 24.8m. Schistosity 52 to 71 deg. in the section of 20-25m.  24.4-26.15m, Quartzite: mostly joint are developed along schistosity.					25			
	26				100	40												26		
12/7	27	408.211	[Pattern]	Quartz mica Schist	100	45	24.00	C	2-3	b-a	CH	CH	Joints at 25.8m = 59 deg., at 26.5m = 54 deg., coated with limonite.	Lo-5.4 Pc-8.6					27	
	28				100	52														28
	29				100	73														29
	30				100	45														30

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-3, 2/4

Hole No: M98-3  
 Ground EL: 417.211 m  
 Hole length: 100.00 m

Location: Dam Axis (Right Bank)  
 Drilling period: Nov. 23, 1958 - Jan. 6, 1959  
 Hole Inclination: 90 degrees (Vertical)

Azimuth:             
 Northing: 1,125,022.212  
 Easting : 3,067,851.069

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugon value	Sample	Casing Cementation	Depth (m)
12/28	31				100	100						Between 31.0 and 32.2, Quartzite with some Paragneiss Schist;					31
12/29	32				100	85						gradually changing into Chlorite-Mica Schist with quartz vein partly Paragneiss Schist	15 33.4m	Lu=0.8 Pc=9.6			32
12/29	33				100	40						Greenish to white, hard to very hard, schistosity well developed, joint mostly schistosity joint, some garnet and crystals present.	2/10 34.8m				33
	34				100	50		C	2-3	b-a	CH CH	Joint planes angles along core axis from 34 to 35-m = 47 deg.					34
	35				100	84						From 35.0 to 41.0 m, Talc-Quartz Sericite Schist; white, med. hard, fresh, schistosity well developed, small black spots probably amphibole observed in core.					35
12/11	36				90	50						Talc gives dull shiny silty luster to the core.					36
	37				100	15	37.80					Schistosity joints range from 46, 54, 56deg.		Lu=0.5 Pc=10.8			37
	38				90	13						Core is fresh and fragment covering to talc content fragment mostly 1 to 2-cm size broken along schistosity.					38
12/17	39			Quartz-mica Schist	90	33		D-C	3-4	a-b	CM CM						39
	40				100	0											40
12/13	41				95	20	40.80					From 41.0m to 43.6m, Talc-Chlorite Schist partly Paragneiss					41
	42				100	17		C-B	2-3	a-b	CH	42.0-43.1m, Isotaxitic	12/31 42.5m	Lu=2.8 Pc=9.0			42
	43				100	72						From 43.6m to 48.8m, Quartz-Chlorite Schist with quartz band.					43
12/14	44				85	20	43.60	E-E	5	c	D						44
	45				90	81											45
	46				90	19											46
12/17	47				100	70						Joint at 48m = 66 deg.					47
	48	48.30	368.911		100	73							12/30 48.5m	Lu=0.2 Pc=11.8			48
12/19	49				100	70						From 48.8m, Chlorite Schist with minor quartz band. This rock could be called Paragneiss or Diabase (Basaltic) Schist rather than Chlorite Schist.	12/29 50.5m				49
	50				100	80						Greenish gray to greenish black, hard to very hard, fresh, schistosity well developed.					50
	51				100	76		C	1-2	a-b	CH CH	Schistosity joints vary from 52 to 68deg. Quartz vein up to 2cm common.	12/28 52.3m				51
12/23	52				96	75						Vertical fracture at 51.0-51.2m.		Lu=0.0 Pc=12.3			52
	53				90	84						ore bolts columnar but several hair crack observed.					53
	54			Green Schist	95	70						52.0-54.4m, a lot of microfolding, sometimes overfolding.	12/27 53.5m				54
	55				80	76						Quartz veins at 50.45m (2cm), 51.4-51.6m, 62.4-62.5m, and 63.3-63.7m.					55
12/24	56				90	64						Vertical fracture at 56.1-56.5m.					56
	57				95	42											57
	58				100	90						57.4-60m, schistosity is high angle.		Lu=0.4 Pc=12.6			58
12/25	59				100	77											59
	60				90	30											60

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-3, 3/4

Hole No.: M98-3  
 Ground EL.: 417.211 m  
 Hole length: 100.00 m

Location: Dam Axis (Right Bank)  
 Drilling period: Nov. 23, 1983 - Jan. 6, 1999  
 Hole inclination: 90 degrees (Vertical)

Azimuth: -  
 Northing: 1,125,022.212  
 Easting: 3,067,851.069

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock mass	Description	G.W.L. S.P.T.	Lugon value	Sample	Casing	Cementation	Depth (m)
	61				95	80						From 60.0m, a little coarse grained with several quartz band						61
12/26	62				95	70						Rock is varying gradually into Chlorite Micr.Schist with quartz band from 61.8m depth.						62
	63				100	70								Ln=0.6				63
	64				100	35						63.8-64.0m and 64.3-64.6m, showing metamorphic texture of metacrysts of amphibole, groundmass is mainly of feldsparoid mineral.						64
12/27	65				93	50						From 64.6m, fine grained (Diabasic) chlorite Schist						65
	66				100	35						From 65.0m, Quartz S/Norite (Doleritic) Schist with quartz vein. Garnet metacrysts are commonly observed. 65.8-65.85m, dark greenish clay is intercalating.						66
	67				100	57												67
12/28	68				100	60						After 67m, Diabasic with several quartz band						68
	69				100	85						Quartz veins are observed at 65.0-65.5m, 65.4m, 65.6m, 65.85-66.0m, 66.1m, 66.5-66.6m, 66.9-67.0m, 67.5m, 67.8m, and 68.1-68.5m. Joint plane angle along core axis is, at 65.5m = 70 deg., 66.4-66.5m = 10-20 and 50deg., at 67.8m 70 deg., and 69.0-70.0m = vertical.						69
	70				85	10						Quartz veins are observed at 70.2m, 70.4m, 70.45m, 70.6m, 71.05m, and 71.1m.						70
	71				100	35						71.4-73.8m, few centimeters of quartz veins observed a lot.						71
12/29	72				100	70		CB	1-2	a	CH	Joint planes angle from 70-75m range from 10-30, 50, 60-70 deg.						72
	73				100	66						73.15-73.45m, Fractured zone; dark green, with 10cm thickness of clay from 73.35 to 73.45m.						73
	74				100	23												74
	75				100	83						Upto 75.3m, Basaltic After 75.3m, rock is formed by large, elongated, ophitic, amphibole phenocrysts, up to 79.5m.						75
	76				100	100						75.3-76.6m, several quartz veins and lenses are observed. Joint plane angles along core axis is at 75.9m = 50 deg.						76
	77				100	40						76.0m = 70 to 80 deg. 76.4-77.0m = 20 to 30, 50 deg. 77.4-77.5m = 30 deg. 78.2m = 60 deg.						77
12/30	78			Green Schist	100	70						79.15-79.25 = crossing two systems of 60-70 deg. and 20 deg. forming fractured zone.		Ln=0.0 F=8.7				78
	79				100	70						At 79.5m, intercalated with greenish clay with 5mm thickness angles 45-50, 20, and 80 deg.						79
	80				100	27						Quartz veins at 80.1m, 80.8m, 81.0m, and 81.4-81.6m.						80
	81				95	38						81.6-84.1m, Dolerite						81
12/31	82				95	90												82
	83				92	80						Joint planes from 80-85m are generally low angle of 10-30 deg., 30-45deg.		Ln=0.3 F=9.0				83
	84				100	54	84.10											84
	85				100	10	85.10	C-D	3	b	CM							85
	86				90	27						85.6-85.7m, clayey soft material intercalating.						86
	87				100	95												87
1/3	88				100	72		CB	1-2	a	CH	Quartz veins at 85.5-85.6m, 90.2m, 90.5-90.8m, 91.2-91.6m, 92.2m, 92.6-92.7m, 94.3-94.5m, 95.1-95.9m, 98.1-98.2m, and 98.5-98.8m. Joints between 80-85m, 10-30, 45, 60-80 deg., and vertical. Between 85-90m, mainly 60-70 deg. develops.		Ln=0.2 F=7.7			88	
	89				100	70												89
	90				100	95												90

## GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-3, 4/4

Hole No.: M98-3

Location: Dam Axis (Right Bank)

Azimuth:           

Ground EL: 417.211 m

Drilling period: Nov. 23, 1988 - Jan. 6, 1989

Northing: 1,125,022.212

Hole length: 100.00 m

Hole inclination: 90 degrees (Vertical)

Easting: 3,067,851.069

Date	Depth(m)	EL(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Luigen value	Sample	Casing	Concentration	Depth (m)
	91			Green Schist	100		90	B	1-2	a	CH CH	91.0-94.8, Dolomite with garnet and amphibole phenocryst. Joints between 90-95m, 10, 30, 70-75 deg. and vertical. Joints between 95-100m, 30, 40, 60-70 deg., and horizontal.		I <sub>s</sub> =0.2 F <sub>c</sub> =8.8				91
	92		100			50	92											
1/4	93		100			90	93											
	94		100			90	94											
	95		100			90	95											
	96		100			93	96											
	97		100			45	97											
1/5	98		100			52	98											
	99		100			75	99											
	100	100.00	317.211			100	75											100.00

# GEOLOGIC LOG OF DRILL HOLE

## FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-4, 1/3

Hole No.: **M98-4**  
 Ground EL.: **379.708 m**  
 Hole length: **70.00 m**

Location: **Dam Axis (Riverbed)**  
 Drilling period: **Feb. 9, 1995 - Feb. 17, 1999**  
 Hole inclination: **60 degrees from horizontal**

Azimuth: **30°00'00"**  
 Northing: **1,125,138.763**  
 Easting: **3,067,817.933**

Date	Depth (m)	EL. (m)	Leg.	Rock type	Core Recovery (%)	RQD	Depth (m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Logon value	Sample	Casing	Cementation	Depth (m)																																		
2/9	1	377.908		Siltaceous Schist	96	13	0.40	E	4-3	b-c	CL	Quartz mica schist: Medium to fine grained, composed of quartz, feldspar, white mica (sericite), ortho-pyroxene (augite), associated with a little pyrite. Moderately weathered to be light brown and silty. Joint planes are stained with iron oxides, with fine clayey joint filler.						1																																		
	2				98	35	3.50	C-D	3	b-c	CM							CM	Chlorite mica schist: Medium grained, greenish grey in the fresh portions. 1.80-3.50: Moderately weathered to be brown and softened along joints intercalated with fine joint filler. 3.50-4.90: Slightly weathered. Joints develop along schistosity.	La-45 Pc-6.9				2																												
	3				99	40																		3	3	3	3	3	3																							
	4				100	56																		4	4	4	4	4	4	4																						
	5				99	28	5.40	C	3-2	b	CH							CH						Quartz mica schist: Light grey to smoky white, fine to medium grained, composed of quartz, feldspar, white mica (sericite), talc, ortho-pyroxene (augite), associated with a little pyrite. Slightly weathered to be brown and softened along joints. Relatively high mica content, highly schistose to be flaky, and joints develop micaceous films along the schistosity. Most of the joints are stained with iron oxides and filled with fine clayey materials.	La-0.3 Pc-5.7				5																							
6	79	12	6	6	6	6						6	6	6																																						
2/11	7	368.208		Siltaceous Schist	43	0	6.00	F	5	d	D	Pneumatic schist: Banded structure of light colored and granitic thin layers and dark colored pelitic thin layers at a thickness of millimetre order. 11.45-13.55: Slightly weathered along joints (50-60, parallel to schistosity), joint planes are stained with iron oxides but scarcely deteriorated. 13.55-19.10: Schistosity is undulated and irregularly folded. Low-dip joints are dominant. Joint planes are slightly stained or almost fresh.	2/17 13.5m					7																																		
	8				92	20	7.80	D	3	b	CM							Pneumatic schist: Banded structure of light colored and granitic thin layers and dark colored pelitic thin layers at a thickness of millimetre order. 11.45-13.55: Slightly weathered along joints (50-60, parallel to schistosity), joint planes are stained with iron oxides but scarcely deteriorated. 13.55-19.10: Schistosity is undulated and irregularly folded. Low-dip joints are dominant. Joint planes are slightly stained or almost fresh.	La-0.3 Pc-5.7				8																													
	9				88	23																	9						9	9	9	9	9	9																		
	10				69	0	D-E	4-3	b-c	CL	CM												Pneumatic schist: Banded structure of light colored and granitic thin layers and dark colored pelitic thin layers at a thickness of millimetre order. 11.45-13.55: Slightly weathered along joints (50-60, parallel to schistosity), joint planes are stained with iron oxides but scarcely deteriorated. 13.55-19.10: Schistosity is undulated and irregularly folded. Low-dip joints are dominant. Joint planes are slightly stained or almost fresh.	La-0.3 Pc-5.7					10																							
	11				96	0																							11	11	11	11	11	11	11																	
	12				92	37	11.45	C-B	3-2	b-a	CM																		Pneumatic schist: Banded structure of light colored and granitic thin layers and dark colored pelitic thin layers at a thickness of millimetre order. 11.45-13.55: Slightly weathered along joints (50-60, parallel to schistosity), joint planes are stained with iron oxides but scarcely deteriorated. 13.55-19.10: Schistosity is undulated and irregularly folded. Low-dip joints are dominant. Joint planes are slightly stained or almost fresh.	2/17 13.5m						12																
	13				88	40																														13	13	13	13	13	13	13										
	14				95	20	13.55	C-B	2	a-b	CH																									Pneumatic schist: Banded structure of light colored and granitic thin layers and dark colored pelitic thin layers at a thickness of millimetre order. 11.45-13.55: Slightly weathered along joints (50-60, parallel to schistosity), joint planes are stained with iron oxides but scarcely deteriorated. 13.55-19.10: Schistosity is undulated and irregularly folded. Low-dip joints are dominant. Joint planes are slightly stained or almost fresh.	2/17 13.5m						14									
	15				85	41																																					15	15	15	15	15	15	15			
	16				90	45	18.50	C-B	2	a-b	CH																																Pneumatic schist: Banded structure of light colored and granitic thin layers and dark colored pelitic thin layers at a thickness of millimetre order. 11.45-13.55: Slightly weathered along joints (50-60, parallel to schistosity), joint planes are stained with iron oxides but scarcely deteriorated. 13.55-19.10: Schistosity is undulated and irregularly folded. Low-dip joints are dominant. Joint planes are slightly stained or almost fresh.	2/17 13.5m						16		
	17				98	52																																												17	17	17
18	100	65	18.50	C-B	2	a-b	CH	Pneumatic schist: Banded structure of light colored and granitic thin layers and dark colored pelitic thin layers at a thickness of millimetre order. 11.45-13.55: Slightly weathered along joints (50-60, parallel to schistosity), joint planes are stained with iron oxides but scarcely deteriorated. 13.55-19.10: Schistosity is undulated and irregularly folded. Low-dip joints are dominant. Joint planes are slightly stained or almost fresh.	2/17 13.5m						18																																					
19	100	74													19	19	19	19	19	19	19																															
2/12	20	360.608		Green Schist	82	65	26.70								B	1	a	B	Chlorite mica schist: Greenish grey, to light grey. Schistosity is a little bit obscure, looks like micro gneissosity (banded structure) of greenish dark grey portion and light grey portion. The dark portion consists of mainly chlorite, amphibole, mica (biotite), the light portion consists of mainly feldspar. Lath to needle shaped amphibole (actinolite?) large crystals exist in some course (highly recrystallized?) portions. White veins of 1 cm to 10 cm thick consist of mainly quartz associated with irregular shape of calcite. 19.10-26.70: Fresh, stiff, nicely jointed. 26.70-30.30: Fresh but slightly disturbed zone, quartz veins and minor shear planes exist frequently, joints exist mainly at	La-0.0 Pc-3.3																																20
	21				96	85																	21	21	21	21	21	21																								21
	22				98	58																	22	22	22	22	22	22																								22
	23				98	77																	23	23	23	23	23	23	23																							
	24				100	70																	24	24	24	24	24	24	24																							
	25				99	45																	25	25	25	25	25	25	25																							
	26				97	50																	26	26	26	26	26	26	26																							
	27				100	32																	27	27	27	27	27	27	27																							
	2/13				28																			Green Schist	99	32	26.70	B-C	2	a	CH	Chlorite mica schist: Greenish grey, to light grey. Schistosity is a little bit obscure, looks like micro gneissosity (banded structure) of greenish dark grey portion and light grey portion. The dark portion consists of mainly chlorite, amphibole, mica (biotite), the light portion consists of mainly feldspar. Lath to needle shaped amphibole (actinolite?) large crystals exist in some course (highly recrystallized?) portions. White veins of 1 cm to 10 cm thick consist of mainly quartz associated with irregular shape of calcite. 19.10-26.70: Fresh, stiff, nicely jointed. 26.70-30.30: Fresh but slightly disturbed zone, quartz veins and minor shear planes exist frequently, joints exist mainly at	La-0.1 Pc-6.8					28														
					29			100	83	29	29	29	29	29											29																											
30		99	73	30	30		30	30	30	30	30																																									

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-4, 2/3

Hole No.: M98-4  
 Ground EL.: 379.708 m  
 Hole length: 70.00 m

Location: Dam Axis (Riverbed)  
 Drilling period: Feb.9, 1998 - Feb.17, 1999  
 Hole inclination: 60 degrees from horizon

Azimuth: 30°00'00"  
 Northing: 1,125,138.763  
 Easting: 3,067,817.933

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lagoon value	Sample	Casing	Cementation	Depth (m)
	31				96	56	33.30	B-C	2	a	CH							31
	32				99	74		B	1	a	B	30.30-33.50: Schistosity (banding) is undulated. Fresh, stiff and rarely jointed.						32
2/13	33				100	96								Lu-0.7				33
	34				100	58	33.50					33.50-35.10: Slightly disturbed geologically, relatively jointed. No distinct softening on rock pieces, but slickensides are seen between 34.40 and 35.10 due to shearing.						34
	35				94	10	34.40	B	2-3	a	CH							35
	36				100	51	35.10	C-B	3-2	a-b	CM	35.10-62.85: Schistosity (banding) is undulated. Fresh, stiff and rarely jointed except the following: 34.40-34.60 (10-30 deg.), 39.45-40.05 (30-50deg dominant), 53.00-54.70 (60 deg., along schistosity).						36
	37				97	37	35.40	B	1-2	a-b	B							37
	38				99	48		B	2-3	a	CH			Lu-0.8				38
	39				100	22												39
2/14	40				95	31	39.45											40
	41				100	58	40.05	C-B	4-3	a	CM							41
	42				100	76		B	1-2	a	B		1/10 43.0m	Lu-0.8				42
	43				100	77												43
	44				98	32												44
	45			Gneiss Schist	99	33	44.40				CH							45
	46				100	88	45.00	B-C	3	a	CH							46
	47				100	40												47
	48				98	95								Lu-1.5				48
2/15	49				100	79		B	1	a	B							49
	50				100	50							2/10 50.3m					50
	51				100	56												51
	52				98	73												52
	53				97	44	53.00							Lu-2.0				53
	54				95	29		B	3	a	CH							54
	55				93	30	54.70											55
	56				100	68												56
	57				100	70		B	1-2	a	B							57
2/16	58				97	67								Lu-1.2				58
	59				98	56												59
	60				99	92												60

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-4, 3/3

Hole No.: M98-4  
 Ground El.: 379.708 m  
 Hole length: 70.00 m

Location: Dam Axis (Riverbed)  
 Drilling period: Feb. 9, 1998 - Feb. 17, 1999  
 Hole inclination: 60 degrees from horizon

Azimuth: 30°00'00"  
 Northing: 1,125,138.763  
 Easting: 3,067,817.933

Date	Depth(m)	El.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Logon value	Sample	Casing	Cementation	Depth (m)			
	61		[Hatched Pattern]	Green Schist	100	55						62.85-70.00: Schistosity (banding) is relatively distinct and partly undulated. Most of joints are along schistosity and where d. S.F.F and fresh.						61			
	62				99	89	B	1-2	a	B											62
	63				100	71											Ln=1.7 Pc=3.2				63
	64				58	71															64
	65				99	69								CH							65
	66				100	73	B	2-1	a-b	CH											66
	67				99	65															67
	68				99	61											Ln=0.7 Pc=7.2				68
	69				99	57			69.00												69
	70	379.708					99	89	70.00	B	1		a	B							70

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-5, 1/1

Hole No.: M98-5  
 Ground EL.: 343.00 m  
 Hole length: 70.00 m

Location: Dam Axis (Riverbed)  
 Drilling period: Feb.22, 1998 - Feb.26, 1999  
 Hole Inclination: 90 degrees (Vertical)

Azimuth:             
 Northing: 1,125,094.000  
 Easting: 3,067,825.000

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	N.O.W.L. S.P.T.	Lugon value Permeability	Sample	Casing	Cementation	Depth (m)	
2/22	1				100	0						Recent river deposit: Cobble and fine- to medium sand. Loose, non-plastic.				430 mm			1
2/23	2				100	0						Cobble: Round and fresh. Granite, meta-sandstone, pelitic schist, green schist, garnetiferous schist, quartz aggregate. 2 - 10 cm in dia. dominant, partly 30 cm.	N=35	9.56E-03		430 mm			2
	3			River Deposit	100	0						Matrix: Fine- to medium grained sand, mostly washed away during sampling.	N=6	3.26E-05		430 mm			2/23
	4				90	0							N=19	4.59E-04		430 mm			3
2/24	4.50	358.500			95	23							N=36	2.60E-03		430 mm			2/24
	5			Green Schist	100	70						Border (or overhang bedrock): Slightly weathered to almost fresh and stiff green schist. Joint planes slightly stained with iron oxides. White veins consist of quartz associated irregular calcite portions.				90 mm			5
	6	6.50	356.500		100	30										90 mm			6
	7			River Deposit	100	0						Recent river deposit: Cobble and fine- to medium sand. Loose, non-plastic (same as the above river deposit).	N=18			90 mm			7
	8	7.90	355.100		100	0	7.90									2.61E-04			8
2/25	9				100	12						Chlorite mica schist: Greenish grey to grey. Medium- to fine grained. Main minerals: chlorite, mica (biotite, muscovite and sericite), feldspar, amphibole (actinolite), pyroxene. Secondary minerals: quartz, calcite, pyrite.							9
	10				100	0		D	4	b-c	CL	Emb- to needle-shaped amphibole (actinolite) large crystals exist in some coarse (highly recrystallized) portions (7.90-9.90, 17.40-18.40, 21.12-21.50).							10
	11				95	0						White veins of 1 mm to 5 cm thick consist of mainly quartz associated with irregular shaped calcite.							11
	12				95	14	11.55												12
	13				100	15	12.60	C-D	3	b	CM	7.90-11.5: Slightly weathered, relatively soft, well jointed, fine clayey intercalation along some joints.							13
	14				100	20		C	3	a-b	CH	11.50-14.60: Vertical sheared zone (T=1.2cm).							14
	15				100	29	14.65					11.50-15.40: Joints along schistosity are dominant.							15
	16				100	0	15.40	C-D	3	b	CM								16
	17				100	37	16.65	D	4-3	b-c	CL	15.40-16.65: Relatively soft. High content of brown mica (biotite) and quartz veins (end-over).							17
	18			Green Schist	100	36		C	2-3	a	CH	16.65-19.00: Fresh and relatively stiff, joints exist along schistosity (60 deg.)							18
	19				100	0	19.00												19
	20				100	0	20.30	C-D	3	a-b	CM								20
	21				100	10	20.70	D	4	b	CL	20.30-20.70: Relatively soft and fragmented.							21
2/26	22				100	48						20.70-25.60: Fresh and relatively stiff. Joints along schistosity are dominant. Joints are mostly adhered with few joint filler.							22
	23				100	81													23
	24				100	57		C	2-3	a	CH								24
	25				100	47													25
	26				100	0	25.60												26
	27				100	0	27.30	C-D	3	a	CM	25.60-30.00: Slightly sheared, partly fragmented along joints (60-90 deg.)							27
	28				100	25		C	2	a	CH								28
	29				100	24	28.75												29
	30	30.00	333.000		100	25	30.20	C-D	3	a-b	CM								30



FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-6, 1/3

Hole No.: M198-6  
 Ground EL.: 395.09 m  
 Hole length: 70.00 m

Location: Plinth Line (Left Bank)  
 Drilling period: Jan. 29 to Feb. 6, 1992  
 Hole inclination: 90 degrees (Vertical)

Azimuth: -  
 Northing: 1,125,149.165  
 Easting: 3,067,562.789

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock cases	Description	G.W.L. S.P.T.	Lugon value	Sample	Casing	Concentration	Depth (m)	
		395.09		Rock deposit			0.50					Overburden: Sandy deposit on the bed of the small gully.							1
1/29	1				75	35						Paragneiss Schist: Up to 1.1 m, moderately hard and massive, moderately weathered. Joints are a little coated with limonite material.							2
	2				80	0		D	3-4	c-b	CL, CL								3
	3				87	0						From 1.1 to 4.9 m, rock is fairly weathered, shaly later, soft to med. hard, fragment mostly 1 to 5-cm size broken along schistosity.							4
	4				78	22	3.30					Some portions are graphitic. 3.0 to 3.2 m, quartz vein.		Lu=7.9 Pc=5.3					5
	5				98	0	4.90	C-D	3-4	b	CM, CM	Joints develop along schistosity (angle 20 to 30 deg.) Joints are coated with limonite.							6
	6				98	76						4.55 to 4.65 m, intercalated with clayey soft material. After 4.9 m, recovered core is fresh, moderately hard, with well developed schistosity.							7
1/30	7				100	64		C	2-3	a	CH	6.9 to 7.65 m, intercalated with sandy soft material.							8
	8				100	32	7.85				CH	Vertical fractures are observed between 7.85 and 8.25 m.		Lu=1.1 Pc=4.8					9
	9				100	20	8.60	D	4	a	CL								10
	10				100	62		C-D	2	a	CH					12.45			11
	11				100	72	10.50					From 10.5 to 10.7 m, rock is deformed into blocks in outcrop, soft and brittle. Joint angle = 30 deg.							12
	12				96	25	11.30	E	3-5	b-c	CL	Joint angle between 11.7 and 12.6 m = 50 and 60 deg. coated with limonite.							13
	13				98	34	12.60	D-C	2-3	b	CM, CM		2.10 13.4m	Lu=1.1 Pc=8.3					14
	14				91	52	13.30	D	4	b	CL	13.50m: a joint (60deg.)							15
1/31	15			Paragneiss Schist (Pelitic)	100	97						Up to 16.0m: Silicious, fine, jointed along schistosity (50 deg.)							16
	16				100	71						Few pieces are around 5-cm in length. Some core between 15 and 30cm length are observed. Maximum length is 50-cm.							17
	17				97	56						Vertical, and 20-40 deg. angle fractures are observed from 19.2 and 19.8m.		Lu=1.7 Pc=5.4					18
	18				100	67						Up to 19.8 m, Paragneiss and Meta Schist are alternating. From 19.8 m, Meta Schist is mainly consisting till 24.55 m.							19
	19				99	68													20
	20				98	31													21
	21				100	66		C	1-2	a	CH, CH								22
	22				100	44						21.5 to 22.0 m, some portions are graphitic.							23
2/1	23				100	47								Lu=1.1 Pc=8.4					24
	24				100	73													25
	25				97	29						From 24.55 m, Paragneiss and Meta Schist are alternating.							26
	26				100	10													27
	27				100	65													28
2/2	28				97	37								Lu=0.3					29
	29				100	63						Joint angle: 28.4-28.6m = vertical, 28.6-29.3m = 10 deg., 29.3-29.75m = vertical, 29.75-31.3m = 30 deg.							30

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-6, 2/3

Hole No.: M98-6  
 Ground EL.: 395.09 m  
 Hole length: 70.00 m

Location: Plinth Line (Left Bank)  
 Drilling period: Jan.29 to Feb. 6, 1999  
 Hole inclination: 90 degrees (Vertical)

Azimuth: \_\_\_\_\_  
 Northing: 1,125,140.165  
 Easting: 3,067,562.789

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock mass	Description	G.W.L. S.P.T.	Lugron value	Sample	Casing	Cementation	Depth (m)	
2/2	31			Psammite Schist (Pelitic)	100	34						From 31.3 m, dark grey to black, shaly luster, soft and brittle, thin layered Micaceous Schists are intercalated with Psammite Schist, or some thickness of layers are alternating each other.		Lu=0.8				31	
	32		97		41						32								
	33		93		27	C-D	1-2	a	CH	33									
	34		97		28						34								
	35		94		24						35								
	35.50	359.59			92	20	36.00					35.0 to 35.4 m, vertical fracture is observed.					36		
	36.50	358.59		Pelitic Schist (Psammite)	93	0		D-C	3-4	a	CM	36.5-37.3m, Micaceous Schist						37	
	37			Psammite Schist (Pelitic)	98	0	37.30				CH	37.3-42.7m, mainly Psammite Schist.						38	
	38		99		44													39	
	39		93		61	C	2-3	a	CH									40	
	40		98		35													41	
2/3	41			Psammite Schist (Pelitic)	88	24	41.30	D	4	b	CL	From 41.3 to 41.6 m, Fractured zone.						42	
	42		82		0	43.00	C-D	3-5	a	CM								43	
	43		88		22								42.7-43.3m, Micaceous Schist with some Graphitic Schist						44
	44	44.20	350.89			99	81						43.3-44.2m, Psammite Schist.						45
	45				Green Schist	99	57						44.2-46.2m, hard and massive sandstone with low schistosity.						46
	46	46.20	348.89		99	74					46.2-52.8m, Psammite rock with some schistosity. Few pieces are less than 5 cm length, recovered core is mostly in between 10 to 30cm.						47		
	47			Psammite Schist (Pelitic)	100	69												48	
	48		99		68													49	
	49		100		47													50	
	50		100		33	C-D	2-4	a-b	CH	CH	Joint planes around 52-53m are horizontal.							51	
	51			Green Schist	100	55												52	
	52		92		15								52.80-52.85m, clay is intercalated.					53	
	53	52.80	342.29			98	77						52.8-58.25m, hard and massive coarse sandstone with low schistosity.					54	
	54			Psammite Schist (Pelitic)	98	76						Recovered core is usually 10 to 20 cm length.						55	
	55		100		36													56	
	56	55.50	339.59		100	43												57	
	57			Green Schist	100	52						Joint planes around 28 m depth is usually broken along schistosity (angle 20 deg.).						58	
	58	57.40	337.69			99	37						58.25-58.35m, Fractured zone.					59	
	59	58.10	336.99		100	44						After 58.35 m, Psammite Schist with well schistosity with microfossiliferous white quartz band fragmented mostly 2 to 5-cm size broken along schistosity.					60		
2.5	60																	60	

## GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-6, 3/3

Hole No.: M198-6  
 Ground EL.: 395.02 m  
 Hole length: 70.00 m

Location: Plinth Line (Left Bank)  
 Drilling period: Jan 29 to Feb, 6, 1999  
 Hole Inclination: 90 degrees (Vertical)

Azimuth: \_\_\_\_\_  
 Northing: 1,125,140.165  
 Easting: 3,067,562.789

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugon value	Sample	Casing	Cementation	Depth (m)	
	61				92	0	60.00	C-D	2-4	a-b	CH							61	
	62				99	10												62	
	63				95	0								Lu=0.8				63	
	64				98	0												64	
	65				98	0		C-D	4-3	a	CM	CH						65	
	66			Fammitic Sand (Felsic)	98	0												66	
	67				99	0													67
27	68				98	0	62.50												68
	69				97	0		C-D	3	a	CH	CH			Lu=0.8				69
28	70.00	325.69			100	10	70.00											70	

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-7, 1/4

Hole No.: **M198-7**  
 Ground EL.: **370.389 m**  
 Hole length: **100.00 m**

Location: **Plinth Line (River)**  
 Drilling period: **Jan 3 to Feb 9, 1999**  
 Hole inclination: **60 degrees**

Azimuth: -  
 Northing: **1,125,018.645**  
 Easting: **3,067,584.831**

Date	Depth(m)	EL.(m)	Leg.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugon value	Sample	Casing	Cementation	Depth (m)	
1/3	1				94	38	1.20	D	2-3	b c	CM	<b>Psammitic Schist</b> Upto 1.2 m, mod. weathered, mod. hard, dark brown to bluish brown in colour. Upto 5.3 m, rock is relatively fresh but slightly weathered along joint planes coated slightly limonitic or limy material. Joint planes are sharp, angle 45 deg.	21 0.6 171 142 171 210						
	2			100	88	2.40	C-D	2	b	CH									
1/4	3				46	25	3.00	F	5	d	D	Upto 3.9 m, mod. to highly hard, gray to black, shaly luster sandstone with low schistosity. From 3.9 to 4.6 m, pure quartz band, very hard, partly fractured, white, fresh.		Lu's 80					
	4			95	53	3.90	C	2-1	b-a	CH									
	5				95	26	5.00	C	3-4	b-c	CM	From 4.6 to 21.8 m, Psammitic Schist with well developed schistosity with some quartz veins. Recovered core is fragmented mostly 1 to 5 cm size broken along schistosity. Joint angle from 5.0 to 5.3m = 60 deg. 5.3-5.5m, fractured zone with 5cm thickness of clay, joint angle is 45 deg. At 5.8m, joint with angle 45deg, is slightly coated with limonite and stained with black graphitic soft material.							
1/5	6			95	38					CH									
	7				65	10		C	2-3	a-b	CH	From 6.1 to 6.5 m, fractured zone, vertical fracture is observed slightly coated with limonite. 7.3-7.6m, fractured zone. 8.0-8.5m, intercalated with sandy soft material. From 9.5 to 10.5m, Sheared zone with vertical clay seams, slightly coated with limonite. 10.5-11.2m, siliceous material stains along joint planes. At 11.4-11.5m, joint of slickenside stained with graphitic material is observed. Between 11.5 and 12.6 m, coarse grained, hard and massive Sandstone with low schistosity.		Lu's 68					
	8			90	30	8.00													
1/13	9				75	0						At 12.2m, a little limonite is coating joint plane. After 12.2m, recovered core is fresh. 12.45 to 12.9m, vertical fracture is observed. At 13.5m, stained with graphite along schistosity.							
	10			80	10		C-B	4	b	CL									
	11				60	0	11.20					14.25-14.5m, fractured zone. 15.25-15.6m, fractured zone. At 15.8m, quartz vein							
	12			90	37														
1/15	13				95	30						16.4-16.8m, fractured zone. 17.05-17.15m, vertical fracture is observed.	Lu's 83						
	14			90	30														
	15				82	11		C-D	3	a-b	CM	17.5-18.3m and 20.0-20.6m, coarse grained Sandstone with low schistosity.		Lu's 4.2 P=7.4					
1/16	16			100	10					CM									
	17				100	18						From 20.6 to 25.0 m, Sheared zone with some quartz veins at 21.5m (T=2cm), 22.1m (T=10cm), and few layers from 23.1 to 23.35m. From 21.8m, black to gray, shaly luster, graphitic biotite schist is common.							
	18			100	58	18.30													
	19				100	18						25.6-26.3m, sandy clayey soft material is intercalating. Joint are stained with graphitic material. 26.6-26.8m, fractured zone stained with graphitic material.							
1/27	20			55	0	20.00	D-C	4	b	CL									
	21				100	55	20.70	C-D	3-4	a-b	CM	28.8-29.6m, fractured zone.		Lu's 0.4 P=6.5					
	22			97	0														
1/28	23				90	0						25.6-26.3m, sandy clayey soft material is intercalating. Joint are stained with graphitic material. 26.6-26.8m, fractured zone stained with graphitic material.							
	24			90	0		D-C	4	b	CL									
1/29	25				90	0						28.8-29.6m, fractured zone.							
	26			56	0	25.60													
1/30	27				70	0	26.30	E	5	d	D	28.8-29.6m, fractured zone.							
	28			85	0		D	4-5	b	CL									
	29				70	0	28.80					28.8-29.6m, fractured zone.							
	30			70	0	29.45	P	6	d	D									
1/31	30				70	0	29.45	D	4-5	b-a	CL								

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-7, 2/4

Hole No.: M98-7  
 Ground EL.: 370.389 m  
 Hole length: 100.00 m

Location: Plinth Line (River)  
 Drilling period: Jan 3 to Feb. 9, 1979  
 Hole inclination: 60 degrees from horizon

Azimuth: -  
 Northing: 1,125,018.643  
 Easting: 3,067,584.851

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugeon value	Sample	Casing	Cementation	Depth (m)
	31			Psammite (Pelitic) Schist	75	0												31
	32				92	0		D	4-5	b-a	CL	CL						32
	33				80	25	32.60								Lu=0.1 Fc=7.3			33
2/1	34				80	20	34.30	C-D	3	a-b	CM	CM	34.3-34.6m, vertical fracture. 34.6-35.0m, clay is intercalating.					34
	35	35.55	334.819	Psammite Schist	50	0	35.00	D-E	4-5	b-c	CL							35
	36				95	55							After 35.0 m, core is Siliceous Psammite rock with low schistosity alternating mainly with Graphitic Biotite Schist. Fine grained, med. to very hard, light gray to light greenish gray, fresh.					36
	37				90	60							Each layer's thickness of the former is between 1 to 15 cm, and the latter is 1 to 3 cm visually included 10 to 20%.		Lu=0.6			37
	38				100	33							Joint develops along the layer of the latter with angle 50 deg. in concordant with schistosity.					38
	39				93	50		C-D	2-3	a	CH	CH	Some joints develop horizontally. Core length is between 10 and 30 cm observed.					39
2/3	40				92	70												40
	41	41.00	329.389		90	50						CH						41
	42				100	50	41.85						After 41.2 m, Graphitic Biotite Schist becomes major. Rate of Siliceous Psammite Schist is about 30%.					42
	43				85	70	42.50	D-E	4-5	b	CL	CL	Including so many thin quartz veins highly microfolding. Black to dark gray with light gray band, medium hard, fresh, highly schistosed.		Lu=0.6			43
	44				80	23		C-D	2-3	a	CH	CH	42.0-42.3m, Fractured zone. 43.5-43.65m, intercalated with sandy soft material.					44
	45			85	34	44.30						44.3 - 44.8 m, intercalated with clayey soft material.					45	
	46			90	41							45.8-45.9m, intercalated with clayey soft material assorted rock fragments.					46	
	47			100	35		C-D	2-1	b-a	CH	CH						47	
	48			92	78							Between 47.0 and 51.25 m, recovered core is Chlorite Biotite Schist with thin Quartz band.		Lu=0.0			48	
	49			80	20	48.30						Highly schistosed, black to brownish black, medium hard to a little soft, fresh.					49	
2/4	50			Psammite (Pelitic) Schist	75	17		C-D	3-5	a-b	CM	CM	Vertical fractures at 48.3-49.0m, 51.9-52.2m, and 54.4-54.9m are observed.					50
	51				90	33	50.85											51
	52				93	79							After 51.0 m, some recovered core is intact with more than 1m long.		Lu=0.0			52
	53				93	66		C	1-2	a	CH	CH	But at the part of Biotite Schist some fractured zones develop.					53
	54				96	68												54
	55				96	43	54.50						54.4-55.2m, Fractured zone.					55
	56			97	90	55.20	D-E	4	a	CL	CH						56	
	57			100	28		C	2-4	a	CH	CH						57	
	58			100	80									Lu=0.0				58
	59			98	44	58.10						58.1 - 58.6m: Fractures of angle 50 to 60 deg. with some clayey soft material.					59	
2/5	60			98	20		C-D	3-2	a-b	CM	CM						60	

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-7, 3/4

Hole No.: M98-7  
 Ground EL.: 370.389 m  
 Hole length: 100.00 m

Location: Plinth Line (River)  
 Drilling period: Jan. 3 to Feb. 9, 1999  
 Hole Inclination: 60 degrees from horizon

Azimuth: -  
 Northing: 1,125,018.645  
 Easting: 3,667,584.851

Date	Depth (m)	EL. (m)	Log.	Rock type	Core Recovery (%)	RQD	Depth (m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugeon value	Sample	Casing	Cementation	Depth (m)					
	61			Felsitic (Feldic) Schist	90	28		C-D	3-2	a-b	CM	60.741.6m: Fractured zone with some clayey material						61					
	62				90	23	61.60																62
	63				95	80													Lu=0.0				63
	64				95	88																	64
	65				94	72																	65
	66				95	41								C	2-3	a	CH						66
	67			95	66												67						
	68			90	74								Lu=0.0				68						
	69			95	90		69.30										69						
2/6	70			92	50		69.70	C	3-4	a	CM	Vertical fracture at 69.3-69.7m is observed.					70						
	71			100	84												71						
	72			100	58												72						
2/6	73			97	93								Lu=0.0				73						
	74			93	85												74						
	75			Felsitic (Feldic) Schist	96	62											75						
	76			100	92												76						
	77			98	87						CH	Minor fractured zones are at 71.3-71.4m, 74.6-74.65m, 79.9-79.95m, 85.85-86.0m, 94.1-94.15m, 96.8-96.85m, 98.0-98.1m, and 98.55-98.6.					77						
	78			100	79							Joint planes angle at: 80 - m = 40 deg., 85.0m = 30 deg., 86.0-90.0m = 50 to 60 deg.	Lu=0.0				78						
	79			100	70												79						
	80			99	50												80						
	81			100	75			C	2-1	a	CH						81						
	82			100	87												82						
	83			100	99								Lu=0.0				83						
	84			100	97												84						
2/7	85			100	98												85						
	86			98	97												86						
	87			100	95												87						
	88			100	99								Lu=0.0				88						
	89			100	80							Quartz veins are at 87.4-87.5m, and 89.85-89.9 m.					89						
	90			100	84												90						

## GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-7, 4/4

Hole No: **M198-7**  
 Ground F.L.: 370.389 m  
 Hole length: 100.00 m

Location: Piñth Line (River)  
 Drilling period: Jan 3 to Feb 9, 1959  
 Hole inclination: 60 degrees from horizon

Azimuth: -  
 Northing: 1,115,018.645  
 Easting : 3,067,384.851

Date	Depth(m)	E.L.(m)	Log.	Rock type	Core Recovery (%)	RQD		Depth(m)	Hardness	Joint interval	Joint condition	Rock mass	Description	G.W.L. S.P.T.	Lugeon value	Sample	Casing	Concentration	Depth (m)													
	91			Famalic (Felsic) Schist	94		70		C	2-1	a	CH CH			Lu=0.0				91													
	92		100			75		92																								
	93		98			66		93																								
	94		100			78		94																								
28	95		96			60		95																								
	96		100			80		96																								
	97		100			82		97																								
	98		100			95		98																								
	99		100			82		99																								
	100	270.389			100	40		100																								
Some fractural zones develop at 99.15-99.30m, and 99.7-99.75m intercalated with clayey soft materials.																																

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-8, 1/3

Hole No.: **M98-8**  
 Ground EL.: **417.032 m**  
 Hole length: **70.00 m**

Location: **Pinth Line (Right Bank)**  
 Drilling period: **Dec. 11, 1998 to Jan. 13, 1999**  
 Hole inclination: **90 degrees (Vertical)**

Azimuth: \_\_\_\_\_  
 Northing: **1,124,831.850**  
 Easting: **3,067,610.461**

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lu-gon value	Sample	Casing	Cementation	Depth (m)			
12/11	1		[Log pattern]	Green Schist	60	0					CL	<p><b>Residual Soil &amp; Highly Weathered Rock:</b>                      Assorted rock fragments and drilled core nod. to highly weathered in earthy brown silty material. Rock pieces up to 5 cm sharp angular or columnar core. Rock type of fragment is Dolerite, altered by hydrothermal solution.</p>						1			
	2				50	10	E-D	3-5	c-d	CL	CL		2								
12/13	3				90	10		2.50	D	3	b		CM	CM	<p><b>Dolerite:</b>                      Dark greenish gray, med. to very hard, massive and tight, mod. to slightly weathered.</p>					3	
	4				90	27										Lu=38			4		
12/14	5				70	51									<p>Joint planes angles along core axis at                      3 to 5 m = 10 to 30 deg.                      5 to 7 m = 60 to 70 deg.                      From 3.8 to 3.9 m, altered and deteriorated into soft material.</p>					5	
	6				90	35										<p>Joint planes are stained some reddish brown earthy material.</p>				6	
	7				100	48								CH			<p>Up to 8.6 m, joint planes are usually coated with limonitic material or altered reddish brown in colour.</p>				7
12/15	8				100	42			C	2-3	a-b			CH	<p>From 8.6 m, joint plane coating become slight.</p>				Lu=41		8
	9				83	40									<p>Between 7 and 13 m, some thin quartz veins are observed.</p>					9	
12/16	10				100	60									<p>Between 7 and 45 m, recovered core is very fine grained Basaltic, except some portion.</p>						10
	11				100	70															11
	12				100	75			12.00												12
12/17	13			50	10			12.40	D	3	b-c	CM	<p>After 12.0 m, recovered core is highly schistose broken into small pieces along schistosity with several of quartz veins, and very brittle.</p>						13		
	14			35	0			13.80	F	5	d	D							14		
	15			100	95			14.20	D-E	4	b-c	CL							15		
12/18	16			100	90								<p>Between 14.2 and 19.0 m, Gabbroic, coarse grained, massive or a little schistose and hard, fresh.</p> <p>At 15.0m, joint plane is a little coated with limonite.</p>						16		
	17			100	90									<p>Joint plane angles along core axis,                      at 12.5 m = 40 deg.,                      at 15.0 m = 60 deg.</p>					17		
	18			100	90										Lu=1.0 P=8.8			18			
12/19	19	18.55		393.062	100	80							<p>From 19.0m, rock is silicified a little and schistosity develops slightly with some quartz veins.</p>						19		
	20				100	65			C-B	1-3	a-b	CH							20		
12/20	21			Fammitic Schist	95	80							<p>At 21.3 m, quartz vein is observed (T = 2mm).                      21.3-21.6m, slightly deteriorated.</p>						21		
	22				100	80								CH	<p>From 21.6 to 23.1m, a lot of thin quartz veins are observed.</p>					22	
	23	21.80		394.232	100	80								Lu=8.9 P=6.1					23		
12/21	24	23.90		393.132	Green Schist	100	70						<p>At 23.1m, a lot of thin quartz veins are observed.</p>						24		
	25				100	40		24.15												25	
12/22	26			Fammitic (Felsic) Schist	95	20			C	3	b	CM	<p>Up to 26.1-m, joints and fractures are slightly coated with limonite.                      From 26.1-m, recovered core is fresh.</p>							26	
	27				100	74									<p>At 28.0 and 28.2m, quartz veins are observed (T = 1cm).</p>					27	
	28				100	76										Lu=11				28	
12/23	29			100	45			C-B	1-3	a		CH	<p>At 29.0 m, joint is stained and intercalated with sandy soft material.                      At 29.5 and 29.9m, quartz veins are observed.</p>						29		
	30			100	84															30	



# GEOLOGIC LOG DRILL HOLE

## FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-8, 2/3

Hole No.: **M198-8**  
 Ground EL.: **417.032 m**  
 Hole length: **70.00 m**

Location: **Plinth Line (Right Bank)**  
 Drilling period: **Dec. 11, 1993 to Jan. 13, 1994**  
 Hole inclination: **90 degrees (Vertical)**

Altitude: **-**  
 Northing: **1,123,881.850**  
 Easting: **3,067,610.461**

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Face	Joint interval	Joint condition	Rock mass	Description	G.W.L. S.P.T.	Lagoon value	Sample	Casing	Cementation	Depth (m)		
1/1	31	384.732		Fammitic (Plethid) Schist	95	90												31		
	32				32.30	100	95													32
1/2	33	381.632		Fammitic Schist	92	70												33		
	34				100	80													34	
	35				35.40	100	77													35
	36				100	67														36
1/3	37	377.632		Fammitic (Plethid) Schist	100	74												37		
	38				100	70													38	
	39				39.40	100	83	C-B	1-3	a	CH									39
	40				377.632	100	73													40
1/4	41				100	72												41		
	42				100	40													42	
	43				90	53														43
	44				90	94														44
	45				97	85														45
1/5	46				100	83	46.30											46		
	47				100	13													47	
	48				47.40	100	10	C	3-4	b	CM									48
1/6	49			Fammitic Schist	100	84												49		
	50				100	74	C-B	2	a	CH									50	
1/7	51				95	66												51		
	52				95	70													52	
	53				100	12	52.60	C-D	3	b-a	CM									53
	54				100	45	53.30	C-B	2	b-a	CH									54
1/8	55	361.432			95	23	54.30											55		
	56				55.60	50	0	55.50	D-C	4	b	CL	CL						56	
1/9	57			Green Schist	60	0												57		
	58				57.50	50	11	E-F	4-5	b-d	D	D							58	
1/9	59				70	10												59		
	60				59.60	85	0	59.60	D	4-3	b-e	CL	CL						60	

## GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-8, 3/3

Hole No.: M98-8  
 Ground EL.: 417.032 m  
 Hole length: 70.00 m

Location: Plinth Line (Right Bank)  
 Drilling period: Dec.11, 1998 to Jan. 13, 1999  
 Hole inclination: 90 degrees (Vertical)

Azimuth: \_\_\_\_\_  
 Northing: 1,124,881.850  
 Easting: 3,067,610.461

Date	Depth(m)	EL.(m)	Log.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugrem value	Sample	Casing	Cementation	Depth (m)		
1/11	60.30	356.731		Green Schist	90	26	64.20	C	3-4	b	CM	Between 60.0 and 61.0 m, bluish green Basaltic rocks with several of quartz veins.  Between 61.0 and 64.2 m. Zone of quartz vein intrusions. This zone is highly fractured and broken into small pieces.	Le=0.3					61		
	61	356.132		Mixed rock														80	32	62
	62			Granitic (Felsic) Schist														82	10	63
	63																	75	0	64
	64	351.032																59	36	65
1/12	65			Green Schist	96	25	C-B	2-3	a-b	CH	From 64.2 m, dark green in colour, fine grained, with schistosity.  Between 65 and 66 m, several quartz veins are observed and generally silicified.  From 66m, core is again bluish green, fine grained.  Lower portion is the zone of quartz vein intrusion and generally silicified with some schistosity.	Le=0.2 For 10.1					66			
	66																95	40	67	
	67																100	72	68	
1/13	68				93	50												69		
	69.30				70	12	C	3-4	b-c	CM	69.3-69.85 m, Fractured zone.							70		

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M198-9, 1/1

Hole No.: **M198-9**  
 Ground EL.: **388.542 m**  
 Hole length: **30.00 m**

Location: **Tunnel Intake (Right)**  
 Drilling period: **Nov. 26 to Dec. 6, 1998**  
 Hole Inclination: **90 degrees (Vertical)**

Azimuth: \_\_\_\_\_  
 Northing: **1,124,779.195**  
 Easting: **3,067,458.727**

Date	Depth (m)	EL. (m)	Log	Rock type	Core Recovery (%)	RQD	Depth (m)	Hardness	Joint interval	Joint condition	Rock case	Description	G.W./L S.P.T.	Logson value	Sample	Casing	Cementation	Depth (m)
	1				60	0					D	<b>Residual Soil:</b> Assorted rock fragments med. to highly weathered in earthy brown silty material. Rock pieces up to 2 cm sharp angular of schist, gneiss, and quartz.						1
	2				50	0	2.20	E-F	5	d	D		N=69					2
11/26	3				75	28						Gray to black, shiny luster, soft to med. hard, med. weathered. Joint and fracture planes coated with limonite. Core develops cracks on exposure to air. Some quartz veins at 2.7 m. Joint planes angles along core axis at 2.8 m = 53 deg. 3.48 m = 73 deg. 4.6 m = 75 deg.						3
	4				93	30		E	3-4	c	CL			Lu=20 Pec 4.3				4
	5				100	21	4.55											5
	6			Paragneiss (Pelitic) Schist	100	20												6
11/27	7				100	0		D-E	3-4	b-c	CM							7
	8				100	0	7.40											8
	9				100	10	9.5	D-E	4	b-c	CL	From 8.5 to 8.6 m depth, white quartz band (thickness 10 cm) observed.		Lu=8.6				9
11/28	10				100	50						Dolerite with some Schist With increasing depth, schist decreases and dolerite increases. From 9.10 to 9.15 m, quartz band is observed. Joint planes at 9.2 m = 29 deg, 9.4 m = 62 deg, 9.8 m = 51 and 23 deg. From 10.10 to 10.34 m some quartz Dolerite: Black to gray, fresh hard, with some thin quartz vein (thickness < 1 cm) After 10.8 m, recovered core is Talc, Micro Schist with some quartz vein with well developed schistosity.					10	
	11	11.20	377.342		100	62												11
12/7	12			Paragneiss Schist	100	38		C	2-3	b	CH	Black to gray, fresh hard, with some thin quartz vein (thickness < 1 cm) After 10.8 m, recovered core is Talc, Micro Schist with some quartz vein with well developed schistosity.						12
	13				100	30								Lu=4.2 Pec 8.3				13
	14	13.90	374.642		100	34	13.90					Joints are ranging from 29 to 36 deg. Limonite is coating along joint planes. Talc decreases with increasing depth.						14
12/3	15				100	20	15.10	D-C	3-4	b-a	CM		12.5 15.0m					15
	16				100	20	16.20	C	2-3	a-b	CH							16
	17				100	0												17
12/4	18				100	0		C-D	4-3	a-b	CM		12.6 18.2m	Lu=0.3				18
	19				100	0												19
	20				100	0	19.70											20
	21			Paragneiss (Pelitic) Schist	100	20	20.95	C	3-2	a-b	CH	Joints are in concordant with schistosity. From 20 to 25 m, joint angles range between 20 to 44 deg.	210 19.47m					21
	22				100	0	21.85	E-D	4	b-a	CL							22
12/5	23				100	0												23
	24				100	0	24.00	C-D	3-4	b-a	CM			Lu=7.5				24
	25				100	0	24.50	C	2-3	a	CH							25
	26				100	0	25.00	C	4	a-b	CM							26
	27				100	0	25.60	C-D	2-3	a-b	CH	Core is fresh and fragment covering to talc existent fragment mostly 1 to 2 cm size broken along schistosity.						27
	28	27.80	360.742		100	0	26.00	C-D	4-3	a-b	CM	Few pieces are over 5 cm in length. Some core between 25 and 30 cm length are observed.						28
12/6	29			Pelite Schist (Paragneiss)	100	0	29.00	D-E	4	b-c	CL			Lu=5.1 Pec 8.3				29
	30	30.00	358.542		100	0	30.00	C-D	3-4	b	CM							30

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-10, 1/1

Hole No.: **M98-10**

Location:

Power Station

Azimuth: -

Ground EL.: **384.106 m**

Drilling period:

Nov. 9 to Nov. 23, 1998

Northing: **1,125,230.008**

Hole length: **30.00 m**

Hole inclination:

90 degrees (Vertical)

Eastings: **3,068,226.471**

Date	Depth(m)	EL.(m)	Leg.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L.	Lugon value	Sample	Casing	Cementation	Depth (m)	
	0.50	383.606		Surficial dep.	35	0	0.50					Surficial deposit (Ternice deposit and Talus deposit)							1
11/9	1				80	25	1.00	F	5	d	D	Bedded schist with intercalation of thin calcareous beds: Greenish gray, hard, well schistose. From 1 to 2-m, abundant quartz veins with thickness 2 to 5 cm. Iron oxide staining observed through out core.							2
11/10	2				90	22	2.15	D	3-5	e	CL	From 2 to 2.6-m, dominant chlorite mica schist, moderately to highly weathered.							3
	3				80	10		C-D	3-2	b-c	CM	From 2.6 to 3.2-m, highly weathered and moderately weathered layers are alternating rhythmically with thickness 3 to 10-cm. At 3.65-m, irregularly phased fracture of dike-side with graphitic material observed with scrape fragment at 20 deg. dip. Joint planes are usually in concordance with schistosity.		Lu=20				4	
	4				100	57	4.80				CM								5
11/11	5				100	58		C-B	2-3	b-a	CH	Dip of schistosity: From 1 to 2-m; approx. 70 deg. From 2 to 3.5-m; approx. 50 deg. From 3.5 to 5-m; approx. 80 deg. From 5 to 11-m; approx. 70 deg. From 11 to 14-m; approx. 50 deg. From 14 to 22-m; approx. 70 deg. From 22 to 30-m; 70-85 deg.						6	
	6				100	55	6.80												7
	7				100	20		D-C	3	b	CM	Up to 14.5-m, joint planes are usually brittle, calcareous, and commonly moderately and weathered with iron oxide staining.		Lu=54					8
	8				100	0	9.15												9
	9				100	15		C	2-3	a-b	CH	Quartz veins (thickness > 10 cm) from 10.8 to 11-m. Joints vary between 30 to 64 deg., at 14.4-m depth 82 deg. coated by iron oxide. Limestone percentage is about 40%.							10
	10				100	52	10.65	D	4	b-c	CL								11
	11				100	12	11.20												12
11/15	12				100	12		D-C	3	b-c	CM	From 14.5-m depth, joint plane is relatively fresh but partly coated by iron oxide up to 20-m. From 20-m depth, iron oxide coat can not be observed. Quartz vein at 15.20-m (thickness 1.5 cm), 15.62-m (5 cm), and 16.62-m (2.5 cm).	11/20 12.7m	Lu=9.9 Pc=9.1				13	
	13				100	55	13.65												14
	14				100	15													15
	15				100	12		C	3-4	a-b	CH	Joint angle from 15-m to 18.2-m range from 46 to 62 deg.	11/18 15.5m					16	
11/16	16				100	12	17.70												17
	17				100	40	18.70	C-D	4	a-b	CM	Limestone content of recovered core is hard, fresh, gray in color interbedded through out the core.	210 17.26m	Lu=5.2 Pc=8.3				18	
	18				70	12		F-D	4-5	d	D	From 18.5 to 20.5-m, recovered core is highly fragmented.							19
11/19	19				80	0	20.00												20
	20	354.106			100	13	20.50	D	4	b-c	CL	From 20 to 26-m, abundant quartz veins present and makes original rock body calcareous.							21
	21				100	13	21.00	C-D	3-4	a-b	CM	From 22.05 to 22.15 is one piece core remaining highly fragmented.							22
	22				100	10	22.00	C-D	4-3	b	CL	Joint angle between 20.75 and 26-m range from 42 to 62 deg. 23.4 to 23.7-m vertical fractures along core axis.							23
11/20	23				100	60						Graphite material observed in core from 24.6-m and at 25-m joint plane.		Lu=2.0					24
	24				100	0		C	3-4	b-c	CM	From 20-m depth, white band intercalated with chlorite mica schist is mainly of quartz.							25
	25				100	50	25.50					Joint angle range between 22 and 64 deg.							26
	26				100	20	26.65	C-B	2-3	b-a	CH	Fresh joint plane, chalcocite and graphite material observed. Fracture at 26.60-m is 74 deg.							27
11/21	27				100	12	27.40	C	3-4	b	CM	27.8 to 27.97-m, Quartz vein.		Lu=4.1					28
	28				100	11	28.50	C	3	a-b	CH								29
	29				100	25	29.00	E-D	4	b-c	CL								30
11/22	30	354.106			100	25	29.40	D-C	3-4	b	CM								30
	30				100	2	30.00	C	2	a	CH								30

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-11, 1/1

Hole No.: **M98-11**  
 Ground EL.: **375.300 m**  
 Hole length: **30.00 m**

Location: **Tunnel outlet**  
 Drilling period: **Nov. 9 to Nov. 22, 1998**  
 Hole inclination: **90 degrees (Vertical)**

Azimuth: \_\_\_\_\_  
 Northing: **1,125,236.704**  
 Easting: **3,668,380.158**

Date	Depth(m)	EL.(m)	Leg.	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Lugeon value Permeability	Sample	Casing	Cementation	Depth (m)	
11/9	1				35	0						Based on the condition of the rock distributed on the ground surface, the core samples are broken and distorted due to damage of drilling in rough manner, and thereby, the rock classes of the section between 0.00 - 8.00 m are determined to be higher than that on the core conditions to meet actual conditions.	N=15	k=5.0E-2				1	
	2				35	0		F-D	5-3	d	D		CL						2
11/10	3				32	0								N=25	k=6.5E-2				3
	4				40	0	4.00							N=18	2.10 4.2m				4
11/11	5				72	0	5.50	E-D	4	b-c	CL	CM						5	
	6				30	0												6	
11/12	7				0	0		F	5	d	D	CL						7	
	8				0	0	8.00						11/19 5.5m		Lu=241			8	
	9				90	35		C-D	2	a	CH							9	
11/14	10			Pe'l'ic Schist	100	15	9.60	D	3	b	CM							10	
	11				100	16	10.20											11	
	12				100	33												12	
	13				100	54												13	
11/15	14				100	44		C	2	a	CH	CH						14	
	15				100	30												15	
11/17	16	365.000			100	20	16.25											16	
	17				100	12	17.00	C-D	3	b	CM							17	
	18				100	20	18.25	C	2-3	a-b	CH					Lu=2.1		18	
11/19	19				100	10												19	
	20			Pe'l'ic Schist (Fammitic)	100	10	18.90	C-D	3	b-a	CM	CM						20	
	21				100	50												21	
	22				100	20												22	
	23				100	55												23	
11/20	24	351.400			100	55												24	
	25				100	33												25	
	26				100	32		C	2	a-b	CH	CH						26	
	27			Pe'l'ic Schist	100	40												27	
11/21	28				100	35												28	
	29				100	30												29	
11/22	30	345.300			100	20	30.00											30	

# GEOLOGIC LOG OF DRILL HOLE

FEASIBILITY STUDY ON MUNDA DAM MULTIPURPOSE PROJECT

M98-12, 1/1

Hole No.: **M98-12**  
 Ground EL.: **401.918 m**  
 Hole length: **30.00 m**

Location: **End of Spillway**  
 Drilling period: **Sep. 21, 1999 - Sep. 29, 1999**  
 Hole inclination: **90 degrees (Vertical)**

Altitude: **•**  
 Northing: **1,125,479.286 m**  
 Easting: **3,066,221.870 m**

Date	Depth(m)	EL.(m)	Log	Rock type	Core Recovery (%)	RQD	Depth(m)	Hardness	Joint interval	Joint condition	Rock class	Description	G.W.L. S.P.T.	Laggon value	Sample	Casing	Cementation	Depth (m)																																						
9/21	1	371.918	[Hatched]	Pelitic Schist	10	0	1.00	F	5	d	D	Wash material is taken. Highly weathered pelitic schist to the depth of 1.0 m.						1																																						
	2				60	13	1.85	D	4	c-d	CL	CL						2																																						
	3				95	10		C-D	3	b	CM	CM						3																																						
	4				93	13	3.35												4																																					
	5				70	0	4.80	D	4-3	b-c	CL	CL						5																																						
9/22	6			392.418	[Hatched]	Pelitic schist (Pegmatitic)	70	0	4.80	F	5	d	D	Joints on schistosity are very common. Joint planes are slightly coated with fine material. At 3.00 m, a 40° smooth schistosity joint. At 6.35 m, a 65° rough fresh joint.	15.16m					6																																				
	7						96	66												7																																				
	8						97	42													8																																			
9/23	9						371.918	[Hatched]	Pelitic schist (Pegmatitic)	98	90											Calcic material decreases and carbonaceous material decreases.	15.16m					9																												
	10									97	68																		10																											
	11									100	71																		11																											
9/27	12									371.918	[Hatched]	Pelitic schist (Pegmatitic)	98	57																Fine pegmatitic schist. At 9.85 m, a 40° smooth fresh joint on the schistosity.	15.16m					12																				
	13												98	37						C-B	2-3	a-b						CH	At 11.00 m, joints dip at 40° with rough planes.	13																										
	14												98	47																							14																			
	15												100	64																							15																			
	16												100	67																							16																			
	17												97	24																							17																			
	18												100	59																							18																			
9/28	19												371.918	[Hatched]						Pelitic schist (Pegmatitic)	98	72																At 14.15 m, joints dip at 35 degrees with rough planes. At 16.40 m, a 45 degree smooth fresh schistosity joint. At 16.50 m, a 7 cm thick intercalation of quartz veins.	15.16m					19												
	20																				80	27						C-B	4-3	a-b						CM	At 19.85 m, a 45 degree smooth schistosity joint.	20																		
	21																				93	39																							21											
9/28	22																				371.918	[Hatched]						Pelitic schist (Pegmatitic)	92	13																At 20.55 m, 15 cm long vertical joint with rough plane. A quartz vein from 20.94 m to 21.05 m. A quartz vein from 21.75 m to 21.77 m. A quartz vein from 22.60 m to 22.57 m.	15.16m					22				
	23																												91	52																							23			
	24																												94	15																							24			
	25																												97	32						B-C	3-2	a-b						CH	A quartz vein from 22.95 m to 23.10 m. At 23.75 m, a 45 degree smooth schistosity joint.	25										
	26																												97	53																							26			
9/29	27																												371.918	[Hatched]						Pelitic schist (Pegmatitic)	93	47											At 25.15 m, a 43 degree smooth fresh schistosity joint.	15.16m					27	
	28																																				98	0																		28
	29																																				97	14																		29
	30																																				85	0						29.00	B-C	4	b-a	CM	At 28.65 m, a 35 degree smooth fresh schistosity joint. At 29.50 m, pyrite segregation on a joint plane. 28.25 m - 30.00 m. Samples are broken into small fragments.						30	