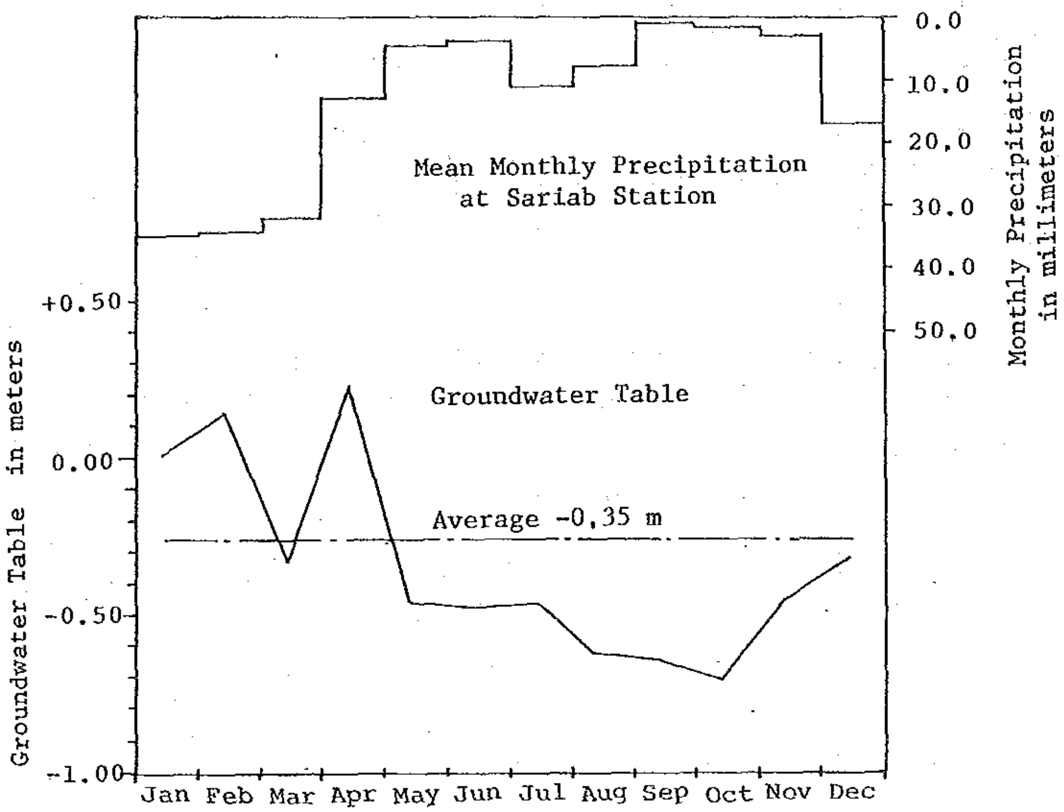
(cont'd)

(Unit : m)

Well Data		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
NO. 197		1969	—	—	—	—	—	—	—	—	-0.73	-0.75	-0.69	0.02	—
COORDINATES	937153	1970	0.00	0.82	0.62	0.23	-0.52	-0.52	-0.96	-0.20	0.12	0.03	0.66	0.60	0.07
TOPO. SHEET NO.	34J/16	1971	0.69	0.66	0.27	-0.36	0.49	(2.01)	(3.25)	(4.50)	(5.00)	(5.69)	(7.42)	(7.34)	—
GROUND EL	1,701.25	1972	—	(7.28)	(5.19)	(6.19)	(6.68)	(5.06)	—	—	—	—	—	—	—
BASE W.L.	1,681.77														
G.W.T. DEPTH (JAN 1970)	19.48	Mean	0.35	0.74	0.45	-0.07	-0.02	-0.52	-0.96	-0.20	-0.31	-0.36	-0.02	0.31	—
NO. 203		1969	—	—	—	—	—	—	—	—	—	-0.08	-0.08	-0.14	—
COORDINATES	925144	1970	0.00	0.07	0.07	0.25	0.05	-0.24	-0.32	-0.70	-0.34	-0.72	-0.37	-0.44	-0.22
TOPO. SHEET NO.	34J/16	1971	-1.31	-0.41	-0.38	-0.53	—	-0.82	-0.81	-1.69	-2.83	-2.58	-3.80	-1.96	—
GROUND EL	1,702.09	1972	-0.99	-1.59	-2.12	—	-2.62	-1.80	—	—	—	—	—	—	—
BASE W.L.	1,690.70														
G.W.T. DEPTH (JAN 1970)	11.38	Mean	-0.77	-0.64	-0.81	-0.14	-1.34	-0.95	-0.57	-1.20	-1.59	-1.13	-1.42	-0.85	—
NO. 208		1969	—	—	—	—	—	—	—	—	-1.02	-1.08	-0.24	-0.14	—
COORDINATES	920160	1970	0.00	0.56	0.41	-0.22	-0.22	-0.43	-0.69	-1.10	-1.14	-0.87	-0.65	-0.20	-0.37
TOPO. SHEET NO.	34J/16	1971	0.60	0.41	0.35	-0.12	-0.47	-1.10	-1.40	-1.76	-1.63	-1.23	-0.69	-0.31	-0.61
GROUND EL	1,680.51	1972	0.30	—	0.24	0.27	—	-0.60	-1.11	—	—	—	—	—	—
BASE W.L.	1,674.72														
G.W.T. DEPTH (JAN 1970)	5.75	Mean	0.30	0.49	0.33	0.02	-0.35	-0.71	-1.07	-1.43	-1.26	-1.06	-0.53	-0.22	—

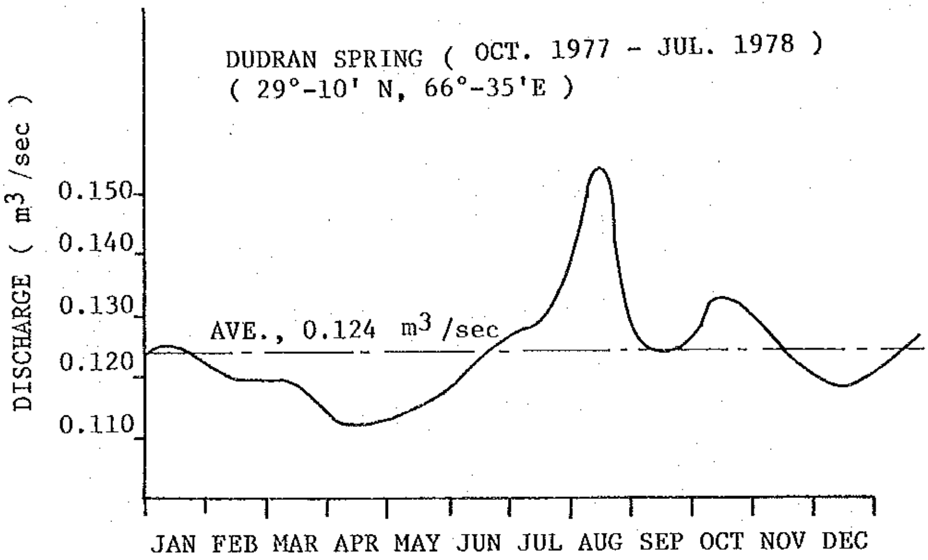
Notes : Figures with (-) means fall and ( ) means raise of the groundwater tabel
"—" indicates no data available

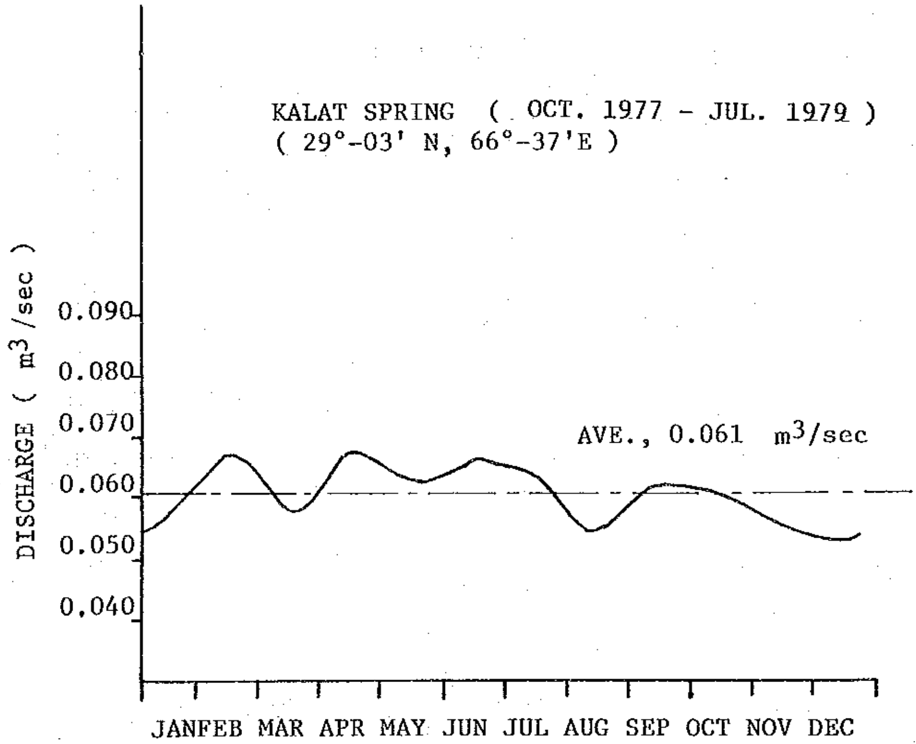
Source : WAPDA Hydrogeology Directorate, Geohydrology of Quetta Valley, 1973



Source : WAPDA, Monitoring Studies on Groundwater Levels in Quetta Valley, Nov. 1986

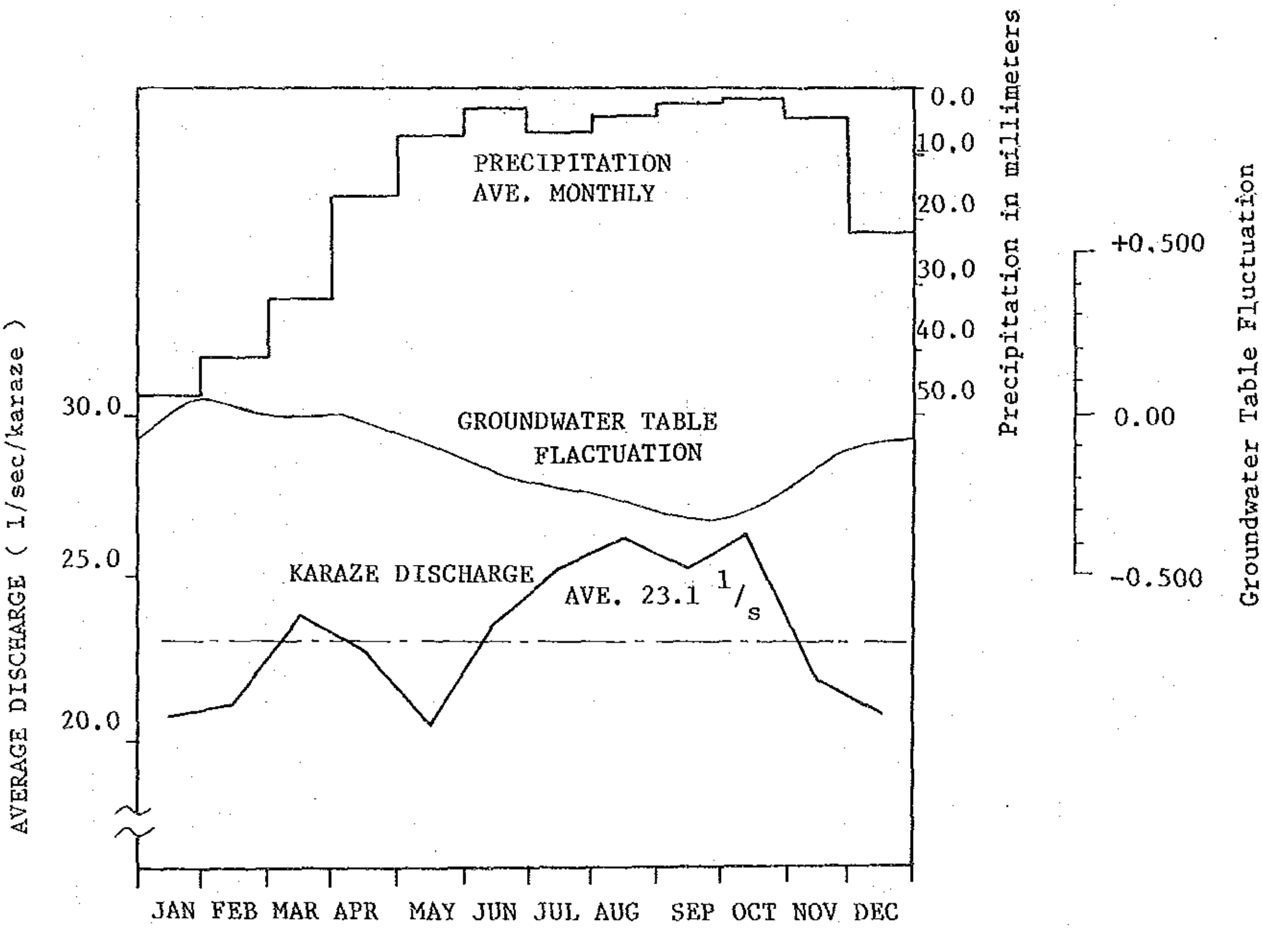
FIG A-4.1.1 Groundwater Table Fluctuation in Northern Quetta





SOURCES : SURFACE WATER HYDROLOGY PROJECT
WASID / WAPDA

FIG A-4.1.2 Monthly Discharge Fluctuation of Springs in Kalat Area



Source : UNDP/PAK/p3/032/04

FIG A-4.1.3 Monthly Discharge Fluctuation of Karazes in Mastung Area

4.2 PRESENT GROUNDWATER USE

TABLE A-4.2.1 Inventory of Existing Wells in Quetta Area

Area/ Well No	Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ/s)	Pump and HP	Owner-ship	Purpose
MG - 1	34J/16	900033	61.0	—	3.8	CF	PV	IR
2		882252	54.9	—	--	BUCKET	PV	DW
3		891050	57.9	—	—	BUCKET	PV	DW
4		891043	63.4	—	3.2	CF	PV	IR
5		892043	61.6	—	3.8	CF	PV	IR
6		893041	63.4	—	3.8	CF	PV	IR
7		893040	61.3	—	3.8	CF	PV	IR
8		902043	54.9	—	—	BUCKET	PV	IR
9		885038	—	—	—	BUCKET	PV	IR
10		88041	72.2	—	3.8	CF	PV	IR
11		—	65.5	1,684.1	5.0	SM/	PV	IR
12		892045	57.3	—	3.5	CF	PV	IR
13		899048	49.4	—	3.8	CF	PV	IR
14		901048	52.4	—	3.8	CF	PV	IR
15		900045	—	—	—	BUCKET	PV	IR
16		901051	47.2	—	3.5	CF	PV	IR
17		902052	53.0	—	3.8	CF	PV	IR
18		901056	61.6	—	—	BUCKET	PV	DW
19		906056	56.4	—	3.8	CF	PV	IR
20		906052	55.8	—	—	BUCKET	PV	DW
21		911053	54.3	—	4.1	CF	PV	IR
22		907048	52.1	—	3.8	CF	PV	IR
23		910045	—	1,675.4	3.5	SM/40	PV	IR
24		910045	56.1	—	—	BUCKET	PV	DW
25		911038	57.0	1,682.5	6.3	SM/40	PB	DW
26		—	73.2	—	2.5	CF	PV	IR
27		906040	57.9	—	3.2	CF	PV	IR
28		—	58.5	—	—	BUCKET	PV	DW
29		881034	69.5	—	—	BUCKET	PV	DW
VF3- 1	34J/16	923141	21,9	1,681.9	10.5	SM/15	PB	DW
2		921141	20.6	—	—	BUCKET	PV	DW
3		904143	9.3	—	3.1	CF	PV	IR
4		908141	11.7	—	1.3	CF	PV	ID
5		910142	9.4	—	2.5	CF	PV	IR
6		920147	9.1	—	1.3	CF	PV	IR
7		920147	9.1	—	0.9	CF	PV	IR
8		918150	6.2	—	2.5	CF	PV	IR
9		920152	5.8	—	—	BUCKET	PV	DW
10		921149	10.2	—	1.6	CF	PV	IR
11		925145	15.2	1,685.5	6.3	SM/15	PV	IR
12		925143	26.0	—	—	BUCKET	PV	DW
13		924150	18.3	—	1.9	CF	PV	IR
14		923151	6.6	—	3.2	CF	PV	IR
15		921155	—	—	1.6	CF	PV	IR
16		922153	—	—	2.8	CF	PV	IR
17		921161	12.2	1,670.3	7.4	SM/20	PV	IR
18		915166	9.8	—	2.5	CF	PV	IR
19		917164	10.9	—	3.2	CF	PV	IR
20		915123	8.7	—	3.2	CF	PV	IR

(to be cont'd)

(cont'd)

Area/ Well No	Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ /s)	Pump and HP	Owner-ship	Purpose
VF3-21	34J/16	916161	14.0	—	2.5	CF	PV	IR
22		915161	11.6	—	2.5	CF	PV	IR
23		913168	10.7	—	3.2	CF	PV	IR
24		913166	13.4	—	1.3	CF	PV	IR
25		913164	9.6	—	1.9	CF	PV	IR
26		912163	7.6	—	3.2	CF	PV	IR
27		912164	6.5	—	3.2	CF	PV	IR
28		908162	6.9	—	3.2	CF	PV	IR
29		910161	6.7	—	—	—	PV	ABANDOND
30		914157	6.9	—	—	BUCKET	PV	DW
31		908158	7.0	—	1.9	CF	PV	IR
32		904154	5.5	—	—	CF	PV	IR
34		906153	4.6	—	1.2	CF	PV	IR
35		907152	6.1	—	2.8	CF	PV	IR
37		908150	5.9	—	2.5	CF	PV	IR
38		908150	25.0	—	—	—	PV	ABANDOND
39		928146	36.3	—	2.8	CF	PV	IR
40		918146	—	—	1.3	CF	PV	IR
41		929151	7.6	1,690.1	?	SM/25	PV	IR
42		929155	6.1	—	—	BUCKET	PV	DW
46		921155	4.4	—	—	—	PV	ABANDOND
47		917157	7.7	—	2.5	—	PV	ABANDOND
48		905154	6.8	—	1.6	CF	PV	IR
78		927162	15.2	1,676.4	—	BUCKET	PV	DW
80		930165	8.5	1,684.6	3.2	SM/20	PV	IR*
81		930168	8.2	1,684.9	18.9	SM/25	PV	IR*
110		903170	—	—	—	—	PV	ABANDOND
111		903168	6.1	—	—	CF	PV	IR
112		897163	5.6	—	2.8	CF	PV	IR
113		897158	—	—	2.8	CF	PV	IR
114		896157	7.9	—	2.5	CF	PV	IR
115		896155	9.4	—	—	CF	PV	IR
116		898159	—	—	1.9	CF	PV	IR
117		899149	—	—	1.9	CF	PV	IR
118		899148	8.2	—	—	—	PV	ABANDOND
119		951151	29.9	—	3.8	CF	PV	IR
120		951147	26.2	—	4.4	CF	PV	IR
121		948143	26.5	—	5.0	CF	PV	IR
122		945168	31.4	—	3.2	CF	PV	IR
123		943164	30.2	—	1.6	CF	PB	DW
124		946165	35.4	—	3.8	CF	PV	IR
125		948161	27.4	—	1.6	CF	PV	IR, KAREZ
126		949159	28.0	—	3.8	CF	PV	IR, KAREZ
127		951161	25.6	—	5.0	CF	PV	IR, KAREZ
128		951158	26.2	—	4.7	CF	PV	IR, KAREZ
129		948152	26.2	—	4.1	CF	PV	IR, KAREZ
138		909103	30.8	—	5.0	CF	PV	IR
147		928161	18.9	1,674.3	2.2	SM/7.5	PV	IR
148		928161	18.9	1,674.3	1.6	SM/45	PV	IR

(to be cont'd)

(cont'd)

Area/ Well No	Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ /s)	Pump and HP	Owner-ship	Purpose
VF4- 1	34J/16	917056	42.1	—	2.8	CF	PV	IR/DW
- 2		912206	39.0	—	2.5	CF	PV	IR/DW
- 3		921068	38.9	—	2.8	CF	PV	IR/DW
- 4		915068	36.0	—	5.0	CF	PV	IR/DW
- 5		914068	38.3	—	2.5	CF	PV	IR/DW
- 6		915069	38.1	—	3.8	CF	PV	IR/DW
- 7		913077	35.1	—	2.8	CF	PV	IR/DW
- 8		910086	31.9	—	5.0	CF	PV	IR/DW
- 9		909070	33.7	—	3.2	CF	PV	IR/DW
- 10		916071	33.3	—	3.2	CF	PV	IR/DW
- 11		915072	33.8	—	2.5	CF	PV	IR/DW
- 12		919074	38.5	—	3.8	CF	PV	IR/DW
- 13		915975	33.8	—	3.5	CF	PV	IR/DW
- 14		918079	31.9	—	5.0	CF	PV	IR/DW
- 15		917085	35.5	—	3.8	CF	PV	IR/DW
- 16		915058	31.8	—	3.8	CF	PV	IR/DW
- 17		913085	30.3	—	3.8	CF	PV	IR/DW
- 18		911082	30.9	—	2.5	CF	PV	IR/DW
- 19		911075	34.1	—	3.8	CF	PV	IR/DW
- 20		905072	27.9	—	3.2	CF	PV	IR/DW
- 21		908068	33.3	—	3.2	CF	PV	IR
- 22		906068	34.0	—	3.2	CF	PV	IR
- 23		905067	36.1	—	3.8	CF	PV	IR
- 24		903067	29.9	—	3.8	CF	PV	IR
- 25		902068	29.3	—	3.2	CF	PV	IR
- 26		900069	35.3	—	3.2	CF	PV	IR
- 27		909075	32.5	—	3.2	CF	PV	ID
- 28		906081	27.1	—	3.2	CF	Pv	ID
- 29		905082	26.8	—	6.3	CF	Pv	ID
- 30		904050	26.8	—	6.3	CF	Pv	ID
- 31		907078	28.9	—	3.8	CF	PV	ID
- 32		904076	24.1	—	6.3	CF	PV	DW
- 33		903075	31.0	—	3.2	CF	PV	IR
- 34		902074	24.7	—	6.3	CF	Pv	IR
- 35		896068	24.7	—	3.2	CF	PV	IR
- 36		895067	33.9	—	2.8	CF	PV	IR
- 37		894067	35.1	—	3.5	CF	PV	IR
- 38		895070	29.2	—	3.2	CF	PV	IR
- 39		889068	33.9	—	3.8	CF	PV	IR
- 40		916095	31.0	—	3.2	CF	PV	IR
- 41		915095	33.4	—	3.8	CF	PV	IR
- 42		915092	32.2	—	3.8	CF	PV	IR
- 43		918092	—	—	6.3	CF	PV	IR
- 44		914092	28.0	—	3.2	CF	PV	LIVESTOC
- 45		912090	—	—	1.9	CF	PV	IR
- 46		899091	25.1	—	—	BUCKET	PV	DW
- 47		912095	—	—	—	BUCKET	PV	DW
- 48		915096	—	—	—	BUCKET	PV	DW
- 49		915100	23.3	—	—	BUCKET	PV	DW

(to be cont'd)

(cont'd)

Area/ Well No	Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ /s)	Pump and HP	Owner-ship	Purpose
VF4- 50	34J/16	915105	22.9	1,680.1	9.5	SM/15	PV	DW
- 51		915006	21.7	—	—	BUCKET	PV	DW
- 52		908108	16.4	—	—	BUCKET	PV	DW
- 53		906105	15.2	—	—	BUCKET	PV	DW
- 54		906102	19.1	—	—	BUCKET	PV	DW
- 55		907114	19.4	—	—	BUCKET	PV	DW
- 56		901114	12.2	—	2.5	CF	PV	IR
- 57		905114	17.4	—	3.2	CF	PV	IR
- 58		909117	19.5	—	2.5	CF	PV	IR
- 59		910119	—	—	1.9	CF	PV	IR
- 60		—	—	—	1.9	CF	PV	IR
- 61		906119	—	—	3.2	CF	PV	IR
- 62		920117	24.4	1,688.6	7.9	SM/10	PV	IR
- 63		920116	—	—	—	BUCKET	PV	DW
- 64		919114	21.3	1,687.1	12.6	SM/10	PV	IR
- 65		920120	25.9	1,681.0	9.5	SM/ 5	PV	IR
- 66		918122	24.4	1,677.9	9.5	SM/10	PV	DW
- 67		918123	21.9	—	—	BUCKET	PV	DW
- 68		914430	21.3	—	3.2	CF	PV	DW
- 69		809131	11.0	1,680.7	7.9	SM/25	PV	DW
- 70		905131	11.0	1,680	7.6	SM/15	PV	DW
- 71		901130	—	—	2.8	CF	PV	ID
- 72		901130	—	—	2.8	CF	PV	IR
- 73		901135	18.3	—	1.6	CF	PV	IR
- 74		911135	12.0	—	—	BUCKET	PV	DW
- 75		917135	—	—	—	BUCEKT	PV	DW
- 76		914139	—	—	—	BUCKET	PV	DW
- 77		903138	8.1	—	—	BUCKET	PV	DW
- 78		888072	—	—	—	BUCKET	PV	DW
- 79		912076	33.2	—	1.5	CF	PV	IR
- 80		924078	35.2	—	3.2	CF	PV	IR
- 81		927079	35.1	1,696.2	12.6	SM/25	PV	IR
- 82		928080	46.3	—	2.5	CF	PV	IR
- 83		928081	46.6	—	2.5	CF	PV	IR
- 84		922082	35.1	—	2.5	CF	PV	IR
- 85		923084	33.1	—	2.5	CF	PV	IR
- 86		922085	34.4	—	2.8	CF	PV	IR
- 87		922085	38.3	—	1.9	CF	PV	IR
- 88		919014	30.4	—	3.2	CF	PV	IR
- 89		920095	30.3	—	2.5	CF	PV	IR
- 90		920096	32.2	—	3.2	CF	PV	IR
- 91		921098	32.3	—	2.8	CF	PV	IR
- 92		927098	36.6	—	2.8	CF	PV	IR
- 93		927095	39.9	—	2.8	CF	PV	IR
- 94		927094	39.9	—	2.5	CF	PV	IR
- 95		927984	36.1	—	9.5	CF	PV	IR
- 96		927601	34.0	—	2.5	CF	PV	IR
- 97		927106	34.0	—	3.2	CF	PV	IR
- 98		925105	28.8	—	2.5	CF	PV	IR

(to be cont'd)

(cont'd)

Area/ Well No	Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ /s)	Pump and HP	Owner-ship	Purpose
VF4- 99	34J/16	920104	29.0	—	2.5	CF	PV	IR
100		921104	—	—	0.6	CF	PV	IR
101		921111	26.2	—	—	BUCKET	PV	DW
102		922114	31.7	—	4.4	CF	PV	IR
103		922113	27.4	1,690.1	7.3	SM/25	PB	DW
104		923114	27.4	1,690.1	9.5	SM/25	PB	DW
105		928113	27.4	1,696.2	4.4	SM/25	PB	IR
106		924115	27.4	1,690.1	4.4	SM/25	PB	IR
107		923115	29.0	1,690.1	4.4	SM/40	PB	IR
108		927116	29.0	1,693.2	4.7	SM/40	PV	IR
109		927119	28.0	1,692.6	4.4	SM/20	PV	IR
110		927119	27.7	—	2.5	CF	PV	ID
111		931125	25.9	—	3.2	CF	PV	ID
112		925128	25.0	—	—	—	PV	ABANDOND
113		925134	25.9	1,687.4	5.0	SM/25	PV	IR
114		931110	34.4	—	5.0	CF	PV	IR
115		931111	33.2	—	2.5	CF	PV	IR
116		930111	32.3	—	2.5	CF	PV	IR
117		936138	27.7	—	2.8	CF	PV	IR
118		941139	27.1	—	3.2	CF	PV	IR
120		895115	36.6	—	4.4	CF	PV	IR
121		892114	38.1	—	3.8	CF	PV	IR
122		891112	34.7	—	3.8	CF	PV	IR
123		896113	35.1	—	5.0	CF	PV	IR
124		892120	37.5	—	3.8	CF	PV	IR
125		983108	32.0	—	3.2	CF	PV	IR
126		895105	21.3	—	—	BUCKET	PV	DW
127		896126	6.7	—	—	—	PV	ABANDOND
128		893129	8.2	—	—	BUCKET	PV	DW
129		893133	25.3	—	3.5	CF	PV	IR
130		895135	24.1	—	3.5	CF	PV	IR
131		895130	10.7	—	1.9	CF	PV	IR

(to be cont'd)

(cont'd)

Area/ Well No	Topo. Sheet	Gride Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ /s)	Pump and HP	Owner-ship	Purpose
CP2- 3	34J/16	892150	—	—	—	—	PV	ABANDOND
- 6		894148	19.2	—	2.5	CF/20	PV	IR
- 7		894144	14.0	1,674.6	15.8	SM/40	PV	IR
- 8		890139	30.8	—	2.5	CF/25	PV	IR
- 9		890141	30.8	—	1.9	CF/25	PV	IR
- 10		893137	10.8	—	—	BUCKET	PV	DW
- 11		888135	38.2	—	2.5	CF/25	PV	IR
- 12		894130	26.8	—	2.5	CF/25	PV	IR
- 13		889129	23.6	—	—	BUCKET	PV	DW
- 14		889129	23.6	—	—	BUCKET	PV	DW
- 15		884124	28.3	—	2.5	CF/25	PV	IR
- 16		884122	31.2	—	3.2	CF/25	PV	IR
- 17		882121	36.1	—	2.5	CF/25	PV	IR
- 18		882119	41.5	—	2.2	CF/25	PV	IR
- 19		885119	32.5	—	2.5	CF/30	PV	IR
- 20		888112	30.8	—	2.5	CF/30	PV	IR
- 21		886108	25.6	—	—	—	PV	ABANDOND
- 22		885105	32.3	—	2.8	CF/25	PV	IR
- 23		887103	31.1	—	2.5	CF/20	PV	IR
- 24		887101	33.4	—	2.2	CF/25	PV	IR
- 25		884104	47.5	—	2.5	CF/30	PV	IR
- 26		884113	39.9	—	2.5	CF/30	PV	IR
- 27		885092	30.5	1,696.2	12.6	SM/40	PV	IR
- 28		886092	29.7	—	2.5	CF/25	PV	IR
- 29		883085	32.6	—	—	BUCKET	PV	DW
- 30		883072	36.1	—	—	BUCKET	PV	DW
- 31		881067	41.5	—	2.2	CF-40	PV	IR
- 32		873062	73.2	1,694.7	15.8	SM/25	PB	DW
- 33		874069	72.5	1,687.7	*14.2	SM/—	PB	DW(QDA)
- 34		879076	44.5	1,686.8	*32.1	SM/—	PB	DW(QDA)
- 35		883091	45.7	1,687.1	*29.3	SM/—	PB	DW(QDA)
- 36		883105	65.8	1,667.0	*22.1	SM/—	PB	DW(QDA)
- 37		881113	55.2	1,671.5	*42.5	SM/—	PB	DW(QDA)

(to be cont'd)

(cont'd)

Area/ Well No	Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ /s)	Pump and HP	Owner-ship	Purpose
MP2- 1	34N/ 4	929077	44.5	—	0.9	CF/10	PV	IR
- 2		924055	54.7	—	0.9	CF/10	PV	ID
- 3		936095	46.0	—	—	BUCKET	PV	DW
- 4		930101	42.1	—	3.2	CF/40	PV	IR
- 5		930101	42.1	1,687.7	12.6	SM/30	PV	IR
- 6		929106	42.1	1,683.1	9.5	SM/25	PB	DW
- 7		931106	38.1	1,687.1	6.3	SM/15	PB	DW
- 8		957152	30.5	—	4.1	CF/25	PV	IR
- 9		956149	30.4	—	3.8	CF/25	PV	IR
- 10		959148	29.3	—	3.8	CF/25	PV	IR
- 11		953148	26.8	—	2.5	CF/25	PV	IR
- 12		952146	30.0	—	2.5	CF/25	PV	IR
- 13		951144	33.6	—	4.4	CF/20	PV	IR
- 14		950143	30.2	—	4.4	CF/25	PV	IR
- 15		950128	38.1	—	2.2	CF/25	PV	IR
- 16		948128	29.0	—	3.8	CF/25	PV	IR
- 17		943135	27.4	—	2.2	CF/25	PV	IR
- 18		944136	32.6	—	2.2	CF/25	PV	IR
- 19		933111	37.8	—	4.7	CF/25	PV	IR
- 33		937086	49.4	1,701.7	—	BUCKET	PB	DW
- 34		943074	65.8	1,709.6	—	BUCKET	PB	DW
HS - 1	34J/16	910028	* 57.7	—	—	BUCKET	PV	DW
- 2		916015	* 68.3	—	—	"	PV	DW
- 3		907992	* 72.4	—	—	"	PV	DW
- 4		920980	* 60.1	—	—	"	PV	DW
- 5		910003	* 75.5	—	—	"	PV	DW
- 6		904001	* 79.2	—	—	"	PV	ABANDOND
- 7		901997	*80.9**DRY	—	—	"	PV	DW
- 8		901997	** 89.5	—	3.8	SM/17	PB	DW
- 9		891997	* 85.1	—	—	BUCKET	PV	DW
- 10		885993	* 81.9	—	—	"	PV	DW
- 11		883993	* 85.4	—	—	"	PV	DW
- 12		876997	* 91.9	—	—	"	PV	DW
- 13		877990	** 89.0	—	—	"	PV	DW
- 14		865016	* 130.3	—	—	SM/—	PV	ABANDOND
- 15		850994	* 110.5	—	—	BUCKET	PV	ABANDOND
- 16		842990	* 110.4	—	—	"	PV	DW
- 17		856985	* 102.3	—	—	"	PV	DW
- 18	34K/13	850964	** 91.5	—	—	"	PV	DW

(to be cont'd)

(cont'd)

Area/ Well No	Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ /s)	Pump and HP	Owner-ship	Purpose
DK - 1	34K/13	872952	* 87.8	—	—	BUCKET	PV	DW
- 2		868948	** 70.0	—	—	"	PV	DW
- 3		886919	** 63.4	—	—	"	PV	DW
- 4		885924	** 72.0	—	4.7	SM/?	PB	DW
- 5		888901	* 69.9	—	—	BUCKET	PV	DW
- 6		888897	* 69.2	—	—	"	PV	DW
- 7		890898	** 64.0	—	5.8	SM/30	PV	IR
- 8		890887	* 75.5	—	—	—	PB	ABANDOND
- 9		891884	* —	—	—	BUCKET	PV	DW
- 10		892883	* 70.7	—	—	"	PV	DW
- 11		896881	* 62.7	—	—	"	PV	DW
- 12		906845	** 42.0	—	—	"	PV	DW
- 13		902953	* 87.6	—	—	"	PV	DW
- 14	34 O/1	956946	** 74.7	—	—	—	PB	ABANDOND
- 15		017881	* 42.3	—	—	"	PV	DW
- 16		035878	** 57.0	—	6.3	SM/11	PV	ID
PV - 1	34 N/4	008988	* 112.0	—	—	BUCKET	PV	DW
- 2		012981	* 109.9	—	—	"	PV	DW
- 3	34 O/1	992949	* 92.2	—	—	"	PV	DW
- 4		973947	* 68.7	—	—	"	PV	DW
- 5		038037	** 101.8	—	—	"	PV	DW
- 6		961040	** 101.0	—	—	"	PV	DW
- 7		015956	** 89.0	—	—	"	PV	DW
- 8		022950	** 97.5	—	1.8?	SM/ ?	PB	DW
- 9		032949	** 87.0	—	—	BUCKET	PV	DW
- 10		016934	** 73.0	—	—	"	PV	DW
- 11		022914	** 63.0	—	—	"	PV	DW

NOTES : Area — MG = Mian Gundi area, VF3 = Valley floor area 3
MP2 = Murdar piedmont area 2, VF4 = Valley floor area 4
PV = Pingove area, DK = Dashit-i-Khuni area
HS = Hassani area CP2 = Chiltan piedmont area 2

Pump type — SM = Submersible pump, CF = Centrifugal pump
Ownership — PV = Private owned, PB = Public. — = without pumping unit
Purpose — IR = Irrigation, DW = Domestic water, ID = Industrial water

SOURCES : WAPDA, Monitoring Studies on Groundwater in Quetta Valley, 1986
*WAPDA, Geohydrology of Quetta Valley, 1973 (surveyed in Aug 1969)
**JICA field survey during the study in Sep-Oct. 1986 and 1987

TABLE A-4.2.2 Inventory of Existing Wells in Kalat Area

Area/ Well No.		Topo. Sheet	Grid Coordinate	Static WL(BGL m)	Water Table Altitude(m)	Discharge (ℓ/s)	Pump and HP	Owner-ship	Purpose
CT	KL-2	34K/ 8			—	—	—	PB	TESTWELL
	122		307823	68.6	—	—	BUCKET	PV	DW
	123		321835	64.4	—	—	"	PV	DW
TG	109		324870	65.6	—	—	"	PV	DW
	110		321860	69.2	—	—	"	PV	DW
	127		319903	57.3	—	—	"	PV	DW
	128		313903	59.5	—	—	"	PV	DW
	129		316898	61.6	—	—	"	PV	DW
	130		316888	63.4	—	—	"	PV	DW
	131		313892	65.9	—	—	"	PV	DW
DL	125		334928	61.0	—	—	"	PV	DW
	133		303935	55.2	—	—	"	PV	DW
	134		310949	48.8	—	—	"	PV	DW
	135		312959	52.2	—	—	"	PV	DW
	136		317975	59.2	—	—	"	PV	DW
	137		344975	45.8	—	—	"	PV	DW
SH	102		377921	29.9	—	—	"	PV	DW
	103		398910	29.9	—	—	"	PV	DW
	104		388903	43.9	—	—	"	PV	DW
	105		389909	41.5	—	—	"	PV	DW
	106		385901	32.0	—	—	"	PV	DW
	107		376905	27.5	—	—	"	PV	DW
	108		369901	16.8	—	—	"	PV	DW
	109		324870	65.6	—	—	"	PV	DW
	110		321860	69.2	—	—	"	PV	DW
	124		360492	59.5	—	—	"	PV	DW
	126		358913	58.0	—	—	"	PV	DW
	KL-1		371920	65.8	1,755.0	—	—	PB	TESTWELL
	KL-4		410927	53.9	1,795.9	—	—	PB	TESTWELL
ZA	101		443912	dry	—	—	BUCKET	PV	DW
KO	138			38.1	—	—	"	PV	DW
OS	47		383733	5.5	—	—	BUCKET	PV	DW
	139		387029	32.9	—		CF	PV	DW
	140		380037	32.9	—	—	BUCKET	PV	DW
	141		372029	40.6	—	—	"	PV	DW
	142		354500	37.8	—	—	"	PV	DW
	143		399031	45.7	—	—	"	PV	DW
	144		399037	45.7	—	—	"	PV	DW
	145		397044	48.8	—	—	"	PV	DW
	KL-3		394035	46.7	1,750.2	—	SM/—	PB/PV	TESTWELL
	5		493946	SPRING	—	8.5	SPRING	PB	IR/DW
	132		376914	SPRING	—	—	SPRING	PB	DW/IR

NOTES : Area CH = Chattii village area, TG = Togau village area,
DL = Dallo village area, SH = Shahar Haji village area,
ZR = Ziarat village area, KL = Kallo village area, OS = outside of the area
Pump type SM = Submersible pump, CF = Centrifugal pump
Ownership PV = Private owned, PB = Public. — = without pumping unit
Purpose IR = Irrigation, DW = Domestic water, ID = Industrial water

SOURCES : WAPDA, Internal Hydrogeologic Report NO.3 Reconnaissance Survey - KALAT AREA, Shirinab-Pishin Basin, JAN.1978
* JICA field survey during the study in SEP-OCT 1986 and 1987

TABLE A-4.2.3 Estimation of Present Groundwater Extraction Amount

Item / Area	Quetta Area				Kalat Area	
	Northern Quetta	Hassania Area	Pingove Area *	Southern Area *	Eastern Area *	Western Area *
1. Number of Population 1/	30,000	2,000	11,000	7,000	30,000	17,000
2. Number of Animals 2/	20,000	1,000	5,000	20,000	40,000	50,000
3. Total pumping capacity for irrigation (Tthausand m3/year)	22,500	—	—	—	3/ 7,000	3/ 700
4. kareze/spring discharge (Tthausand m3/year)	160	—	—	—	5,400	—
5. domestic water consumption (Tthausand m3/year)	272	17	94	102	322	250
6. irrigation water consumption (Tthausand m3/year)	6,413	—	—	—	1,995	200
Total in thausand m3/year	6,845	17	94	102	7,717	450
Total in m3 / day	18,753	47	258	279	21,142	1,233

Notes : Areas with asterisk mark include the upstream area OF The Study Area
1/ estimated based on Population Census of Pakistan, District Census Report Quetta/Kalat, 1981
2/ estimated based on Pakistan Census of Agriculture 1980, Provincial Report Baluchistan
3/ average capacity : 4.5 ℓ /sec (= 70 GPM)

TABLE A-4.2.4 Groundwater Quality in Quetta Area

Date	Well No.	Sampled Depth BGL(m)	Milliequivalent per Liter Ca	Mg	Na	CO3	HCO3	Cl	SO4	Total Anions	E. C. (μS/cm) at 25 °C))	PH	SAR
20/AUG/1985	MG - 1	61.0	2.16	1.17	4.08	—	3.96	1.57	1.88	7.41	750	8.0	3.2
20/AUG/1985	- 4	63.4	1.22	4.09	1.74	—	4.09	1.10	1.88	7.05	700	8.1	1.1
20/AUG/1985	- 5	61.6	1.69	2.54	1.34	—	3.85	0.94	0.78	5.57	600	8.1	0.9
20/AUG/1985	- 9		1.50	2.73	1.09	—	3.63	0.86	0.39	5.32	580	8.4	0.7
20/AUG/1985	- 13	49.4	2.54	3.76	2.34	—	3.08	3.06	2.28	8.54	900	8.3	1.3
20/AUG/1985	- 19	56.4	2.07	3.33	3.05	—	3.74	2.67	2.04	8.45	900	8.1	1.9
20/AUG/1985	- 22	52.1	1.50	2.64	3.35	—	3.41	2.51	1.57	7.49	800	8.2	2.3
20/AUG/1985	- 23		1.50	3.38	5.60	—	2.42	3.92	3.76	10.54	1,100	8.4	3.5
16/OCT/1985	VF3 - 1	21.9	2.05	2.76	3.05	0.47	2.69	2.35	2.35	7.86	810	8.4	1.9
21/SEP/1985	- 2	20.6	2.44	3.95	3.01	—	3.52	1.49	4.39	9.40	990	7.7	1.5
21/SEP/1985	- 3	9.3	2.06	2.86	1.18	—	3.46	1.26	1.41	6.13	620	7.7	0.7
16/OCT/1985	- 7	9.1	2.33	2.48	3.19	0.44	3.63	1.89	2.04	8.00	810	8.4	2.0
28/SEP/1985	VF4- 1	42.1	0.87	2.56	3.26	—	3.19	1.88	1.57	6.64	680	8.0	2.5
26/SEP/1985	- 8	31.9	1.23	2.54	2.87	—	3.19	1.88	1.57	6.64	700	7.8	2.1
30/SEP/1985	- 15	35.5	2.60	4.96	6.03	—	3.52	5.34	4.71	13.57	1,360	8.1	3.1
30/SEP/1985	- 22	34.0	1.51	3.30	3.36	—	3.63	2.19	2.35	8.17	820	8.2	2.2
06/OCT/1985	- 31	28.9	2.33	3.39	3.15	—	3.30	3.69	1.88	8.87	905	8.1	1.8
07/OCT/1985	- 34	24.7	3.29	5.94	5.08	—	3.63	7.38	3.30	14.31	1,450	8.0	4.7
07/OCT/1985	- 37	35.1	1.92	2.63	2.40	—	4.29	1.57	1.09	6.95	700	8.2	1.6
09/OCT/1985	- 41	33.4	2.85	2.50	4.71	0.22	3.08	3.45	2.51	9.26	980	8.3	3.1
09/OCT/1985	- 49	23.3	1.37	2.53	2.45	0.44	3.08	1.57	1.26	6.35	650	8.4	1.7
12/OCT/1985	- 52	16.4	1.78	2.30	2.15	0.44	3.52	1.41	0.94	6.31	640	8.4	1.5
12/OCT/1985	- 57	17.4	1.64	3.82	2.86	0.66	3.74	2.04	1.88	8.32	900	8.5	1.7
14/OCT/1985	- 65	25.9	1.78	1.73	2.37	—	3.52	1.10	1.26	5.88	600	8.2	1.8
14/OCT/1985	- 73	18.3	1.78	1.99	2.67	—	3.30	1.57	1.57	6.44	690	8.2	1.9
16/OCT/1985	- 77	8.1	2.19	7.17	11.53	0.55	5.28	3.45	11.61	20.89	2,100	8.5	5.3
20/OCT/1985	- 85	33.1	1.94	4.27	7.73	0.43	3.36	4.39	5.49	13.94	1,400	8.3	4.6

(to be contd')

(contd')

Date	Well No.	Sampled Depth BGL(m)	Milliequivalent per Liter								E. C. (μS/cm) at 25 ° C))	PH	SAR
			Ca	Mg	Na	CO3	HCO3	Cl	SO4	Total Anions			
25/OCT/1985	VF4- 90	32.2	1.84	2.72	5.82	0.57	2.72	3.04	3.84	10.38	1,000	8.4	3.8
25/JAN/1986	- 95	36.1	1.84	3.20	3.11	0.35	2.83	2.16	2.56	8.15	800	8.3	1.9
26/JAN/1986	- 98	28.8	4.08	6.10	7.81	0.57	2.57	6.67	7.87	17.99	1,800	8.4	3.4
29/JAN/1986	-103	27.4	1.43	2.16	3.13	0.57	2.43	1.69	2.01	6.72	700	8.4	2.5
29/JAN/1986	-111	25.9	1.53	1.96	2.43	0.57	2.86	0.93	1.46	5.92	590	8.3	1.8
06/FEB/1986	-117	27.7	3.47	3.80	3.22	0.53	0.88	3.96	5.12	10.49	1,060	8.3	1.7
04/MAY/1986	-120	36.6	1.78	3.01	2.58	—	4.25	1.73	1.39	7.37	750	7.5	1.6
15/JAN/1986	CP2- 10	10.8	2.01	3.03	1.63	—	3.65	1.69	1.33	6.67	700	7.9	1.0
15/JAN/1986	- 12	26.8	0.66	6.48	4.94	—	4.22	3.12	4.74	12.08	1,200	7.7	2.6
15/JAN/1986	- 24	33.4	3.92	5.84	7.13	—	3.79	6.76	6.34	16.89	1,700	7.9	3.2
19/JAN/1986	- 28	29.7	2.04	4.65	7.64	0.86	4.00	4.39	5.12	14.37	1,550	8.4	4.2
19/JAN/1986	- 30	36.1	1.22	2.76	1.80	0.29	3.43	0.67	1.39	5.78	540	8.4	1.3
29/JAN/1986	MP2- 2	54.7	2,24	3.77	6.53	0.86	2.93	3.88	4.87	12.54	826	8.3	3.8
02/FEB/1986	- 10	29.3	1.94	2.13	2.49	0.14	3.43	1.01	1.83	6.56	468	8.3	1.7
21/AUG/1967	HS - 3	73.2	3.00	6.12	29.50	0.00	2.97	22.00	14.14	38.62	3.750	7.5	14.0
21/AUG/1967	- 4	61.3	3.60	6.00	26.50	0.00	2.61	18.30	15.57	36.40	3.600	7.8	12.0
18/AUG/1967	- 5	77.4	2.80	4.52	22.20	0.00	5.04	12.00	10.30	29.52	2,700	7.5	12.0
18/AUG/1967	- 7	81.7	1.44	2.38	3.55	0.45	3.30	1.30	2.77	7.37	720	8.7	2.1
02/OCT/1986	- 8	89.5	—	—	—	—	—	—	—	—	1,320	8.0	—
16/AUG/1967	- 12	92.7	1.44	2.86	2.00	0.36	3.38	—	1.60	6.50	610	8.3	1.5
02/OCT/1986	- 13	89.0	—	—	—	—	—	1.10	—	—	680	7.8	—
16/AUG/1967	- 17	102.4	1.34	2.66	2.20	0.27	3.11	1.20	1.60	6.20	610	8.1	1.6
02/OCT/1986	- 18	91.5	—	—	—	—	—	—	—	—	650	8.1	—

(to be cont'd)

(cont'd)

Date	Well No.	Sampled Depth BGL(m)	Milliequivalent per Liter								E. C. (μS/cm) at 25 ° C))	PH	SAR
			Ca	Mg	Na	CO3	HCO3	Cl	SO4	Total Anions			
29/SEP/1986	DK - 2	70.0	—	—	—	—	—	—	—	—	680	7.8	—
29/SEP/1986	- 3	63.4	—	—	—	—	—	—	—	—	1,200	8.0	—
29/SEP/1986	- 4	72.0	—	—	—	—	—	—	—	—	750	7.8	—
29/SEP/1986	- 7	64.0	—	—	—	—	—	—	—	—	1,600	8.1	—
16/SEP/1986	- 11	62.8	1.73	2.55	4.39	0.00	3.89	2.69	2.08	8.67	850	7.7	2.8
29/SEP/1986	- 12	42.0	—	—	—	—	—	—	—	—	1,200	7.9	—
29/SEP/1986	- 16	57.0	—	—	—	—	—	—	—	—	620	7.9	—
01/OCT/1986	PV - 5	101.8	—	—	—	—	—	—	—	—	920	8.0	—
01/OCT/1986	- 6	101.0	—	—	—	—	—	—	—	—	880	7.8	—
01/OCT/1986	- 7	89.0	—	—	—	—	—	—	—	—	820	7.9	—
01/OCT/1986	- 9	87.0	—	—	—	—	—	—	—	—	680	7.9	—
01/OCT/1986	- 10	73.0	—	—	—	—	—	—	—	—	640	7.9	—
01/OCT/1986	- 11	63.0	—	—	—	—	—	—	—	—	1,600	8.1	—

NOTES : Area ; MG = Mian Ghundi area, VF3 = Valley Floor area 3, VF4 = Valley Floor area 4
CP2 = Chiltan Piedmont area, MP2 = Murdar Piedmont area, HS = Hassani area
DK = Dasht-i-Khuni area PV = Pingove area

SOURCES 1. WAPDA, Monotoring Studies on Groundwater in Quetta Valley, 1986
2. WAPDA, Geohydrology in Quetta Valley, 1973 (survey conducted from 1967 till 1972)
3. JICA, field survey results cnducted Oct 1986 and Oct 1987

TABLE A-4.2.5 Groundwater Quality in Kalat Area

Date	Well No.	Sampled Depth BGL(m)	Milliequivalent per Liter								E.C. (μS/cm at 25 °C)	PH	SAR
			Ca	Mg	Na	CO3	HCO3	Cl	SO4	Total Anions			
15/SEP/1987	KL1/JICA												
27/SEP/1987	KL2/JICA												
05/OCT/1987	KL3/JICA												
02/SEP/1977	KL - 2	71/ 76											1.9
02/SEP/1977	KL - 3	46/146	1.76	2.47	3.77	—	4.88	2.49	0.63	8.00	800	8.1	2.6
02/SEP/1977	KL - 4	55/152	2.88	3.33	4.08	—	7.10	2.98	0.21	10.29	1,000	7.9	2.3
25/OCT/1976	102	29.9	3.52	3.88	5.57	—	5.37	4.32	3.38	13.07	1,320	7.9	2.9
25/OCT/1976	103	29.9	2.35	4.01	6.73	—	6.49	3.94	2.66	13.09	1,400	7.7	3.8
25/OCT/1976	104	43.9	1.76	5.46	4.28	—	3.84	4.14	1.52	9.50	1,000	7.8	2.6
06/OCT/1986	106(K 9)	"									1,050	7.8	
25/SEP/1976	107	27.4	2.74	4.86	5.86	—	5.44	4.51	3.61	13.56	1,400	7.9	3.0
06/OCT/1986	107(K10)	"									1,600	7.6	
06/OCT/1976	109	65.5	3.04	3.89	3.75	—	1.98	3.19	5.51	10.68	1,100	7.7	2.0
06/OCT/1986	109(K 3)	"									1,050	7.8	
13/SEP/1987	109(K 3)	"									940	8.2	
06/OCT/1976	110	69.2	2.35	3.92	3.37	—	1.98	3.38	2.66	9.64	1,000	7.7	1.9
07/NOV/1976	121	15.2	1.27	1.58	2.51	—	1.92	2.07	1.38	5.37	540	7.6	2.1
07/NOV/1976	122	68.6	0.58	3.31	2.66	—	2.88	1.69	1.98	6.55	650	7.9	1.9
06/OCT/1986	122(K 1)	"									680	8.0	
08/NOV/1976	123	64.3	2.35	3.06	4.72	—	3.04	4.32	2.77	10.13	1,100	7.7	2.9
06/OCT/1986	123(K 2)	"									1,200	7.9	
13/SEP/1987	123(K 2)	"									1,030	8.1	
08/NOV/1976	124	59.4	4.51	3.75	3.36	—	6.56	3.38	1.98	11.92	1,300	7.4	1.6
08/NOV/1976	126	57.9	4.21	3.01	5.52	—	6.40	3.57	2.77	12.74	1,320	7.8	2.7
08/NOV/1976	127	57.3	5.19	5.71	9.99	—	5.60	6.58	8.71	20.89	2,200	7.6	4.3
06/OCT/1986	127(K42)	"									2,150		
08/NOV/1976	128	59.4	4.80	4.89	9.32	—	4.48	6.02	8.51	19.01	2,000	7.5	4.3
08/NOV/1976	130	63.4	1.18	3.00	6.28	—	3.52	3.57	3.37	10.46	1.150	7.6	4.9
06/OCT/1986	130(K 4)	"									2,050	7.6	
14/SEP/1987	130(K 4)	"									1,310	8.2	

(to be cont'd)

(cont'd)

Date	Well No.	Sampled Depth BGL(m)	Milliequivalent per Liter								E. C. (μS/cm) at 25 ° C))	PH	SAR
			Ca	Mg	Na	CO3	HCO3	Cl	SO4	Total Anions			
08/NOV/1976	133	55.2	2.74	4.19	5.79	—	4.80	3.76	4.16	12.72	1,300	8.1	3.1
08/NOV/1976	134	48.8	3.04	5.32	7.24	—	6.56	5.08	3.96	15.60	1,700	8.1	3.5
08/NOV/1976	136	59.1	2.25	3.16	11.27	—	4.16	6.39	6.13	16.68	1,700	8.2	6.8
06/OCT/1986	136(K 5)	"									1,760	7.8	
09/NOV/1976	138	38.1	3.62	3.50	3.90	—	5.28	3.57	2.17	11.02	1,130	8.1	2.1
14/SEP/1987	138(K 8)	"									1,400	7.8	
09/NOV/1976	139	32.9	2.64	2.87	4.33	—	3.68	3.00	3.16	9.84	1,000	7.6	2.6
14/SEP/1987	139(K21)	"									860	7.4	
09/NOV/1976	141	40.5	3.23	4.56	4.32	—	5.60	3.94	2.57	12.11	1,100	7.3	2.2
09/NOV/1976	142	37.8	2.74	4.84	4.88	—	5.60	4.51	2.37	12.48	1,300	7.7	2.5
14/SEP/1987	142(K20)	"									1,180	7.4	
12/NOV/1976	47	5.5	2.54	4.30	7.33	—	5.60	4.77	3.80	14.17	1,500	8.2	4.0
06/OCT/1986	47(K 7)	"									1,200		
06/OCT/1986	47(K 7)	"									1,440	7.4	
06/OCT/1986	Dudran										700	7.6	
14/SEP/1987	"										590	7.8	

SOURCES : (1) JICA/WAPDA, Well test results at the field for the study during Sep-Oct 1987
(2) UNDP/WAPDA, Preliminary Hydrogeological Report No.4 Kalat Area, Shirinab-Pishin Basin, Jan.1978
(3) WAPDA, Internal Hhdrogeologic Report NO.3 Reconnaissance Survey Kalat Area, Shirinab-Pishin Basin, Jan,1978
(4) JICA, Field Survey for the Study during Sep-Oct.1986 and Sep-Oct.1987

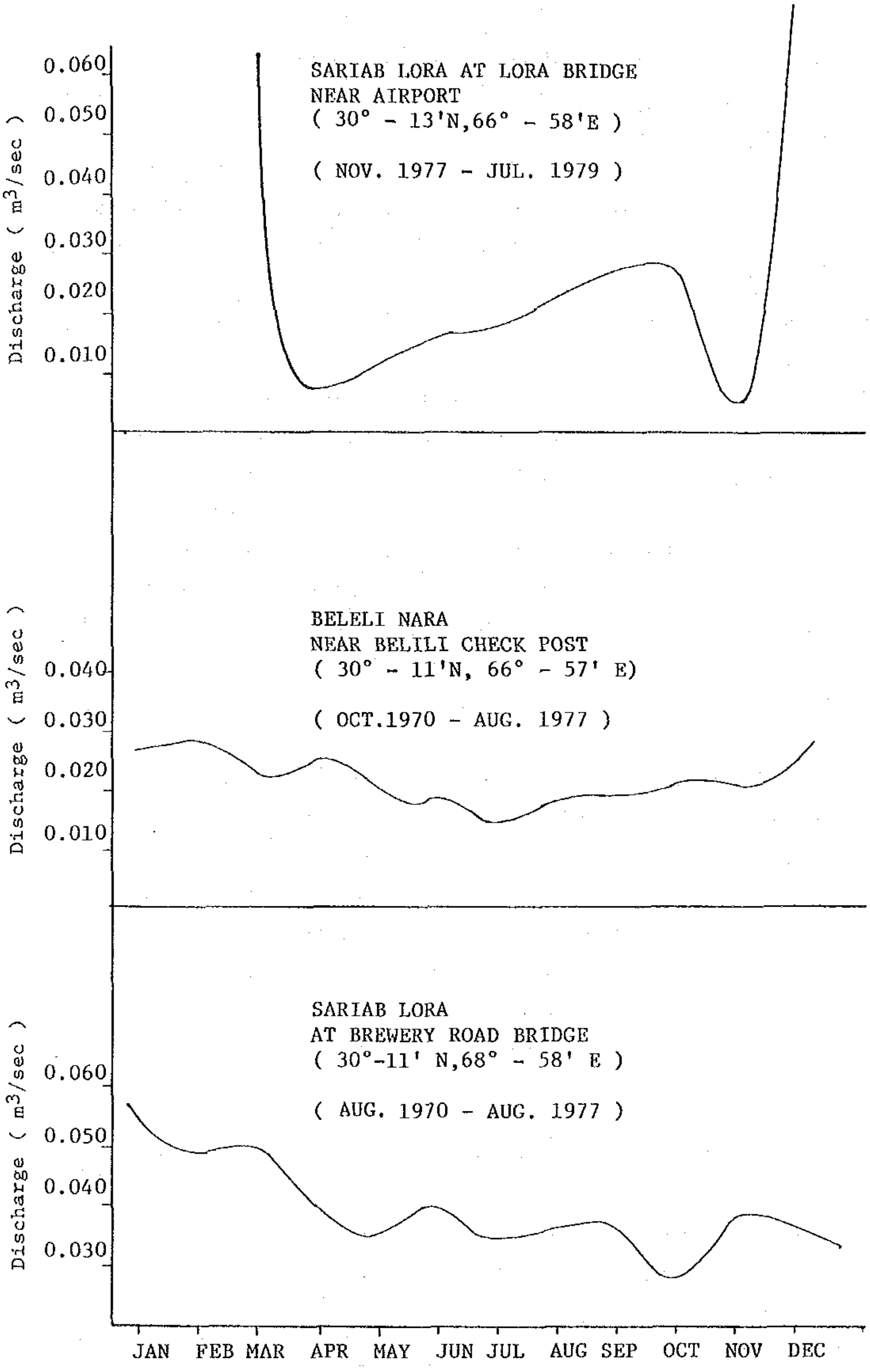
TABLE A-4.2.6 Surface Water Quality of the Sariab Lora at Berwery Bridge

Date	Milliequivalent per Liter								Electric. Conductivity	PH	SAR
	Ca	Mg	Na	CO3	HCO3	Cl	SO4	Total Anions	($\mu S/cm$ at 25° C)		
AUG/10/1970	11.45	23.55	66.00	0.00	3.77	25.87	71.15	100.79	8,310	7.9	16.0
OCT/02/1970	2.55	8.91	11.16	0.70	3.91	4.36	13.46	22.43	2,150	8.5	4.6
JAN/20/1971	2.99	12.56	17.00	0.78	5.73	6.07	20.00	32.53	3,000	8.4	6.1
FEB/28/1971	2.42	10.60	13.75	0.79	4.70	4.61	16.50	26.60	2,459	8.6	5.1
MAR/24/1971	2.47	11.44	14.00	0.79	4.85	5.14	17.00	27.78	2,550	8.6	5.3
APR/21/1971	2.65	9.89	13.50	0.86	4.26	4.56	16.20	25.89	2,230	8.6	5.4
MAR/03/1972	3.00	13.74	12.76	1.21	5.89	7.16	16.50	39.45	2,950	—	4.4
APR/22/1972	1.51	14.42	11.07	1.71	5.43	5.81	14.27	27.22	2,700	—	2.8
JUL/18/1972	1.62	10.35	10.03	—	5.06	5.09	12.54	22.69	2,200	—	4.1
AUG/11/1972	1.95	11.29	8.64	—	4.68	5.22	11.98	21.88	2,200	—	3.4
SEP/23/1972	1.88	12.48	9.59	1.09	4.32	5.17	13.37	23.95	2,390	8.7	3.6
OCT/17/1972	2.04	13.06	11.96	1.19	4.43	5.50	15.94	27.06	2,720	8.7	4.3
NOV/06/1972	2.21	14.64	9.65	—	6.54	5.79	14.21	26.50	2,670	8.9	3.3
DEC/19/1972	2.14	12.39	11.69	—	6.84	5.98	13.40	26.22	2,700	8.6	4.3
FEB/06/1973	1.11	34.50	14.21	1.92	4.71	6.18	17.01	29.87	2,900	8.5	5.1
MAR/07/1973	1.00	3.10	24.29	1.56	4.20	6.00	16.64	28.40	2,740	8.7	17.0
APR/20/1973	1.50	11.24	11.15	1.34	4.24	4.72	13.59	23.89	2.390	8.5	4.3
MAY/12/1973	1.25	11.53	10.67	1.30	4.11	4.90	13.14	23.45	2,400	8.4	4.1
JUN/16/1973	1.22	9.40	9.72	0.93	3.81	4.26	11.34	20.34	2,020	8.9	4.2
JUL/06/1973	1.47	9.62	11.39	1.86	3.53	4.85	12.24	22.48	2,200	8.9	4.8
SEP/07/1973	1.20	11.08	10.16	1.48	3.53	4.65	12.78	22.44	2,230	8.6	4.0
OCT/08/1973	1.30	11.27	11.89	2.23	3.34	4.85	14.04	24.46	2,400	8.6	4.7
NOV/06/1973	1.80	0.43	1.87	0.74	1.48	0.57	1.31	4.10	400	8.8	1.7
DEC/01/1973	2.20	16.71	3.20	1.86	4.46	6.33	9.46	22.11	2,200	8.9	1.0

(to be cont'd)

(cont'd)

Date	Milliequivalent per Liter								Electric. Conductivity	PH	SAR
	Ca	Mg	Na	CO3	HCO3	Cl	SO4	Total Anions	(μS/cm at 25° C)		
MAR/24/1974	2.90	13.47	4.42	1.86	5.56	5.56	7.81	20.81	2,000	8.4	1.5
APR/01/1974	1.53	12.46	8.62	2.73	4.61	5.56	9.73	22.63	2,200	8.6	3.1
NOV/21/1974	6.45	11.99	12.69	—	7.52	5.56	18.05	31.13	3,000	8.5	4.2
DEC/16/1974	14.10	2.90	14.00	—	7.10	6.80	17.10	31.00	3,000	8.9	4.7
JAN/10/1975	3.90	13.30	7.00	0.60	7.50	4.70	11.40	24.20	2,400	8.5	2.3
FEB/02/1975	2.74	3.03	2.78	—	3.70	1.57	3.90	9.17	940	8.1	1.5
MAR/04/1975	2.15	11.10	12.33	1.02	5.98	5.56	13.02	25.58	2,410	8.6	4.7
APR/11/1975	1.76	12.34	9.21	1.19	5.96	5.56	10.58	23.31	2,400	8.5	3.4
MAY/02/1975	2.25	10.02	10.58	0.85	5.98	5.76	15.40	22.83	2.200	8.8	4.2
JUN/17/1975	1.98	10.03	10.60	0.85	5.60	4.80	1.51	22.97	2,100	8.6	4.3
JUL/24/1975	2.13	1.67	10.37	0.68	2.05	4.03	7.41	14.17	1,400	8.5	7.4
AUG/12/1975	1.54	9.09	10.98	1.71	3.76	4.60	11.64	21.71	2,000	8.9	4.7
SEP/16/1975	1.90	9.74	12.83	1.36	5.13	4.60	13.38	24.47	2,200	8.7	5.3
OCT/19/1975	2.90	10.77	8.84	1.36	5.64	4.80	10.71	22.51	2,200	8.6	3.4
NOV/13/1975	2.50	12.05	11.94	0.20	6.23	5.95	14.11	26.49	2,440	8.7	4.4
DEC/19/1975	3.26	12.99	18.73	1.68	6.27	5.70	13.39	27.01	2,640	8.7	3.8
JAN/25/1976	2.91	13.11	12.93	0.99	6.27	5.32	16.37	28.95	2,750	8.7	4.6
MAY/12/1976	1.56	10.72	8.96	2.24	4.00	5.91	9.09	21.24	2,200	8.7	3.6
JUL/02/1976	1.07	9.49	10.56	2.24	3.84	4.97	10.07	21.12	2.060	8.6	4.6
JUL/25/1976	1.27	9.53	10.75	1.60	4.32	5,37	10.26	21.55	2,300	8.6	4.6
SEP/03/1976	1.96	9.82	9.04	1.60	4.16	5.37	9.69	20.82	2,100	8.5	3.7
OCT/24/1976	2.17	2.03	1.39	—	3.14	1.50	0.95	5.59	580	8.1	0.9
JUN/16/1977	1.12	9.41	12.27	2.47	5.45	5.05	9.89	22.80	2,100	8.9	5.3
JUL/11/1977	1.24	8.81	10.28	1.77	5.62	4.46	8.48	20.33	2,000	8.5	4.6
AUG/12/1977	1.57	2.75	7.33	1.77	2.51	2.71	4.66	11.67	1,200	8.3	5.0



Source : WASID

FIG A-4.2.1 Fluctuation of Surface Water Discharge

4.4 SEISMIC PROSPECTING

4.4.1 General

(1) Subject

Seismic survey for groundwater development for Baluchistan Irrigation Development Project

(2) Objective

The aerial selective gamma-ray spectro prospecting was carried out as a comprehensive groundwater survey in the Quetta and Kalat Areas of Baluchistan Province.

In order to supplement the above survey, the seismic prospecting is conducted in the areas where the high gamma-ray intensity has been detected through rough analysis of the recorded data at the site and which have the high potentiality for irrigation development.

The objectives of the seismic survey in this study are to supplement the existing geological data and to secure higher precision of the possible yield and safe yield of groundwater to be estimated on the basis of the results of the analysis of the data collected through aerial selective gamma-ray spectro prospecting and the existing geological/hydro- geological data.

(3) Work

Method: Refraction method

Quantity:	Quetta-A Line:	2,200 m
	Quetta-B Line:	1,500 m
	Kalat Line:	2,300 m
	Total	6,000 m

(4) Term

Field survey: Nov. 9, 1986 - Dec. 10, 1986 (1 month)
Analysis: Dec. 11, 1986 - Feb. 11, 1987 (2 months)

4.4.2 Geological Condition of Survey Area

(1) Quetta Area

Both A and B lines are located at the Northern alluvial plain of Dasht-i-Khuni area in the southern part of the Study Area.

Geology: Chiltan limestone of Mesozoic era is superior and developed widely on the highlands near the survey area. Parh Group (alternation of limestone and shale) that is younger than Chiltan limestone and Brewery limestone of Tertiary era are outcropped with the small scale in the eastern part of Landi Hill between two survey lines. FIG A-4.4.3 is prepared based on the recent data about tube wells by Irrigation Department and also UNDP test borings extensively drilled 15 years ago. The section indicates a trend that coarse sediments of gravel etc. are developed in the piedmont part and shifted to fine sediments of clay etc. gradually in the central part of the plain. Especially, QA-14 and QA-16 wells in the center of Dasht-i-Khuni area are mostly clay up to the deep portion. These wells do not reach the base rock except Hassni Well located at the southern piedmont of Landi Hill.

Geological Structure: There are two faults passing north to south at the Landi Hill and some faults of east to west direction at the eastern highlands.

(2) Kalat Area

The prospecting line is located on the alluvial plain in the southern part of Shahar Haji village and small hills lie at the both sides.

Geology: Shirinab Formation of the Mesozoic era is outcropped on the western hill and is rich of shale. At the western side of the hill, Wakabi formation of the Tertiary era is developed and is very rich of shale. Spintangi limestone of the same era is secondly distributed on the eastern hills. In this area, some test holes have been drilled in the past year. FIG A-4.4.4 shows the well logs of these test holes. From the figure, KL-1 and KL-2 Wells located at the northern and southern parts of the seismic prospecting line attain the base rock at the depth of 100 m but KL-4 Well at the far northern part at the depth of about 220 m. Gravel is developed well at the shallow depth and shift to clay at the depth of about 70 m as shown on the well logs of KL-1 and KL-2.

Geological Structure: A fault is estimated to pass through the eastern side of the seismic prospecting line. According to the existing geological section (FIG A-4.4.5), the Tertiary Formation is distributed near the survey line.

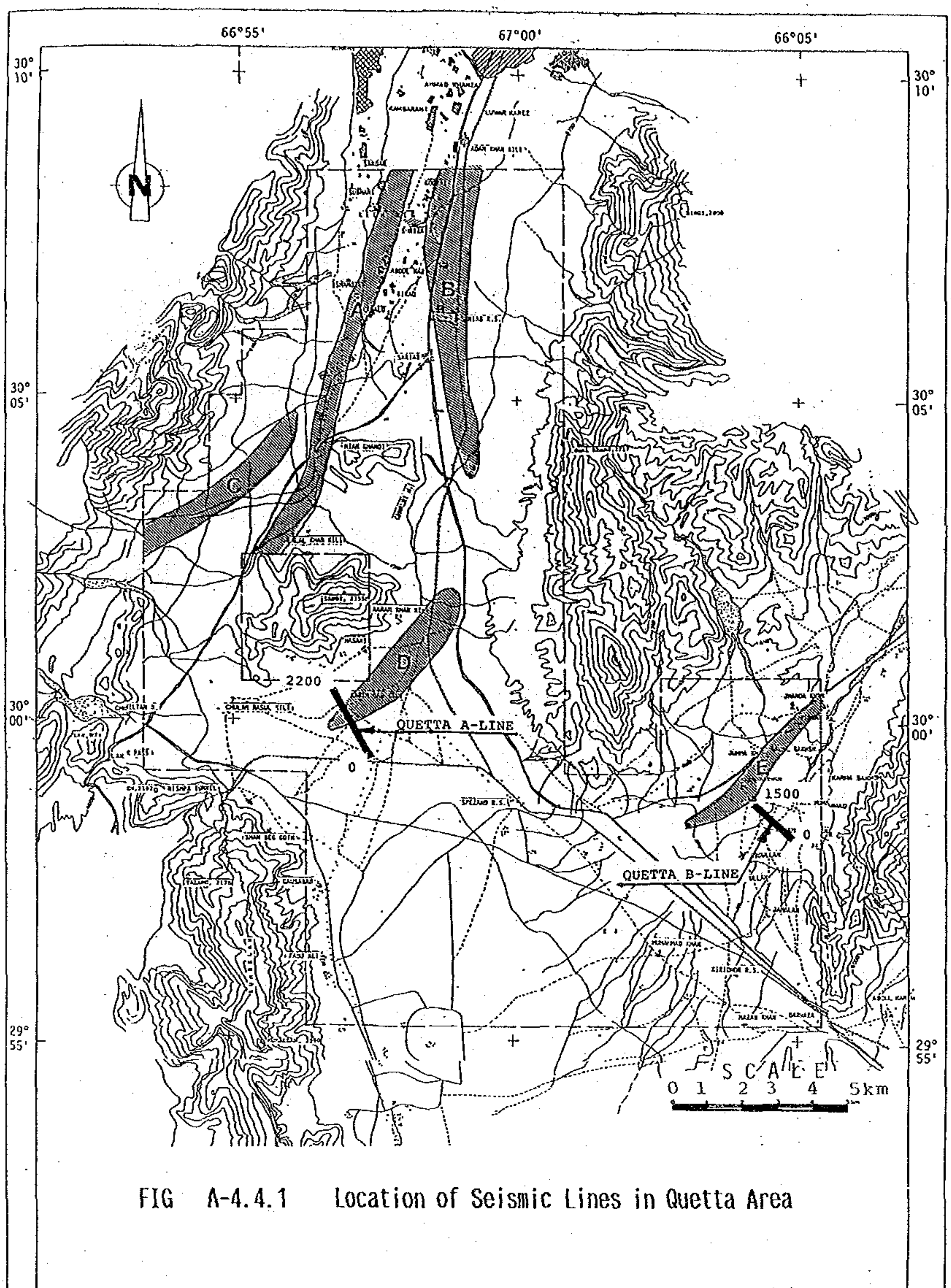


FIG A-4.4.1 Location of Seismic Lines in Quetta Area

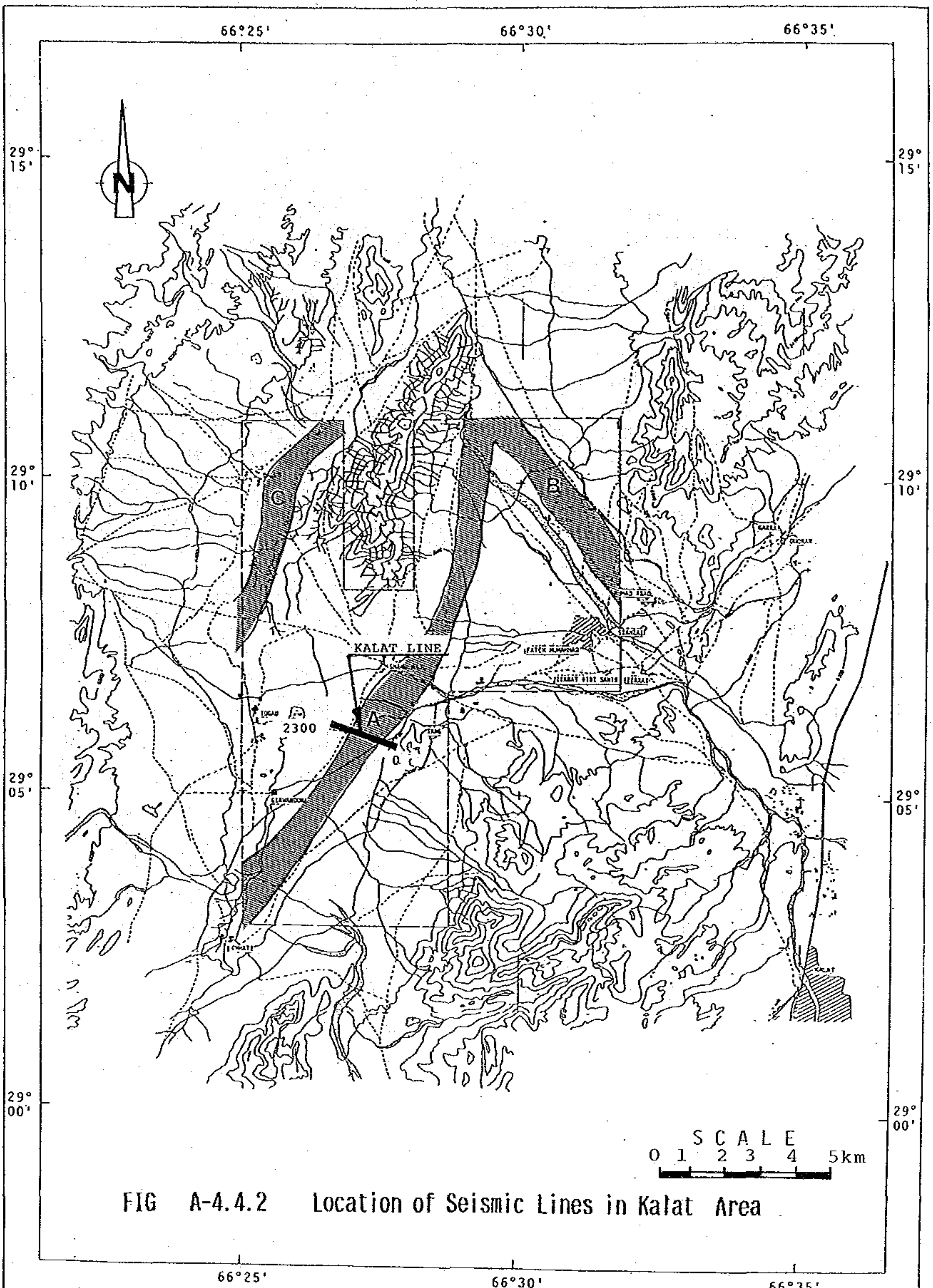


FIG A-4.4.2 Location of Seismic Lines in Kalat Area

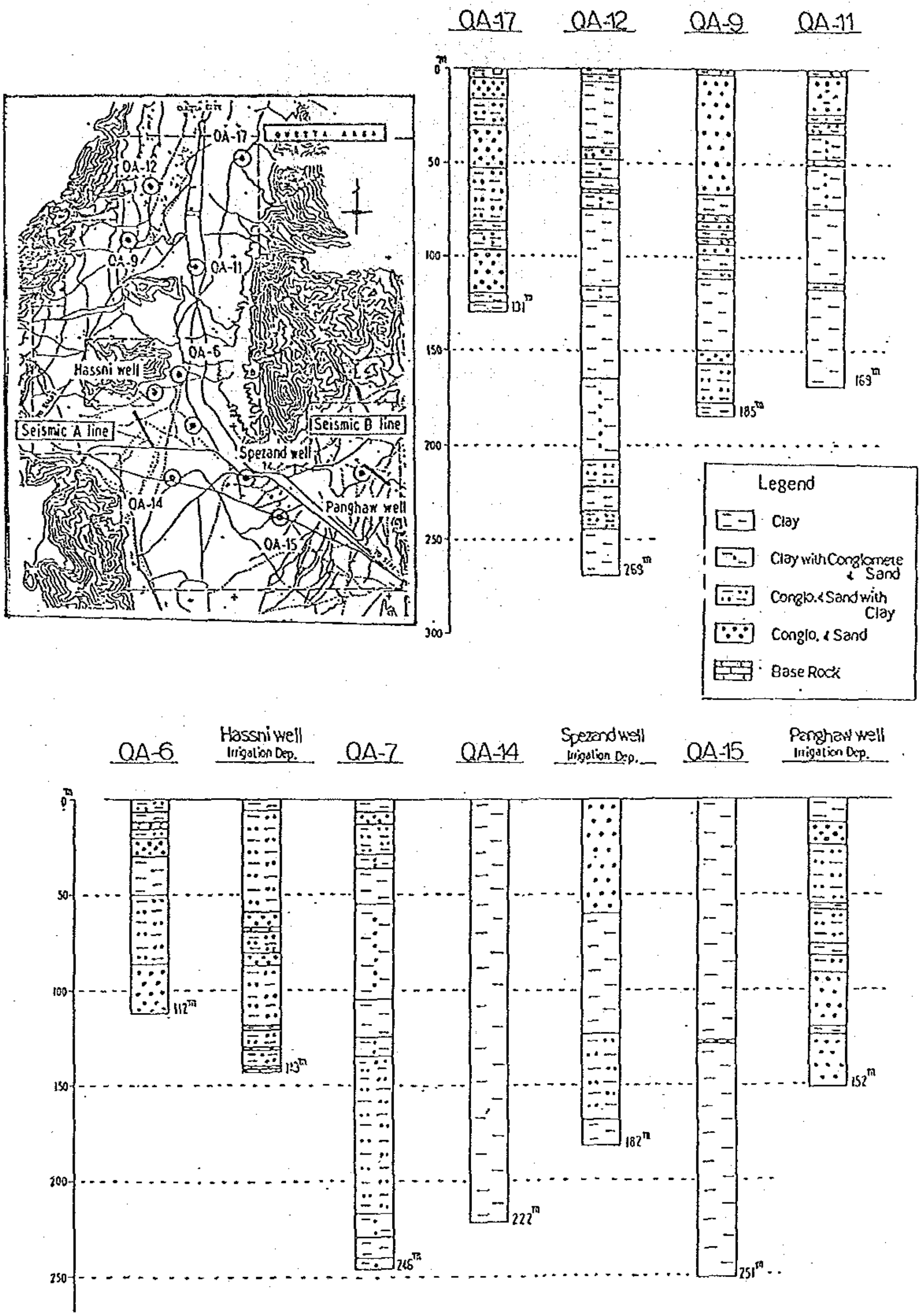


FIG A-4.4.3 Test Well Logs in Quetta Area

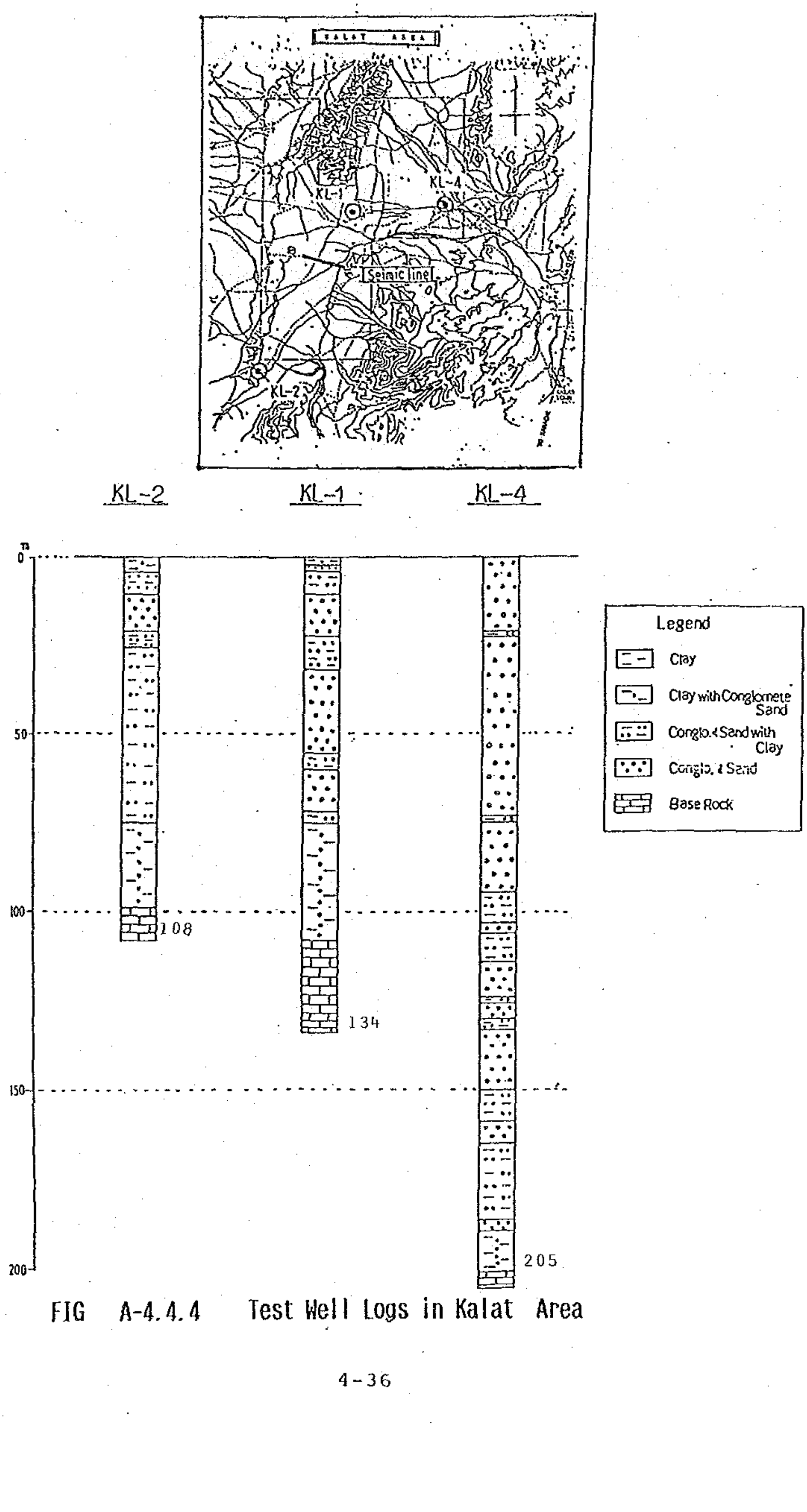
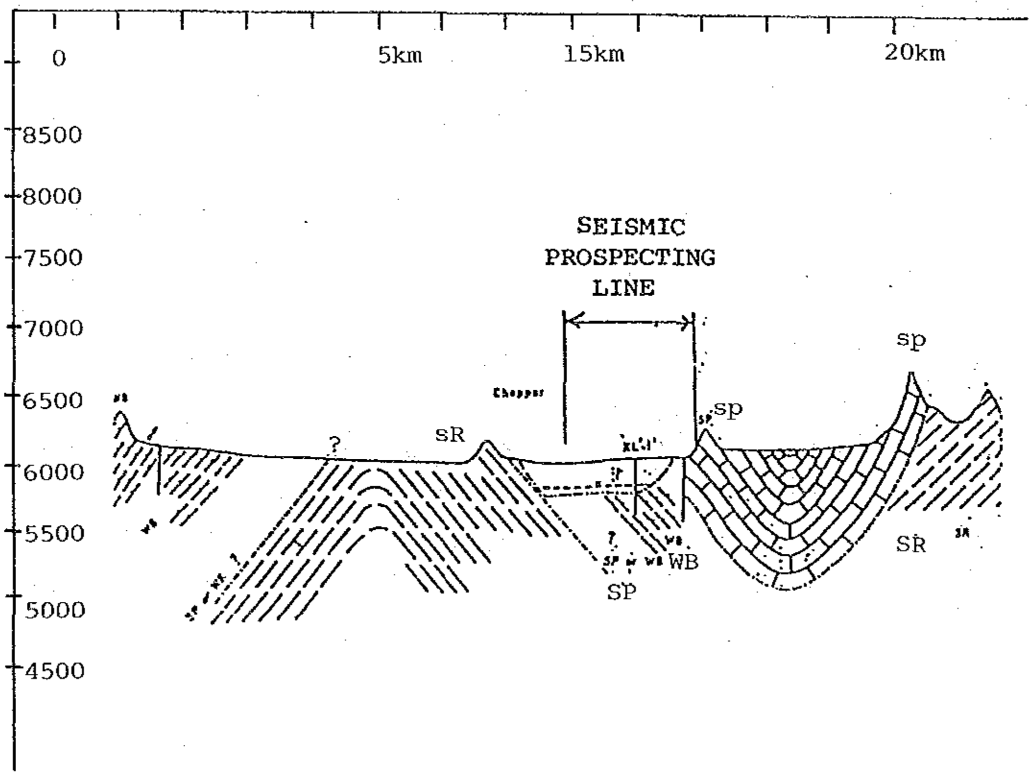


FIG A-4.4.4 Test Well Logs in Kalat Area



Source : Preliminary Hydrogeological Report

FIG A-4.4.5 Geological Cross-section in Kalat Area

4.4.3 Outline of Prospecting Method

Seismic prospecting aims to obtain the data of rock hardness and underground structure by measuring the velocity of seismic wave that transmits the earth; i.e. this method is to apply the characteristics of ground that the seismic wave velocity varies with the kind of soils and rocks, it becomes higher with the ground becoming harder, the velocity through the lower layers is higher than that of the upper layers, etc.

The outline of the refraction seismic method is as follows:

a. A vibration is generated by blasting in the earth near the ground surface.

b. The generated vibration (seismic waves) that transmits the earth as direct or refracted wave is received by some seismometers installed on the ground surface before blasting.

c. These received waves are amplified about 500 to 50,000 times and recorded on the oscillograph that has time interval lines of 1/100 second. Therefore, the velocity difference of 1/1,000 can be identified.

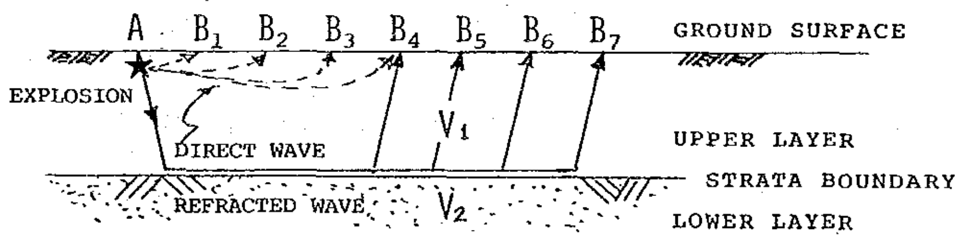


FIG A-4.4.6 Path of Seismic Waves

d. From these records, the first movement of the seismic waves transmitted to the receiving points are pointed out, and the travel times from the shot point to the receiving points are obtained.

e. Based on the above, the travel time - distance curve is drawn. In this graph, the travel times are plotted on vertical line and the distances from the shot point to the receiving points on horizontal line. In general, firstly the direct wave line is drawn near "0" point and the refracted wave lines follow it.

f. From the travel time - distance curve, velocity and depth of each layer are calculated by experimental formula and finally velocity section graph is drawn.

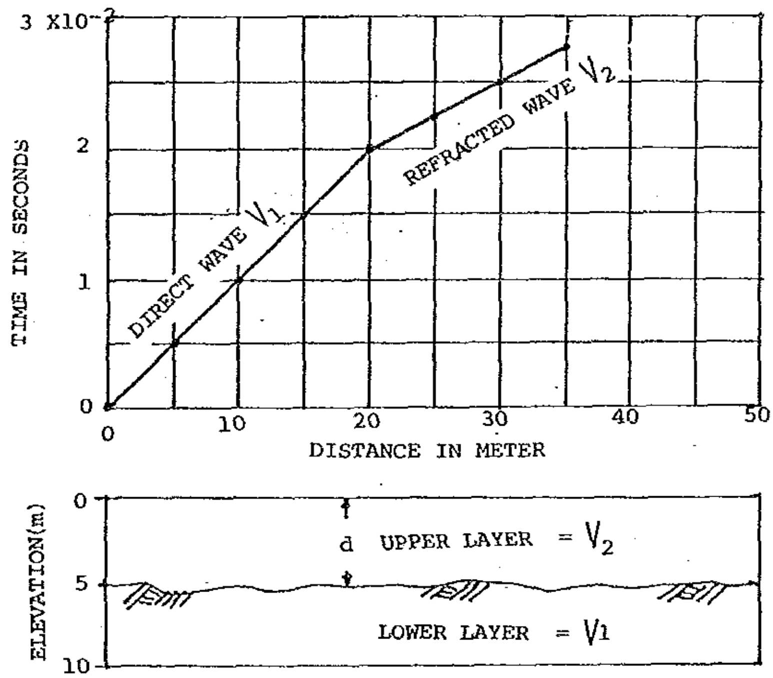


FIG A-4.4.7 Travel Time Distance Curve and Velocity Section

g. In the refraction method, the upper layer's velocity is required to be lower than that of the lower layer and the total length of a survey line necessitates 5 times the survey depth required.

h. The velocity values computed with the above procedure are checked with nearby geology and existing well data etc., and the underground geology around the survey line is estimated.

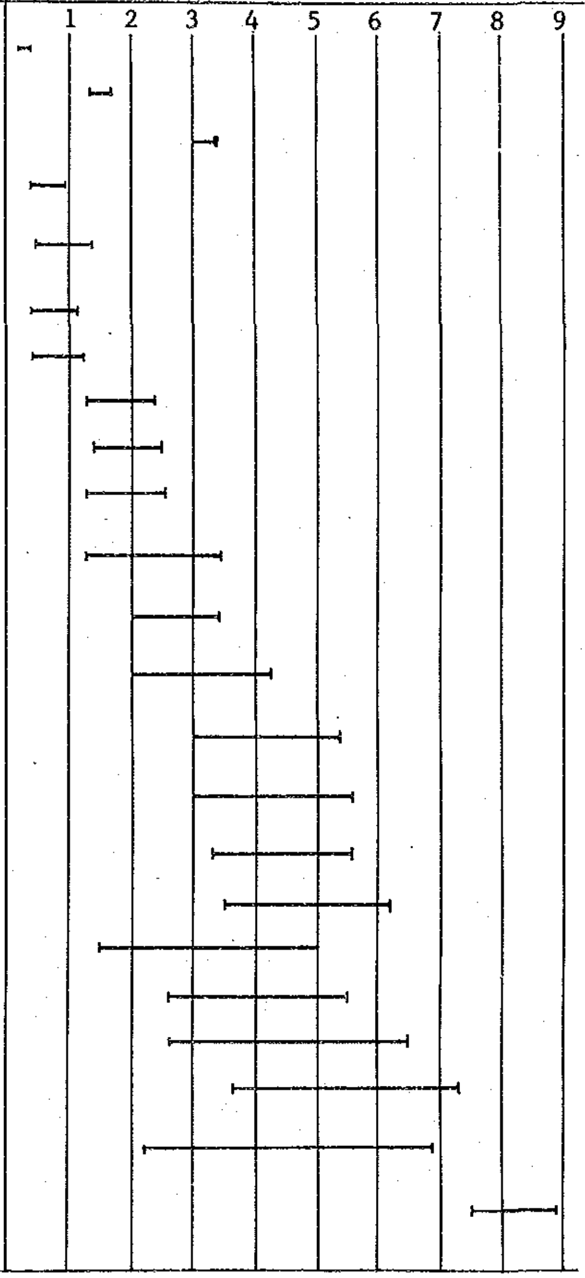
The general seismic wave velocity of sediments and rocks are shown in TABLE A-4.4.1.

As seen from the table, the hardness of rocks and seismic wave velocity in the rocks become higher in proportion to the increase of the geological ages. Therefore, the seismic wave velocity is a standard in the interpretation of underground structure.

TABLE A-4.4.1 Seismic Wave(P-wave) Velocity in Different Type of Layers and Rocks

Name of Rock		
		Sound (in air)
		Water
		Ice
Sedimentary Rock	Quarternary	Soil
		Dry Sand and Gravel
		Loam
		Volcanic Clastic Rock
		West Sand and Gravel
	Tertiary	Tuff
		Shale
		Sandstone and Conglomerate
		Angglomerate
		Tufficious Conglo-merate
	Mesozoic/ Paleozoic	Slate
		Sandstone and Conglomerate
		Gray Wacke
		Limestone
Ignious Rock		Andecite
		Ponphyrite
		Granite
		Basalt and Gabbro
Netamonphic Rock		- Crystal Schist
Under Home Plane		- Garnet Peridot

Seismic Wave (P-wave) (km/sec)



4.4.4 Prospecting Work

(1) Preparation

1) Procurement of Dynamite and Detonator

The dynamite of 200 kg and detonators of 500 pieces were procured locally.

The specifications of these items are as follows:

Dynamite

- Name	:	WAVOX 80%
- Size	:	25 mm dia. x 200 mm long
- Density	:	1.45 g/cm^3, Gelatinous
- Grade of strength	:	80
- Velocity of detonation	:	5,000 m/sec

Detonator

- Kind	:	Electric detonator No. 8 aluminium casing, 51 mm long with 2 m wire
- Total resistance	:	1.1 - 1.6 ohms per detonator

2) Selection of Survey Sites

Ten (10) areas where emit the high gamma-ray intensity, six (6) in Quetta and four (4) in Kalat, were tentatively selected through the rough analysis of the detected data at the site. Based on the above, the sites for seismic prospecting were selected in consideration of the following:

a) The survey sites are located in the areas which indicated strong intensity of gamma-ray during the measurement with helicopter.

b) The survey sites are located in the areas which have high potentiality for the future irrigation development.

c) The survey sites have comparatively large watersheds and the previous studies indicate that the Quaternary Formations in these area are thick and that the gravel development is remarkable around the plains of the areas.

d) The previous water quality tests show that the well waters around the survey sites are of good quality.

e) No houses nor public structures/facilities exist near the survey lines.

f) The survey results will be used most effectively in the analysis of the data of aerial gamma-ray spectro prospecting as supplementary information to the existing geological data.

g) The length of a survey line should be more than 1,500 m judging from the depth up to the base rock estimated based on the existing data.

In view of the above and also considering the seismic prospecting being the supplemental survey to the aerial gamma-ray prospecting and the maximum total length of seismic line being 6,000 m due to the limited survey period, two sites in Quetta (A line: 2,200 m and B line: 1,500 m) and one site in Kalat (2,300 m) were selected.

3) Survey of Prospecting Line

The profile of the prospecting lines was surveyed by a local contractor before the seismic prospecting work. Through this survey, the locations and elevations of the shot point and the receiving points were fixed on the prospecting line with 10 m interval. These points were marked with wooden sticks at the site, and the profile of scale 1:2,000 for respective lines was prepared in order to put the detected seismic values on it.

4) Adjustment and Transportation of Equipment

The survey equipment required for the field survey work were adjusted carefully in Japan and transported to Pakistan with the air cargo. The equipment used is shown in TABLE A-4.4.2

TABLE A-4.4.2 List of Equipment for Seismic Prospecting

Item	Type	Specification	Quantity
Amplifier	TR-7	• 24 elements • Gain: 90db • Filter: 70^{Hz}	1
Oscillograph	Fieldgraph 32 (Model -3220)	• 25 elements, dry record • Galuanometer, 3313-CIW • Sensitivity: 23.3 mm/mA • Paper speed: 15, 30, 60, 100 cm/sec	1
Geophone	HS-J type	• Native frequency: 28Hz • Native resistance: 215Ω	24
Blaster	Model -1330	• Short mask circuit attacked • Telephone circuit attacked	2
Take out cable		• 12 elements (24 core) • 10 m use	2 rolls
Telephone cable		• Steel wire included • 1 roll: 500 m	4 rolls
Blasting cable		• Parallel vinyl wire: 100 m	3 rolls
Safety tools		• Alarm siren and flute • Explosive store tent • Explosive transport box, Delivery box • Others	1 set

(2) Measuring Work

FIG A-4.4.9 show the concept of the seismic refraction prospecting method.

One spread of measuring work in the field is divided into three (3) items as follows:

- Installation of measuring instructions
- Blasting work
- Observation work

The field measuring work was conducted by repeating the above spread.

The interval of the receiving points was 10 m and those of the shot points were 460 m in Quetta Area and 230 m in Kalat Area due to the anticipated comparatively deep and shallow base rock, respectively. The maximum distances between the shot point and receiving points were 1,000 - 1,300 m in Quetta Are and 700 - 1,000 m in Kalat Area. These survey distances were determined in consideration of grasping the underground formation effectively.

1) Installation of Measuring Equipment

The telephone cable is placed for the entire length of a prospecting line. Twenty four (24) pieces of geophone for one spread (230 m) are installed beside the survey wooden sticks and the main equipment such as seismic amplifier and recording oscillograph is placed at the central section of the geophones for respective spreads. The connection of these instruments by using wire is then performed in preparation for the blasting.

2) Blasting Work

At the shot point, a small pit of 1 m deep is dug and dynamite and a detonator are changed in it. The volume of dynamite is increased or decreased depending upon the distance up to the receiving points. The blasting work is conducted with the signal through telephone from the operator at the main instruments.

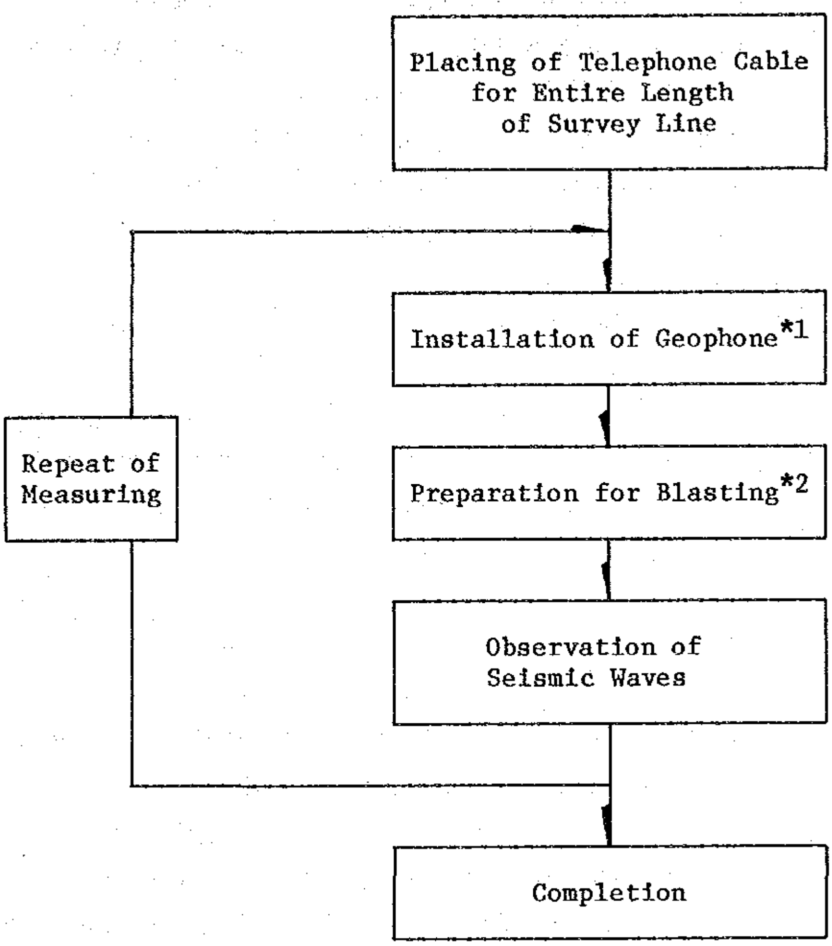
3) Observation Work

The seismic waves generated by the blasting are transmitted to the main instruments at the central section through various paths due to the change of geological structures.

The received seismic waves are changed to electric signals. They pass through the take-out cables, amplified by the amplifier and finally recorded automatically on the oscillograph.

The prospecting work is advanced on the survey line by repeating the procedure mentioned above. However, the blasting and its observation are conducted from both sides of the spread for confirmation purposes.

FIG A-4.4.8 show the concept of the seismic refraction prospecting method.



*1: 24 pieces with 10 m pitch for one spread of 230 m

*2:
- Drilling of shot holes
- Charge of explosive
- Warning

FIG A-4.4.8 Flow Chart of Measuring Work

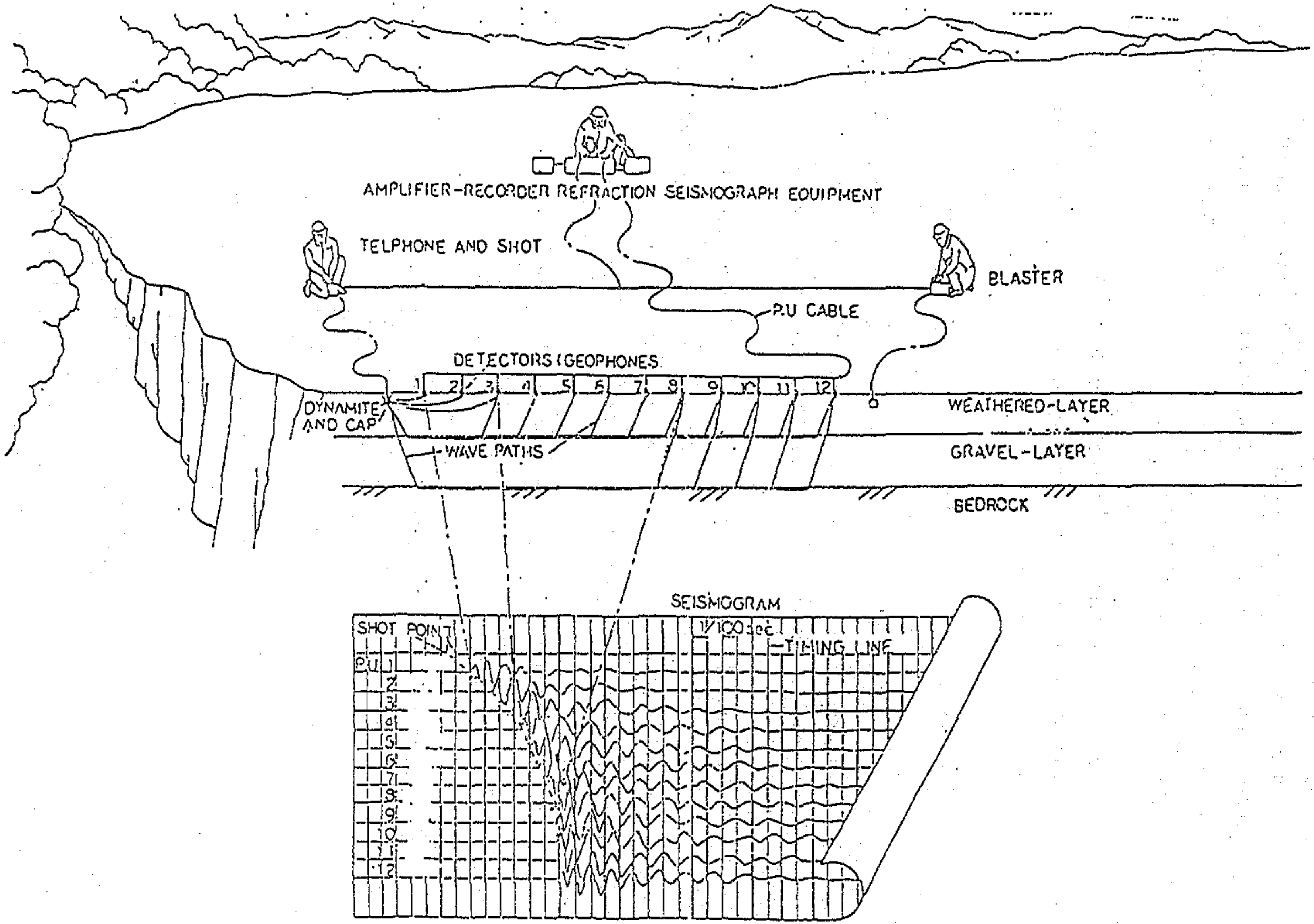


FIG A-4.4.9 Diagram of Seimic Prospecting

4.4.5 Analysis of Observed Data

From the observed data, the travel time - distance curve is prepared. Based on the curve, the data are analysed with the theory of seismic wave propagation, and the underground structures are shown as a section diagram of the seismic velocity. Many analysing methods have been developed due to the complicated underground structures.

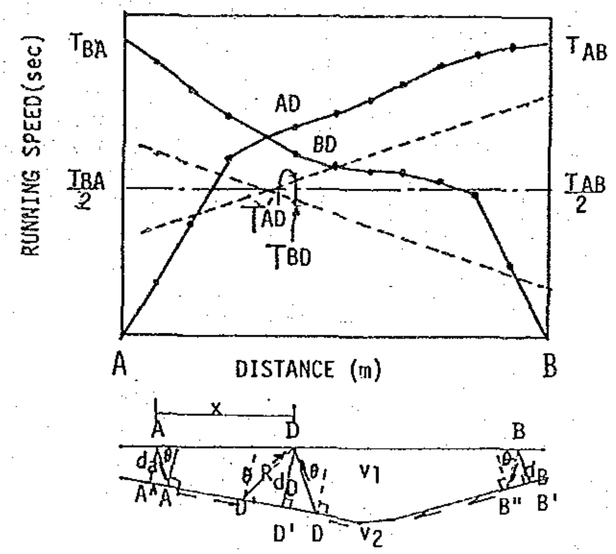
Usually, the analysis is performed with ABC Method (known as Hagiwara's Method) and the section diagram is modified and finalized through the path calculations.

The following is the outline of Hagiwara's Method:

a. To prepare the travel time - distance curve by receiving the seismic waves from two shot points that are in adverse direction each other against the observation points.

b. To calculate the travel time and real velocity of the 2nd layer on the assumption that the 1st layer is excluded apparently and that the receiving points are set on the surface of the 2nd layer.

c. To calculate the thickness of the 1st layer



d_A, d_B, d_D : Depth of V_1 layer at A,B and D
DD' ⊥ D'R
θ : Refraction angle

FIG A-4.4.10 Seismic Speed Graph and Seismic Water Path

In the case of the undulated boundary surface (A - D - B), the travel time T_{AD} of refracted wave from the shot point A to the observation points is:

$$T_{AD} = \frac{\overline{AA''}}{V1} + \frac{\overline{A''D''}}{V2} + \frac{\overline{D''D}}{V1} \quad \text{.......} \quad (1)$$

where; $\overline{AA''}$, $\overline{A''D''}$ and $\overline{D''D}$ are distance of route the waves pass through.

With the same manner, T_{BA}, T_{AB} and T_{BA} are:

$$T_{AD} = \frac{\overline{BB''}}{V1} + \frac{\overline{B''D''}}{V2} + \frac{\overline{D''D}}{V1} \quad \text{.......} \quad (2)$$

$$T_{AB} = T_{BA}$$

$$= \frac{\overline{AA''}}{V1} \quad \frac{\overline{A''D''} \quad \overline{D''D'} \quad \overline{D'D'''} \quad \overline{D'''B''}}{V2} \quad \frac{\overline{B''B}}{V1} \quad \text{.......} \quad (3)$$

From expressions (1), (2) and (3),

$$T_{AD} + T_{BD} - T_{AB} = \frac{\overline{D''D}}{V1} + \frac{\overline{D'''D}}{V1} - \frac{\overline{D''D'}}{V2} - \frac{\overline{D'D'''}}{V2} \quad \text{.......} \quad (4)$$

$$\frac{\overline{RD''}}{V1} = \frac{\overline{RD''}}{V2\mathrm{Sin}\theta} = \frac{\overline{D''D'}}{V2}$$

$$\frac{\overline{D''D}}{V1} = \frac{\overline{DR}}{V1} + \frac{\overline{RD''}}{V1} = \frac{dD\mathrm{Cos}\theta}{V1} + \frac{\overline{D''D'}}{V2} \quad \text{.......} \quad (5)$$

With the same manner,

$$\frac{\overline{DD''}}{V1} = \frac{dD\mathrm{Cos}\,\theta}{V1} + \frac{\overline{D'''D'}}{V2} \quad \text{.......} \quad (6)$$

$$\frac{\overline{AA''}}{V1} = \frac{dA\mathrm{Cos}\,\theta}{V1} + \frac{\overline{A'''A'}}{V2} \quad \text{.......} \quad (7)$$

$$\frac{\overline{BB''}}{V1} = \frac{dB\mathrm{Cos}\,\theta}{V1} + \frac{\overline{B'''B''}}{V2} \quad \text{.......} \quad (8)$$

From expressions (4), (5) and (6),

$$T_{AD} + T_{BD} - T_{AB} = \frac{2\ dDCos\theta}{V1}$$

$$dD = \frac{V1}{Cos\,\theta} \cdot \frac{T_{AD} + T_{BD} - T_{AB}}{2} \quad \text{.........................} \quad (9)$$

In expression (9), V1 is obtained easily from travel time, and T_{AD}, T_{BD} and T_{AB} are values to be measured. Here, if Cos θ is identified, thickness dD of the layer is obtained. Cos θ becomes clear, if velocity V2 is obtained.

From expressions (1), (5) and (7),

$$T_{AD} = \frac{dACOS\theta}{V1} + \frac{\overline{A'A''}}{V2} + \frac{\overline{A'D''}}{V2} + \frac{\overline{D''D'}}{V2} + \frac{dDCos\theta}{V1} \quad \text{.............} \quad (10)$$

Travel time T'_{AD} is expected as follows:

$$T'_{AD} = T_{AC} - \frac{T_{AD} + T_{BD} - T_{AB}}{2} \quad \text{...........................} \quad (11)$$

The values in the right side of this expression are obtained through measurement.

From expressions (10) and (11),

$$T'_{AD} = \frac{dACos\,\theta}{V1} + \frac{\overline{A'D'}}{V2} \quad \text{.................................} \quad (12)$$

This is a linear expression to $\overline{A'D'}$. In the case that an angle d of boundary surface to horizontal plane, $\overline{A'D'}$ is equal to the distance between points A and D. When it is placed as X, expression (12) become as follows:

$$T'_{AD} = \frac{dACos\,\theta}{V1} + \frac{X}{V2}$$

Namely, due to a pair travel time - distance curves from shot points A and B of both sides, T'_{AD} of every observation points are calculated using expression (12) and V2 can be obtained from gradient of straight line (ABC method line) connected those points. Further, thickness dD of V1 layer is known using expression (9). ABC method lines can be drawn easily by applying "Figure Drawing Method".

From expression (11),

$$T'_{AD} = T_{AD} = \frac{T_{AD} + T_{BD} + T_{AB}}{2} = \frac{T_{AD} - T_{BD}}{2} + \frac{T_{AB}}{2} \quad \ldots\ldots\ldots \quad (13)$$

Namely, half values of total travel time T_{AB} (T_{BA}) are drawn parallel to the horizontal line. Next, values of $(T_{AD} - T_{BD})/2$ in every receiving points are picked up and plotted on the upper and lower sides of the parallel lines in each points, and these points are connected. Also, using depth dD of each receiving points obtained from expression (14) as a radius, if half circles are drawn centering the points of each ground surface and its circular top are connected, its line become a boundary between upper and lower layers.

Path calculation is as follows:

Firstly, underground structures are roughly estimated, and the propagated routes of seismic waves from the shot point to each observation point are drawn on the figure and its transmitted times are calculated. Next, these are compared with former travel time - distance curves. In the case of these two values being not matched, the underground structure is corrected. When path routes are drawn, a theory of incident refraction in boundary by Snell rule is applied. By this way, the values obtained through ABC method can be corrected.

4.4.6 Result of Analysis

(1) Quetta A-Line

The ground velocities of this line are classified as shown in TABLE A-4.4.3.

TABLE A-4.4.3 Seismic Sneed and Description on Each Layer in Quetta A-Line

Classification	Velocity (km/sec)	Average thickness (m)	Maximum thickness (m)	Estimated Geological Conditions	
No. 1 layer	0.2-0.3	5-6	10	Dry soil and clay	Quaternary, Unconsolidated
No. 2 layer	0.6	10	18	Clay	
No. 3 layer	0.8-1.0	35-40	60	Gravel and clay	
No. 4 layer	1.5-2.0	150	320	Semi-consolidated gravel and clay	
No. 5 layer	4.6, 5.6	-	-	Base rock	Mesozoic, Consolidated

Nos. 1 and 2 layers are comparatively dry formation judging from their main composition of clay and slow velocity of 0.2 - 0.6 km/sec. No. 2 layer exists only at the section of - 300 m. No. 3 layer is formed mainly by gravel containing some clay, and the velocities in the layer are 0.8 - 1.0 km/sec. It is not consolidated and comparatively dry.

No. 4 layer is widely distributed with its average thickness of 150 m. It is semi-consolidated due to its composition of gravel and clay and the velocities in it being 1.5 - 2.0 km/sec. No. 5 layer is base rock and velocities in it are 4.6 and 5.6 km/sec with little variations.

The comprehensive analysis of the above and previous geological data has concluded as follows:

The formations from No. 1 to No. 4 layers are unconsolidated sediments of the Quaternary Formation and No 5 layer is the base rock of Chiltan limestone of Mesozoic Formation. The estimated depths up to the base rock are 250 m in deep portion and 200 m in shallow portion.

(2) Quetta B-Line

The ground velocities of this line are classified as shown in TABLE A-4.4.4

TABLE A-4.4.4 Seismic Sneed and Description on Each Layer in Quetta B-Line

<table>
<tr><th>Classification</th><th>Velocity (km/sec)</th><th>Average thickness (m)</th><th>Maximum thickness (m)</th><th colspan="2">Estimated Geological Conditions</th></tr>
<tr><td>No. 1 layer</td><td>0.3-0.5</td><td>5-6</td><td>14</td><td>Dry soil and clay</td><td rowspan="3">Quaternary, Unconsolidated</td></tr>
<tr><td>No. 2 layer</td><td>0.9-1.1</td><td>10</td><td>16</td><td>Dry gravel and clay</td></tr>
<tr><td>No. 3 layer</td><td>0.8-1.0</td><td>90-100</td><td>140</td><td>Semi-consolidated gravel and clay</td></tr>
<tr><td rowspan="2">No. 4 layer</td><td>3.0-4.8</td><td>-</td><td>-</td><td>Base rock</td><td rowspan="2">Tertiary/ Mesozoic Consolidated</td></tr>
<tr><td>2.1, 2.8</td><td>-</td><td>-</td><td>Low velocity zone</td></tr>
</table>

No. 1 layer is dry soil and clay with the velocity in it being 0.3 - 0.5 km/sec. No. 2 layer is composed of gravel and clay in dry condition with the velocities in its being 0.9 - 1.1 km/sec. No. 3 layer with the velocity of 1.6 - 2.2 km/sec is thick and widely distributed, and may correspond to No. 4 layer of A-Line. It is composed of gravel and clay.

The lower part of this layer may be weathered sediments. No. 4 layer has a variety of velocities, 4.8 km/sec in highlands and 2.1 and 2.8 km/sec in lowlands. The depths of the layer are shallow in the mountain side and deep (about 150 m) in the low plain.

Consequently, No. 1 and No. 3 layers are consolidated sediments of the Quaternary Formation and No. 4 layer is the base rock of Tertiary/Mesozoic Formations. The low velocity in the base rock may show the existence of young Tertiary Formation or weathered zone. The lower velocity zone may reflect the fissured zone.

(3) Kalat Line

The ground velocities of this line are classified as shown in TABLE A-4.4.5.

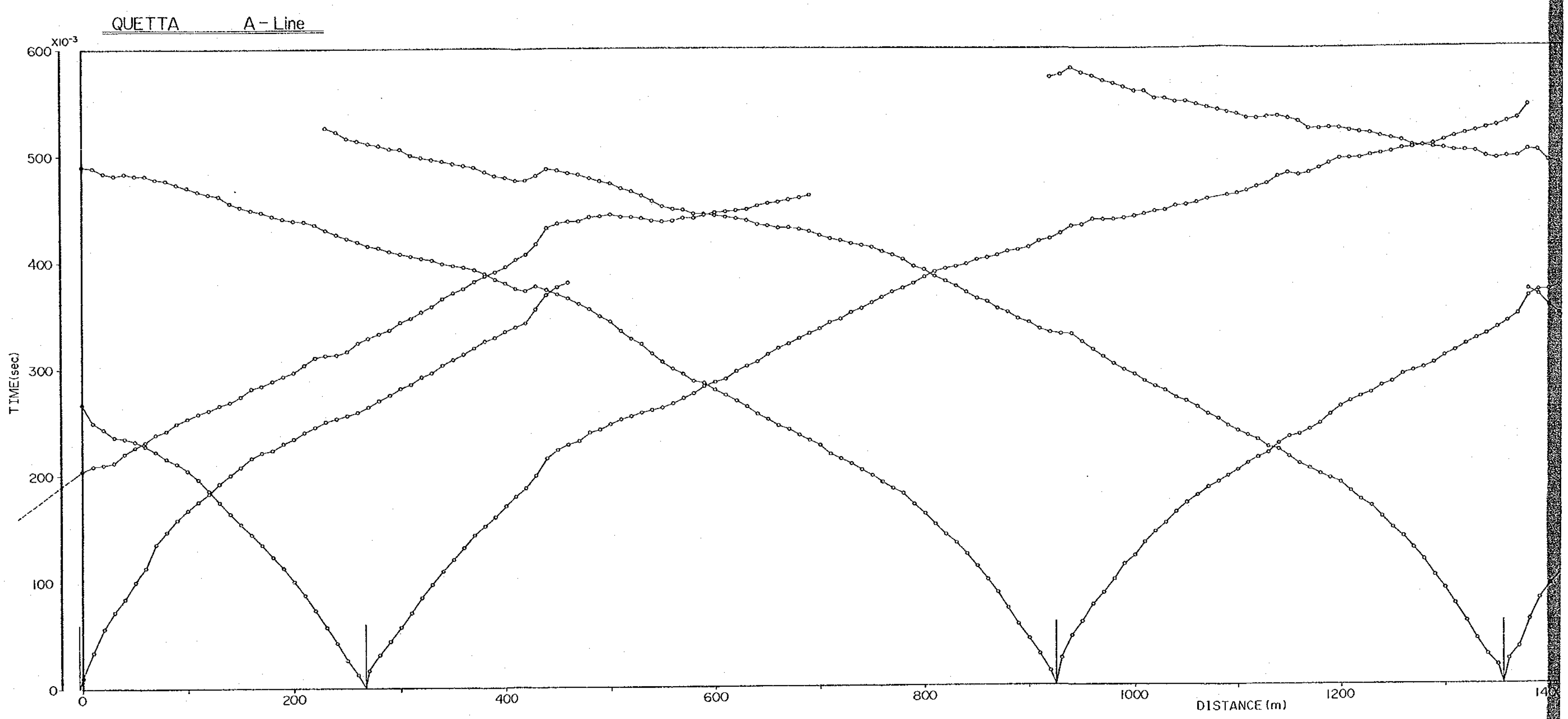
TABLE A-4.4.5 Seismic Speed and Description on Each Layer in Kalat Line

Classification	Velocity (km/sec)	Average thickness (m)	Maximum thickness (m)	Estimated Geological Conditions	
No. 1 layer	0.2-0.7	4-5	10	Soil and clay	Quaternary, Unconsolidated
No. 2 layer	0.6-0.8	10	16	Clay and sand	
No. 3 layer	0.8-1.0	90-100	140	Gravel and clay	
No. 4 layer	2.0-3.5	-	-	Base rock	Tertiary/ Mesozoic Consolidated

No. 1 layer is dry soil and clay with velocities in it being 0.2 - 0.7 km/sec. No. 2 layer is composed of clay and sand in dry condition. It is distributed only in the section of the line between 1,400 and 1,600 m. No. 3 layer indicates the velocities of 1.2 - 2.0 km/sec and is composed of gravel and clay. It is thick in the section between 1,400 and 2,300 m. It may contain the weathered rocks near point 0 m.

No. 4 layer is the base rock with the velocities in it being comparatively low, 2.0 - 3.5 km/sec.

Consequently, No. 1 to No. 3 layers are unconsolidated sediments of the Quaternary Formation and No. 4 layer is the base rock of Tertiary/Mesozoic Formations. The low velocity in the base rock may show the existence of young Tertiary Formation or weathered zone. The lower velocity zone may reflect the fissured zone. The depth of the sediments is shallow; 70 m at the deep section.


QUETTA A - Line
x10^-3
600
500
400
300
200
100
0
TIME(sec)
0
200
400
600
800
1000
1200
140
DISTANCE (m)

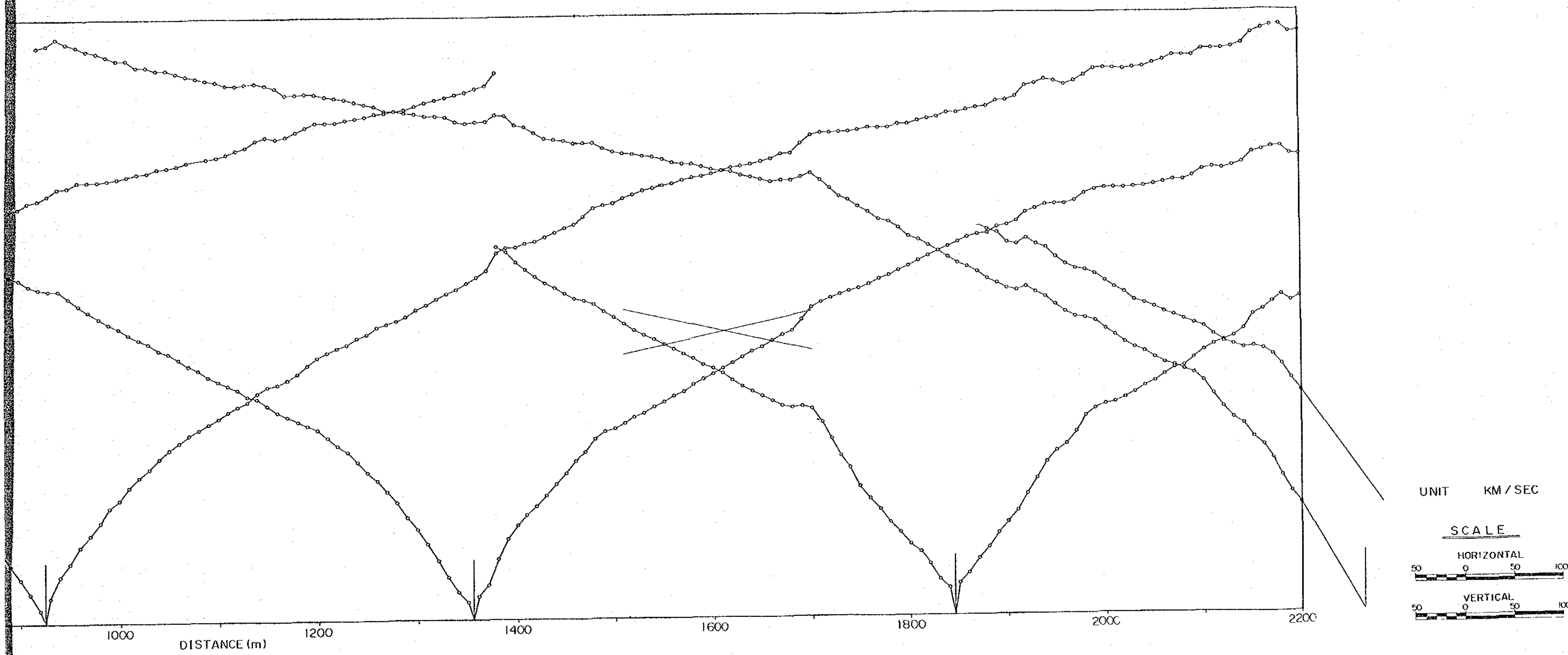


FIG A-4.4.11 Seismic Speed Graph. Quetta A-line

THE ISLAMIC REPUBLIC OF PAKISTAN
MASTER PLAN STUDY
ON
BALUCHISTAN IRRIGATION DEVELOPMENT PROJECT
THROUGH GROUNDWATER DEVELOPMENT

SEISMIC PROSPECTING
SEISMIC SPEED GRAPH
QUETTA A - LINE

DATE MAR 1987 | DWG. NO. A-1

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

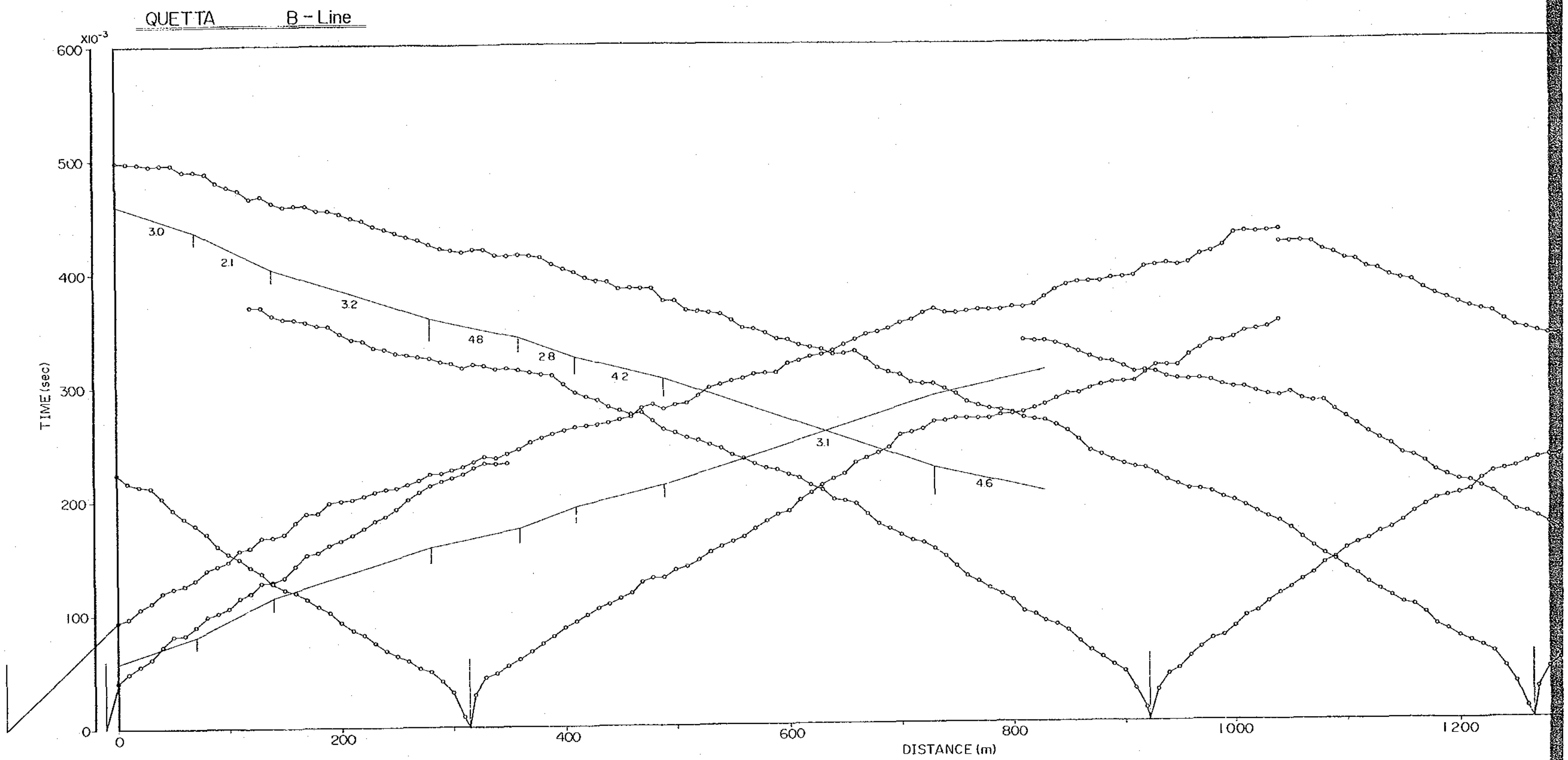


FIG A-4.4.12 Seismic Spe

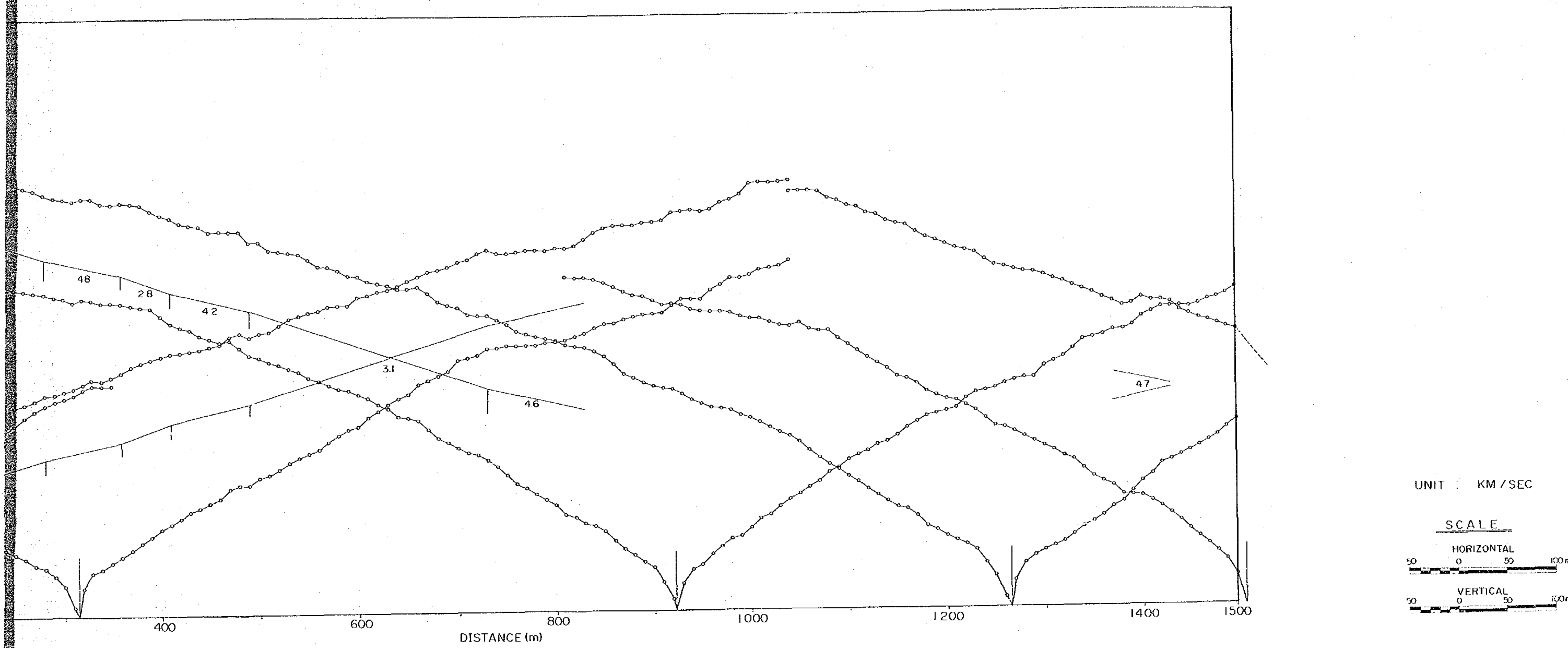


FIG A-4.4.12 Seismic Speed Graph. Quetta B-line

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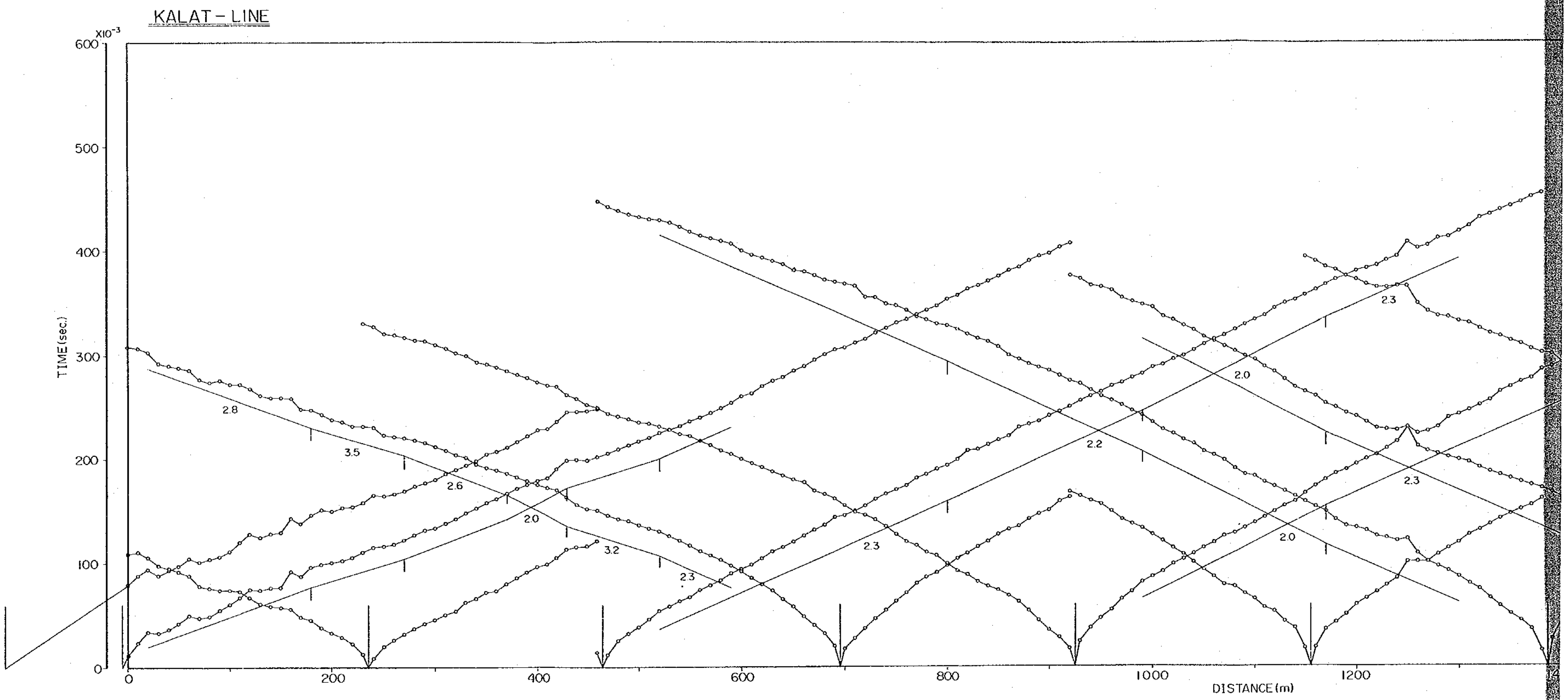
THROUGH GROUNDWATER DEVELOPMENT

SEISMIC PROSPECTING
SEISMIC SPEED GRAPH
QUETTA B - LINE

DATE MAR 1987 DWG NO A-2

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)



KALAT - LINE
X10⁻³
600
500
400
300
200
100
0
TIME (sec.)
0
200
400
600
800
1000
1200
DISTANCE (m)
2.8
3.5
2.6
2.0
3.2
2.3
2.3
2.2
2.0
2.3
2.3
2.0

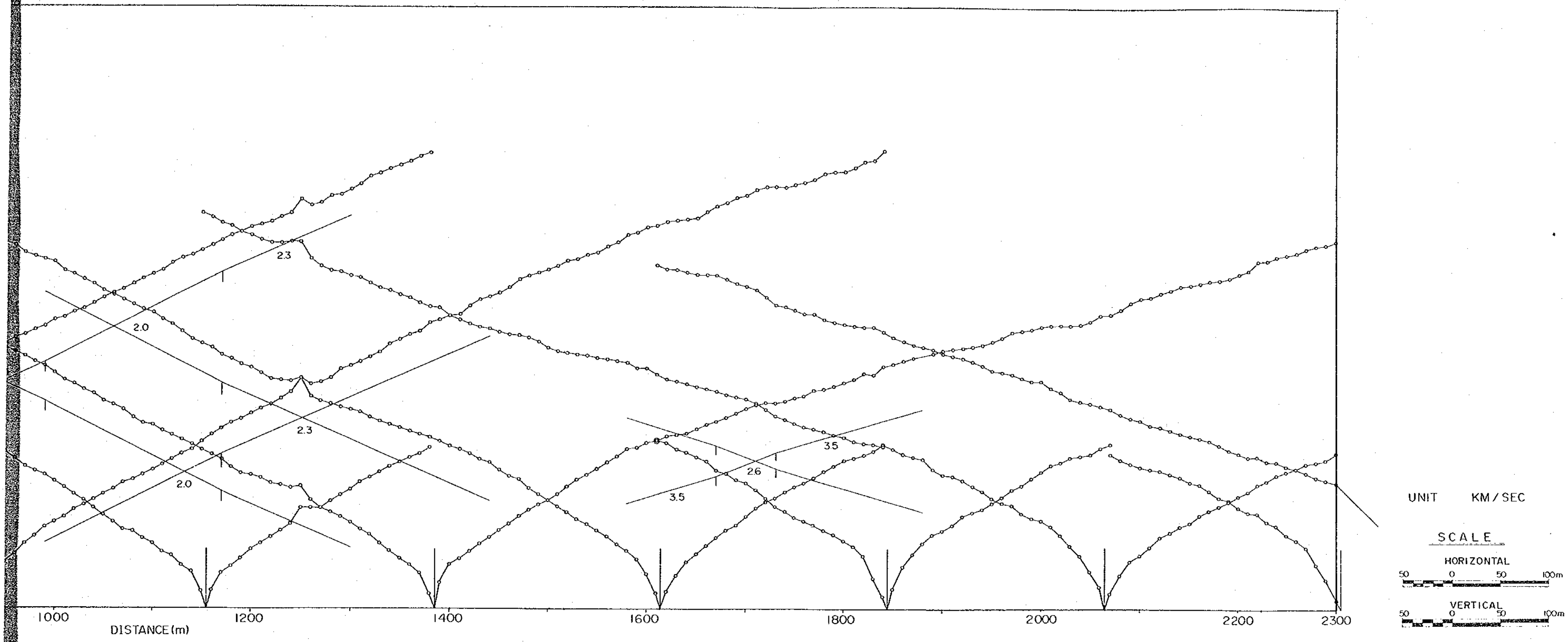


FIG A-4.4.13 Seismic Speed Graph. Kalat line

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ON
BALUCHISTAN IRRIGATION DEVELOPMENT PROJECT
THROUGH GROUNDWATER DEVELOPMENT

SEISMIC PROSPECTING
SEISMIC SPEED GRAPH
KALAT LINE

DATE MAR 1987 | DWG. NO A-3

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

4.5 WELL TEST

4.5.1 GENERAL

(1) Objectives

The field well test was carried out to confirm the results obtained through the aerial selective gamma-ray spectro prospective conducted in the First Phase of the Study.

(2) Executing Agency

All the well test works are being executed by Hydrogeology Project, WAPDA, Quetta under the assistance of the JICA Study Team.

(3) Locations

The locations of the test wells were selected on the basis of the results of the groundwater survey in consideration of the possibility of future irrigation development, necessity of test result to supplement the existing test results, the verification of the uncertain results come up through the analysis, etc. The following seven (7) sites were selected through discussions between the Government agencies concerned and the Study Team and site investigations.

Vein Name	Location	Boring No.
Quetta Area		
Vein A:	1,000 m NNE of Balal Khan village	QT-JICA-4*
Vein B:	1,500 m NNE of cross of Bolan Road and Railway	QT-JICA-3*
Vein D:	Beside Karam Dad Village	QT-JICA-2
Vein E:	600 m west of Rasul Bukhsh Village	QT-JICA-1

Note: * Tentative number

Vein Name	Location	Boring No.
Quetta Area		
Vein A:	1,000 m SEE of Shahr Haji Village	KL-JICA-1
Vein B:	1,000 m east of Kallu Village	KL-JICA-2
Vein C:	1,000 m SE of Dallo Village	KL-JICA-3

(4) Term (ref. FIG. A-4.5.1)

KL-JICA-1: July 16, 1987 ~ September 17, 1987
KL-JICA-2: September 21, 1987 - November 27, 1987
KL-JICA-3: September 28, 1987 - December 3, 1987

QT-JICA-1: November 18, 1987 -
QT-JICA-2: November 15, 1987 -
QT-JICA-3:
QT-JICA-4:

4.5.2 Drilling and Water Sampling

The drilling works and water sampling test were conducted with the following procedure: (also ref. FIG. A-4.5.2)

Step	Description
1.	To drill the 8-3/4" ϕ pilot hole upto the bedrock and to stop the drilling operation after penetrating into the bedrock by about 5 m.
2.	To conduct the electric logging in order to obtain SP and resistivity values.
3.	To conduct the first water sampling test in the alluvial layer.

(to be cont'd)

(Cont'd)

Step	Description
4.	To continue the drilling of 8-3/4" ø pilot hole upto the designated depth (max. approx. 300 m from the ground surface).
5.	To conduct the electric logging in the rock layer.
6.	To conduct the second "composite" water sampling test only in the rock layer.
7.	To ream the pilot hole to 17-1/2" ø hole and stop the reaming operation after penetrating into the bedrock by at least 1 m.
8.	To install the 10" ø casing pipe
9.	To make gravel packing outside the 10" ø casing pipe installed.
10.	To fill the clay pack at the top of the casing pipe for the depth of min. 15 m after the gravel pack is completely settled.
11.	To install the 6" ø casing pipe in rock layer section in case it is judged necessary.

The locations of the strainer pipes for water sampling test was decided based on the cutting samples and electric logging results. In the case of water sampling in the bedrock, the strainer pipes (16 feet long) were placed at all the expected groundwater layers. In order to cope with the above anticipated requirement, five (5) pieces of strainer pipe were stocked at the site during the boring operation.

The works after step 7 were conducted only in the case of good results of water sampling test.

4.5.3 Pumpig Test

The pumping test should be performed by using a submersible pump in order to obtain the accurate well capacity. However, in case that the groundwater level is too low for the submersible pump available, the air-lift pumping test could be conducted after the well is completed.

(1) Pumping Test with Submersible Pump

The pumping test at the site is to be performed with the following procedures:

a. After well drilling, completion works and hole cleaning are finished, a submersible motor pump (ø7 - 8") for the pumping test shall be lowered into the well hole.

b. The pump shall be lowered upto near the base rock, because the drawdown of water level during the test operation is expected to be big.

c. No observation wells[1/] for the test are to be drilled in consideration of the usual pumping test adopted for deep tubewells.

d. An observation pipe for measuring the change of groundwater level (i.e. 3/4" gas pipe) shall be lowered into the well hole at the same time when the test pump is lowered.

1/ This is used popularly in deep well of Japan as a simple method.

e. The pumping test shall be conducted in the following four (4) steps:

1st step: Preliminary pumping test
2nd step: Step drawdown test
3rd step: Continuous discharge test
4th step: Recovery test

f. The preliminary pumping test shall be performed for 2 to 3 days, and water level, discharge, lifted sand and turbidity shall be observed and recorded from time to time. Through this test, approximate maximum discharge capacity will be obtained.

g. The step drawdown test shall be performed by changing the discharge volume in 3 steps from small volume step to the max. volume step. Each pumping period shall be min. 2 hours and the same values mentioned in item f. shall be observed and recorded every 15 minutes. Through this test, the critical and optimum discharge will be defined.

h. On next day of the step drawdown test, the continuous discharge test shall be performed by pumping out the optimum discharge volume for at least 24 hours after measuring the static water level, and the water levels shall be recorded continuously (depression test).

The observation of water levels shall be made with the following manner:

0 - 10 min	=	1, 1.5, 2, 2.5, 3, 4, 5, 6.5, 8 & 10 min
10 - 100 min	=	10, 15, 20, 25, 30, 35, 40, 50, 60 & in 80 min
100 - 310 min	=	30 min interval
310 - 550 min	=	60 min interval
550 - 950 min	=	100 min interval
950 - completion	=	200 - 300 min interval

During this period, lifted sand, turbidity, water temperature and electric conductivity shall also be recorded. At the final stage, a water sample of 5 litres shall be collected for quality test.

i. After the pumping operation is stopped, the recovery test shall be performed with the same manner as for continuous discharge test for at least 24 hours and the field pumping test will be completed.

By analysing data recorded at the site, the values of transmissibility, permeability, storage coefficient, specific capacity and the circle of influence shall be obtained.

(2) Air-lift Pumping Test[1/]

The air-lift pumping test should be conducted with the similar manner applied for the pumping test with a submersible pump except for the step drawdown and depression tests which can not be made by this test.

Since the storage coefficient can not be obtained in this case, the actual surveys for influence to nearby wells are required.

4.5.4 Drilling Rigs and Equipment

(1) Drilling

Rig:	:	Top-750, truck mounted type
Engine	:	235 HP
Mast	:	12.2 m high, steel framed

1/ This method was used usually in past time when no submersible pump was available. (FIG A-4.5.3).

Bit	:	8-3/4" tricone
Reamer	:	12-1/4", 17-1/2" opener
Compressor	:	XRH, Atlas Copco Discharge 21 m^3/ min X working pressure 20.3 kg/cm^2

(2) Casing

10" ϕ	:	Outside dia. 262 mm x inside dia. 252 mm thickness 5 mm, mild steel
Strainer	:	Slit type, slit width 1.5 mm, open area 7.21%
Gravel Packing	:	Gravel size 1/4" and 1/8"

(3) Measuring Instrument

Electric Logger	:	Widco logger, Gearhart - Owen made type 1300 & 3200 Electrode interval 18 cm
Water Table Measurer	:	Welbhd, England made

4.5.5 Results

(1) KL-JICA-1

1) Progress

As shown in FIG A-4.5.4, gravel rich layers exists from around ground surface to the depth of 69 m and then clay layers continue upto the base rock of shale at the depth of 103 m. At 108 m, first drilling was stopped and the water sampling test was performed. Then the pilot hole was reamed and 10" ϕ casing pipes were placed upto 104 m. Outside of the casing pipe was packed with gravel. The strainer pipes were placed at the sections of 48 to 54 m and 60 to 66 m.

The additional drilling was performed upto 200 m in 6 days. The geology from 108 m to 200 m judging from cutting samples are mainly shale and thin limestone layers exist in some portions. Second water sampling test was performed but satisfactory discharge was not obtained. The additional drilling was further performed and finished at the depth of 300 m. The cutting samples of this section showed a little more limestone content than that of the upper section.

2) Electric Log

The electric logging tests were performed at each drilling end (108 m, 200 m and 300 m). It displays high resistivity upto around 65 m. It corresponds to gravel layers.

The curves between 108 and 200 m of S.P. and resistivity indicate that the shale including thin limestone layers is superior. Moreover, this limestone layer is expected to be high permeability due to the shape of resistivity and S.P. curves.

High resistivity was not measured in the thin limestone layers between 200 and 300 m. This is maybe due to the limestones being shaley.

3) Drilling Rate

The drilling rate shown in FIG A-4.5.4 displays that soft layers of rate between 10 and 20 min/m. continue upto the bottom except sticky clay layer around 150 m depth. The geology of the said well is assumed to be the Quaternary and Tertiary formations.

4) Water Sampling

At each drilling end, water sampling test was conducted and groundwater table was measured. The test results are as follows:

a. The first water sampling (depth 94 to 100 m) (FIG A-4.5.5)

- . Lift pipe : 2-1/2" ϕ
- . Air pipe : 3/4" ϕ
- . Discharge of 7.5 l/min at the beginning became 5.6 l/min after 3.5 hours.
- . Static water level: 72 m
- . Conductivity : 470 μS/cm
- . Temperature : 25°C

b. The second water sampling (depth 100 m)

- . Lift pipe : 4" ϕ
- . Air pipe : 1" ϕ
- . Casing pipe : 10" ϕ
- . After 3 hours, discharge became zero.
- . Dynamic level : 100 m

c. The third water sampling (depth 183 to 189 m)

- . After air drilling, it was conducted.
- . Small discharge after one hour.
- . Conductivity : 900μ S/cm
- . Temperature : 25°C
- . Water level : more than 133 m
- . Recovery of water level : 24 m in 50 hours

d. Water level observation (starting depth 251 m)

- . Recovery of water level : 40 m in 31 hours

e. The forth water sampling (depth 266 to 272 m) (FIG A-4.5.5)

. At the beginning, discharge was 68 l/min due to water filled in the hole during electric logging, but decreased to 22 l/m gradually after 3 hours, and 5.6 l/min after 8 hours.

. Conductivity : 1,185μ S/cm

. Temperature : 25.5°C

f. Water level observation (starting depth 205 m) (FIG A-4.5.6)

. Recovery of Water level: 24 to 48 m per day

. Water level finally reached 57 m after 4 days

5) Conclusions

a. Judging from the above results, the average specific capacity will be 1.5 m^3/d/m d.d, ranging 0.6 to 2.4 m^3/d/m d.d due to the depths and layers.

b. The rate of the discharge is assumed to be 25% from the alluvial section, 50% from the layer 100 to 200 m and 25% from the layer lower than 200 m.

c. A few groundwater is stored in the Quaternary Formation due to its shallow depth.

d. The fissures in the base rock may not contribute to the storage of groundwater due to its soft layers of shale, causing the plugging of fissures through its collapse.

e. Limestone is not fully developed in the base rock, may causing little discharge from the base rock.

f. The fact that there was a discharge from the base rock, even though its quantity was very few, proves the possibility of the existence of aquifer in the base rock, if the limestone is developed and it has fissures.

(2) KL-JICA-2

1) Progress

Gravel continues from ground surface to the depth of 93 m and combined layers of clay and gravel appear upto the depth of 110 m. Then clay layer continues upto the base rock of shale at 150 m depth. Limestone layer starts from 160 m. The drilling was stopped at 162 m and the first electric logging and water sampling tests were performed.

The drilling works were continued. the limestone layer ends at the depth of 168 m. Then combined layers of shale and limestone continue upto the depth of 199 m. Then pure shale continues upto the depth of 292 m. Then limestone appears only for 6 m thickness and again it is changed to shale. The drilling was stopped at the depth of 300 m. After that, the second electric logging and water sampling tests were performed. Then the installation of 10" casing in its upper portion and pumping test were undertaken.

2) Electric Logging

The curves show the high resistivity upto 100 m and low resistivity in deeper part, corresponding to gravel and clay, respectively. At the depth around 160 m, there is high resistivity value layer of about 10 m thickness. This corresponds to limestone and is expected to have high permeability due to its curve shapes.

Then, low resistivity values continue upto near the drilling end of 300 m. At the deepest part, a little high value appear but it is thin. From these curves, gravel layers in the upper part and limestone at around 160 m depth were expected as aquifers.

3) Drilling Rate

The drilling rate shown in FIG A-4.5.7 displays that soft layers of rate between 10 and 29 min/m continue upto around 200 m depth and then change to hard layers of about 30 min/m. It is assumed that the former is the Quaternary and Tertiary formations and the latter is Mesozoic formation.

4) Water Sampling Test

The test was performed by using compressor, lift pipe (4" ϕ) and air pipe (1" ϕ) as same as for KL-JICA-1. The results are as follows:

a. The first Water sampling (drilling end: 162 m)

- First stage (strainer depth: 87 - 93 m)
  - . Discharge : 25 gpm (95 1/min)
  - . Conductivity : 720 μS/cm
  - . Temperature : 25 ℃
  - . Water level : 44 m

- Second stage (strainer depth: 70 - 76 m)
  - . Discharge : 20 gpm (76 1/min)
  - . Conductivity : 720 μS/cm
  - . Temperature : 18 ℃
  - . Water level : 44 m

- Third stage (strainer depth: 44 - 50 m)
  - . Discharge : nil

b. The second Water Sampling (drilling end: 300 m)

- First stage (strainer depth: 159 - 165 m)
  - . Discharge : nil

These results show that upper part is good aquifer and lower part has less possibility to bear water. Accordingly, the casing installation upto 107 m and cleaning of lower part into the bottom have been determined between WAPDA Hydrogeology Project and JICA Study Team. 10" dia. strainer were installed between 47 and 53 m, 56 and 62 m and 64 and 97 m. Its total length becomes 45 m.

5) Pumping Test

After the preliminary pumping test for 5 days, the step drawdown, continuous discharge and recovery tests were undertaken. The results of these tests are as follows:

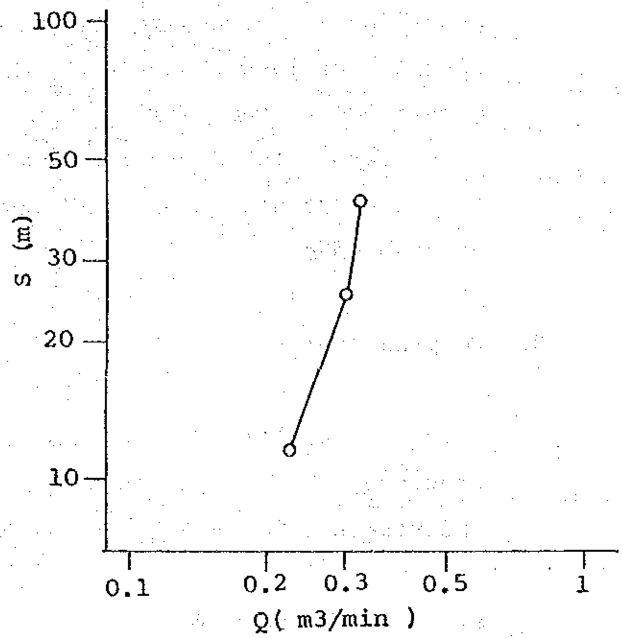
a. Step Drawdown Test

The step drawdown test of three (3) steps were performed. The results are as follows;

No.	Discharge	Drawdown	Specific Capacity	Remarks
1	60 gpm (0.227 m^3/min)	11.34 m		
2	80 gpm (0.303 ")	25.44 m	17 m^3/d/m	Static water level 44.11 m
3	85 gpm (0.322 ")	40.41 m		

The above figures are plotted on log-log paper and a step drawdown curve is obtained.

In general, its curve has the slope of angle 45° in the lower part and changes to over 45° at the some point in the upper part. At this changing point, the critical discharge is obtained and the optimum discharge is 80% of it.



Since the slope of the curve is over 45° wholly, the critical discharge of this well cannot be obtained. One of the causes is the exposure of the strainer at its upper portion.

Judging from the sand content in the sample through the process of the pumping tests, 80 gpm (0.303 m^3/min) in the second step of the step drawdown test in which the sand content is 10 to 50 ppm would be the suitable maximum discharge of this well. Allowable standard discharge of the submergible pump in Japan is 50 ppm for example.

The specific capacity would be 17 m^3/d/m taking the value at that time.

b. Continuous Discharge and Recovery Tests

The continuous discharge test with 80 gpm ($0.303\ m^3/min$) and the depression test were undertaken.

After the test operation for 24 hours, the pumping was stopped and the recovery test was conducted. Through these tests, the aquifer coefficients (transmissibility, permeability and storage) were calculated as follows:

- Theis Method

  As shown in FIG. A-4.5.7, the depression test results are drawn as $s - r^2/t$ curve on log-log paper which takes drawdown (s) on the vertical axis and r^2/t (r: in general, distance from this well to observation, but in this case, radius of this well, t: time from the start of pumping) on the horizontal axis.

  Based on this graph and standard curve of W(u)-u, the aquifer coefficients are obtained using the following Theis Equation.

$$T = \frac{Q}{4\pi s} W(u)$$

$$S = \frac{4uTt}{r^2}$$

$$K = \frac{T}{M}$$

Where;

T:	transmissibility ($m^3/min/m$)
Q:	discharge ($0.303\ m^3/min$)
s:	drawdown (17.7 m)
W(u):	well function (5),
u:	well function (2×10^{-3})
S:	storage
r^2/t:	(radius of well)^2/time ($8.9 \times 10^{-4}\ m^2/min$)
K:	permeability (cm/sec)
M:	aquifer thickness (45 m)

$$T = \frac{0.303 \times 5}{4 \times 3.14 \times 17.7} = 6.81 \times 10^{-3}\ m^3/min/m$$

$$S = \frac{4 \times 2 \times 10^{-3} \times 6.81 \times 10^{-3}}{8.9 \times 10^{-4}} = 6.12 \times 10^{-2}$$

$$K = \frac{6.81 \times 10^{-3} \times 100}{45 \times 60} = 2.52 \times 10^{-4}\ cm/sec$$

- Recovery Method

As shown in FIG. A-4.5.8, the recovery testresults are drawn as sr - t/t' curve on semi-log paper that takes drawdown (sr) on the ordinary scale and t/t' (t: time from the start of pumping, t': time from theend of pumping) on the log scale. From this curve, Δsr that is thedrawdown in one cycle of log t/t' is obtained and the aquifer coefficients are calculated using the following equation.

$$T = \frac{0.183Q}{\Delta sr}$$

$$K = \frac{T}{M}$$

Where;

T: transmissibility ($m^3/d/m$)

Q: discharge (0.303 m^3/min)

Δsr: drawdown in one cycle of log t/t (8.0 m)

K: permeability (cm/sec)

M: aquifer thickness (45 m)

$$T = \frac{0.183 \times 0.303}{8.00} = 6.93 \times 10^{-3}\ m^3/min/m$$

$$K = \frac{6.93 \times 10^{-3} \times 100}{45 \times 60} = 2.57 \times 10^{-4}\ cm/sec$$

The summary of the results obtained through above two methods is as follows:

Method	Transmissibility(T)	Permeability(K)	Storage(S)
	$m^3/min/m$	cm/sec	
Theis	6.81×10^{-3}	2.52×10^{-4}	6.12×10^{-2}
Recovery	6.93×10^{-3}	2.57×10^{-4}	-
Average	6.87×10^{-3}	2.55×10^{-4}	6.12×10^{-2}

c. Circle of Influence

The influence to nearly wells is calculated using Theis Equation.

$$T = \frac{Q}{4\pi s} W(u)$$

$$S = \frac{4uTt}{r^2}$$

Where;

T: 6.87×10^{-3} $m^3/min/m$

s: 0.01 m (supposing the influence of drawdown is 1 cm)

S: 6.12×10^{-2}

t: 1080 min (operation for 18 hours a day)

Q: 0.303 m^3/min

R: r (distance upto the place whichgive the influence of 1 cm drawdown)

$$W(u) = \frac{4\pi Ts}{Q} = \frac{4 \times 3.14 \times 6.87 \times 10^{-3} \times 0.01}{0.303}$$

$$= 0.00285$$

From u - W(u) function table, u that correspond to W(u) of 0.00285 is 4.2. R (circle of influence) is calculated as follows:

$$R = \sqrt{\frac{4Ttu}{S}} = \sqrt{\frac{4 \times 6.87 \times 10^{-3} \times 1080 \times 4.2}{0.0612}}$$

$$\fallingdotseq 45 \text{ m}$$

Therefore, the wells that are located far from this well by more than 45 m will not be influenced.

6) Conclusion

Specific capacity of 17 m3/d/m was obtained from the pumping test. this was not able to attain fairly to primary expected value.

It is judged, from viewpoint of the geology, that the Quaternary formation is good condition for aquifer due to rich gravel layers but base rock in deeper portion is not good due to poor limestone thickness as same as KL-JICA-1, even if there is limestone layer of 8 m thick at 160 m and it is expected to has permeability according to electric log curves.

Based on the pumping test results, it is estimated that transmissibility coefficient is 6.87 x 10^{-3} m^3/min/m, permeability 2.55 x 10^{-4} cm/sec and storage 6.12 x 10^{-2}.

(3) KL-JICA-3

1) Progress

Gravel rich layers continue from 9 m to 108 m and then change to clay. Gravel layer appears again at 186 m and continues upto 205 m from where limestone layer starts. The drilling was stopped at 210 m. Then electric logging and water sampling tests were performed. The limestone layer continues upto 252 m and then changes to combined layer of shale and limestone. It changes to clay at 263 m. The drilling was stopped at 300 m. After that, the second electric logging and water sampling tests were performed. After these tests, the instalation of 10" casing in its upper portion and pumping test were undertaked.

2) Electric Logging

The logging results show the following: High resistivity is recorded from 9 m to 108 m due to gravel rich layers. The ground layers enter clay layer at 108 m and change to high resistivity layer at 180 m. This continues upto 220 m corresponding to gravel upto 205 m and limestone layer is found in deeper part. It is expected that this limestone layer is permeable due to its sharp curve and that it is good aquifer because it is fairly thick. From 220 m, thecurves change to low resistivity and it continues upto the bottom.

3) Drilling Rate

The data show that soft layer is from the depth of 0 m to 264 m and hard layer is in deeper part. It is expected that the Quaternary and Tertiary formations are upto around 260 m and Mesozoic formation in deeper part.

4) Water Sampling Test

a. The first Water Sampling (drilling end: 210 m)

- First stage (strainer depth: 187 - 193 m)
  - . Discharge : 0.5 gpm (1.8 l/min)
  - . Conductivity : 1,150 μ S/cm
  - . Temperature : 18.3 C
  - . Water level : 51.5 m

- Second stage (strainer depth: 94 - 100 m)
  - . Discharge : 35 gpm (132 l/min)
  - . Conductivity : 1,300 μ S/cm
  - . Temperature : 18.3 C
  - . Water level : 51.5 m

- Third stage (strainer depth: 70 - 76 m)
  . Discharge : 10 gpm (37 l/min)
  . Conductivity : 1,150 μS/cm
  . Temperature : 18.3 C
  . Water level : 51.5 m

b. The Second Water Sampling (drilling end: 300 m)

- First stage (composite strainer depth:
  203 - 208 m
  215 - 220 m
  238 - 243 m)
  . Discharge : nil

These tests show that upper part has high possibility to be good aquifer and lower part has less. Therefore the casing upto the depth of 120 m and cleaning of lower part upto the bottom have been determined. 10" dia. strainer is installed at 54 - 57 m, 61 - 67 m, 69 - 93 m, 95 - 104 m and 107 - 110 m. The total length becomes 45 m.

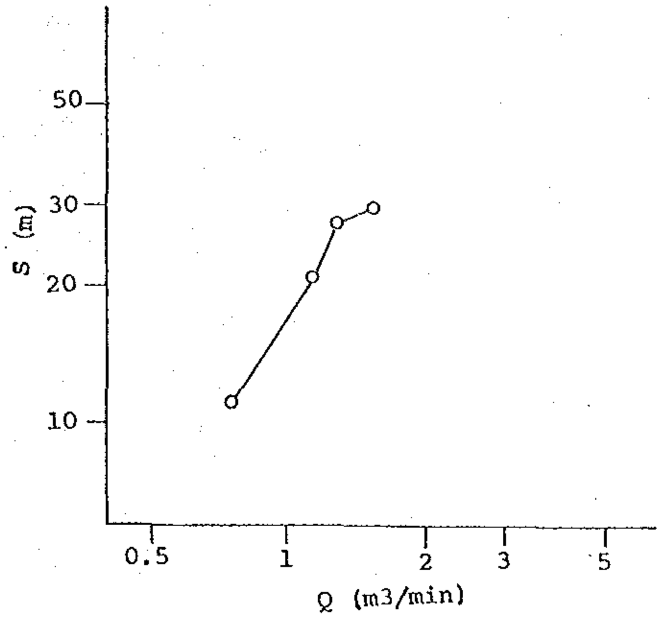
5) Pumping Test

Afterthe preliminary pumping test for 4 days, the step drawdown, continuous discharge and recovery tests were conducted. The results of these tests are as follows:

a. Step Drawdown Test

The test results are as follows.

No.	Discharge	Drawdown	Specific Capacity	Remarks
1	200 gpm (0.757 m^3/min)	11.20 m		Static water level 51.69 m
2	300 gpm (1.136 ")	20.94 m	78 m^3/d/m	
3	336 gpm (1.272 ")	27.90 m		
4	400 gpm (1.514 ")	29.55 m		



Since the slope of th curve is over 45° wholly, the critical discharge cannot be obtained. Judging from the sand content in the sample through the pumping tests, 300 gpm (1.136 m^3/min) in the second step of the step drawdown test would be the suitable maximum discharge of this well, because the sand content in the third step is much in the beginning of the pumping.

The specific capacity would be 78 m^3/d/m taking the value at that time.

b. Continuous Discharge and Recovery Tests

The continuous discharge test with 336 gpm (1.272 m^3/min) and the depression test were undertaken.

- Theis Method

$$T = \frac{1.272 \times 10}{4 \times 3.14 \times 20.5} = 4.94 \times 10^{-2}\ m^3/min/m$$

$$S = \frac{4 \times 7 \times 10^{-6} \times 4.94 \times 10^{-2}}{2.65 \times 10^{-4}} = 5.22 \times 10^{-3}$$

$$K = \frac{4.94 \times 10^{-2} \times 100}{45 \times 60} = 1.83 \times 10^{-3}\ cm/sec$$

- Recovery Curve Method

$$T = \frac{0.183 \times 1.272}{2.8} = 8.31 \times 10^{-2}\ m^3/min/m$$

$$K = \frac{8.31 \times 10^{-2} \times 100}{45 \times 60} = 3.08 \times 10^{-3}\ cm/sec$$

Method	Transmissibility(T)	Permeability(K)	Storage(S)
	$m^3/min/m$	cm/sec	
Theis	4.94×10^{-2}	1.83×10^{-3}	5.22×10^{-3}
Recovery	8.31×10^{-2}	3.08×10^{-3}	-
Average	6.63×10^{-2}	3.06×10^{-3}	5.22×10^{-3}

c. Circle of Influence

$$W(u) = \frac{4 \times 3.14 \times 6.63 \times 10^{-2} \times 0.01}{1.136} = 0.00733$$

$$R = \sqrt{\frac{4Ttu}{S}} = \sqrt{\frac{4 \times 6.63 \times 10^{-2} \times 1080 \times 3.5}{5.22 \times 10^{-3}}}$$

$$= 438\ m$$

There fore, the wells that are located far from this well by more than 438 m will not be influenced.

6) Conclusion

The pumping test results show the specific capacity of 78 $m^3/d/m$. This is a good well closing to primarily expected one.

It is expected that much of the discharge will be flowing from gravel layers but some volume may be from gravel (at the depth around 190 m) and limestone (may be the Tertiary formation) in base rock because its relatively high resistivity and fair thickness according to electric log. Therefore, if well test is performed in the area where the Tertiary limestone layers are developed, it will be very hopeful.

Based on the pumping test results, it is estimated that the transmissibility coefficient is 6.63×10^{-2} $m^3/min/m$, permeability 2.46×10^{-3} cm/sec and storage 5.22×10^{-3}.

(4) QT-JICA-1

1) Progress

Gravel predominant layers continue between depth 3 m and 105 m and then change to limestone of base rock. Limestone layer continues upto 205 m the bottom of well. Then electric logging and water sampling tests were performed. Now reaming for 10" dia. casing installation in its upper portion is in progress.

2) Electric Log

The curves show that the high resistivity layer excels upto 105 m, corresponding to gravel rich layers of Quaternary formation. From the above depth, the layer with higher resistivity continues upto 205 m of the drilling end, corresponding to limestone layer of the base rock i.e. Mesozoic formation. The resistivity curve of thebase rock shows that its shape in the middle part is flat but its upper and lower parts are wavy. It is expected that the former may have less fracture due to the block-like rock but that the latter will be good fractured zone.

3) Water Sampling Test

The results are as follows.

- First Stage (strainer depth: 194 - 200 m)
  - . Discharge : 20 gpm (76 l/min)
  - . Conductivity : 800μS/cm

- Second Stage (strainer depth: 176.5 - 182.5 m)
  - . Discharge : 16 gpm (61 l/min)
  - . Conductivity : 800μS/cm

- Third Stage (strainer depth: 144 - 150 m)
  - . Discharge : 4 gpm (15 l/min)
  - . Conductivity : 820μS/cm
  - . Water level : 110 m

These tests show the limestone layer in base rock is a good aquifer. Accordingly, 10" dia. casing installation upto the depth of 135 m and cleaning of lower part upto the bottom are in progress.

(5) QT-JICA-2

1) Progress

Almost all clay layers continue from the depth of 0 m to 163 m containing very thin gravel layer at 39 - 40 m and 49 - 50.5 m. Then these change to limestone layer of base rock and continue upto the depth of 263 m, the bottom of the well. Through these drilling, there were no sign of fissure zone according to mud losses. Then electric logging and water pumping tests were performed. The reaming for 10" dia. casing installation in its upper portion is being undertaken.

2) Electric Log

The low resistivity layer that reflects clay continues upto 163 m (the same result can be obtained from the lithological log). Then, thehigh resistivity layer that reflects limestone of the base rock i.e. Mesozoic formation appears and continues upto 263 m of the drilling end. Since the shape of the resistivity curve in the base rock is wavy, these sections will be good fractured zone.

3) Water Sampling Test

The results are as follows.

- First stage (strainer depth: 256 - 262 m)
  - . Discharge : nil

- Second stage (strainer depth: 227.5 - 233.5 m)
  - . Discharge : 0
  - . Conductivity : 1,700 μS/cm

- third stage (strainer depth: 212 - 218 m)
  - . Discharge : 35 gpm (132 l/min)
  - . Conductivity : 1,600 μS/cm

- fourth stage (strainer depth: 188 - 194 m)
  - . Discharge : 28 gpm (106 l/min)
  - . Conductivity : 1,600 μS/cm

- fifth stage (strainer depth: 163 - 169 m)
  - . Discharge : 25 gpm (95 l/min)
  - . Conductivity : 1,280 μS/cm
  - . Water level : 65 m

The test results show to be good aquifer of limestone in bed rock. Therefore the composite casing installation of 10" and 6" dia. (10": 0 - 160 m, 6": 160 - 248 m) were determined. 6" dia. strainer installations are plan to be 162.20 - 169.51 m, 171.95 - 174.39 m, 176.83 - 184.15 m, 190.55 - 202.74 m, 207.62 - 210.06 m, 213.11 - 215.55 m, 217.99 - 232.62 m, 234.45 - 236.89 m and 239.33 - 241.77 m. These total lengths will be 53.65 m.

Now the reaming for 10" dia. casing in its upper portion is being undertaken.

TABLE A-4.5.1 Tube Well Development of KL-JICA-2

Name of well	:	KL-JICA-2	Time date started	:	09:00 10 Nov.1987
Time date completed	:	09:00 21 Nov.1987	Static water level	:	44.45 m AGL (as of 9 Nov.1987)
Pump settinf depth	:	103.04 m	Stick up	:	0.50 m AGL
Orifice size 3", inner dia. of discharge pipe 5"			Initial sounding	:	104.1 m

Date/Time (hr)	Head (m)	Dischage USGPM(ℓ /sec)	Pumping water level (m)	Temparature (℃)	E/conductivity (μs/cm)	Sand contain (PPM)	Remarks
10/11/1987	0.08						
09:00	~0.15	60~80(3.8~5.0)	—	—	—	—	pumping started, water and cutting of gravel
09:30	0.13	77 (4.85)	79.80	—	—	—	with and and silt back wash after after 10
10:00	0.10	69~77(4.3~4.9)	81.90	—	—	—	minutes, water became muddy
10:30	~0.12	77 (4.85)	81.90	—	—	3,000 ~ 400	after back wash
11:00	0.12	77 (4.85)	81.90	—	—	"	"
11:30	0.12	77 (4.85)	—	—	—	"	
12:00	0.12	—	—	—	—	600	
12:30	0.30	119 (7.50)	—	—	—	—	suction breaks after 2 minutes
13:00	—	—	—	—	—	—	back wash
13:50	0.13	77 (4.85)	79.90	—	—	—	
14:30	0.13	77 (4.85)	80.30	—	—	—	
15:00	0.13	175 (11.03)	80.60	—	—	—	
15:30	0.13	175 (11.03)	80.30	—	—	—	
16:00	0.13	175 (11.03)	80.45	—	—	—	water became muddy after back wash
16:30	0.13	175 (11.03)	80.50	—	—	—	water muddy after back wash
17:00	—	—	—	—	—	—	
17:30	—	—	—	—	—	—	accelerating the R.P.M. back wash
18:00	0.13	175 (11.03)	80.70	—	—	—	water clear after 20 minutes
11/11/1987							
09:45	—	—	—	—	—	—	turbine lowered upto 103 meters
10:00	0.15	84 (5.29)	80.60	—	—	—	water muddy w/cutting of gravel & bentonite
10:50	0.15	84 (5.29)	80.50	19	1,600	300	
11:15	0.18	91 (5.73)	—	—		11,000~2000	after back wash
12:45	0.15	84 (5.29)	82.90	18-	1,600	—	
13:15	0.14	81 (5.10)	83.10	18	1,600	400	
14:00	0.15	84 (5.29)	82.95	18	1,600	500	
14:45	0.14	81 (5.10)	83.25	—	—	—	
15:30	0.13	77 (4.85)	83.30	18	1,600	200	
16:00	0.14	81 (5.10)	83.20	—	—	80	
17:00	0.14	81 (5.10)	83.10	—	—	50	
18:00	0.13	77 (4.85)	83.80	—	—	—	

(to be cont'd)

(cont'd)

Date/Time (hr)	Head (m)	Dischage USGPM(ℓ /sec)	Pumping water level (m)	Temparature (℃)	E/conductivity (μs/cm)	Sand contain (PPM)	Remarks
12/11/1987							
10:00	0.14	—	—	—			turbine started E/Tape no in order
10:45	0.13	81 (5.10)	—	19	1,600	1,200	
12:00	0.13	77 (4.85)	—	—		—	
13:00	0.13	77 (4.85)	—	19	1,600	1,100	after back wash
14:00	0.13	77 (4.85)	—		—	1,000	"
15:00	0.13	77 (4.85)	—	19	1,600	2,000	
16:00	0.13	77 (4.85)	—	19	1,600	800	
17:00	0.14	81 (5.10)	78.20	19	1,600	400	5 minutes after back wash, turbine stopped
18:00	0.13	77 (4.85)	78.80	19	—	—	
13/11/1987							
10:00	0.14	81 (5.10)	—	—	—	—	E/Tape out of order
10:45	0.13	77 (4.85)	—	19	1,600	1,200	5 minutes after back wash
12:00	0.13	77 (4.85)	—	19	1,600	1,250	"
13:00	0.13	77 (4.85)	—	19	1,600	1,100	
14:00	0.13	77 (4.85)	—	19	1,600	1,000	
15:00	0.13	77 (4.85)	—	19	1,600	1,000	
16:00	0.13	77 (4.85)	—	19	1,600	2,000	
17:00	0.13	77 (4.85)	—	19	1,600	1,000	
18:00	0.13	77 (4.85)	—	19	1,600	800	turbine stopped
14/11/1987							
08:30	0.15	84 (5.29)	—	—	—	—	
09:30	0.15	84 (5.29)	—	19	1,600	100	
10:30	0.15	84 (5.29)	—	—	—	75	
12:00	0.15	84 (5.29)	—	—	—	50	
13:00	0.15	84 (5.29)	—	—	—	50	
14:00	0.14	81 (5.10)	—	—	—	50	
15:00	0.14	81 (5.10)	—	—	—	50	
16:00	0.14	81 (5.10)	—	—	—	40	
17:00	0.15	84 (5.29)	—	—	—	40	
18:00	0.15	84 (5.29)	—	—	—	40	

TABLE A-4.5.2 Stepdown Pumping Test of KL-JICA-2
(Stage I; Q=3.87 l/sec)

Static water level : 46.63 m
Stick up : 0.50 m
Date : 15 Nov.1987

Date Time (Hr)	Elapsed Time (minute)	Pumping Water Level (m)	Drawdown (m)	Head (m)	Discharge USGPM (ℓ /sec)	Sand cond. (ppm)	Tempe-rature (℃)	Electric Conduct. (μs/cm)	Remarks
1001	1	54.85	8.22	0.07		20	18	1,200	
	5	55.85	9.22	0.07					
	10	56.03	9.40	0.07		20	19	1,250	
	15	58.55	11.92	0.07	60.00	20	19	1,250	
	30	57.93	11.30	0.07	(3.78)	20	19	1,250	
	45	57.88	11.25	0.07		20	19	1,250	
	60	58.55	11.92	0.07		20	19	1,250	
	75	57.85	11.22	0.07		20	19	1,250	Specific
	90	58.00	11.37	0.07		10	19	1,150	Capacity
	105	57.59	10.96	0.07		10	19	1,150	1.60gpm/ft
	120	57.97	11.34	0.07		10	19	1,150	28.6m3/d/m

TABLE A-4.5.3 Stepdown Pumping Test of KL-JICA-2
(Stage I; Q=5.36 l/sec)

Static water level : 46.63 m
Stick up : 0.50 m
Date : 15 Nov.1987

Date Time (Hr)	Elapsed Time (minute)	Pumping Water Level (m)	Drawdown (m)	Head (m)	Discharge USGPM (ℓ /sec)	Sand cond. (ppm)	Tempe-rature (℃)	Electric Conduct. (μs/cm)	Remarks
1201	1	61.3	14.70	0.15		10	19	1,125	
	5	60.35	19.72	0.15					
	10	70.45	23.82	0.15					
	15	73.69	27.06	0.15					
	30	77.70	31.07	0.15		100	18	1,120	water turb
	45	81.88	35.25	0.15	85.00	50	18	1,100	id
	60	81.97	35.34	0.15	(5.36)	50	18	1,100	
	75	82.64	36.01	0.15		50	18	1,100	Specific
	90	84.65	38.02	0.15		25	18	1,100	Capacity
	105	86.26	39.63	0.15		20	18	1,100	0.64gpm/ft
1400	120	87.04	40.41	0.15		15	18	1,100	11.4m3/d/m

TABLE A-4.5.4 Constant Discharge Pumping Test of KL-JICA-2

Static water level : 44.61 m
Stick up : 0.50 m
Date : 16 Nov.1987

Date Time (Hr)	Elapsed Time (minute)	Pumping Water Level (m)	Drawdown (m)	Head (m)	Discharge USGPM (ℓ /sec)	Sand cond. (ppm)	Tempe-rature (℃)	Electric Conduct. (μs/cm)	Remarks
1001	1	55.75	11.14	0.13					
	1.5	56.23	11.62	0.13					
	2	56.73	12.12	0.13					
	2.5	57.25	12.64	0.13					
	3	58.08	13.47	0.13		300			water rust
	4	59.11	14.50	0.13					y
	5	60.50	15.89	0.13		100	16	1,280	water clea
	6.5	60.82	16.21	0.13					r
	8	63.37	18.76	0.13					
	10	64.77	20.16	0.13		50	17	1,300	
	20	68.09	23.48	0.13		25	18	1,300	
1030	30	68.89	24.28	0.13		15	18	1,300	
	40	69.35	24.74	0.13		10	18	1,300	
	50	69.37	24.76	0.13					
	60	69.35	24.74	0.13					
	70	70.50	25.89	0.13		25	18	1,300	
	80	71.05	26.44	0.13					
	90	71.80	27.19	0.13					
	100	71.81	27.20	0.13		10	18	1,300	
	130	72.78	28.17	0.13					
	160	72.88	28.27	0.13	80.00	10	18	1,300	
	190	73.22	28.61	0.13	(5.04)				
	220	73.13	28.52	0.13			18	1,300	
	250	73.15	28.54	0.13		10			
	280	73.25	28.64	0.13			18	1,300	
	310	73.35	28.74	0.13		20			
	430	73.50	28.89	0.13		20			
	490	73.35	28.72	0.13		10			
	550	73.37	28.76	0.13		10			
	650	73.50	28.89	0.13		50			
	750	73.20	28.59	0.13		75			
	850	72.85	28.24	0.13		100			
	950	70.05	25.44	0.13		100			Specific
	1,150	70.00	25.39	0.13		50			Capacity
	1,340	70.05	25.44	0.13		50			0.95gpm/ft
	1,440	74.77	30.15	0.13		50			17.0m3/d/m

TABLE A-4.5.5 Recovery Test Data

Test well no. : KL-JICA-2
Recovery started : 17 Nov.1987
Recovery completed : 18 Nov.1987
Static water level BGL : 44.61
Total pumping time : 1,440 minutes
Observed by : S.M.Mohiuddin(Geologist)

Date Time Hours	Elapsed Time (minutes)	Water Level Measurement		t / t1	Remarks
		Water level from MP(m)	Residual D/D (m)		
17/NOV 10:01	1	53.52	8.91	1,441.00	
	1.5	52.33	7.72	961.00	
	2	51.27	6.66	721.00	
	2.5	50.30	5.69	577.00	
	3	49.49	4.88	481.00	
	4	48.23	3.62	361.00	
	5	47.34	2.74	289.00	
	6.5	46.55	1.94	222.53	
	8	46.07	1.46	181.00	
	10	45.79	1.18	145.00	
	20	45.51	0.90	73.00	
	30	45.45	0.84	49.00	
	40	45.35	0.74	37.00	
	50	45.35	0.74	29.80	
	60	45.31	0.70	25.00	
	70	45.27	0.66	21.57	
	80	45.19	0.58	19.00	
	90	45.16	0.55	17.00	
	100	45.16	0.55	15.00	
	130	45.10	0.49	12.07	
	160	45.09	0.48	10.00	
	190	45.01	0.40	8.57	
	220	44.97	0.36	7.54	
	250	44.95	0.34	7.00	
	280	44.95	0.34	6.33	
	310	44.95	0.34	5.64	
	370	44.91	0.30	4.89	
	430	44.90	0.29	4.34	
	490	44.89	0.28	3.93	
	550	44.85	0.24	3.61	
	650	44.85	0.24	3.21	
	750	44.85	0.24	2.92	
18/NOV 00:10	850	44.83	0.22	2.69	
	950	44.82	0.21	2.51	
	1,150	44.81	0.20	2.25	
	1,350	44.80	0.19	2.06	
	1,440	44.78	0.17	2.00	
	1,560	44.67	0.06	1.90	

TABLE A-4.5.6 Tube Well Development

Name of well	: KL-JICA-3		Time date started	: 09:00 21 Nov.1987
Time date completed	: 22:00 25 Nov.1987		Static water level	: 52.03 m AGL
Pump setting depth	: 103.04 m		Stick up	: 0.06 m AGL
Orifice size 4", inner dia. of discharge pipe 5"			Initial sounding	: 112.00 m

Date/Time (hr)	Head (m)	Dischage USGPM(ℓ /sec)	Pumping water level (m)	Temparature (℃)	E/conductivity (μs/cm)	Sand contain (PPM)	R e m a r k s
21/10/1987							
09:00	0.25	246 (21.35)	—	-	—	10,000	pumping started, muddy water after back wash
10:00	0.25	246 (21.35)	67.77	-	—	18,000	
11:00	0.25	246 (21.35)	68.20	-	—	6,000	
12:00	0.36	293 (18.46)	69.40	-	—	5,000	
13:00	0.36	293 (18.46)	69.85	-	—	4,000	
14:00	0.36	293 (18.46)	70.00	-	—	3,500	
15:00	0.36	293 (18.46)	70.19	-	—	3,000	
16:00	0.36	293 (18.46)	73.80	-	—	2,000	
17:00	0.36	293 (18.46)	73.97	-	—	1,000	
18:00	0.36	293 (18.46)	73.97	19	1,200	1,000	
22/11/1987							
09:00	0.13	175 (11.03)	—	-	—	—	pumping started
10:00	0.13	175 (11.03)	56.95	-	—	2,000	
11:00	0.25	246 (15.50)	—	-	—	2,000	
12:00	0.64	390 (24.57)	87.85	-	—	4,000	
13:00	0.64	390 (24.57)	88.00	-	—	3,000	
14:00	0.25	246 (15.50)	69.85	-	—	1,000	
15:00	0.25	246 (15.50)	69.15	-	—	1,000	
16:00	0.25	246 (15.50)	69.95	-	—	1,000	
17:00	0.25	246 (15.50)	70.00	19	1,200	800	
18:00	0.25	246 (15.50)	70.00	19	1,200	800	
23/11/1987							
10:00	0.25	246 (15.50)	69.85	-	—	3,000	muddy water with sand and silt
11:00	0.25	246 (15.50)	—	-	—	2,000	
12:00	0.25	246 (15.50)	—	-	—	2,000	
13:00	0.25	246 (15.50)	—	-	—	2,000	
14:00	0.25	246 (15.50)	—	-	—	2,000	
15:00	0.25	246 (15.50)	—	-	—	1,500	
24/11/1987							diesel supply
25/11/1987							
09:00	0.25	246 (15.50)	68.30	-	—	1,000	
10:00	0.25	246 (15.50)	68.30	-	—	1,000	
11:00	0.25	246 (15.50)	—	-	—	900	
12:45	0.76	427 (26.90)	90.15	-	—	10,000	cutting of gravel, silt, sand and bentonite pulling out 18 m column pipe
16:00	0.43	322 (20.29)	—	-	—	2,000	
17:00	0.38	302 (19.03)	—	-	—	800	
18:00	0.18	206 (12.98)	—	-	—	1,000	
19:00	0.38	302 (19.03)	—	-	—	500	
20:00	0.51	350 (22.05)	—	-	—	500	
21:00	0.56	366 (23.06)	—	-	—	300	
22:00	0.56	366 (23.06)	—	-	—	70	

TABLE A-4.5.7 The First Stage Pumping Test for KL-JICA-3

Static water level : 52.15 Date : 26 Nov. 1987

Date Time (Hr)	Elapsed Time (minute)	Pumping Water Level (m)	Drawdown (m)	Head (m)	Discharge USGPM (ℓ /sec)	Sand cond. (ppm)	Tempe-rature (℃)	Electric Conduct. (μs/cm)	Remarks
0901	1	60.32	8.17	0.18		1,500			
	5	61.05	8.90	0.18		700	15		
	10	61.85	9.70	0.18		300	15		
	15	61.95	9.80	0.18		150	15		
	30	62.43	10.28	0.18	200.00	100			
	45	63.05	10.90	0.18	(12.6)	60	17		
	60	63.05	10.90	0.18		50			
	75	63.10	10.95	0.18		50	18		Specific
	90	63.25	11.10	0.18		50			Capacity
	105	63.37	11.22	0.18		40			5.44gpm/ft
	120	63.35	11.20	0.18		40	18		97.3m3/d/m

TABLE A-4.5.8 The Second Stage Pumping Test for KL-JICA-3

Static water level : 52.15 Date : 26 Nov. 1987

Date Time (Hr)	Elapsed Time (minute)	Pumping Water Level (m)	Drawdown (m)	Head (m)	Discharge USGPM (ℓ /sec)	Sand cond. (ppm)	Tempe-rature (℃)	Electric Conduct. (μs/cm)	Remarks
1101	1	67.53	15.38	0.38		800	19		
	5	70.19	18.04	0.38		600			
	10	70.78	18.63	0.38		200			
	15	71.00	18.85	0.38		150			
	30	71.37	19.22	0.38					
	45	71.95	19.80	0.38	300.00	500			
	60	72.49	20.34	0.38	(18.9)	100			
	75	72.55	20.40	0.38		100			Specific
	90	72.80	20.65	0.38		80			Capacity
	105	72.95	20.80	0.38		70			4.36gpm/ft
	120	73.09	20.94	0.38		60			78.0m3/d/m

TABLE A-4.5.9 The Third Stage Pumping Test for KL-JICA-3

Static water level : 52.15 Date : 26 Nov. 1987

Date Time (Hr)	Elapsed Time (minute)	Pumping Water Level (m)	Drawdown (m)	Head (m)	Discharge USGPM (ℓ /sec)	Sand cond. (ppm)	Tempe-rature (℃)	Electric Conduct. (μs/cm)	Remarks
1301	1	78.68	26.53	0.66		400			
	5	81.62	29.47	0.66	400.00	300			
	10	81.65	29.50	0.66	(25.2)				
	15	81.60	29.45	0.66	(63.0)				
	30	81.67	29.52	0.64	1,000.00				
	45	81.65	29.50	0.64	400.00				
	60	81.67	29.52	0.64	300.00				
	75	81.68	29.53	0.64	300.00				Specific
	90	81.69	29.54	0.64	100.00				Capacity
	105	81.67	29.52	0.64	60.00				4.12gpm/ft
	120	81.70	29.55	0.64	30.00				73.7m3/d/m

TABLE A-4.5.10 Pumping Test at Constant Discharge for KL-JICA-3

Static water level : 52.15 m from MP
Date : 27 Nov. 1987

Date Time (Hr)	Elapsed Time (minute)	Pumping Water Level (m)	Drawdown (m)	Head (m)	Discharge USGPM (ℓ /sec)	Sand cond. (ppm)	Tempe-rature (℃)	Electric Conduct. (μs/cm)	Remarks
1001	1.0								
	1.5	63.09	10.94	0.48		muddy			
	2.0	65.94	13.79	0.48					
	2.5	67.07	14.92	0.48					
	3	67.71	15.56	0.48					
	4	69.02	16.57	0.48		muddy, terbid			
	5	70.00	17.85	0.48		2,000			
	6.5	70.52	18.37	0.48					
	8	71.09	18.94	0.48					
	10	71.65	19.50	0.48		200			
	15	72.15	20.00	0.48					
	20	72.65	20.50	0.48					
	25	73.35	21.20	0.48					
	30	73.99	21.80	0.48		300			
	35	74.45	22.30	0.48					
	40	74.77	22.62	0.48					
	50	74.31	23.16	0.48	336.00				
	60	75.75	23.60	0.48	(21.2)	300			
	70	76.25	24.10	0.48					
	80	76.49	24.34	0.48					
	90	76.63	24.48	0.48		80			
	100	76.88	24.73	0.48					
	130	77.45	25.30	0.48		40			
	160	77.90	25.75	0.48					
	190	78.23	26.08	0.48		30			
	220	78.34	26.19	0.48					
	240	78.50	26.35	0.48					
	270	78.64	26.49	0.48		20			
	310	78.85	26.70	0.48		20			
	370	78.90	26.75	0.48		20			
	430	78.06	26.91	0.48		20			
	490	79.15	27.00	0.48		20			
	550	79.25	27.10	0.48		20			
	650	79.37	27.22	0.48		20			
	750	79.56	27.41	0.48		20			
	850	79.64	27.49	0.48		20			
	950	79.75	27.60	0.48		20			
	1,150	79.80	27.65	0.48		20			
	1,340	79.90	27.75	0.48		20			
	1,440	80.05	27.90	0.48		20			

TABLE A-4.5.11 Recovery Test Data

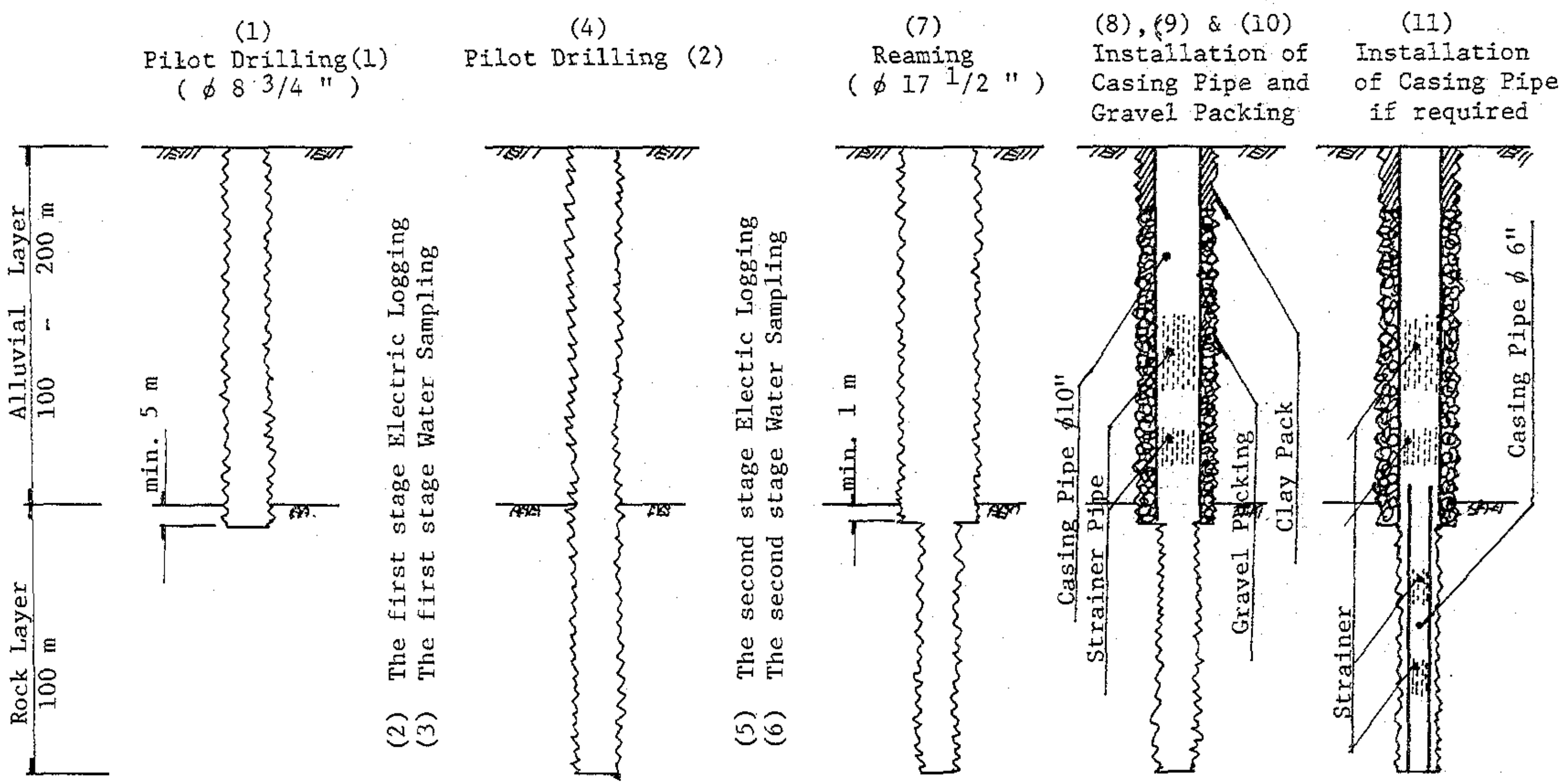
Test well no. : KL-JICA-3
Recovery started : 28 Nov.1987
Recovery completed : 29 Nov.1987
Static water level BGL : 51.69
Total pumping time : 1,440 minutes
Observed by : S.M.Mohiuddin(Geologist)

Date Time Hours	Elapsed Time (minutes)	Water Level Measurement		t / t'1	Remarks
		Water level from MP(m)	Residual D/D (m)		
	1	57.55	5.40	1,441.00	
	1.5	57.17	5.02	961.00	
	2	56.67	4.52	721.00	
	2.5	56.41	4.26	577.00	
	3	56.19	4.04	481.00	
	4	55.81	3.66	361.00	
	5	55.51	3.36	289.00	
	6.5	55.15	3.00	222.53	
	8	54.93	2.78	181.00	
	10	54.72	2.57	145.00	
	15	54.25	2.10	97.00	
	20	53.98	1.83	73.00	
	25	53.77	1.62	58.60	
	30	53.61	1.46	49.00	
	35	53.49	1.39	42.14	
	40	53.38	1.23	37.00	
	50	53.21	1.06	29.80	
	60	53.09	0.94	25.00	
	70	52.98	0.83	21.57	
	80	52.91	0.76	19.00	
	90	52.81	9.66	17.00	
	100	52.77	0.62	15.00	
	130	52.66	0.51	12.07	
	160	52.59	0.44	10.00	
	190	52.48	0.33	8.57	
	220	52.43	0.28	7.54	
	250	52.37	0.22	7.00	
	280	52.35	0.20	6.33	
	310	52.33	0.18	5.64	
	370	52.29	0.14	4.89	
	430	52.27	0.12	4.34	
	490	52.25	0.10	3.93	
	550	52.25	0.10	3.61	
	650	52.25	0.10	3.21	
	750	52.24	0.09	2.92	
	850	52.21	0.06	2.69	
	950	52.19	0.04	2.51	
	1,150	52.15	0.00	2.25	
	1,350	52.135	-0.015	2.06	
	1,440	52.12	-0.030	2.00	

FIG A-4.5.1 Work Schedule of Test Well

Well No.	Drilling Depth(m)			1987						1988		
	Alu.	Rock	Total	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
KL-JICA-1	103	197	300	15 ◎====	====	====◎ 17						
KL-JICA-2	150	150	300			21 ◎——	——	——◎ 27				
KL-JICA-3	205	95	300			28 ◎====	====	====	====◎ 3			
QT-JICA-1	105	100	205					18 ◎——	——◎ 20			
QT-JICA-2	163	100	263					15 ◎====	====◎ 15			
QT-JICA-3	*200	*100	*300						20 ◎——	——	——◎ 10	
QT-JICA-4	*200	*100	*300								◎ 10*	

Note : * indicates expected date or depth
◎====◎ WAPDA/TONE NO. 1 RIG
◎——◎ WAPDA/TONE NO. 2 RIG



Notes : 1. Submersible pump of ϕ 7-8" may be used for pumping test.
2. Maximum drilling length of test well shall be 300 m.
It may be reduced with max. penetration into rock layer of 100 m.
3. Upper casing pipe (ϕ 10 ") shall be penetrated into rock layer for min. 5 m.
4. Lower casing pipe will not be needed in case of good rock layer conditions.

FIG A-4.5.2 Procedure of Construction of Test Well

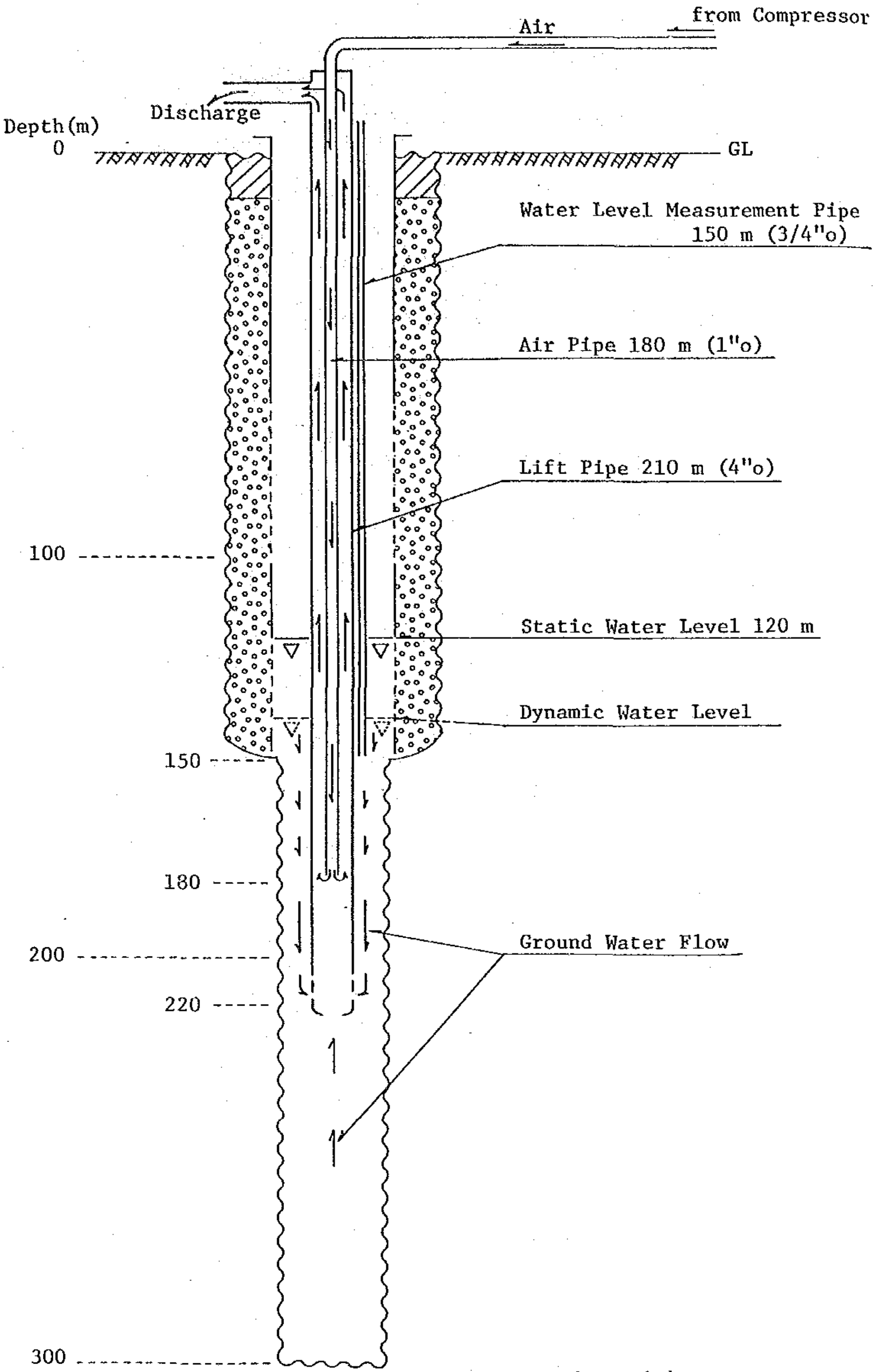


FIG A-4.5.3 Air Lift Pumping Test (example)

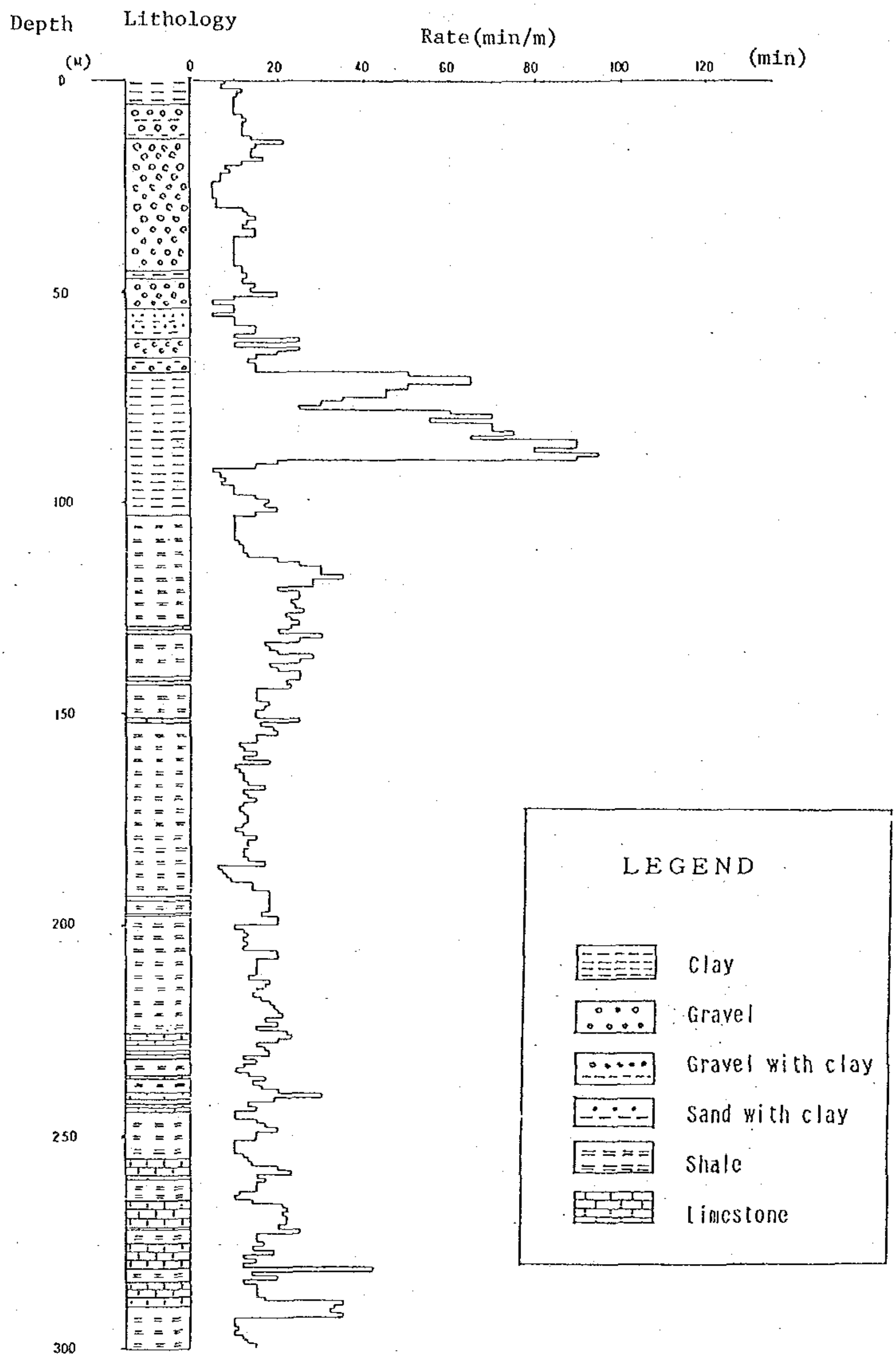
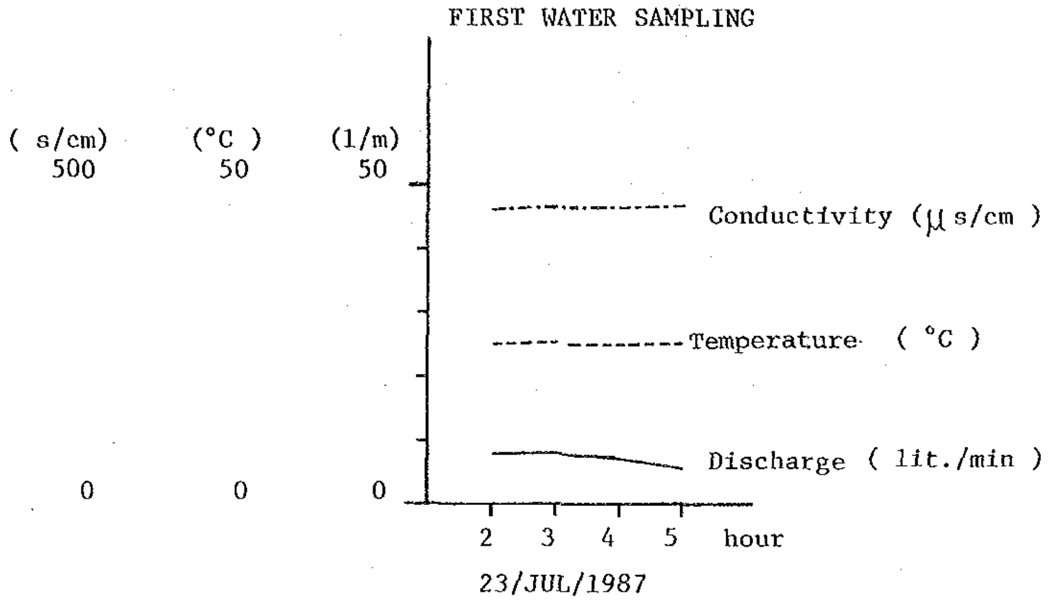


FIG A-4.5.4 Drilling Rate of KL-JICA-1



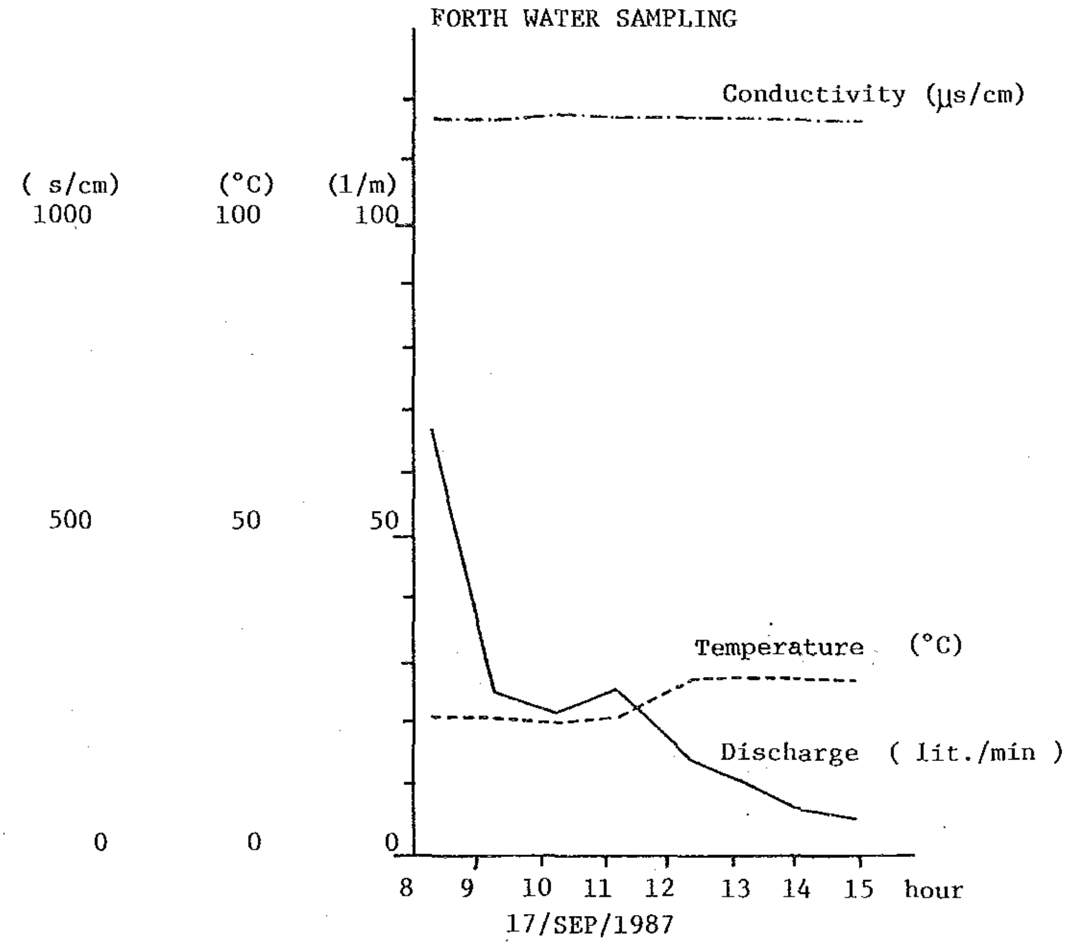


FIG A-4.5.5 Result of Water Sampling Test KL-JICA-1

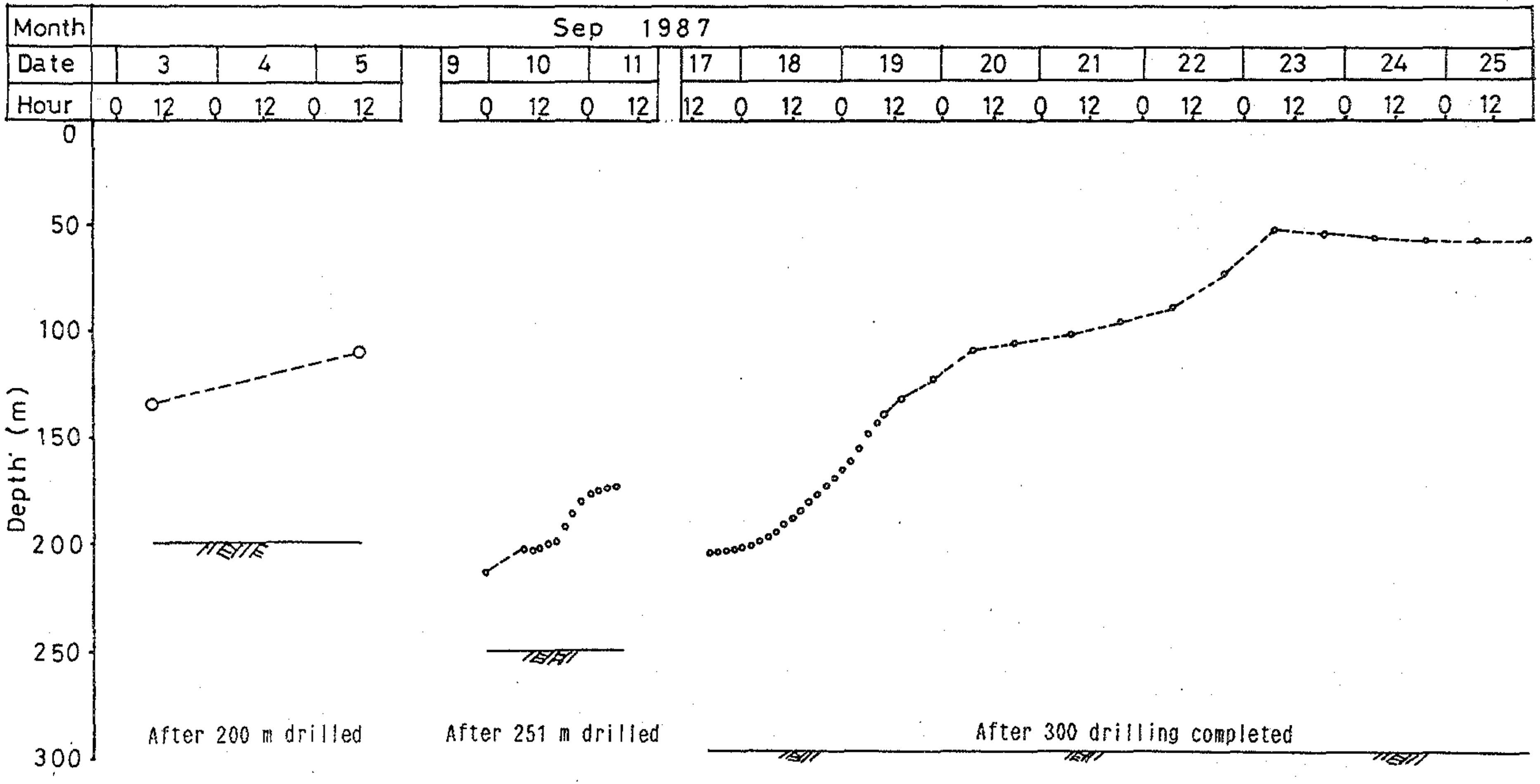


FIG A-4.5.6 Groundwater Table Observation at KL-JICA-1

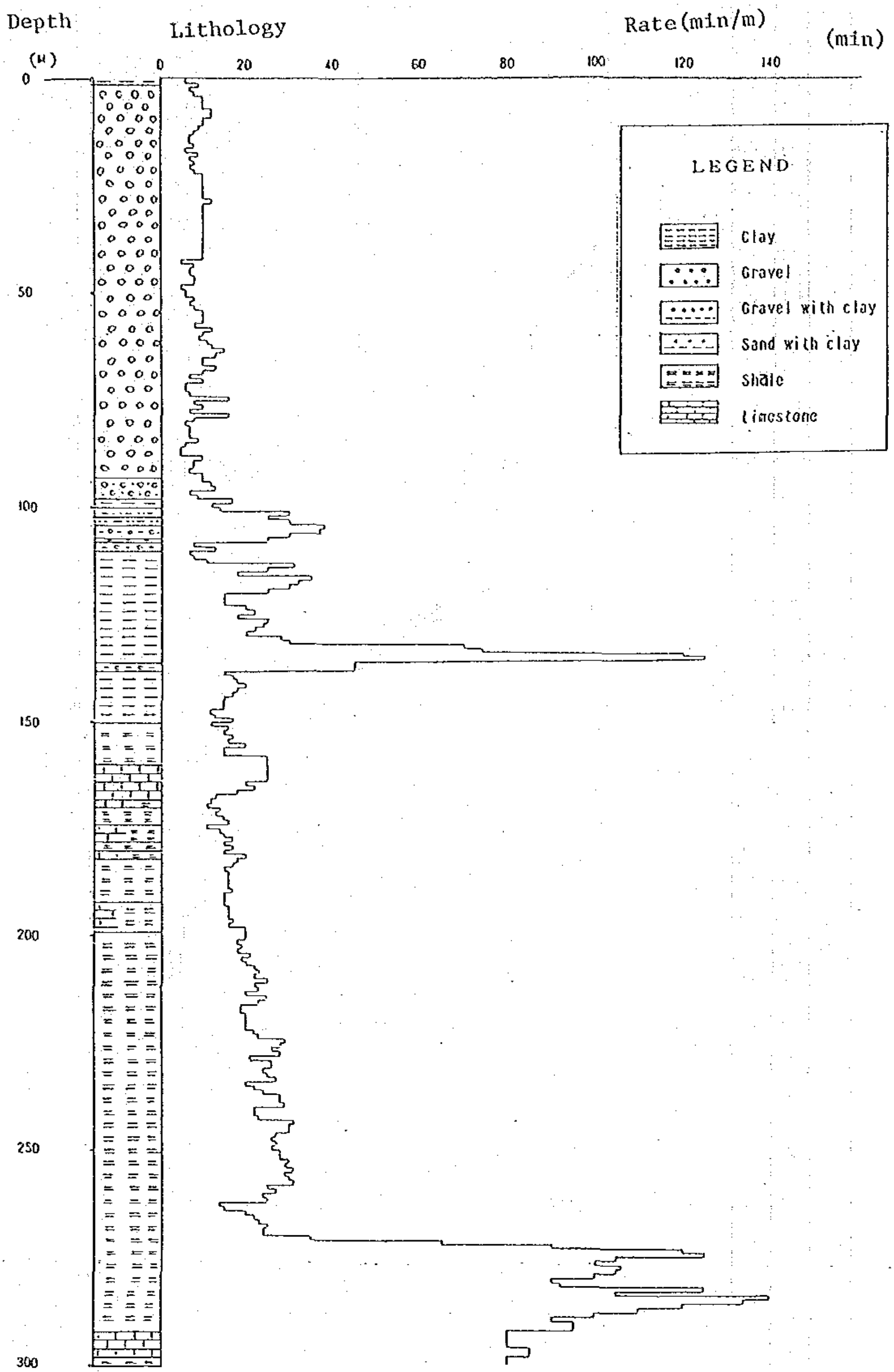
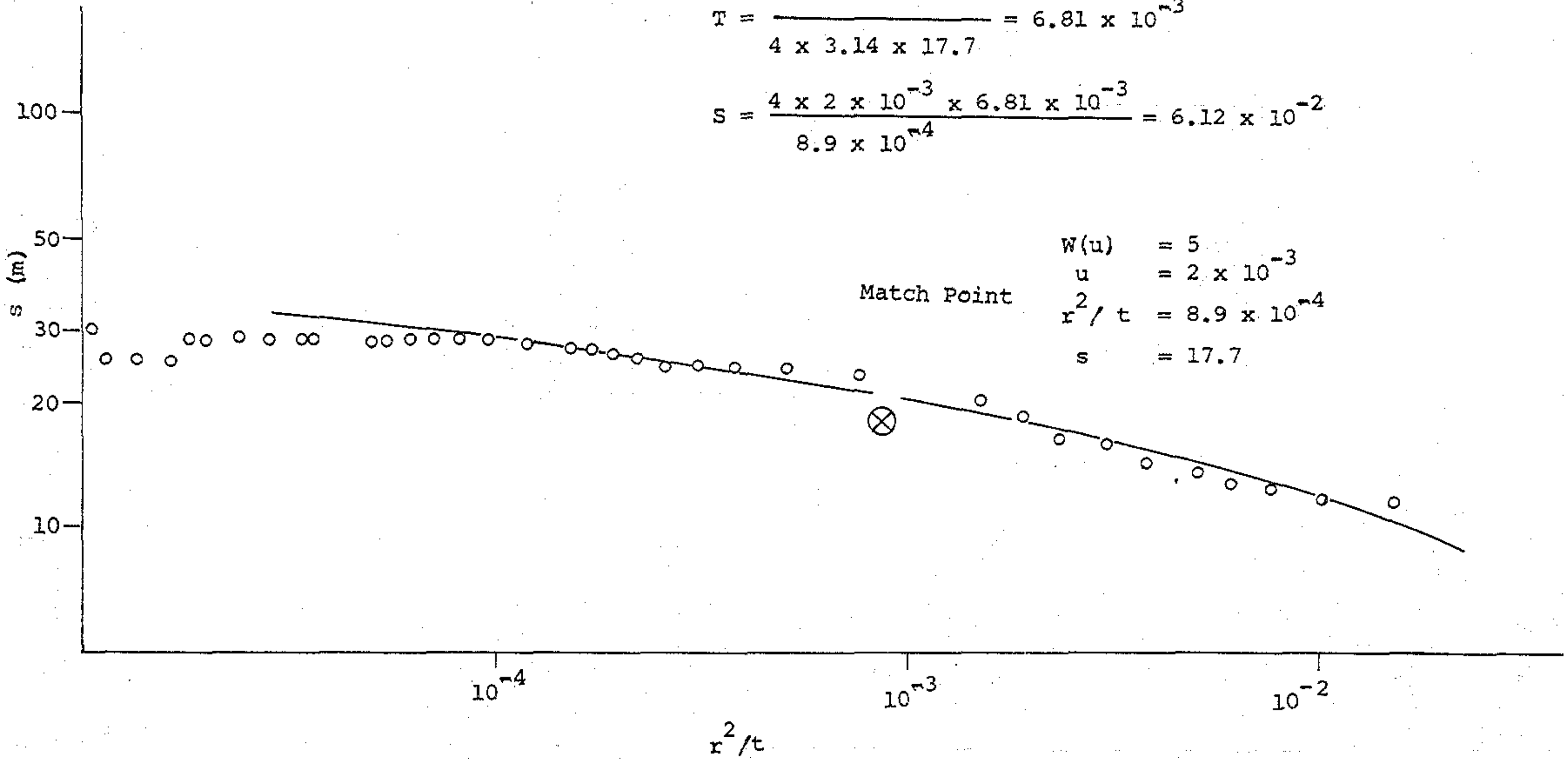


FIG A-4.5.7 Drilling Rate of KL-JICA-2



$$T = \frac{0.303 \times 5}{4 \times 3.14 \times 17.7} = 6.81 \times 10^{-3}$$

$$S = \frac{4 \times 2 \times 10^{-3} \times 6.81 \times 10^{-3}}{8.9 \times 10^{-4}} = 6.12 \times 10^{-2}$$

Match Point

$W(u) = 5$
$u = 2 \times 10^{-3}$
$r^2/t = 8.9 \times 10^{-4}$
$s = 17.7$

FIG A-4.5.8 S-r/t Curve in KL-JICA-2

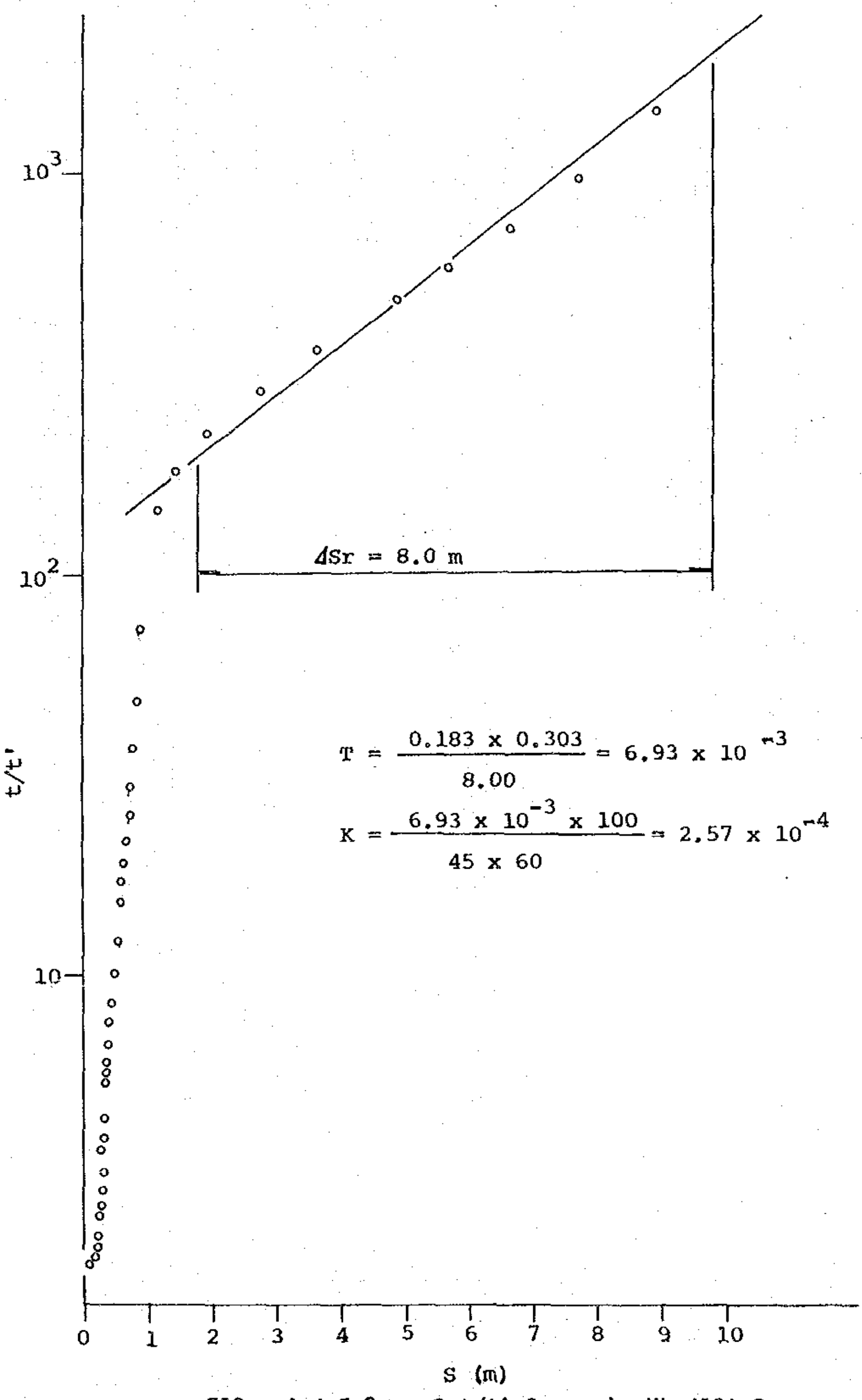


FIG A-4.5.9 S-t/t' Curve in KL-JICA-2

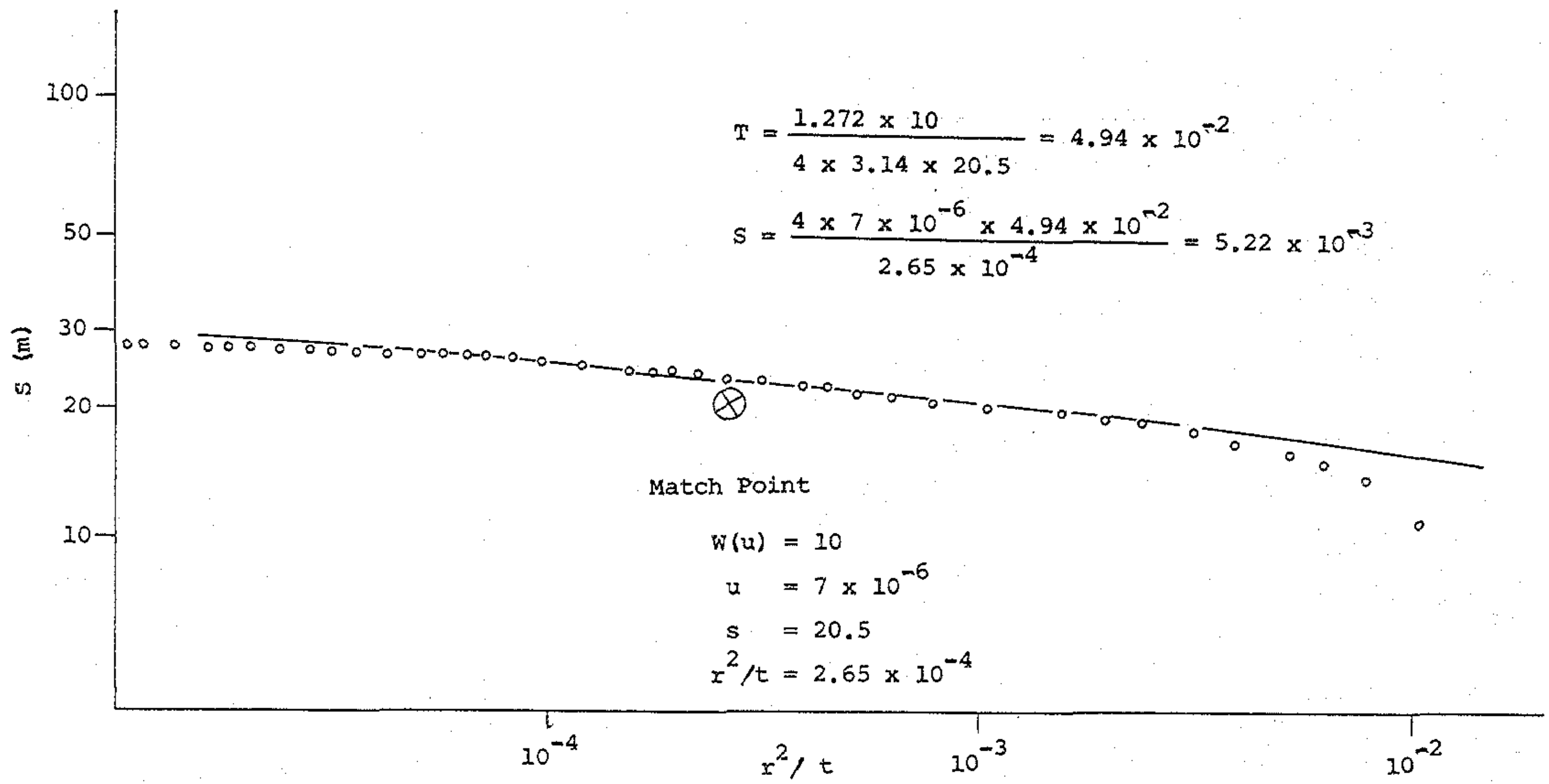


FIG A-4.5.10 S-r/t Curve in KL-JICA-3

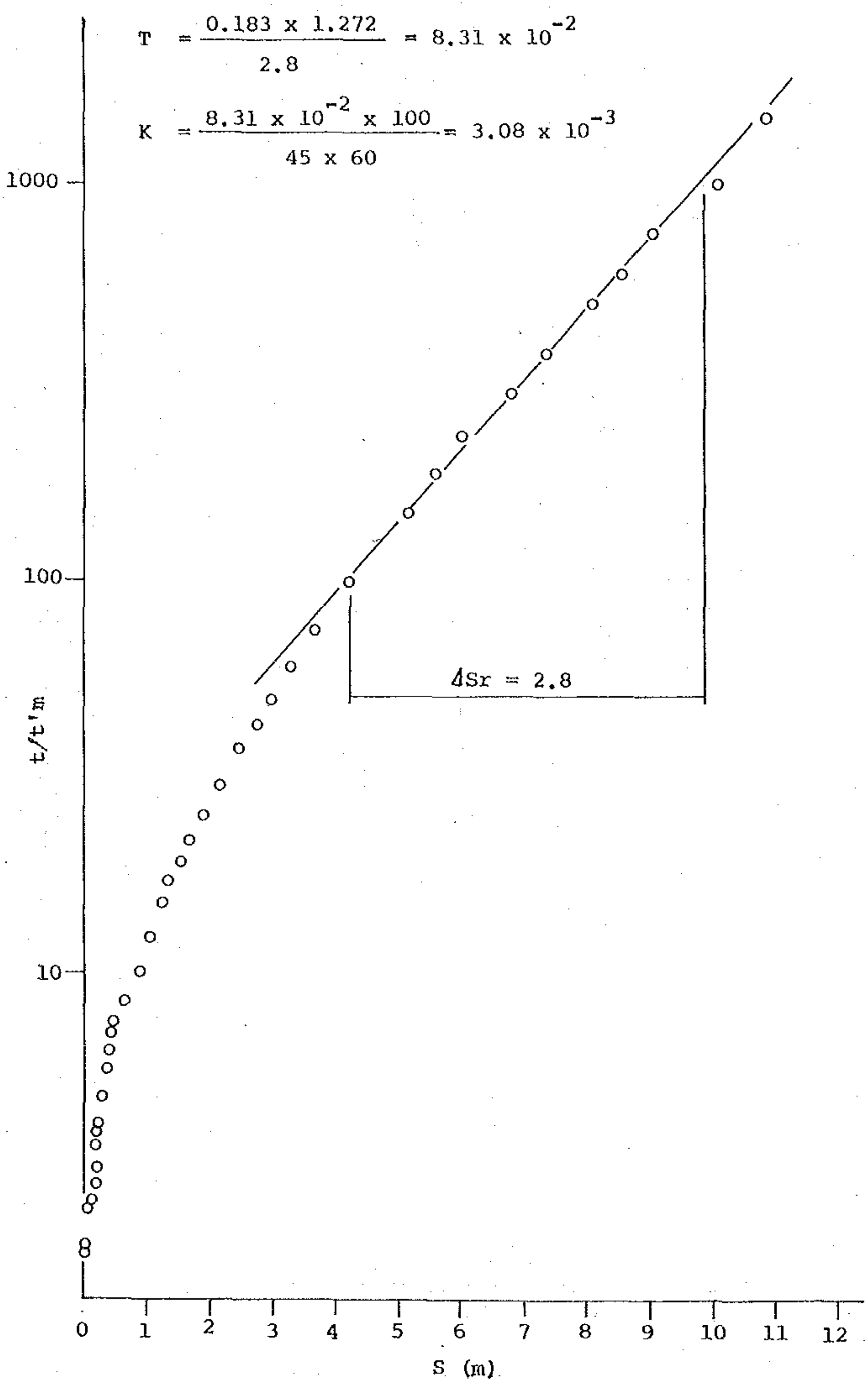


FIG A-4.5.11 S-t/t' Curve in KL-JICA-3

5. THE PROJECT

5.1 Objectives (None)

5.2 Project Formulation

5.3 Proposed Agriculture Development Plan

5.4 Infrastructure Facilities Planned

TABLE A-5.2.1 ETo by Blanney-Criddle Method

Calculation ETo for Quetta.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean Temp	4.0	6.0	10.8	16.0	20.6	24.2	27.2	25.4	20.5	14.2	8.3	4.8
P(Table1) *1	0.24	0.25	0.27	0.29	0.31	0.32	0.31	0.30	0.28	0.26	0.24	0.23
p(0.46T+8)	2.4	2.7	3.5	4.5	5.4	6.1	6.4	5.9	4.9	3.8	2.8	2.3
RHmin %	69	61	59	49	40	37	44	49	41	40	51	66
Class of RHmin	H	H	H	M	M	M	M	M	M	M	H	H
n	6.9	7.5	7.4	9.0	10.9	11.5	10.5	10.3	9.8	9.6	9.3	7.5
n/N	0.66	0.68	0.62	0.70	0.80	0.82	0.76	0.78	0.79	0.83	0.88	0.74
Daily Wind Km/hr	9.1	10.7	11.5	10.2	10.9	10.9	12.1	10.6	8.5	7.4	6.5	6.7
Estimated Uday Time	3.4	4.0	4.2	3.8	4.0	4.0	4.5	3.9	3.1	2.7	2.4	2.5
Selection *2	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]
ETo(mm/day)	0.9	1.0	2.0	4.5	6.0	7.7	7.2	6.7	5.2	4.2	1.7	0.8

Calculation ETo for Kalat.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean Temp	2.8	5.1	9.1	14.0	18.8	22.3	24.4	23.1	18.9	13.3	8.3	4.6
P(Table1) *1	0.24	0.25	0.27	0.29	0.31	0.32	0.31	0.30	0.28	0.26	0.24	0.23
p(0.46T+8)	2.2	2.6	3.3	4.1	5.2	5.8	6.0	5.6	4.7	3.7	2.8	2.3
RHmin %	64	58	50	42	38	33	41	40	35	35	44	45
Class of RHmin	H	H	H	M	M	M	M	M	M	M	M	M
n	69	61	59	49	40	37	44	49	41	40	51	66
N	10.4	11.1	12.0	12.9	13.6	14.0	13.9	13.2	12.4	11.5	10.6	10.2
n/N	M	M	H	M	M	H	M	M	M	H	H	M
Daily Wind	7.6	9.1	9.8	9.5	9.5	9.5	8.2	7.6	8.2	8.2	7.8	7.6
Estimated Uday Time	2.8	3.4	3.6	3.5	3.5	3.5	3.0	2.8	3.0	3.0	2.9	2.8
Selection *2	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]
ETo(mm/day)	0.8	1.1	2.0	4.0	5.3	7.5	6.6	6.1	4.8	3.6	2.5	1.2

*1: Mean daily percentage of total annual daytime hours obtained for a given month and latitude from Table 1 of the FAO Report *3

*2: Selection of figure of Prediction of ETo from Braney-Criddle f factor for different conditions of minimun relative humidity, sunshine duration and day time wind on page 7 of the FAO Report.

*3: FAO IRRIGATION AND DRAINAGE PAPER No 24. CROP WATER REQUIREMENTS.1977 FAO ROME

*4: Refer to " Blaney-Criddle Method" in the Report (*3) for Detail.

TABLE A-5.2.2 Effective Rainfall, Re

	Total	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Spezand/Quetta													
Long term rain	135.3	36.3	31.8	25.0	8.4	3.5	1.0	9.0	2.7	1.0	1.0	2.3	13.3
Monthly ratio %	100.0	26.9	23.5	18.5	6.2	2.6	0.7	6.7	2.0	0.7	0.7	1.7	9.8
Re mm/M	88.0	23.8	20.8	16.3	5.5	2.3	0.6	5.9	1.8	0.6	0.6	1.4	8.4
Kalat													
Long term rain	233.0	55.4	47.5	37.1	15.2	6.1	3.3	30.7	14.2	2.0	0.0	3.0	18.5
Monthly ratio %	100.0	23.8	20.4	15.9	6.5	2.6	1.4	13.2	6.1	0.9	0.0	1.3	7.9
Re mm/M	104.0	24.8	21.2	16.5	6.8	2.7	1.5	13.7	6.3	0.9	0.0	1.4	8.2

TABLE A-5.2.3 Crop Water Requirement (Quetta)

Crops	%	Month / Eto	JAN 0.9	FEB 1.0	MAR 2.0	APR 4.5	MAY 6.0	JUN 7.7	JUL 7.2	AUG 6.7	SEP 5.2	OCT 4.2	NOV 1.7	DEC 0.8	Peak (mm/d)
		Kc	-	-	0.50	0.61	0.73	0.84	0.95	0.95	-	-	-	-	
ONION	8.25	ETcrop	-	-	1.00	2.74	4.38	6.47	6.84	6.37	-	-	-	-	6.84
CUMIN/		Kc	1.00	1.00	1.00	-	-	-	0.22	0.51	0.70	-	-	1.00	
TUNIP	8.25	ETcrop	0.90	1.00	2.00	-	-	-	1.58	3.42	3.64	-	-	0.80	3.64
PEAS/		Kc	-	-	0.30	1.10	-	-	-	0.40	0.72	-	-	-	
CABBAGE	8.50	ETcrop	-	-	0.60	4.95	-	-	-	2.68	3.74	-	-	-	4.95
		Kc	-	-	0.50	0.68	0.87	1.05	0.90	0.70	-	-	-	-	
POTATO	8.25	ETcrop	-	-	1.00	3.06	5.22	8.09	6.48	4.69	-	-	-	-	8.09
BROAD-B		Kc	-	-	0.30	1.10	-	-	0.27	0.64	0.90	-	-	-	
TUNIP	8.25	ETcrop	-	-	0.60	4.95	-	-	1.94	4.29	4.68	-	-	-	4.95
TOMATO/		Kc	-	-	-	0.50	1.05	0.50	-	0.73	0.95	0.90	-	-	
CALIFLOWER	8.50	ETcrop	-	-	-	2.25	6.30	3.85	-	4.89	4.94	3.78	-	-	6.30
CHILI/		Kc	-	-	0.50	0.75	1.00	0.85	-	0.30	0.60	1.00	1.00	0.70	
CAROT	8.25	ETcrop	-	-	1.00	3.38	6.00	6.55	-	2.01	3.12	4.20	1.70	0.56	6.55
OKRA/		Kc	-	-	-	0.40	1.00	0.85	-	0.50	0.90	-	-	-	
BROAD-B	8.25	ETcrop	-	-	-	1.80	6.00	6.55	-	3.35	4.68	-	-	-	6.55
CUCUMBER/		Kc	-	-	-	0.35	0.70	0.90	0.70	0.60	1.00	0.90	-		
RADISH	8.50	ETcrop	-	-	-	1.58	4.20	6.93	5.04	4.02	5.20	3.78	-	-	6.93
		Kc	-	-	0.40	0.45	0.85	1.15	1.25	1.25	1.20	1.00	0.95	-	
APPLE	12.50	ETcrop	-	-	0.80	2.03	5.10	8.86	9.00	8.38	6.24	4.20	1.62	-	9.00
		Kc	-	-	0.25	0.45	0.60	0.70	0.70	0.65	0.55	0.45	0.35	-	
GRAPES	12.50	ETcrop	-	-	0.50	2.03	3.60	5.39	5.04	4.36	2.86	1.89	0.60	-	5.39
TOTAL			0.07	0.08	0.68	2.57	3.76	4.98	3.57	4.57	3.65	1.75	0.42	0.11	4.98

TABLE A-5.2.4 Crop Water Requirement (Kalat)

Crops	%	Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Peak
		Eto	0.8	1.1	2.0	4.0	5.3	7.5	6.6	6.1	4.8	3.6	2.5	1.2	(mm/d)
		Kc	-	-	0.50	0.61	0.73	0.84	0.95	0.95	-	-	-	-	
ONION	10.00	ETcrop	-	-	1.00	2.44	3.87	6.30	6.27	5.80	-	-	-	-	6.30
CUMIN/		Kc	1.00	1.00	1.00	-	-	-	0.24	0.48	0.80	0.72	-	1.00	
RADISH	10.00	ETcrop	0.80	1.10	2.00	-	-	-	1.58	2.93	3.84	2.59	-	1.20	3.84
TOMATO/		Kc	-	-	-	0.50	1.05	0.40	0.58	0.84	0.24	-	-	-	
BROAD-B	10.00	ETcrop	-	-	-	2.00	5.57	3.00	3.83	5.12	1.15	-	-	-	5.57
		Kc	-	-	0.30	0.68	0.87	1.05	0.90	0.70	-	-	-	-	
POTATO	10.00	ETcrop	-	-	0.60	2.72	4.61	7.88	5.94	4.27	-	-	-	-	7.88
CARROT/		Kc	-	-	0.30	0.64	0.90	-	-	0.30	0.60	1.00	1.00	0.70	
TURNIPS	10.00	ETcrop	-	-	0.60	2.56	4.77	-	-	1.83	2.88	3.60	2.50	0.84	4.77
CABBAGE/		Kc	-	-	0.30	1.05	0.30	-	-	0.73	0.95	0.90	-	-	
BROAD-B	10.00	ETcrop	-	-	0.60	4.20	1.59	-	-	4.45	4.56	3.24	-	-	4.56
		Kc	-	-	0.40	0.45	0.85	1.15	1.25	1.25	1.20	1.00	0.95		
APPLE	20.00	ETcrop	-	-	0.80	1.80	4.51	8.63	8.25	7.63	5.76	3.60	2.38	-	8.63
		Kc	-	-	0.25	0.45	0.60	0.70	0.70	0.65	0.55	0.45	0.35	-	
GRAPPES	20.00	ETcrop	-	-	0.50	1.80	3.18	5.25	4.62	3.97	2.64	1.62	0.88	-	5.25
TOTAL			0.08	0.11	0.74	2.11	3.58	4.49	4.34	4.76	2.92	1.99	0.90	0.20	4.76

TABLE A-5.3.1 Cultivation Method by Crop

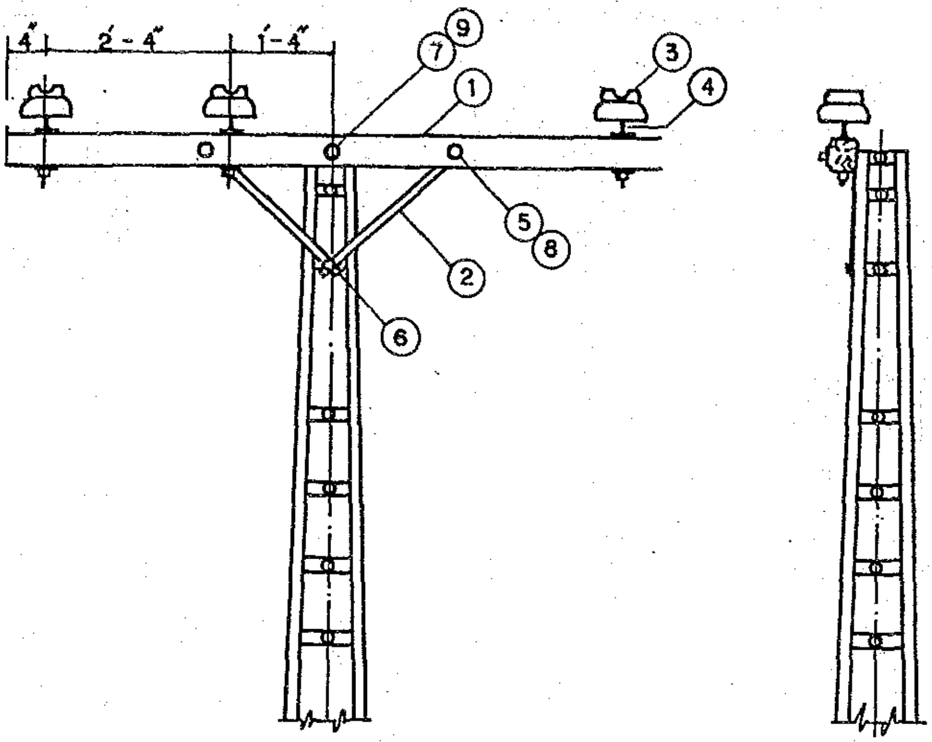
Crops	Land Preparation	Fertilizing Manuring	Sowing	Weeding Thining	Molding Intertillage	Spraying	Harvesting Packing
Onion	tractor or animal	man	man broadcast	man	-	sprayer	man
Potato	ditto	tractor or man	man	tractor man	tractor animal	sprayer	tractor man
Peas	ditto	ditto	man drilling	man	man	sprayer	man
Carrot	ditto	ditto	ditto	man	tractor animal/man	sprayer	man
Turnip	ditto	ditto	man broadcast	man	-	sprayer	man
Radish	ditto	ditto	man drilling	man	tractor animal/man	sprayer	man
Cabbage	ditto	ditto	man (transplant)	man	ditto	sprayer	man
Broad B	ditto	ditto	man drilling	man	ditto	sprayer	man
Cucumber	ditto	ditto	ditto	man	man	sprayer	man
Tomato	ditto	ditto	man (transplant)	man	ditto	sprayer	man
Okra	ditto	man	man drilling	man	tractor animal	sprayer	man
Chillies	ditto	ditto	ditto	man	ditto	sprayer	man
Cumin	ditto	ditto	man broadcast	man	-	sprayer	man
Alfalfa	ditto	ditto	ditto	-	-	sprayer	man
Apple	making hole	ditto	transplant	man	-	sprayer	man
Grape	making trench		ditto	man	-	sprayer	man

TABLE A-5.3.2 Agricultural Production by Development Area

Project Area	Crops	Yield/ha (t)	5 ha Acreage (ha)	5 ha Product (t) 1/	10 ha Acreage (ha)	10 ha Product (t)	15 ha Acreage (ha)	15 ha Product (t)
Quetta	Onion	17.0	0.42	7.1	0.84	14.3	1.26	21.4
	Potato	15.0	0.42	6.3	0.84	12.6	1.26	18.9
	Peas	11.0	0.83	9.1	1.66	18.3	2.49	27.5
	Carrot	18.0	0.42	7.6	0.84	15.1	1.26	22.7
	Turnip	18.0	0.83	14.9	1.66	29.9	2.49	44.8
	Radish	15.0	0.42	6.3	0.84	12.6	1.26	18.9
	Cabbage	17.0	0.83	14.1	1.66	28.2	2.49	42.3
	Broad B.	10.0	0.42	4.2	0.84	8.4	1.26	12.6
	Cucumber	15.0	0.42	6.3	0.84	12.6	1.26	18.9
	Tomato	17.0	0.42	7.1	0.84	14.3	1.26	21.4
	Okra	12.0	0.42	5.0	0.84	10.1	1.26	15.1
	Chillies	7.5	0.42	3.2	0.84	6.3	1.26	9.5
	Cumin	0.7	0.42	0.3	0.84	0.6	1.26	0.9
	Alfalfa	30.0	0.50	15.0	1.00	30.0	1.50	45.0
	Apple	18.0	0.63	11.3	1.26	22.7	1.89	34.0
	Grape	13.0	0.62	8.1	1.24	16.1	1.86	24.2
	Total		8.44		16.88		25.32	
Kalat	Onion	17.0	1.03	17.5	2.06	35.0	3.09	52.5
	Potato	15.0	0.76	11.4	1.52	22.8	2.28	34.2
	Cucumber	15.0	0.50	7.5	1.00	15.0	1.50	22.5
	Radish	15.0	0.50	7.5	1.00	15.0	1.50	22.5
	Carrot	18.0	0.50	9.0	1.00	18.0	1.50	27.0
	Turnip	18.0	0.50	9.0	1.00	18.0	1.50	27.0
	Tomato	17.0	0.50	8.5	1.00	17.0	1.50	25.5
	Broad B.	10.0	1.00	10.0	2.00	20.0	3.0	30.0
	Cabbage	17.0	0.50	8.5	1.00	17.0	1.50	25.5
	Apple	18.0	1.00	18.0	2.00	36.0	3.00	39.0
	Total		7.99		15.58		23.37	

1/ Yield/ha: marketable quantity

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY	No. ES/DD-1L



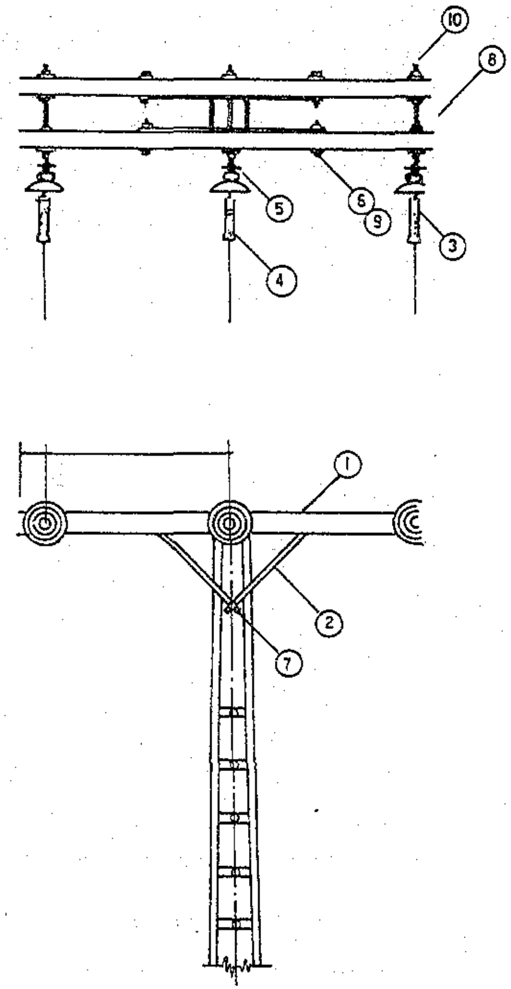
APPLICATION TABLE

CONDUCTOR	LINE ANGLES
GOPHER	0° TO 25°
RABBIT	0° TO 19°
DOG	0° TO 8°

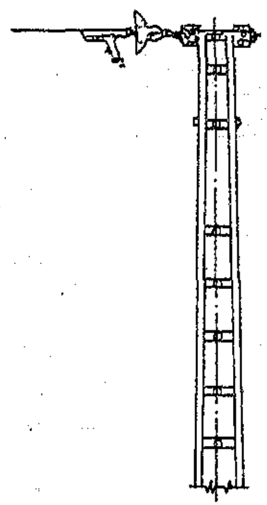
ITEM	QTY.	DESCRIPTION	DWG.No.	STOCK No.
1	1	WOOD CROSSARM, 4"x5"x8"-0"	EW/DF-251	T-1173
2	2	CROSSARM BRACE 1 1/4"x1/4"x28"	EW/DF-254	T-1352
3	3	11KV.PIN TYPE INSULATOR	EW/DF-252	T-1173
4	3	INSULATOR PIN	EW/DF-256	T-3217
5	2	M.S. BOLT 3/8"x6"	EW/DF-272	S-1265
6	1	M.S. BOLT 5/8"x2"	EW/DF-260	S-1297
7	1	M.S. BOLT 5/8"x14"	EW/DF-260	S-1303
8	2	ROUND WASHER 1"DIA 7/10" HOLE	EW/DF-268	S-1791
9	1	SQUARE WASHER 2 1/4" x 2 1/4" x 11/16"	EW/DF-269	S-1792

FIG A-5.4.1 11 K.V. Single Crossarm Assembly

11K. V. SINGLE CROSSARM ASSEMBLY 1-L



ITEM	QTY	DESCRIPTION
1	2	WOOD GROSSARM 4"x5"x8'
2	4	CROSS ARM BRACE $1^{1}/_{4}$"x$^{1}/_{4}$"x28"
3	3	11KVA DISC INSULATOR 10"DIA CLEVIS-EYE TYPE
4	3	DEAD CLAMP
5	3	EYE NUT 5/8"
6	4	M.S. BOLT 3/8"x6"
7	2	M.S.BOLT 5/8"x2"
8	3	DOUBLE ARMING BOLT 5/8"x20"
9	4	ROUND WASHER 1"DIA,7/16" HOLE
10	10	SQUARE WASHER 2 1/4"x2 1/4",LL/16" HOLE

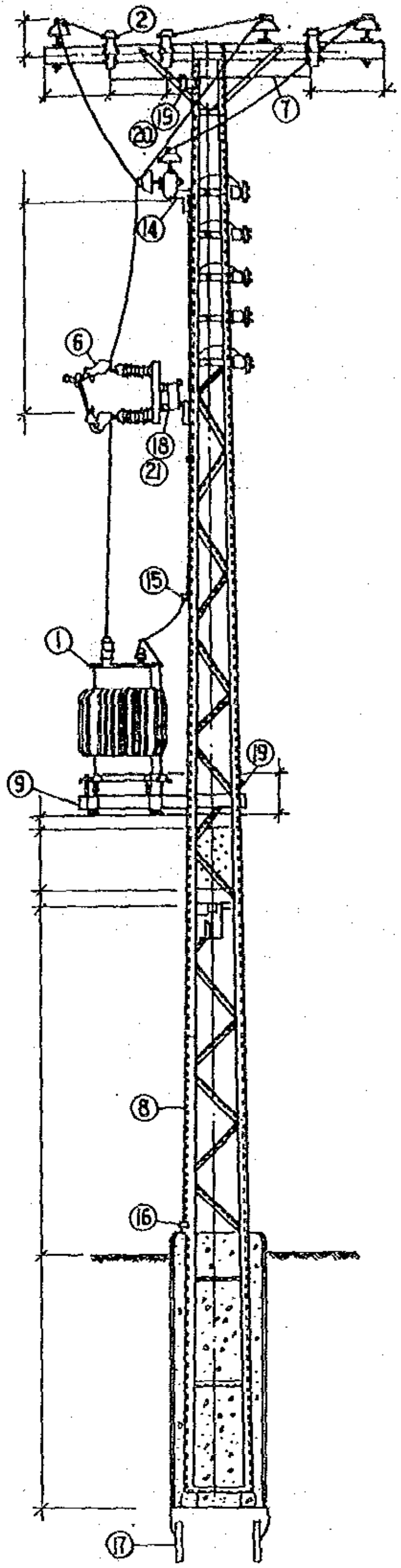


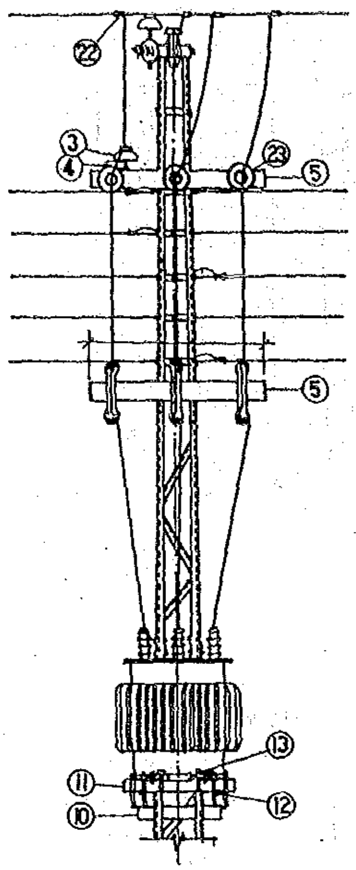
NOTE: DEADEND ASSEMBLY FOR GOPHER AND RABBIT CONDUCTORS.

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY ENGINEERING DEPARTMENT

11K.V. HORIZONTAL SINGLE DEADEND
ASSEMBLY 7L (WOOD CROSSARM)
FOR LATTICE STEEL POLE

FIG A-5.4.2 11 K.V. Horizontal Single Deadend Assembly





NO.	DESCRIPTION	QTY
1	TRANSFORMER	1
2	LIGHTNING ARRESTER	3
3	PIN INSULATOR	4
4	INSULATOR PIN	4
5	1225 L6. WOODEN X-ARM	2
6	DROP OUT CUT OUT ASSEMBLY	3
7	CNAT CONDUCTOR	2m
8	G.S. STRANDED WIRE 10	B.M
9	CHANNEL	2
10	CHANNEL	2
11	CHANNEL	2
12	U-BOLT (UB)	4
13	J-BOLT (JB)	4
14	ANGLE IRON BRACKET	4
15	CABLE CLAMP	4
16	GROUND CONNECTOR CLAMP	2
17	EARTHING ROD WITH CLAMP	1
18	12 150 LG M.S. BOLT	4
19	12 37 LG M.S. BOLT	17
20	ROUND WASHER HOLE 14	2
21	SQUARE WASHER 50x50x3	4
22	P.G. CLAMP	12
23	TIE WIRE 4	1m

IG A-5.4.3 25 K.V.A Distribution Transformer

PAKISTAN
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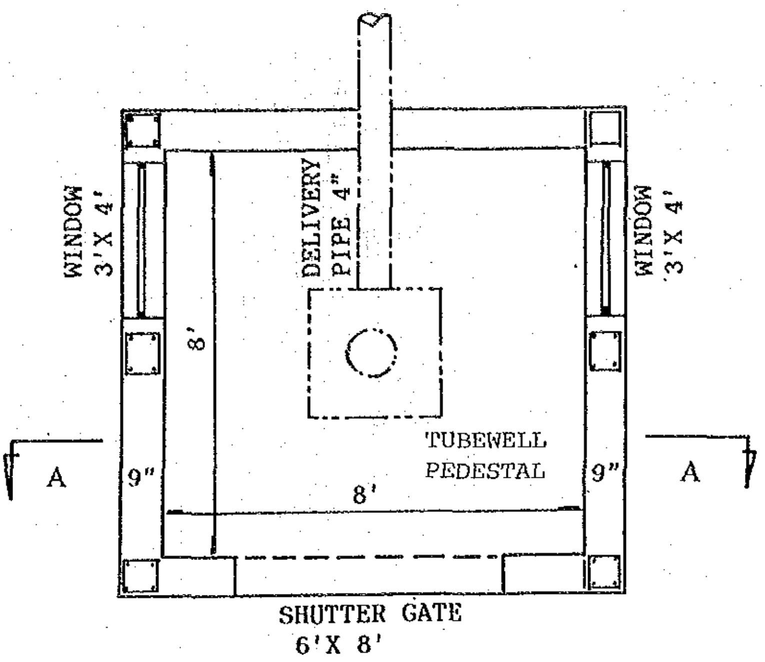
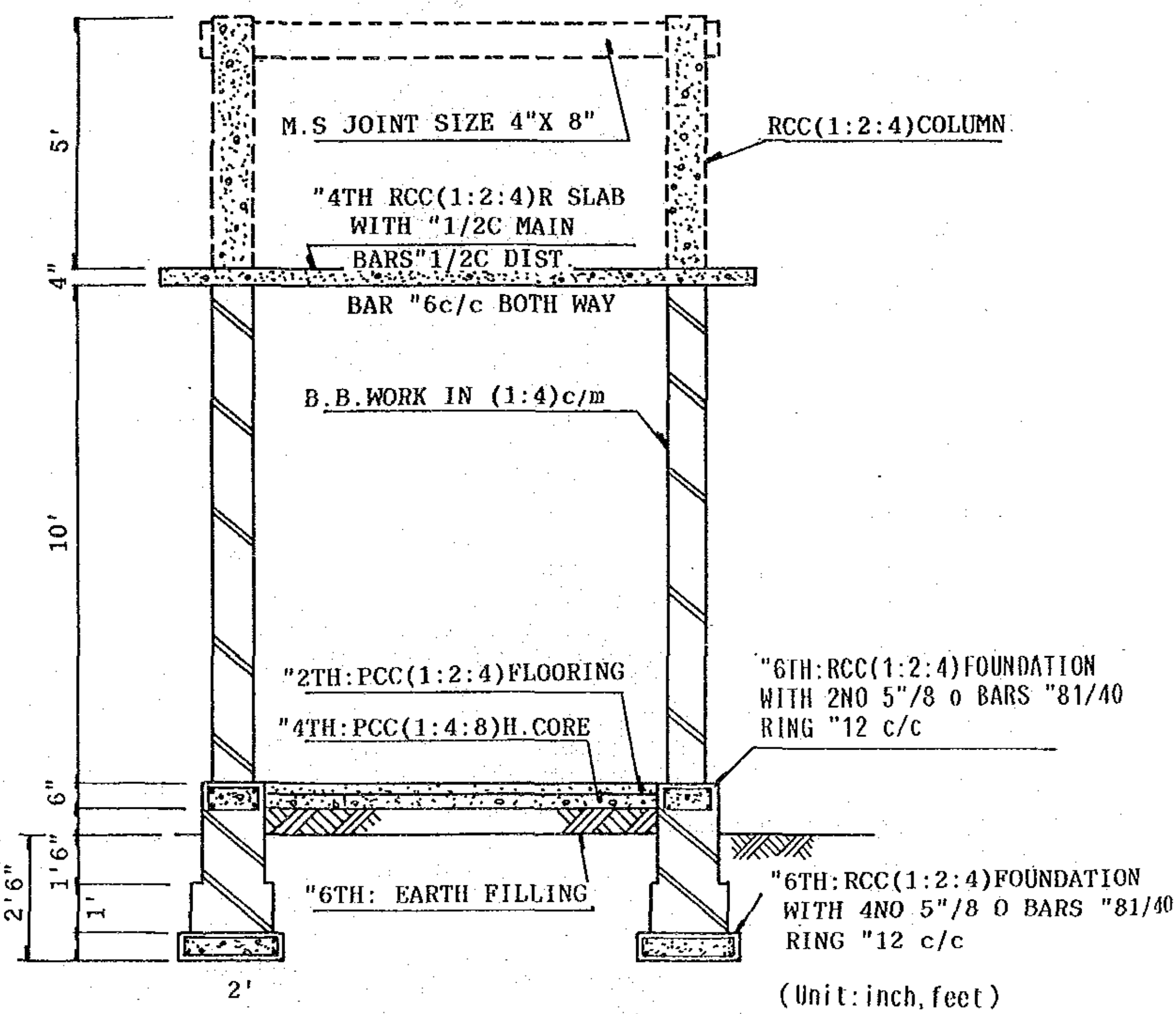
25 OR 50 KVA DISTRIBUTION
TRANSFORMER STATION ON SINGLE STRUCTURE
(DTS-IS)

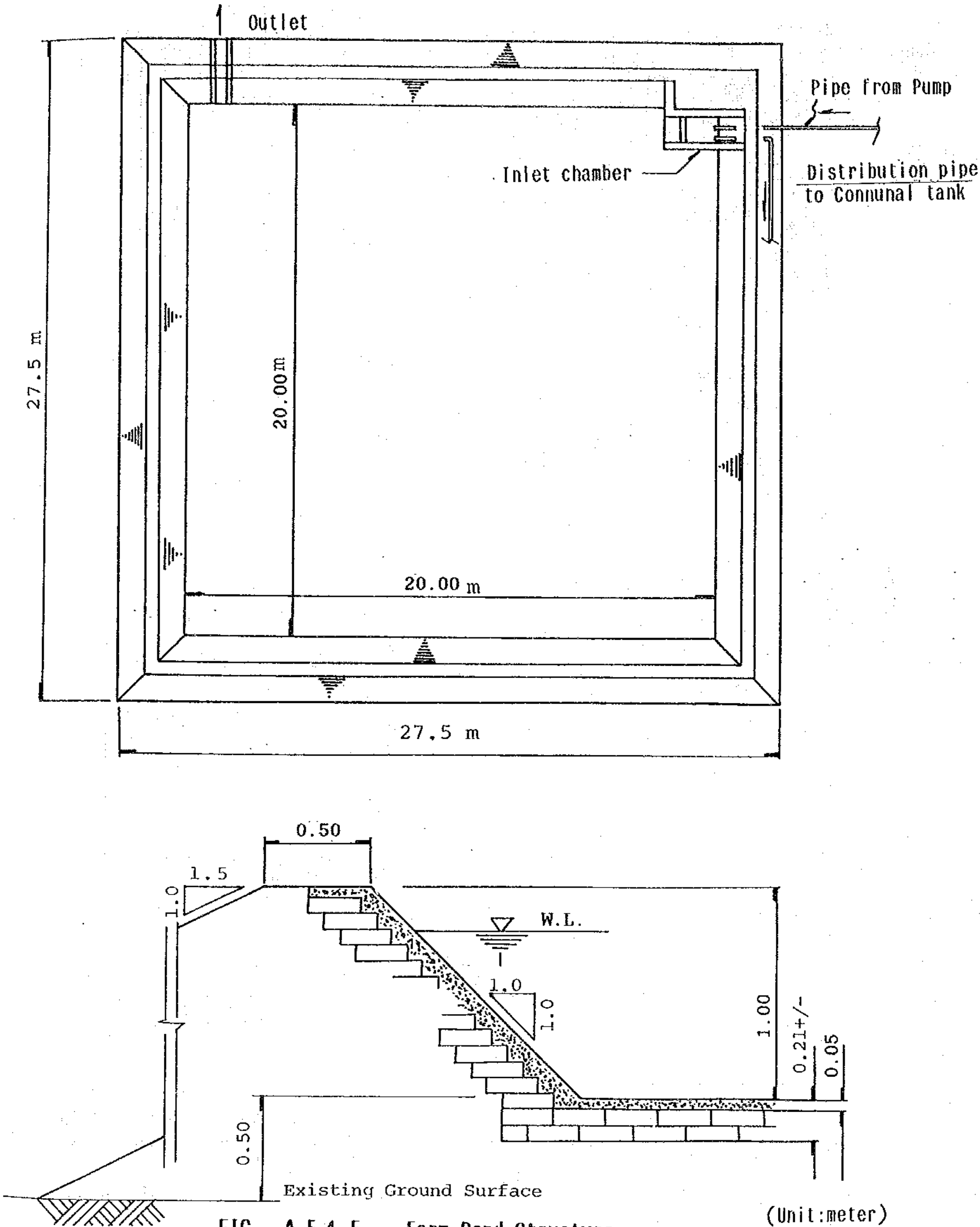


SECTION A-A



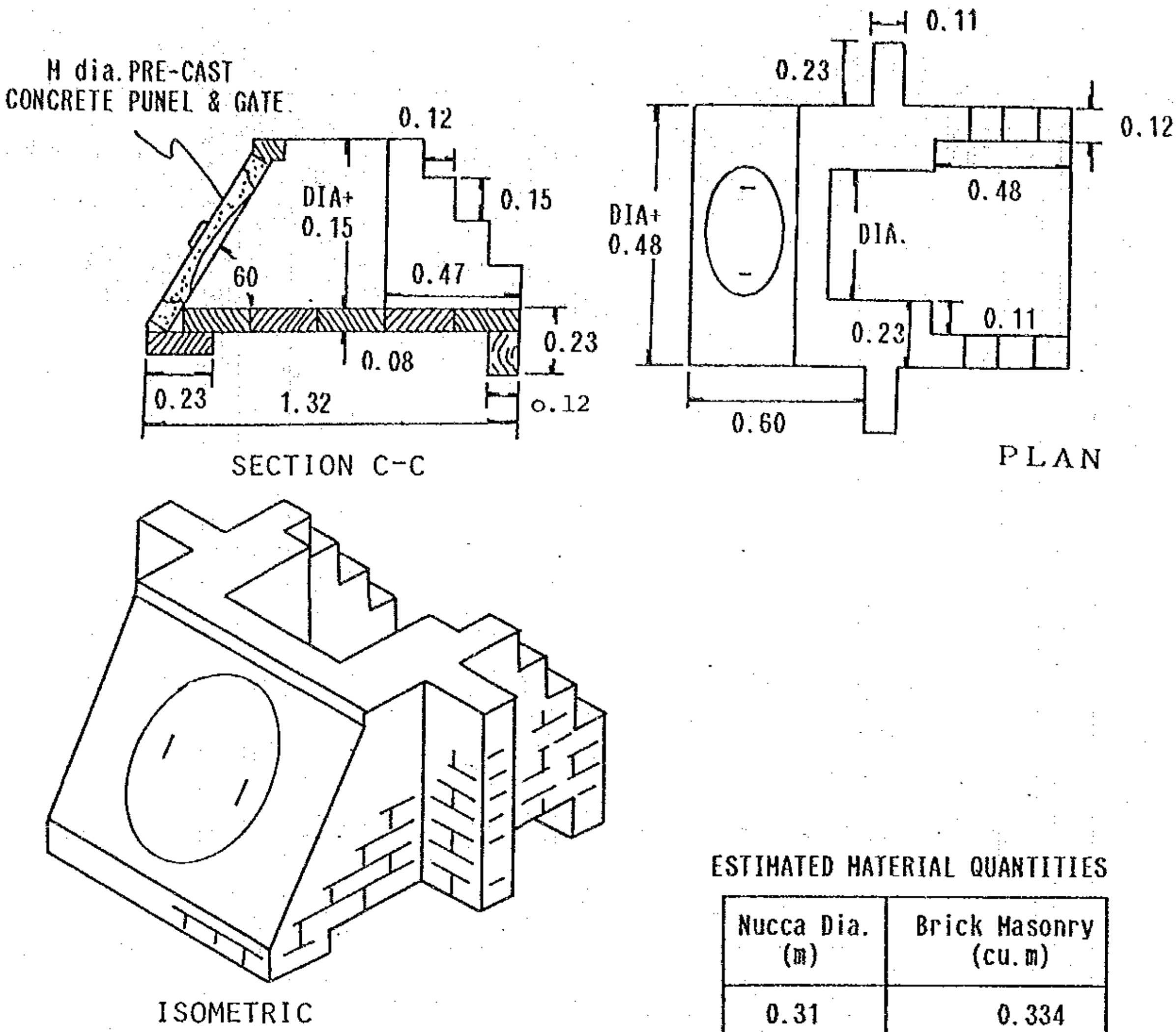
(Unit: inch, feet)

FIG A-5.4.4 Pump House Structure



(Unit:meter)

FIG A-5.4.5 Farm Pond Structure



ESTIMATED MATERIAL QUANTITIES

Nucca Dia. (m)	Brick Masonry (cu.m)
0.31	0.334
0.38	0.359
0.45	0.400
0.51	0.441

NOTE: ① One cu.m of brick & mortal marsonry contains approx. 4.38 bricks, 0.19 cu.m of mortar and 0.07 cu.m of plaster

② When a drop is included increase the material estimate by 152 for each 0.08m of drop.

Source:

On Farm Management Field Manual, Vol, V, Minisrty Of Food, Agriculture & Cooperations, Dec/80.

FIG A-5.4.6 Turnout Structure

(Unit:meter)

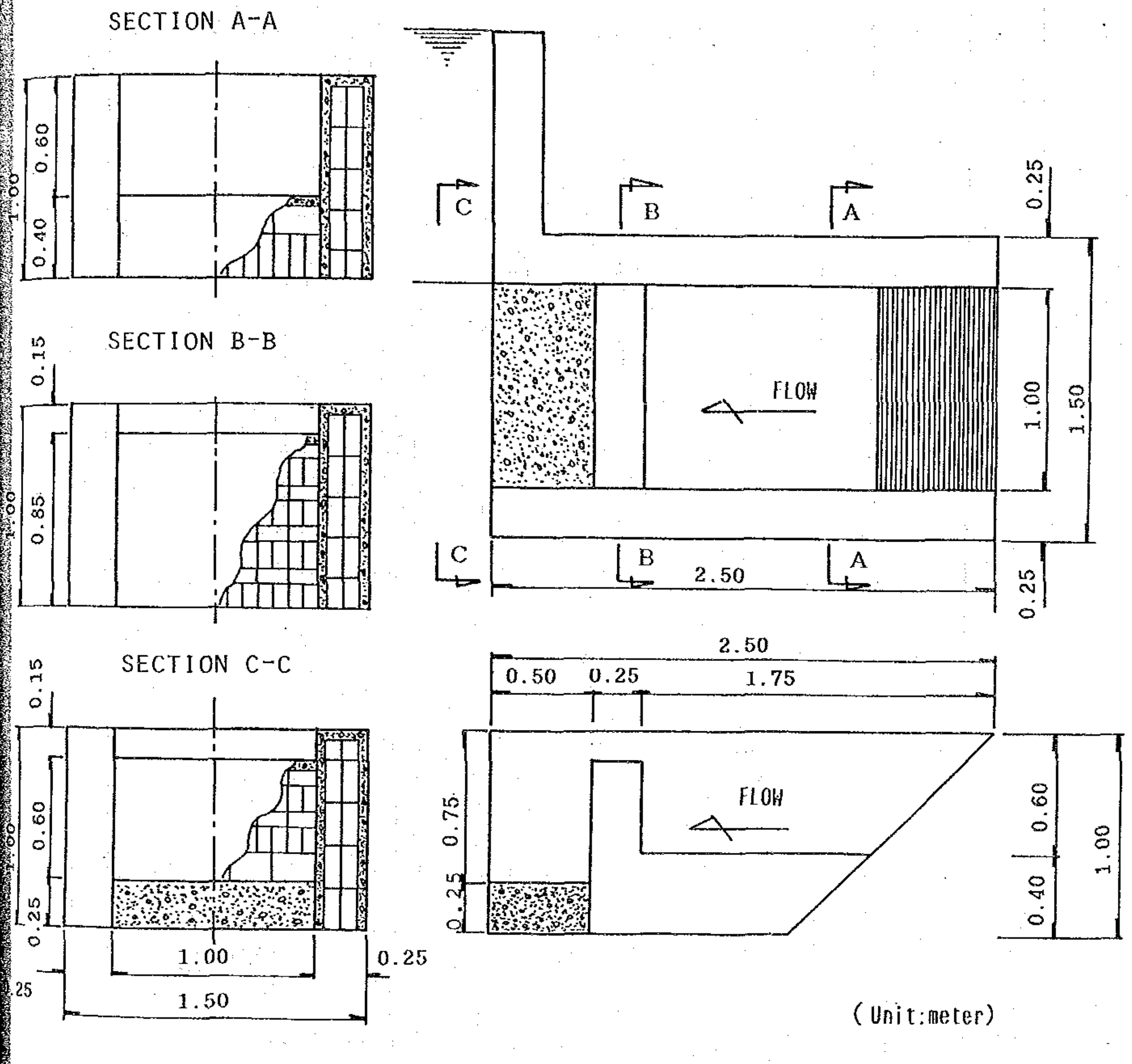


FIG A-5.4.7 Inlet Chamber Structure

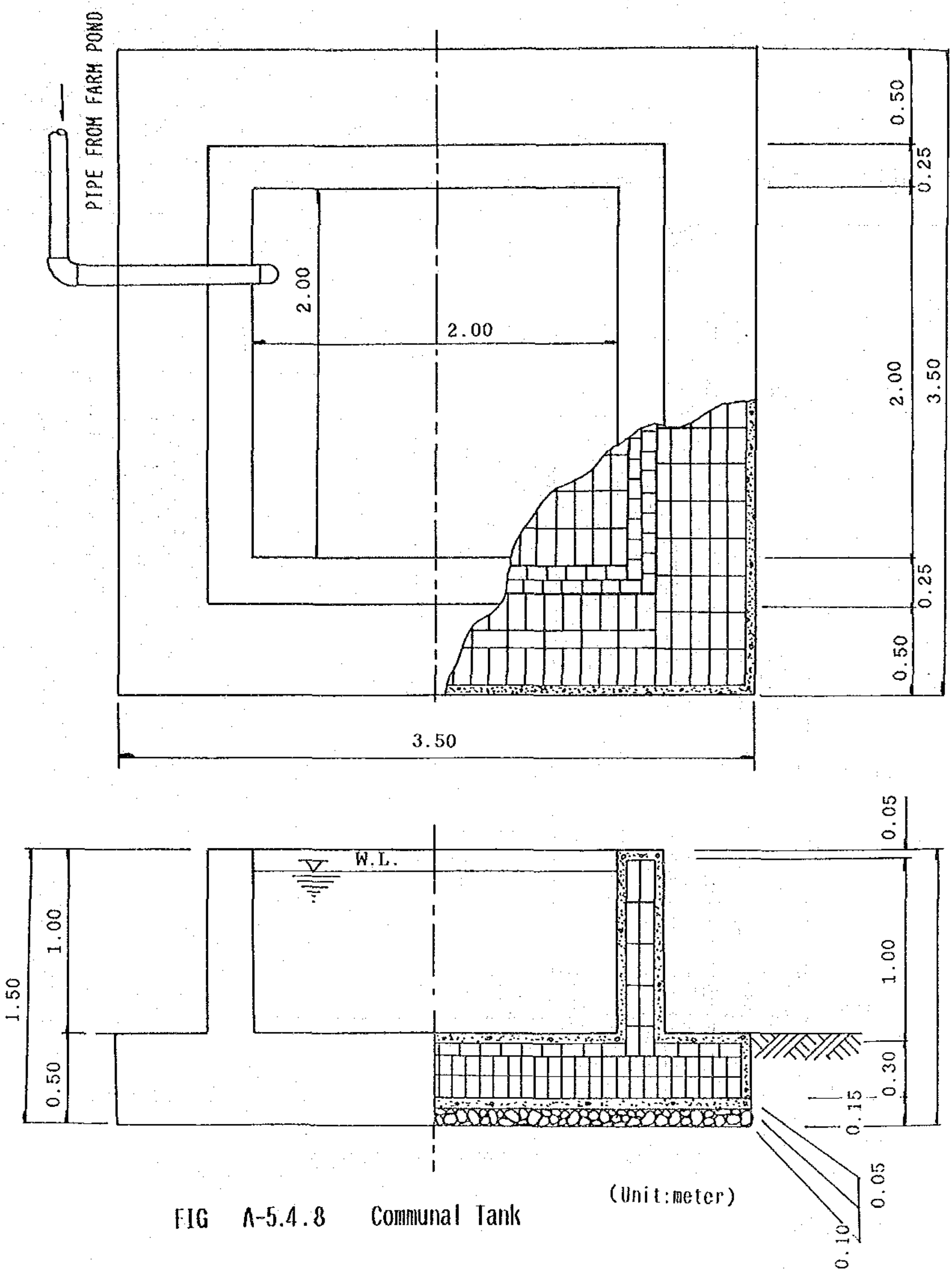


FIG A-5.4.8 Communal Tank

6. PROJECT IMPLEMENTATION PLAN

6.1 Project Implementation ********************** (None)

6.2 Arrengement of Project Construction ********* (None)

6.3 Project Cost

6.3.1 Scenario of Cost Estimate

TABLE A-6.3.1 Scenario of Cost Estimate

6.3.2 Construction Cost

TABLE A-6.3.2(1) Unit Wages and Prices
TABLE A-6.3.2(2) Construction Unit Cost
TABLE A-6.3.3(1) Summary of Construction Cost QT-D Drilling Depth = 200 m
TABLE A-6.3.3(2) Summary of Construction Cost QT-E Drilling Depth = 200 m
TABLE A-6.3.3(3) Summary of Construction Cost KL-B Drilling Depth = 200 m
TABLE A-6.3.3(4) Summary of Construction Cost KL-C Drilling Depth = 200 m
TABLE A-6.3.3(5) Summary of Construction Cost QT-D Drilling Depth = 250 m
TABLE A-6.3.3(6) Summary of Construction Cost QT-E Drilling Depth = 250 m
TABLE A-6.3.3(7) Summary of Construction Cost KL-B Drilling Depth = 250 m
TABLE A-6.3.3(8) Summary of Construction Cost KL-C Drilling Depth = 250 m
TABLE A-6.3.3(9) Summary of Construction Cost QT-D Drilling Depth = 300 m
TABLE A-6.3.3(10) Summary of Construction Cost QT-E Drilling Depth = 300 m
TABLE A-6.3.3(11) Summary of Construction Cost KL-D Drilling Depth = 300 m
TABLE A-6.3.3(12) Summary of Construction Cost KL-E Drilling Depth = 300 m

TABLE A-6.3.4(1) Construction Cost Calculation. QT-D, D=200m
TABLE A-6.3.4(2) Construction Cost Calculation. QT-E, D=200m
TABLE A-6.3.4(3) Construction Cost Calculation. KL-B, D=200m
TABLE A-6.3.4(4) Construction Cost Calculation. KL-C, D=200m
TABLE A-6.3.4(5) Construction Cost Calculation. QT-D, D=250m
TABLE A-6.3.4(6) Construction Cost Calculation. QT-E, D=250m
TABLE A-6.3.4(7) Construction Cost Calculation. KL-B, D=250m
TABLE A-6.3.4(8) Construction Cost Calculation. KL-C, D=250m
TABLE A-6.3.4(9) Construction Cost Calculation. QT-D, D=300m
TABLE A-6.3.4(10) Construction Cost Calculation. QT-E, D=300m
TABLE A-6.3.4(11) Construction Cost Calculation. KL-B, D=300m
TABLE A-6.3.4(12) Construction Cost Calculation. KL-C, D=300m

6.3 PROJECT COST

6.3.1 Scenario of Cost Estimate

(1) Background of Scenario

Agriculture development planning depends upon the design groundwater yield and groundwater condition strictly. For instance, the design yield provides the irrigable area, size of farm pond, pump capacity and so on. Also the groundwater table will decide the depth of borehole drilling and pump head.

But the pumping test is now in progress in the Study Area. Consequently the plan/design criteria are still not defined finally.

So far each vein, several cases for cost estimates would be established regarding the yield, pump head and the depth of borehole. The number of the production well would be fixed as follows.

Number of Production Well

Quetta:	Vein-D	:	4 nos
	Vein-E	:	5 nos
Kalat :	Vein-B	:	4 nos
	Vein-C	:	3 nos

(2) Scenario of Cost Estimate

The scenario of cost estimate would be decided as following, depending on the yield, pump head and borehole depth for each vein.

TABLE A-6.3.1 Scenario of Cost Estimate

Drilling Depth (m)	Design Yield (1/sec)	Pump Head	
		100m	150m
A: 200	5.0	A-1	A-2
	10.0	A-3	A-4
	15.0	A-5	A-6
B: 250	5.0	B-1	B-2
	10.0	B-3	B-4
	15.0	B-5	B-6
C: 300	5.0	C-1	C-2
	10.0	C-3	C-4
	15.0	C-5	C-6

(3) Project Evaluation Scheme

Project evaluation would be studied following the scenario mentioned previously at each vein. After the study at each vein, proper development scheme for whole study area would be obtained.

6.3.2 Construction Cost

(1) Background

For the construction cost estimate, the experiences of GOB and economic condition have been taken full advantage. The cost for estimates were selected and generalized among the actual ones by related agencies. For example,

i. Drilling cost/Well installation cost
ii. Pump house installation cost
iii. Electrification facility cost

And also the pump costs were estimated following the scenario by pump supplier in Quetta. Other work items were provided based on "Composite Schedule of Rate, GOB, 1986" mainly. So that inflation rate 1.08 were multiplied for each rate to adjust the prices.

(2) Construction Unit Cost

TABLE A-5.3.2 shows the summary of construction unit cost regarding to the Project. These costs are based on the previous conditions.

(3) Construction Cost

The construction costs under the scenario for each vein are summarized in TABLE A-6.3.3 (1) - A-6.3.3 (8) and FIG 6.3.1.

(4) Breakdown

The breakdown and the process of cost estimates are summarized as follows:

a. Drilling Cost

WAPDA Hydrogeology project estimated and generalized the drilling cost as shown in TABLE A-6.3.5.

b. Pump House

TABLE A-6.3.6 shows the estimated and provided by WAPDA Hydrogeology project.

c. Electrification

The cost estimates regarding to Electrification are made based on the actual quotations prepared by WAPDA Power Wing. TABLE A-6.3.1 shows the 11 kV Feeder line installation cost per 1 km. This estimate is also turned to the cost of Tee-off. TABLE A-6.3.8 explains the cost of 25 kVA transformer installation cost. Service and meter costs are indicated in TABLE A-6.3.9.

d. Pump Unit

Pump unit costs including installation cost are summarized in TABLE A-6.3.10.

e. Land Levelling Cost

The cost estimate for land levelling is based on the operation cost of 100 H.P. Bulldozer. The operational cost per hour is supplied by the Directorate of Agricultural Engineering, Government of Baluchistan, Quetta.

The operational cost has been estimated as follows:

- Average working hours per hectare for slight to moderate levelling	:	15 hours
- Total working hours of one dozer for 12 ha	:	180 hours
- Operation rate of 100 HP dozer per hour	:	500 Rs/hr
- Total cost for 180 hrs operation	:	Rs90,000/-
- Average rate of stone removing work (I/P.S. No. 29-1)	:	Rs 1.0/sm
- total cost for 10 ha stone removing	:	Rs100,000/-
Grand Total		Rs190,000/-
O/H 25%		47,500
		237,500/-
Unit Cost	:	Rs19,792/ha

f. On-farm Facility Construction Cost

Cost of the on-farm facilities for 10 ha irrigation area is estimated. The summary of the cost is as follows:

Conditions for the estimate is explained in TABLE A-6.3.12.

g. Farm Pond Construction Cost

Cost of farm pond is estimated in three cases depending on available groundwater yield at 5 lit/sec, 10 lit/sec and 15 lit/sec. The summary of the cost is summarized in TABLE A-4.6.13.

h. Communal Tank Cost Estimate

The cost of the communal tank construction is shown in TABLE A-6.3.18.

i. Connection Road Construction Cost

Unit costs of connection road construction are estimated as follows:

i) Connection Road (per 1 km)

ii) Submergible Road (per 100 m)

These are summarized in TABLE A-6.3.19 and A-6.3.20.

TABLE A-6.3.2(1) Unit Wages and Prices

Item	Unit	Rate(Rs)	Remarks
1. Cooly	man-day	30.00	Working 8hr/day
2. Skilled Cooly	"	35.00	" "
3. Excavator	"	35.00	" "
4. Earth Carrier	"	35.00	" "
5. Digger	"	35.00	" "
6. Mason Helper	"	35.00	" "
7. Technician	"	40.00	" "
8. Supervisor	"	44.00	" "
9. Truck Driver	"	60.00	" "
10. Electrician	"	60.00	" "
11. Steel Fixer	"	60.00	" "
12. Mason	"	70.00	" "
13. Carpenter	"	75.00	" "
14. Driller for Wells	"	80.00	" "
15. Welder	"	80.00	" "
16. Foreman	"	80.00	" "
17. Portland Cement	kg	1.60	
18. Fine Sand	m3	85.00	
19. Coarse Sand	"	90.63	
20. Gravel	"	75.00	
21. Shingle 25mm	"	70.00	
22. Stone Ballast 10mm	"	150.00	
23. Stone Ballast 25mm	"	135.00	
24. Stone Ballast 50mm	"	131.00	
25. Reinforce Steel Bar	kg	4.80	
26. M.S.Angle	kg	5.60	mild steel
27-1. R.C.Pipe 300mm	m	98.50	ASTM C-76 Wall A
27-2. " " 525mm	m	213.25	"
27-3. " " 600mm	m	262.50	"
27-4. " " 1,050mm	m	738.00	"
27-5. " " 300mm	m	98.50	ASTM C-76 Wall B
27-6. " " 525mm	m	236.25	"
27-7. " " 600mm	m	278.75	"
27-8. " " 1,050mm	m	803.50	"
28-1. Steel Pipe 100mm	m	91.80	mild steel,blind,seemless
28-2. " " 150mm	m	164.00	" " " "
28-3. " " 200mm	m	223.00	" " " "
28-4. " " 300mm	m	426.40	" " " "
28-5. " " 375mm	m	541.20	" " " "
29-1. PVC Pipe 100mm	m	64.90	blind,Class B
29-2. " " 150mm	m	100.75	" "
29-3. " " 200mm	m	243.60	" "
30-1. Gate Valve 2"	each	276.00	franged Class 150
30-2. " " 4"	"	720.00	" "
30-3. " " 6"	"	1,040.00	" "
31. Gasoline	lit.	6.55	regular
32. Light Oil	"	3.87	diesel
33. Kerosine Oil	"	3.25	

SOURCE : GOB, Composite Schedule of Rates 1986