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

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

FINAL REPORT

VOLUME III
SUPPORTING REPORT

MARCH 2000

NIPPON KOEI CO., LTD.
NIPPON GIKEN INC.

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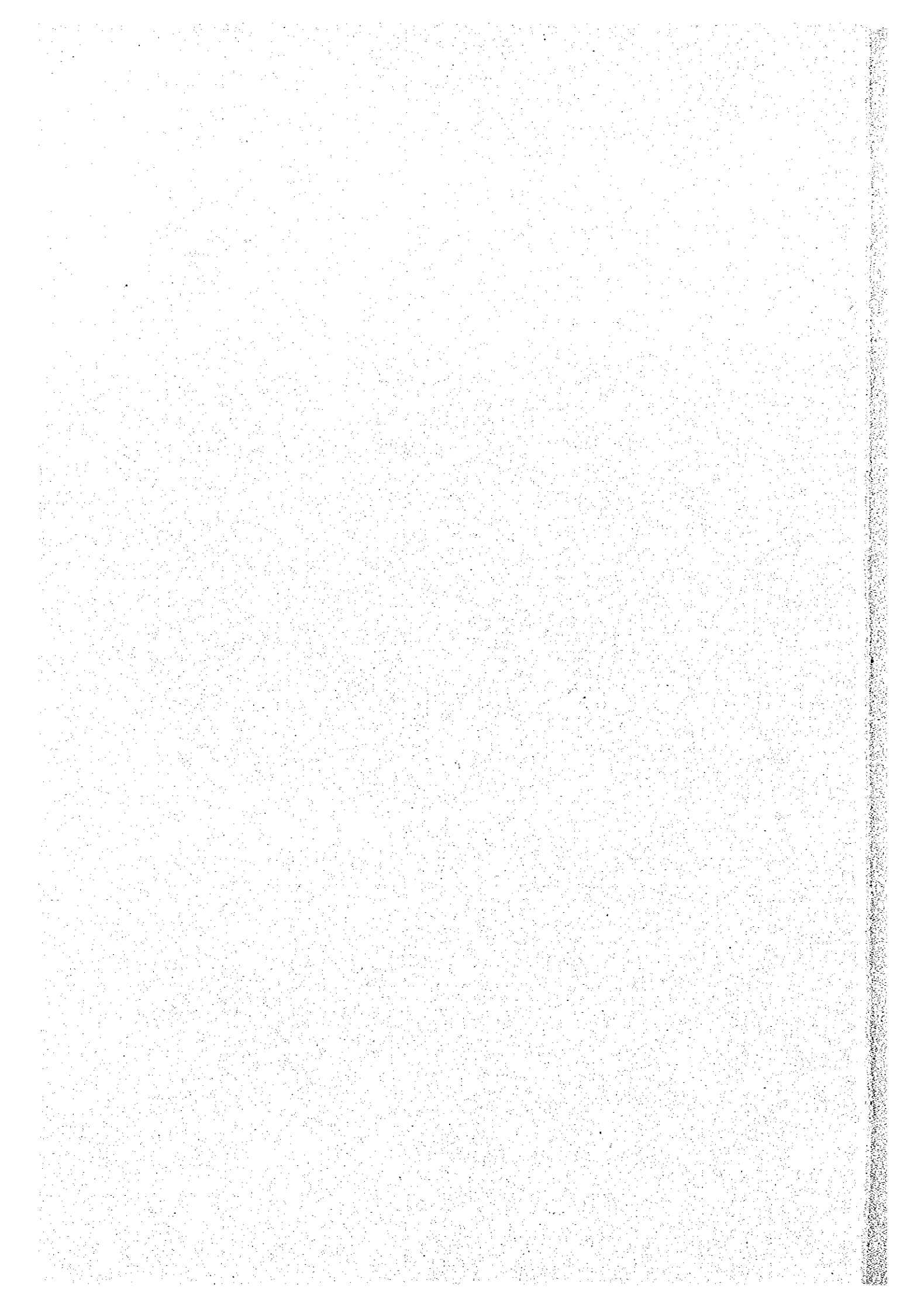FINAL REPORT

VOLUME III
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Abbreviations

Abbreviations	Meanings
ADA	Agricultural Development Authority
ADB	Asian Development Bank
AEB	Area Electricity Boards
AJ&K	Azad Jam and Kashmir
AUP	Agriculture University Peshawar
BOO	Build, Own, and Operate
BOOT	Build, Own, Operate, and Transfer
CA	Command Area/ Catchment Area
CAD	Command Area Development
CCA	Cultivable Command Area
(GCA)	Gross Command Area
(GIA)	Gross Irrigable Area
CFRD	Concrete Face Rockfill Dam
CMTL	Central Material Testing Laboratory
C&W	Communication and Works Department
DSM	Demand Side Management
EAD	Economic Affairs Division
ECNEC	Executive Committee of National Economic Council
ECRD	Earth Core Rockfill Dam
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FAS	Fuel Adjustment Surcharge
FATA	Federally Administrative Tribal Area
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GDP	Gross Domestic Product
GIS	Geographic Information System
GOJ	Government of Japan
GOP	Government of Pakistan
GTZ	Deutsche Gesellschaft für Techniche Zusammenarbeit
HEPO	Hydro Electric Planning Organization
IBRD	International Bank for Reconstruction and Development
ID	Irrigation Department
IEE	Initial Environmental Examination
IFIC	Institution for International Cooperation
IPP	Independent Power Producer
IRSA	Indus River System Authority
ISRIP	International Sedimentation Research Institute of Pakistan
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
KESC	Karachi Electricity Supply Corporation
LOS	Letter of Support
LSC	Lower Swat Canal
MAF	Million Acre Feet
MBT	Main Boundary Thrust
MCE	Maximum Credible Earthquake
M/M	Minutes of the Meeting
MMT	Main Mantle Thrust
M/P	Master Plan
msp	million short ton

Abbreviations	Meanings
MWP	Ministry of Water and Power
NDP	National Drainage Program
NEPRA	National Electric Power Regulatory Authority
NGO	Non-Governmental Organization
NPCC	National Power Control Center
NPP	National Power Plan
NWFP	North-West Frontier Province
O&M	Operation and Maintenance
OECD	Organization for Economic Cooperation and Development
OECF	Overseas Economic Corporation Fund
PARC	Pakistan Agricultural Research Council
PASSCO	Pakistan Agricultural Storage and Services Corporation
PD	Project Description
PE&D	Planning Environment and Development Department
PEPCO	Pakistan Electric Power Company
PHED	Public Health Engineering Department
PHLC	Pehur High Level Canal
PMF	Probable Maximum Flood
PMS	Pakistan Meteorological Service
PPC	Private Power Cell
PPIB	Private Power and Infrastructure Board
PLC	Power Line Carrier
Q/N	Questionnaire
RCC	Roller Compacted Concrete, Regional Control Center
SCADA	Supervisory Control And Data Acquisition
SCARP	Salinity Control and Reclamation Project
SCF	Standard Conversion Factor
SDA	Sarhad Development Authority
SHYDO	Sarhad Hydel Development Organization
SIDB	Small Industries Development Board
S/W	Scope of Work
SWHP	Surface Water Hydrology Project
SWR	Shadow Wage Rate
UNEP	United Nations Environment Program
USC	Upper Swat Canal
UTM	Universal Terrain Model
WAPDA	Water and Power Development Authority
WASP	Wien Automatic System Planning Package
WB	World Bank
WEC	WAPDA Environmental Cell
WMO	World Meteorological Organization
WPPO	WAPDA Power Privatization Organization

Conversion Factors

Length (1)

m	cm	yard	ft	inch
1	100	1.09361	3.28084	39.370
0.01	1	0.010936	0.032803	0.39370
0.91440	91.4400	1	3	36
0.30480	30.480	0.33333	1	12
0.02540	2.54000	0.02778	0.08333	1

Length (2)

km	nautical mile (nm)	yard	mile
1	0.5400	1093.61	0.62137
1.852	1	2026.67	1.1515
0.000914	—	1	—
1.60934	0.869	1760	1

Area (1)

m^2	cm^2	ft^2	in^2
1	10000	10.764	1550
0.09290	929.0	1	144.0
0.0001	1	0.001076	0.1550
0.0006452	6.4516	0.006944	1

Area (2)

ha	km^2	acre	$mile^2$
1	0.0100	2.471	0.00386
100	1	247.10	0.3861
0.4047	0.004047	1	0.001563
259	2.590	640	1

Volume

in^3	U.S. gallon	Imperial gallon	ft^3	m^3	acre-ft
1	0.00433	0.00361	5.79×10^{-4}	1.64×10^{-5}	1.33×10^{-8}
231	1	0.833	0.134	0.00379	3.07×10^{-6}
277	1.20	1	0.161	0.00455	3.68×10^{-6}
1728	7.48	6.23	1	0.0283	2.30×10^{-5}
61,000	264	220	35.3	1	8.11×10^{-4}
7.53×10^7	3.26×10^5	2.71×10^5	43,560	1230	1

Discharge

U.S. gallon /day (gpd)	ft^3/day	U.S. gal/min	Imperial gpm	acre-ft/day	ft^3/sec (cfs)	m^3/sec
1	0.134	6.94×10^{-4}	5.78×10^{-4}	3.07×10^{-6}	1.55×10^{-6}	4.38×10^{-8}
7.48	1	5.19×10^{-3}	4.33×10^{-3}	2.30×10^{-5}	1.16×10^{-5}	3.28×10^{-7}
1440	193	1	0.833	4.42×10^{-3}	2.23×10^{-3}	6.31×10^{-5}
1728	231	1.20	1	5.31×10^{-3}	2.67×10^{-3}	7.57×10^{-5}
3.26×10^5	43,560	226	188	1	0.504	0.0143
6.46×10^5	86,400	449	374	1.98	1	0.0283
2.28×10^7	3.05×10^6	15,800	13,200	70.0	35.3	1

Weight

kg	t	oz	lb	short ton	long ton
1	0.001	35.27	2.204 6	0.00110	9.8420×10^{-4}
1000	1	3.527×10^4	2204.6	1.1023	0.984
0.02835	2.835×10^{-5}	1	0.06250	3.125×10^{-5}	2.790×10^{-5}
0.4536	4.536×10^{-3}	16	1	0.0005	4.464×10^{-4}
907.2	0.9072	32.000×10^3	2.000×10^3	1	0.8529
1016	1.016	3.584×10^4	2.240×10^3	1.12	1

Velocity

m/sec	km/hr	ft/sec	mile/hr	Kn
1	3.600	3.2808	2.237	1.9438
0.2778	1	0.9113	0.6214	0.5400
0.3048	1.0973	1	0.6818	0.5925
0.4470	1.6093	1.4667	1	0.8690
0.5144	1.8520	1.6878	1.1508	1

Density   (c.g.s.Unit)

gr/cc	kg/m³=(gr/l)	gr/m³	lb/ft³	oz/ft³
1	1×10^3	1×10^6	62.43	998.8
0.001	1	1×10^3	0.06243	0.9988
1×10^{-6}	1×10^{-3}	1	6.243×10^{-5}	9.988×10^{-4}
0.016018	16.018	1.6018×10^4	1	16
0.0010012	1.0012	1.0012×10^3	0.0625	1

Pressure

M Pa =(N/mm²)	Pa =(N/m²)	bar	kgf/cm²	atm	mmH₂O	mmHg
1	1×10^6	10	10.197	9.869 2	1.0197×10^5	7500.617
1×10^{-6}	1	1×10^{-5}	1.0197×10^{-5}	9.8692×10^{-6}	0.101 971 6	7.5006×10^{-3}
0.1	1×10^5	1	1.019 716	0.986 923 3	1.0197×10^4	750.0617
0.098 0665	98 066.5	0.980 665	1	0.967 841 1	1×10^4	735.559 3
0.101325	101 325	1.01325	1.03323	1	1.0332×10^4	760
9.8067×10^{-6}	9.806 65	9.806×10^{-5}	1×10^{-4}	9.6784×10^{-5}	1	7.3555×10^{-2}
1.3332×10^{-4}	133.322 4	1.3332×10^{-3}	1.3595×10^{-3}	1.3158×10^{-3}	13.595 10	1

Appendix A
Topography
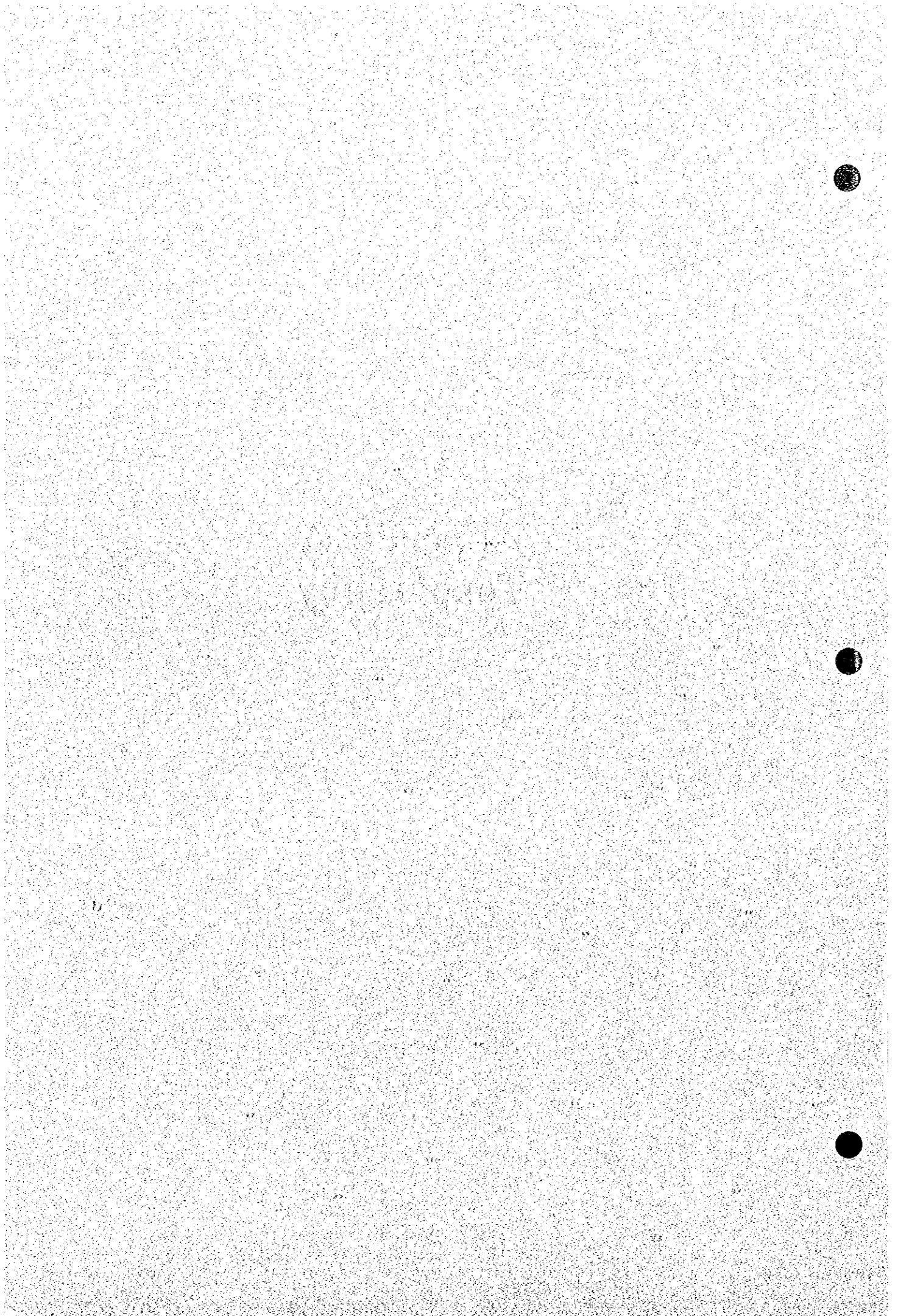
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Appendix A : Topography

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APPENDIX A   TOPOGRAPHY

A1   **Introduction**

The topographic survey conducted during the Feasibility Study include photogrammetric mapping for the reservoir area and topographic survey for the dam site.

(1) Photogrammetric mapping for reservoir area with a scale of 1:10,000 at 10 m contour intervals.

Photogrammetric mapping with aerial photography and ground control survey was undertaken by the Survey of Pakistan (SOP) from June 1998 to March 1999.   The works sublet included:

- aerial photography of around 400 km² with a scale of 1:30,000,
- ground control survey,
- aerial triangulation, and,
- photogrammetric mapping at a scale of 1:10,000.

(2) Topographic survey for dam site with a scale of 1:1,000 at 2 m contour intervals and river survey.

The topographic survey for the dam site and river survey were carried out by Water and Power Development Authority (WAPDA) from October 1998 to March 1999.   The survey included:

- control survey for determination of horizontal points and establishment of bench marks,
- detailed topographic survey and mapping of dam site with the area of around 5 km², and,
- river profile and cross section survey.

A2   **Aerial Photography and Photogrammetric Mapping for Reservoir Area**

A2.1   **Aerial Photography**

A2.1.1   Flight Plan

The flight plan was designed to cover the reservoir area of approximately 400 km² with the photo scale of 1:30,000 and average overlap of 60 % and side lap of 25 %.

The flight index for the aerial photography is shown in Figure A2.1.

A2.1.2   Aerial Shooting

The following are the flight and aerial shooting records:

Flight and Aerial Shooting Record

Items		Description
(1)	Date of flight	June 10, 1998 : July 22, 1998
		September 17, 1998 : September 22, 1998
(2)	Camera	Wild RC-8
(3)	Focal length	152.30 mm
(4)	Flight course	10 courses
(5)	Average flight height	4,500 m
(6)	Average photo scale	1 : 30,000
(7)	Overlap	60 %
(8)	Side lap	25 %

A2.2 Ground Control Survey

A2.2.1 Grid and Datum

The ground control and mapping are related to the National Grid/Universal Transverse Mercator Grid (UTM) in meters. All control points, heights and contours are related to the SOP datum in meters.

A2.2.2 Plan Control

Plan control for photogrammetric mapping was established by photo-identification of existing features after photography. New plan control points of 27 numbers were established throughout the mapping area to an accuracy of better than one part in 20,000 as determined by loop closures. The coordinate values of adjacent control points were in sympathy with each other to a root mean square error of better than 0.06 mm at map scale. Standard horizontal deviation error was less than 0.2 m. The equipment used for the traversing was EDM Sokkia Set II-C and EDM Sokkisha.

A2.2.3 Height Control

The height control was carried out for a length of 100 km establishing 29 new bench marks. Adjacent new height control points were in sympathy to better than one tenth of the specified contour interval, and all height control points were in sympathy with existing bench marks or a reference bench mark to better than one third of the specified contour interval. Standard vertical deviation error was less than 0.2 m. The equipment used for levelling was Topcon ATF-3.

A2.3 Aerial Triangulation

Analytical aero-triangulation was made to establish supplemental horizontal and vertical control for 119 stereoscopic models. Analytical plotter ZEISS P-3 was used for the supplementation of control by the aerial triangulation. The standard deviation and maximum error were as follows:

Standard deviation horizontal and vertical: less than 0.04% for flight height
(4,500m) (approx. 1.8m)

Maximum error horizontal and vertical: less than 0.08% for flight height
(4,500m) (approx. 3.6m)

Results of the aerial triangulation were shown in Table A2.1.

A2.4 Photogrammetric Mapping

Photogrammetric Mapping was carried out on scale 1:10,000 with 10 m contour interval using 1:30,000 scale aerial photography on ADAM-Promap Analytical Plotter and PG-2/JX3 Analytical Plotter.

Grid lines and control points are drawn to an accuracy better than 0.3 mm maximum tolerance. Well-defined points of detail are plotted in their true positions at map scale to better than ± 0.3 mm root mean square error, when coordinates are scaled off the map from the nearest grid lines and compared with coordinates determined by precise measurement on the ground from the nearest control point.

The index of the photogrammetric maps is shown in Figure A2.1 and the reduced maps are given in Figure A2.2.

A3 Topographic Survey for Dam Site and River Survey

A3.1 Topographic Survey for Dam Site

A3.1.1 Ground Control

The topographic mapping at a scale of 1:1,000 with 2 m contour interval was carried out at the dam site by ground survey method. The mapping area is approximately 5 km^2.

Horizontal control was established with 125 control points by triangulation and traverse. Total Station TOPCON GTS-313 was used for the control point survey. The accuracy achieved was less than 15 cm + 5 cm$\sqrt{N}$ · ΣS for connected traverse, and 5 cm$\sqrt{N}$ · ΣS for closed traverse, where N is number of each length and S is total length (km).

Vertical control with 125 points are accomplished by direct differential leveling, but in mountain area the vertical control survey is established by indirect (trigonometric) leveling using TOPCON GTS-313 and Auto Level TOPCON AT-G3.

The accuracy was less than 20 cm + 15 cm $\Sigma S/\sqrt{N}$ for connected traverse, and 15 cm $\Sigma S/\sqrt{N}$ for closed traverse.

Density of distributed control points was 1 point for 8,000 m^2 for the plain table method.

A3.1.2 Topographic Survey

Detailed topographic survey was carried out mainly by plane table method based on the above mentioned control points.

A3.1.3 Topographic Mapping

The topographic mapping was conducted with the area of approximately 5 km^2. Figure A3.1 shows index of the topographic maps.

The coordinate grid lines conform to SOP coordinates and horizontal control points are plotted within 0.25 mm of true position. At least 90% of all well-defined planimetric features are plotted within 0.6 mm of true position, and the remaining features are plotted within 1.2 mm of true position.

A3.2 River Survey

A3.2.1 River Cross Sectional Survey

The river cross sectional survey was carried out by WAPDA. At dam foundation area, a total of 5 sections were surveyed at 100 m intervals. From downstream end of dam slope to Munda Headworks, a total of 20 sections were surveyed at 250 m intervals. Figure A3.2 shows location of the cross sections.

A3.2.2 Plotting of River Survey Results

The result of the river cross sectional survey is summarized in Table A3.1 and illustrated in Figure A3.3. The longitudinal section was also plotted covering all the cross sections.

A4   Final Products of Topographic Survey

A4.1   Photogrammetric Mapping for Reservoir Area

The final products of the topographic survey for the reservoir area are as follows:

Photogrammetric Map for Reservoir Area

Final Products	Scale	Details	No. of Sheets
Photogrammetric Map	1:10,000	10 m contour interval	11

A4.2   Topographic Survey for Dam Site and River Survey

The final products of the topographic survey for dam site and river survey are as follows:

Topographic Map for Dam Site and River Survey Results

Final Products	Scale	Details	No. of Sheets
Topographic Map at Dam Site	1:1,000	2 m contour interval	9
River Profile	H=1:5,000 V=1:200	5.3 km	1
River Cross Section at Dam Site	H=1:1,000 V=1:200	100 m interval	5
River Cross Section downstream of Dam Site	H=1:1,000 V=1:200	250 m interval	20

TABLES

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BLOCK ADJUSTMENT WITH INDEPENDENT MODELS                   REVISION 890206

PROJECT : MUNDA DAM


ADJUSTMENT OF BLOCK 1
LINES   2 (01-11)   10 models
        3 (01-19)   18    do
        4 (01-18)   17    do

CONTROL POINT COORDINATES AND RESIDUALS
****************************************
( IN UNITS OF THE TERRAIN SYSTEM )


                          HORIZONTAL CONTROL POINTS
PT.NO.      X                Y                          RX        RY
1001    3070632.370    1122917.690HV 3 -> HV 2/3     0.025     0.017       1   .
1002    3070689.970    1119151.680HV 2 -> HV 1/ 2   -0.031     0.011       1   .
1003    3074530.970    1122931.910HV 3              -0.020     0.013       1   .
1004    3075224.590    1125974.320HV 2               0.005     0.042       1   .
1005    3074057.190    1126764.080HV 4               0.037    -0.032       1   .
1006    3075249.360    1120170.980HV 1               0.012    -0.006       1   .
1007    3070340.590    1126085.740HV 5              -0.014    -0.041       1   .
1008    3070139.970    1126301.690HV 5              -0.029     0.019       1   .
1009    3068959.400    1128070.230HV 4               0.001    -0.035       1   .
1010    3066355.330    1128681.500HV 5 -> HO 5/ 5   -0.024     0.065       1   .
1011    3067405.880    1124942.330HV 5 -> HV 4/ 5    0.042     0.060       1   .
1012    3066157.670    1124467.780HV 3               0.015     0.028       1   .
1014    3065924.340    1119753.940HV 1              -0.008    -0.026       1   .
1015    3064744.650    1126599.730HV 3              -0.042    -0.016       1   .
1016    3062689.070    1127308.940HV 3              -0.058    -0.044       1   .
1021    3060092.280    1132997.140HV 2               0.001    -0.014       1   .
1022    3058426.710    1138401.190HO 2              -0.017     0.012       1   .
1023    3061206.250    1139199.010HV 2               0.004    -0.087       1   .
1024    3062061.030    1141687.900HV 2               0.007     0.032       1   .
1025    3065028.170    1140851.130HV 2               0.006    -0.036       1   .
1027    3067756.490    1143810.270HV 1               0.018     0.025       1   .
9702    3067566.400    1134931.550HV 2               0.069    -0.002       1   .
9708    3064805.600    1134111.630HV 4              -0.022    -0.012       1   .
9711    3070215.150    1135504.050HV 2 -> HV 1/ 2    0.012     0.025       1   .


                          VERTICAL CONTROL POINTS

1001              440.810     HV 3 -> HV 2/ 3     -0.074       1   .
1002              370.570     HV 2 -> HV 1/ 2      0.008       1   .
1003              379.091     HV 3                 0.068       1   .
1004              418.210     HV 2                -0.001       1   .
1005              419.023     HV 4                -0.006       1   .
1006              355.756     HV 1                -0.020       1   .
1007              564.745     HV 5                -0.051       1   .
1008              566.057     HV 5                -0.025       1   .
1009              746.998     HV 4                 0.016       1   .
1011              385.859     HV 5 -> HV 4/ 5      0.122       1   .
1012              606.482     HV 3                 0.024       1   .
1014              511.530     HV 1                -0.009       1   .
1015              599.100     HV 3                -0.059       1   .
1016              773.406     HV 3                 0.017       1   .
1021              852.646     HV 2                -0.061       1   .
1023              626.640     HV 2                 0.063       1   .
1024              593.137     HV 2                -0.030       1   .
1025              634.441     HV 2                -0.001       1   .
1027              660.647     HV 1                -0.003       1   .
9702              919.000     HV 2                 0.022       1   .
9708              438.700     HV 4                 0.029       1   .
9711             1403.300     HV 2 -> HV 1/ 2     -0.029       1   .
```

END

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BLOCK ADJUSTMENT WITH INDEPENDENT MODELS   REVISION 890206

PROJECT : MUNDA DAM

ADJUSTMENT OF BLOCK 2
LINES 6B (18-01)   17 models
       7B (01-14)   13 do
       8A (01-22)   21 do
       11 (01-12)   11 do
       12 (13-01)   12 do

CONTROL POINT COORDINATES AND RESIDUALS
****
 (IN UNITS OF THE TERRAIN SYSTEM)

                         HORIZONTAL CONTROL POINTS
PT.NO.   X   Y   RX   RY

PT.NO.	X	Y			RX	RY	
1027	3067756.490	1143810.270HV	1		-0.020	0.038	1 .
1028	3079669.700	1151218.670HV	5 -> HV 5/ 4		-0.103	-0.041	1 .
1029	3077345.990	1152986.570HV	2		-0.041	-0.001	1 .
1030	3074407.440	1153851.920HV	2		-0.013	0.035	1 .
1031	3081182.810	1149050.370HV	2		-0.034	0.011	1 .
1032	3082314.640	1146110.680HV	2		0.020	-0.033	1 .
1033	3083811.490	1142865.590HV	1		0.030	-0.023	1 .
1034	3076312.590	1142272.260HV	2 -> HV 2/ 1		0.013	0.017	1 .
1801	3070550.620	1137580.740HV	1		-0.023	0.013	1 .
1804	3069988.600	1140216.570HV	1		-0.006	0.019	1 .
4052	3068145.560	1143737.290HV	1		-0.024	0.036	1 .
4062	3069142.151	1142139.170HV	1		0.032	-0.003	1 .
4072	3069557.254	1140169.940HV	1		0.019	0.004	1 .
4082	3070305.331	1138013.140HV	1		-0.001	-0.024	1 .
7001	3110958.890	1154819.270HV	1		0.015	-0.012	1 .
7002	3110589.580	1151712.090HV	1		-0.036	0.020	1 .
7003	3111153.660	1158310.040HV	2		0.021	-0.047	1 .
7004	3111000.450	1158962.560HV	2		-0.018	0.055	1 .
7005	3110752.470	1161845.200HV	1		0.025	0.022	1 .
7006	3100169.700	1152011.660HV	2		-0.026	-0.040	1 .
7007	3100760.750	1154837.990HV	2		-0.022	-0.023	1 .
7008	3099211.270	1156343.900HV	4		0.066	-0.040	1 .
7009	3100254.170	1158326.460HV	3		-0.028	0.062	1 .
7010	3099017.690	1159529.640HV	2		0.024	0.012	1 .
7011	3099103.910	1162300.510HV	2		-0.075	-0.053	1 .
8002	3084582.930	1145610.020HV	2		0.066	0.012	1 .
8007	3082592.520	1146744.980HV	2		-0.017	0.033	1 .
8035	3089078.160	1158259.530HV	5 -> HV 4/ 4		0.028	-0.027	1 .
8043	3087824.770	1154951.320HV	5		0.047	-0.011	1 .
8044	3087523.960	1154259.530HV	4 -> HV 4/ 3		-0.040	-0.047	1 .
8046	3088462.600	1155082.640HV	5		0.079	-0.040	1 .
8058	3088887.300	1151454.380HV	1		0.015	0.000	1 .
8073	3090997.980	1159983.050HV	3		-0.006	0.067	1 .
8104	3087581.500	1159450.630HV	3		0.014	0.027	1 .
8110	3086638.270	1161114.800HV	2		-0.045	0.018	1 .
8112	3085283.400	1161986.130HV	2		0.009	0.029	1 .
8113	3084601.360	1162138.970HV	2		-0.018	0.019	1 .
8120	3082152.670	1162786.270HV	1		0.004	-0.010	1 .
8123	3079713.740	1163330.830HV	1		0.013	-0.015	1 .
8125	3080480.900	1163294.250HV	1		0.010	-0.039	1 .
8150	3068823.040	1144485.170HV	1		-0.025	0.027	1 .
8153	3071472.310	1143404.550HV	3 -> HV 2/ 2		-0.006	-0.011	1 .
40722	3068445.788	1139688.450HV	1		0.051	-0.026	1 .
40822	3068741.630	1137816.820HV	1		0.025	-0.012	1 .

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                   VERTICAL CONTROL POINTS
PT.NO.             Z                                    RZ
1027            660.647      HV 1                      0.030         1 .
1028            519.005      HV 5 -> HV 5/ 4           0.075         1 .
1029            812.959      HV 2                      0.048         1 .
1030            798.090      HV 2                     -0.025         1 .
1031            978.683      HV 2                      0.036         1 .
1032            660.068      HV 2                     -0.007         1 .
1033            573.964      HV 1                      0.007         1 .
1034            755.725      HV 2 -> HV 2/ 1          -0.004         1 .
1801           1430.142      HV 1                     -0.006         1 .
1804           1445.411      HV 1                     -0.012         1 .
4052            843.901      HV 1                      0.083         1 .
4062            917.478      HV 1                     -0.045         1 .
4072           1253.081      HV 1                      0.041         1 .
4082           1354.332      HV 1                     -0.022         1 .
7001            702.940      HV 1                      0.057         1 .
7002            855.636      HV 1                     -0.015         1 .
7003            678.742      HV 2                      0.019         1 .
7004            709.450      HV 2                     -0.050         1 .
7005            728.280      HV 1                     -0.024         1 .
7006            679.330      HV 2                     -0.015         1 .
7007            630.321      HV 2                     -0.019         1 .
7008            763.459      HV 4                      0.044         1 .
7009            634.387      HV 3                      0.016         1 .
7010            730.028      HV 2                     -0.114         1 .
7011            890.360      HV 2                      0.113         1 .
8002            972.579      HV 2                      0.053         1 .
8007            688.689      HV 2                     -0.084         1 .
8011            595.858      VE 3 -> VE 3/ 2          -0.036         1 .
8023            925.861      VE 3 -> VE 3/ 1          -0.057         1 .
8024           1203.076      VE 3 -> VE 3/ 2          -0.009         1 .
8035            623.849      HV 5 -> HV 4/ 4           0.001         1 .
8043           1107.732      HV 5                     -0.011         1 .
8044           1171.719      HV 4 -> HV 4/ 3           0.001         1 .
8046            972.017      HV 5                      0.065         1 .
8058            884.026      HV 1                      0.002         1 .
8073            832.689      HV 3                     -0.003         1 .
8104            578.889      HV 3                     -0.072         1 .
8110           1096.075      HV 2                     -0.047         1 .
8112           1264.196      HV 2                      0.065         1 .
8113           1302.891      HV 2                      0.024         1 .
8120           1579.143      HV 1                     -0.053         1 .
8123           1706.262      HV 1                     -0.007         1 .
8125           1733.508      HV 1                      0.032         1 .
8150            927.492      HV 1                      0.027         1 .
8153            602.765      HV 3 -> HV 2/ 2          -0.025         1 .
40522           755.956      VE 1                     -0.100         1 .
40722           830.590      HV 1                     -0.037         1 .
40822           918.969      HV 1                      0.060         1 .
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END

Table A3.1 Survey Results of River Cross Sections (1/2)

US200		US100		Dam Site		DS100		DS200		DS450		DS700		DS950		DS1200		DS1450		DS1700		DS1950		DS2200	
Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)	Dist. (m)	Elev. (EL.m)
132.0	408.500	145.0	419.000	119.6	425.194	126.0	429.920	128.0	445.800	139.0	417.500	108.0	411.900	166.0	449.700	149.0	442.100	143.0	405.700	191.0	378.600	152.0	378.388	120.0	449.700
119.0	407.200	120.0	408.500	118.0	419.081	119.0	423.666	123.0	437.500	127.0	414.120	98.0	401.400	149.0	436.800	140.0	429.000	121.0	389.100	165.0	378.000	122.0	377.700	109.0	429.300
110.0	399.900	104.0	399.600	115.0	416.142	113.0	417.991	121.0	435.700	93.0	412.000	91.0	393.600	141.0	427.600	117.0	404.100	105.0	383.800	132.0	374.800	102.0	376.900	95.0	418.700
101.0	390.500	101.5	395.400	111.0	406.165	107.0	412.642	110.0	427.000	79.0	405.900	87.0	386.400	136.0	416.900	113.0	394.000	70.0	380.700	122.0	372.000	81.0	375.400	82.0	411.700
84.0	386.323	95.7	390.500	103.0	399.084	98.0	405.315	103.0	417.300	66.0	397.400	76.0	382.500	129.0	406.045	107.0	380.000	54.0	379.300	118.0	369.000	74.0	373.100	68.0	394.400
79.0	386.126	87.0	385.800	95.0	393.341	90.0	399.351	94.0	410.000	57.0	390.000	60.0	377.800	105.0	390.900	86.0	373.100	35.0	377.800	107.0	369.700	31.0	370.000	56.0	384.200
67.5	379.160	69.7	383.100	88.6	386.617	81.0	393.602	82.0	399.900	50.0	386.400	45.0	377.000	82.0	381.400	60.0	371.500	19.5	371.000	84.0	367.900	16.0	363.900	39.0	375.549
59.0	378.279	67.0	383.900	75.6	381.817	78.0	390.885	70.3	391.100	44.0	383.800	37.0	373.168	75.0	378.100	27.0	368.200	19.3	365.900	20.0	364.600	15.0	363.600	29.0	368.900
44.5	378.520	37.7	381.700	75.0	381.817	68.0	385.394	55.6	385.000	37.0	380.900	36.0	373.200	64.0	378.800	21.2	365.900	19.0	364.870	19.0	364.400	10.0	363.000	23.0	363.400
36.5	374.565	30.0	372.300	64.0	381.533	59.0	382.137	49.6	385.300	33.5	372.600	35.0	367.799	62.0	375.800	21.0	362.870	18.0	364.170	16.0	364.000	5.0	362.300	22.0	361.900
23.0	371.062	21.6	369.400	38.0	382.404	44.0	378.730	37.6	382.100	33.5	369.500	25.0	365.893	60.0	369.900	19.0	361.770	16.0	361.370	11.0	363.600	0.0	362.500	17.0	361.890
16.3	364.000	16.5	366.000	32.0	379.526	40.0	378.447	27.0	373.060	25.5	368.000	20.0	365.700	51.0	368.000	14.0	361.870	11.0	356.670	6.0	363.200	5.0	363.000	12.0	361.910
16.0	362.250	16.2	364.000	28.0	379.110	38.0	378.510	25.0	368.600	17.5	365.900	17.0	364.900	38.0	368.300	9.0	362.570	6.0	357.670	1.0	363.000	10.0	363.400	7.0	361.900
11.0	362.000	14.0	362.600	19.5	373.340	32.0	377.730	23.0	367.900	17.0	359.500	15.0	364.600	28.0	368.300	4.0	363.170	6.0	359.700	0.0	362.400	13.0	363.700	2.0	362.100
9.0	364.000	9.0	362.500	17.5	362.000	28.4	377.400	17.0	366.000	16.5	359.000	10.0	364.000	27.6	365.800	0.0	363.300	0.0	360.870	4.0	361.400	15.0	364.000	0.0	362.400
3.5	365.000	4.0	363.400	12.0	362.510	28.0	375.220	16.6	363.000	7.5	360.900	5.0	363.750	27.5	363.750	1.0	363.410	4.0	362.270	9.0	359.100	58.0	366.620	3.0	362.700
0.0	365.000	0.0	364.000	7.0	363.300	20.8	373.314	16.5	363.700	2.5	361.900	0.0	363.500	26.5	363.500	6.0	363.870	9.0	363.620	12.0	357.600	84.0	366.282	8.0	362.200
1.5	365.000	6.0	364.600	2.0	363.401	20.0	371.777	13.5	363.700	0.0	362.400	5.0	361.400	22.0	364.070	11.0	364.370	14.0	363.620	14.0	356.600	90.0	364.023	13.0	361.700
6.5	364.750	8.0	365.150	0.0	363.350	18.0	366.500	8.5	365.800	2.5	362.900	10.0	360.500	16.5	364.520	16.0	364.770	17.0	364.620	19.0	363.600	100.0	363.512	18.0	360.400
8.5	364.200	16.0	365.600	2.0	363.300	16.4	366.000	3.5	363.000	7.5	362.200	15.0	359.900	11.5	364.670	19.0	365.830	19.0	365.870	20.0	364.601	103.0	369.924	23.0	361.000
16.5	363.400	22.0	368.000	7.0	362.600	16.0	365.910	0.0	365.500	12.5	362.900	17.0	359.300	7.0	365.000	21.0	365.870	61.0	368.800	21.0	365.541	107.0	377.440	24.0	363.010
16.5	366.000	23.6	368.123	12.0	362.250	14.0	365.410	1.5	363.400	14.5	362.900	20.0	364.900	2.0	365.000	34.0	382.985	81.0	369.600	35.0	372.700	133.0	382.250	25.0	369.600
18.5	375.000	30.0	374.000	17.0	364.000	5.0	365.010	6.5	363.250	16.0	364.900	25.0	365.893	3.5	365.000	45.6	384.000	102.0	371.500	50.0	384.400	156.0	381.522	38.0	374.369
25.5	378.411	30.3	375.000	17.5	366.000	4.0	362.810	11.5	363.400	17.0	365.900	31.0	375.863	8.5	365.270	59.0	384.800	127.0	373.900	54.0	385.700	203.0	390.207	43.0	370.752
32.4	379.080	39.6	384.110	19.5	368.466	0.0	362.900	14.0	363.400	17.5	366.000	34.0	379.663	13.0	365.570	121.6	389.600	134.0	378.164	56.0	386.231			81.0	370.622
47.0	377.000	44.4	392.065	20.5	377.103	6.0	363.410	15.5	362.900	18.0	368.100	56.0	381.942	18.0	365.670	136.0	391.100	137.0	380.414	77.0	391.000			82.0	373.916
52.0	378.200	50.0	400.765	38.0	385.093	11.0	363.410	16.5	365.900	28.0	375.900	62.0	382.012	23.0	365.870	154.0	394.600	146.0	382.400	86.0	389.400			89.0	379.580
58.0	387.608	59.3	404.210	51.0	398.022	16.0	364.610	16.6	363.410	35.0	381.181	88.0	387.551	27.5	365.870			163.0	383.280	100.0	392.400			105.0	380.000
77.0	401.518	68.0	407.800	54.3	400.800	16.4	366.000	20.0	369.500	42.0	381.200	124.0	395.370	27.8	366.000			183.0	384.130					120.0	380.908
82.3	403.200	80.0	415.100	59.0	405.310	19.0	368.100	32.0	375.600	52.0	383.300	128.0	410.100	42.0	375.000			220.0	387.500					162.0	382.361
97.4	408.900	94.5	421.755	71.0	411.354	29.0	374.600	40.0	381.300	76.0	392.700	144.0	417.860	51.0	383.374			243.0	390.000						
110.9	415.500	105.7	429.000	76.0	414.705	33.0	379.500	46.0	387.050	83.0	402.100			64.0	384.960										
120.4	421.405	119.0	438.400	78.5	417.023	39.0	386.950	52.3	390.400	95.0	415.900			84.0	387.000										
		123.0	442.000	90.6	424.061	44.0	388.900	58.0	395.700	100.0	425.200			114.0	395.300										
				97.0	429.000	50.0	392.915	62.6	400.200	104.0	430.000			128.0	402.900										
				106.0	429.000	56.5	393.400	77.5	412.300	116.0	446.000			142.0	412.500										
				114.8	437.213	2.0	392.000	88.0	420.200	130.0	458.800			154.0	420.800										
				125.0	444.644	59.0	398.600	101.7	434.300																
					450.758	62.0	398.600	107.3	434.000																
						70.0	401.600	112.4	438.900																
						80.0	405.700	117.7	441.500																
						83.0	408.100	123.0	442.000																
						104.0	418.000	127.6	443.000																
						126.0	429.200	131.0	445.210																
						139.0	436.160	135.0	448.300																
								142.0	453.800																

Table A3.1 Survey Results of River Cross Sections (2/2)

DS2450 Dist.(m)	DS2450 Elev.(EL.m)	DS2700 Dist.(m)	DS2700 Elev.(EL.m)	DS2950 Dist.(m)	DS2950 Elev.(EL.m)	DS3200 Dist.(m)	DS3200 Elev.(EL.m)	DS3450 Dist.(m)	DS3450 Elev.(EL.m)	DS3700 Dist.(m)	DS3700 Elev.(EL.m)	DS3950 Dist.(m)	DS3950 Elev.(EL.m)	DS4200 Dist.(m)	DS4200 Elev.(EL.m)	DS4450 Dist.(m)	DS4450 Elev.(EL.m)	DS4700 Dist.(m)	DS4700 Elev.(EL.m)	DS4950 Dist.(m)	DS4950 Elev.(EL.m)	DS5200 Dist.(m)	DS5200 Elev.(EL.m)
158.0	377.100	152.0	391.700	146.0	394.101	152.0	393.828	156.0	376.298	166.7	369.594	216.0	369.500	310.0	376.700	158.0	367.530	163.0	369.630	191.0	366.160	242.0	371.860
143.0	374.900	120.0	379.200	126.0	385.880	136.0	392.078	137.0	375.896	151.8	370.154	195.0	366.700	290.0	376.280	143.0	367.800	152.0	370.000	164.0	367.670	230.0	364.870
108.0	370.700	97.0	374.100	102.0	380.000	131.0	366.958	115.0	375.858	146.3	371.154	180.0	366.220	270.0	375.840	122.0	367.920	148.0	368.080	147.0	367.760	226.0	364.800
83.0	374.000	65.0	372.400	83.0	378.000	110.0	381.958	96.0	375.680	136.5	367.814	155.0	368.960	250.0	375.520	98.0	367.080	145.0	368.240	134.0	367.720	222.0	363.110
74.0	370.000	56.0	370.600	74.0	377.600	95.0	377.248	74.0	372.648	110.7	366.624	133.0	369.630	221.0	373.500	95.0	367.450	137.0	364.210	118.0	367.840	220.0	361.240
70.0	373.700	54.0	369.000	56.0	376.000	85.0	377.048	68.0	370.548	89.5	363.454	99.0	369.630	210.0	370.710	90.0	367.460	135.0	363.030	112.0	368.120	208.0	360.500
52.0	371.600	48.7	371.000	43.0	373.832	79.0	375.384	60.0	367.148	61.7	362.980	85.0	372.310	206.0	367.530	73.0	366.380	131.0	362.030	103.0	368.740	195.0	361.860
42.0	369.200	42.0	370.800	38.0	366.806	57.0	372.900	52.0	366.436	27.5	362.920	62.0	374.940	202.0	364.830	56.6	364.220	129.0	361.100	86.5	368.870	194.0	363.100
41.0	366.900	31.0	366.900	34.0	364.642	46.0	370.091	47.0	364.856	22.5	362.820	60.0	368.720	187.0	365.380	50.0	362.870	119.0	360.900	86.0	362.860	182.0	369.590
38.0	364.700	28.6	363.000	32.0	363.157	44.0	366.618	35.0	362.940	17.5	362.620	44.9	368.610	164.0	365.910	45.0	360.940	112.0	361.200	80.0	360.460	178.5	369.620
16.5	363.300	27.5	362.000	29.0	361.380	42.0	362.960	32.0	362.440	12.5	362.320	35.0	371.540	151.0	365.350	40.0	360.660	107.0	362.020	70.0	361.820	175.0	369.620
16.0	363.200	26.5	361.200	27.0	361.480	31.0	361.860	27.0	361.930	7.5	362.320	30.0	364.800	140.0	368.360	35.0	360.460	100.0	363.100	60.0	362.160	163.0	367.500
13.5	361.900	21.5	361.650	22.0	360.580	30.0	361.560	22.0	361.940	2.5	362.900	25.0	362.900	132.0	369.120	30.0	360.160	94.0	369.000	50.0	361.870	161.0	368.440
8.5	361.600	16.5	361.600	17.0	360.040	25.0	361.560	17.0	361.560	0.0	361.780	20.0	361.200	105.0	369.350	20.0	360.350	82.0	369.570	40.0	361.860	140.0	366.660
3.5	361.500	11.5	361.600	12.0	360.030	20.0	361.360	12.0	361.440	2.5	361.560	10.0	360.500	95.0	370.640	10.0	360.560	71.0	369.390	30.0	361.660	125.0	363.500
0.0	361.150	6.5	361.650	7.0	360.020	15.0	360.960	7.0	361.090	7.5	361.620	5.0	360.200	85.0	370.000	0.0	360.700	70.0	370.160	20.0	361.680	122.0	361.790
1.5	360.500	1.5	361.700	2.0	360.780	10.0	360.760	2.0	361.000	12.5	361.320	0.0	360.100	73.0	368.200	10.0	360.560	60.5	366.820	10.0	361.870	90.0	362.000
6.5	360.300	0.0	361.750	0.0	361.000	5.0	360.460	0.0	361.010	17.5	361.120	5.0	359.900	60.0	370.300	20.0	360.860	60.0	362.870	0.0	361.700	55.0	362.300
11.5	359.600	3.5	361.800	4.0	361.230	0.0	360.410	5.0	360.940	22.5	362.820	0.0	359.900	40.0	372.400	25.0	361.260	50.0	359.010	10.0	361.260	14.0	362.210
16.0	362.300	8.5	361.700	9.0	361.630	5.0	360.360	8.0	360.840	27.5	362.920	10.0	357.700	31.0	362.380	30.0	361.360	40.0	358.300	20.0	361.060	0.0	361.000
16.5	363.300	13.0	361.800	14.0	361.780	10.0	360.460	13.0	360.740	33.3	363.201	15.0	357.500	25.0	355.340	40.0	362.160	30.0	359.370	30.0	361.650	22.0	361.030
28.5	375.100	18.5	361.700	19.0	362.230	15.0	360.560	18.0	360.640	43.8	367.854	20.0	358.980	20.0	353.840	50.0	362.870	20.0	360.050	40.0	361.780	68.0	361.590
31.0	376.925	23.5	361.700	24.0	362.480	20.0	360.210	25.0	360.540	49.0	370.554	25.0	360.800	10.0	354.940	56.0	364.840	10.0	360.620	50.0	361.670	99.0	363.210
34.0	378.764	25.0	361.800	27.0	362.780	25.0	360.460	28.0	360.490	52.2	371.284	30.0	362.980	5.0	356.500	67.0	370.060	0.0	360.820	60.0	360.860	125.0	364.560
68.0	380.200	28.5	362.000	29.0	362.950	28.0	360.960	32.0	360.960		House	36.0	365.130	0.0	358.640	69.0	370.670	10.0	361.130	70.0	361.460	132.0	366.610
111.5	385.300	28.6	363.000	48.0	364.775	30.0	362.960	33.0	362.940			43.0	369.840	5.0	359.840	77.0	372.080	20.0	361.330	80.0	361.850	137.0	363.400
123.0	392.000	29.5	366.850	50.0	368.333	35.0	368.848	39.0	367.558			53.0	374.400	10.0	360.940	94.0	383.040	30.0	361.870	86.0	362.860	139.0	362.240
128.0	398.200	42.0	379.200	51.0	370.877	39.0	372.908	45.4	370.188			70.0	396.400	15.0	361.440	120.0	394.430	40.0	362.070	91.0	369.240	143.0	361.140
140.6	404.500	53.0	379.865	79.0	373.151	59.0	373.518	57.0	369.368			87.0	417.750	20.0	361.340	130.0	384.490	50.0	362.430	96.0	368.370	147.5	362.450
155.6	409.300	68.8	381.700	109.0	374.615	73.0	373.888	74.5	370.424			95.0	413.900	25.0	361.140	134.0	390.140	55.0	362.550	97.0	362.000	150.0	363.350
160.0	415.400	90.0	382.330	120.0	374.178	81.0	369.908	78.5	372.228			115.0	401.600	31.0	362.880	145.0	396.800	60.0	362.900	103.0	361.200	163.0	367.590
172.0	422.900	104.0	380.840	121.0	373.668	112.0	369.157	87.0	372.728			128.0	399.500	41.0	373.600	156.0	402.270	70.0	372.340	109.0	362.850	165.5	367.500
		114.0	378.430	140.0	373.913	128.0	370.258	94.0	373.384			135.0	396.150	43.0	379.610	174.0	410.500	82.0	374.870	119.0	367.370	168.0	367.520
		119.0	379.620	149.0	374.716			109.0	374.578			140.0	402.500	61.0	399.800			89.0	375.210	134.0	370.040	193.0	368.710
		125.0	382.200	156.0	377.507			116.0	373.898					70.0	399.330			115.0	376.880	139.0	367.500	214.0	371.700
		155.0	383.570	174.0	378.207			133.0	371.898					87.0	414.740			124.0	381.730	145.0	369.660	232.0	373.030
				178.0	379.237									96.0	419.410			140.0	386.940				
														107.0	422.700			150.0	388.610				
														127.0	426.500			163.0	392.060				
														150.0	430.170			176.0	395.280				

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