Water Management in the South Caucasus

REPORT

Background Information On the Mingechevir Reservoir

Prepared under:

Grant Agreement No. 3335-105-007

Prepared by:

Professor Magbet Mammadov
International Hydrological Programme
Baku, Azerbaijan

September 25, 2002

Water Management in the South Caucasus

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Mr. Peter Argo
Director
Office of Energy & Environment
U.S. Agency for International Development
20 Telavi Street, 5th Floor
Tblisi 380003 Georgia

Dear Mr. Argo,

We are pleased to provide to you with the attached report titled "Background Information on the Mingechevir Reservoir" completed by Professor Magbet Mammadov, Chairman of the International Hydrological Programme, in Baku as part of the Water Management in the South Caucasus Project. The report was completed based on a Grant Agreement (No. 3335-105-007) that was executed on September 9, 2002.

This report summarizes the tasks identified in the Grant Agreement and is a detailed summary of the information collected at this reservoir since construction in 1953 and is not readily available in any other source. The information contained in this report will assist Dr. Gregory L. Morris, DAI Sedimentation Specialist, in the evaluation of the Mingechevir Reservoir which is scheduled to be completed in early October.

The Mingechevir Reservoir is arguably the most important water body in Azerbaijan with multiple uses and is an example of a demonstration project in a bi-lateral setting. We are pleased to distribute this document to the interested parties in the region on behalf of USAID. Thank you for your assistance and support for this project.

Sincerely,

Paul C. Dreyer, PE
Chief of Party

Enclosure
cc: Mr. William McKinney, USAID/Baku
Mr. Rafig Verdiyev, DAI/Baku
Dr. Gregory L. Morris, GMA/DAI

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1. Development of the Mingechevir Reservoir

The Mingechevir Reservoir is built on the Kura River on a natural hollow in the form of cup. Its borders are limited on the north side by the Khodjashen Ridge and on the south side by the Bozdag Ridge. The latest in its own turn in the area of the Town of Mingechevir transfers to the left side by creating the narrow ravine. In this place is built the land made alluvial dam with height 80 m, and length 1.5 km. This dam allows the long term water regulation of waters from the Kura River, the Gabirri (Iori) River, and the Ganikh (Alazan) River.

2. Characteristics of the Reservoir

The reservoir is under exploitation since 1953. The total storage capacity of the reservoir is estimated (by Dr. Tariverdiyev) to be 16.6 cu km of which 8.7 cu km is usable capacity and the dead capacity is 7.9 cu km, or almost half of the storage volume. The current estimate of the storage capacity of the reservoir is 16.1 cu km.

The water surface area at the maximum water level is 605 km^2 and the average depth and width are 26.4 m and 8.9 km, respectively. The maximum depth and width are 64.7 m and 20.0 km, respectively. The length of the reservoir is 72.5 km with a coast line of approximately 300 km. The bathometric curve of reservoir is provided in Figure 2.

The reservoir comprises the lake and four bays including the Ganikh (Alazan) Bay which has the area of 23.3 sq km, a capacity of 217.5 million cu m, a length of 5.3 km, an average width of 4.4 km, an average depth of 9.2 m, and a maximum depth 21 m.

Filling of reservoir began in 1953 and ended in 1956 by reaching of level 82.41 m (the highest allowable level is 83.0 m). However, in 1959 the maximal observed level was 83.87m (see Table 1). Coordinates of curve of water level and reservoir capacity dependence is given in Table 2.

3. Climatic Conditions in the Area

To determine climatic condition there is meteorological station which measures weather condition several times a day (i.e., every three hours).

The climatic conditions of the area at the Mingechevir Station are summarized. The air temperature is an average annual of 15.0^{o}C, the average temperature at hottest month of the year (July) is 27.5^{o}C, and for the coldest month (January) is 3.3^{o}C. The absolute maximum temperature was 41^{o}C and the absolute minimum was -19^{o}C. The average annual relative humidity is 65-70 per cent.

The average annual precipitations is 340 mm. The average annual wind speed is about 3.6-4.0 m/s. The annual evaporation from water surface is 1,060 mm while the evaporation from the land surface is 330 mm. The estimated water lost from evaporation from the reservoir is 730 mm (1050mm - 330mm). The maximal monthly evaporation is 115mm in August with the minimal monthly evaporation of 15-20 mm in February-March.

Information about evaporation and precipitation for the reservoir also amount of water taken from reservoir by two channels – the Garabakh and the Shirvan is provided in Table 3

4. Sedimentation Accumulation in the Reservoir

The sedimentation accumulation in the reservoir was projected for about 410 years. Prior to the construction of the cascade reservoirs on the Kura River (Shamkir and Yenikend Reservoirs), the

sedimentation buildup of the reservoir was formed mainly by materials transported by the Kura, Alazan (Ganikh), Gabirri, and Ganjachay Rivers (see Tables 4 to 7 in the Appendix).
The turbidity and suspended materials in the rivers show that annual amounts of turbidity in the Kura River before the Mingechevir Reservoir (at Khuluf Station) makes up 560-3400 gr/cu m, with the average amount 1,680 gr/cu m. The maximal amount of which occurs in the spring and summer period (the flooding period).

The average amount of suspended materials for the long-term period is 500 kg/s and the silt runoff was more than 16 million tons during a 40 year period (between approximately 1930 to 1980). The maximal monthly amount of suspended materials is 6,880 kg/s which was observed in May 1964.

The Alazan River is the second source after the Kura River which has a high amount of turbidity. The annual amount from the Ganikh River make up 7,000-3,800gr/cu m, with the average amount of 2,314 gr/cu m. The average amount of suspended materials for the long-term period is 254 kg/s and the silt runoff was approximately 9 million tons during a 30-year period (between approximately 1947 to 1980). The maximal monthly amount of suspended materials is 3,000 kg/s which was observed in June 1977.

For the Iori River, the annual amounts of suspended materials for the long-term period is 20-30 kg/s and the silt run off was about 0.8 million tons. The maximal monthly amount of suspended materials is 1,200 kg/s which was observed in June 1952.

For the Gangachay River, the annual amounts of suspended materials for the long-term period is 0.5 kg/s and the silt run off was more than 0.01 million tons during a 30-year period (between approximately 1947 to 1980).

The average amount of materials brought by rivers into the Mingechevir Reservoir during a 28-year period (from approximately 1953 to 1980) is estimated to be 24.5 million tons annually.

The average granulometric content of suspended materials of Kura River at Khuluf Station (from 1950 to 70) is, as follows:

No.	Kura-Khuluf	Alazan-Ayrichay
1	Fine dust -28%	Fine dust -33%
2	Fine silt - 28%	Fine silt - 5%
3	Fine sand - 9%	Fine sand - 5%
4	Average sand -2.5%	Average sand - 4 %
5	Large dust - 18%	Large dust - 9 %
6	Large silt -14%	Large silt - 44%

The diameter of suspended materials from the Kura River changes between 0.018-0.085 mm with an average 0.05 mm and for the Alazan River it changes between 0.008-0.2 mm with the average 0.05 mm.

The results of research completed more than ten years ago (by Magbet Mammadov, Ramazan Tariverdiyev, Shakhvalad Khalilov) show that the bottom sediments of the reservoir were formed mainly by accumulation of materials brought by rivers and materials from shore erosion and made up approximately an average of 20 million cu m annually. After the construction of Shamkir Reservoir in 1981, the silting of Mingechevir Reservoir is due primarily to Ganikh (Alazan) and Gabirri (Iori) Rivers.

In connection with exploitation of these reservoirs and change of shore erosion process in the Mingechevir Reservoir, the amount of sediments and their annual increase has changed. It is estimated that the average capacity of sediments in the reservoir is more than 10 per cent of dead

capacity. Unfortunately, during last 10 years research of the sedimentation processes of the Mingechevir Reservoir and their composition have not been conducted.
The turbidity of the Mingechevir Reservoir water strongly differs from the turbidity of the rivers falling into it. This is connected with decreasing of the river waters speed and falling out of sediments. In accordance with the sedimentation regime the Mingechevir reservoir is divided into three areas (see Figure 1), as follows:

1. Area of river mouths where turbidity changes depending of run off characteristics;
2. Deep water area (middle area of reservoir) where the turbidity is low; and
3. Shore area where Turbidity changes depending of water level change, precipitation and wind-wave processes.

The turbidity in the spring-summer period at the Area 1 changes from 500 to 2,000-3,000 gr/cu m. In the Area 2, it changes between 15-30 gr/cu m and in the autumn-winter period, it decreases to 1 to10 gr/cu m.

The sedimentation in the reservoir consists of small particles (60 percent) diameter of which is less than 0.05 mm. Large particles are disposed near the shore. For example, elements with diameter larger than 0.25 mm near the shore of 15 per cent.

The thickness of sediments near the Kura River mouth is 125 cm, Alazan River is 90 cm, and the Iori River is 80 cm (based on information collected in 1970). Total content of sediment for the reservoir from their sources and areas is provided in Tables 8 to 10.

5. Thermal Regime of the Reservoir

The temperature in the hottest month is July where water temperature in the surface reaches 26.9^{o}C (which decreases to 10^{o}C at the bottom of the reservoir).

In summer, the difference between water temperature near the shore and in the middle of reservoir is 2.0 to 3.0^{o}C. Also, the water temperature in the north by comparing with the south of reservoir is below by 2.0 to 3.0^{o}C. In winter, water temperature decreases to 6.6^{o}C (in February) at the surface of reservoir (which is about 5^{o}C at the bottom of the reservoir).

The average annual temperature of the water changes from 15.0 to 16.2^{o}C.

6. Hydro-chemical Regime of the Reservoir

Before the reservoir mineralization of Kura river near Mingechevir was about 200-450 mg/l in flooding period and 300-550 in winter and related to hydrocarbon class and calcium group After constructing of the reservoir chemical content of water did not change but to ion composition of water were added biogen elements (NO_2, NO_3, NH_4, P, Si, Fe) connected with organic process in the reservoir. Was changed also composition of $O_{2,}$ CO_2 and pH

Total chemical composition of reservoir approximately is the same as that is in Kura River with mineralization of 250 to 450 mg/l. The information on chemical content of the reservoir waters and its tributaries is provided in Tables 11 to 15 in the Appendix.

APPENDIX

Table 1. Mingechevir Reservoir Water Level

Years	Average water level (m)	Years	Average water level (m)
1953		78	79,51
54	63,42	79	74,71
55	67,50	1980	75,40
56	77,55	81	78,00
57	78,18	82	79,68
58	78,09	83	78,82
59	80,36	84	79,61
1960	79,72	85	73,70
61	71,96	86	73,16
62	69,98	87	78,08
63	77,30	88	80,49
64	79,63	89	75,68
65	80,06	1990	73,63
66	77,88	91	74,27
67	75,69	92	74,28
68	79,89	93	78,88
69	78,70	94	76,72
1970	75,40	95	74,40
71	76,67	96	71,36
72	78,71	97	75,20
73	80,74	98	75,54
74	80,09	99	72,96
75	79,68	2000	70,37
76	79,76		
77	78,76		

Note: The datum is the Baltic Syatem

Table 2 - Co-ordinates of Volume Curve of Mingechevir Reservoir

No.	Water Level (m)	Volume of Water (cu km)
1	30	0.15
2	35	0.42
3	40	0.93
4	45	1.60
5	50	2.50
6	55	3.67
7	60	5.10
8	65	6.95
9	70	9.10
10	75	11.55
11	80	14.30
12	83	16.07

Table 3 -Water Balance from Mingechevir Reservoir

Years	Shirvan Channel	Karabakh Channel	Kura-Yevlakh Water Discharge (cu m/sec)	Evaporation (cu m/sec)	Precipitation (cu m/sec)
1953			174		5.30
54			299	17.6	2.59
55			262	17.6	6.00
56			298	11.9	5.93
57			356	17.9	5.47
58			266	15.1	5.70
59			417	26.9	5.60
1960			427	21.4	4.69
61			300	21.4	3.07
62			161	17.8	3.74
63		19.9	359	19.2	9.88
64	18.4	34.2	394	22.9	4.22
65	22.1	43.2	345	21.7	6.80
66	26.5	44.8	252	20.1	5.96
67	19.5	30.8	244	19.6	6.70
68	23.1	31.4	387	21.0	5.70
69	15.2	33.1	336	15.1	9.03
1970	24.5	51.0	245	21.3	4.02
71	32.3	38.3	183	22.4	3.88
72	24.8	36.2	238	17.9	6.81
73	31.3	38.7	298	14.2	6.70
74	33.2	46.7	271	12.2	8.36
75	36.3	49.6	273	16.1	6.89
76			355	13.9	5.75
77			289	14.4	5.37
78			419	14.4	4.86
79			269	13.0	5.05
1980			231	12.2	
81			186		
82			341		
83			277		
84			416		
85			221		
86			168		
87			294		
88			398		
89			283		
1990			220		
91			221		
92			191		
93			303		
94	46.7	68.0	270		
95	47.1	79.1			
96	39.2	65.0	201		
97	39.2	67.0	194		
98	47.1	74.1	245		
99	40.1	74.2	200		
2000					

Table 4 - Annual Water Discharge and Suspended Materials of the Kura River at Khuluf Station

Year	Water Discharge (cu m/sec)	Suspended Materials (kg/s)
1970		
71	238	320
72	296	820
73	257	340
74	245	310
75	267	410
76	370	680
77	258	227
78	361	570
79	249	
1980	233	130
81	231	237
82	246	280
83	206	4,52
84	279	3,92
85	153	0,52
86	222	1,40
87	381	5,80
88	360	5,90
89	261	5,10
1990	260	0,88
91	254	
92	283	
93	338	
94	198	
95	207	
96	230	
97	289	
98	238	
99	213	
2000	205	
01	184	
02		

Table 5 - Annual Water Discharges and Suspended Materials of the Ganikh (Alazan) River at Ayrichay Station

Years	Discharge (cu m/sec)	Suspended Materials (kg/s)
1970	82.4	
71	77.9	88
72	101	
73	124	360
74	132	330
75	81.8	84
76	145	241
77	109	380
78	151	190
79	105	210
1980	108	70
81	105	98
82	121	210
83	155	380
84	123	91
85	91.3	76
86	90.4	100
87	115	140
88	134	470
89	77.0	130
1990	110	290
91	100	
92	104	
93	120	
94	98.6	
95	105	
96	94.5	
97	105	
98	92.0	
99	81.6	
2000	103	
01	91.7	
02		

Table 6 - Annual Water Discharges and Suspended Materials of the Gangachay River at Zurnabad Station

Years	Water Discharge (cu m/sec)	Suspended Materials (kg/s)
1970	2,47	0,47
71	2,98	0,83
72	4,47	2,0
73	4,22	0,90
74	5,48	0,96
75	4,06	0,29
76	4,93	0,71
77	4,51	0,57
78	5,64	0,84
79	4,52	0,35
1980	3,68	0,41
81	5,95	1,2
82	5,48	0,73
83	5,28	0,71
84	4,09	0,53
85	4,13	0,53
86	5,24	0,75
87	2,88	0,54
88	3,89	0,52
89	3,11	
1990	3,73	
91	2,69	
92	3,39	
93	4,50	
94	3,43	
95	3,70	
96	3,13	
97	3,60	
98		
99	3,62	
2000	4,31	
01		
02		

Table 7 - Annual Water Discharge and Suspended Materials of the Iori River at Kesaman Station

Years	Water Discharge (cu m/sec)	Suspended Materials (kg/s)
1970	12.8	
71	11.0	
72	9.98	
73	10.7	
74	11.5	
75	10.6	
76	14.2	
77	15.5	4.49
78	17.0	0.94
79	3.54	0.91
1980	3.19	0.79
81	5.40	2.2
82	3.65	0.40
83	5.59	1.77
84	6.01	1.80
85	4.39	0.56
86	2.40	1.0
87	2.18	0.26
88	3.50	0.084
89	1.25	0.004
1990	2.33	
91	-	
92	0.79	
93	1.45	
94	0.55	
95		
96		
97		
98		
99		
2000		
01		
02		

Table 8 - Sedimentation Regime of Mingechevir Reservoir

No.	Years	Volume of silt run off (10^6 m^3)	Volume of sedimentation (10^6 m^3)	Relative Annual Silt Percentage (%)
1	1953	29.29	28.41	0.18
2	1954	54.14	53.26	0.33
3	1955	31.07	30.19	0.19
4	1956	50.85	49.97	0.13
5	1957	25.67	24.79	0.15
6	1958	33.08	32.20	0.20
7	1959	62.37	61.49	0.35
8	1960	36.96	36.08	0.22
9	1961	18.91	18.03	0.11
10	1962	17.98	17.10	0.10
11	1963	59.32	58.44	0.36
12	1964	38.06	37.18	0.23
13	1965	41.34	40.46	0.25
14	1966	25.11	24.23	0.15
15	1967	33.41	32.53	0.20
16	1968	57.12	56.24	0.35
17	1969	32.61	31.73	0.19
18	1970	20.89	20.01	0.12
	Average	37.12	36.24	0.22

Table 9 - Sedimentation Sources for Mingechevir Reservoir

Year	River silt runoff at station (10^6 m^3)	Slope wash off (10^6 m^3)	Capacity of shore Erosion (10^6 m^3)	Difference between silt runoff at station and near mouth (10^6 m^3)	Materials brought by winds (10^6 m^3)	Total silt volume (10^6 m^3)	Volume of sediments (10^6 m^3)	Overflow of silt up to down stream (10^6 m^3)
Average 28 years	22.27	6.57	3.93	3.90	0.445	37.12	36.24	0.88
1953 to 1980	623.63	183.97	110.17	109.14	12.47	1039.38	1014.74	24.64
Per cent	60.0	17.7	10.6	10.5	1.2	100	97.6	2.4

Table 10 - Total Amount of Sediment by Areas of Mingechevir Reservoir

No.	Areas	Area, F		Total Silt Amount	Weight of Sediments	Volume of Silt	
		Km^2	%	$R_z \times 10^6$ m^3	V t/m^3	P= $R_z \times 10^6$	%
1	Kura cone	205.7	31.9	274.46	1.91	258.08	42.2
2	Area between Kura and Iori Rivers	13.3	2.1	6.92	0.85	5.88	0.90
3	Iori River area	40.9	6.3	25.58	0.80	20.46	3.3
4	Area between Iori and Alazan Rivers	17.0	2.6	8.38	0.91	7.63	1.2
5	Alazan river area	65.3	10.1	115.86	0.99	114.70	18.7
6	Small bays of North-West	8.6	1.4	10.32	0.95	9.80	1.6
7	Right shore	109.9	17.1	110.96	0.95	105.41	17.1
8	Left shore	165.4	25.7	78.83	0.90	70.54	11.5
9	Small bays of South-East	17.4	2.8	21.48	0.95	20.41	3.5
	Total	644	100	652.34	-	612.91	100

Table 11 - Analysis of Water Quality in 2000 of the River Kura at the Town of Mingechevir

	Date	23/3/00	8/6/00	9/8/00	16/10/00
IONS CONTENTS (mg/l)	Temperature	8.4	16.8	22.4	19.2
	Suspended sub. (mg/l)	27	43	93	7.3
	Oxygen	9.73	8.20	7.89	8.24
	BOR* 5mg/l	1.44	1.60	1.51	1.74
	CO2	3.9	1.5	1.3	1.2
	pH	7.90	8.13	8.23	8.57
	Ca^{2+}	50.8	61.4	63.0	79.8
	Mg^{2+}	17.9	17.8	26.0	17.3
	NH^{4+}	0.06	0.09	0.05	0.11
	Na+K+	54.2	27.8	31.20	17.0
	$HCO^{-}3$	149.7	119.0	146.4	129.8
	CL^{-}	5.4	3.7	6.9	13.8
	$SO^{2-}4$	137.4	150.1	150.0	150.6
	$NO2^{-}$	0.010	0.010	0.030	0.023
	NO3	1.4	1.62	1.79	2.22
	Sum of Ions (mg/l)	444.6	397.9	455.0	425.5
CHEMICAL ELEMENTS	$PO4^{3-}$ (mg/l)	0.005	0.018	0.011	0.013
	Si (mg/l)	3.9	7.4	5.3	7.0
	Fe (mg/l)	0.03	0.10	0.06	0.14
	Zn^{2+} (mkg/l)	5	5	3	6
	Cu^{2+} (mkg/l)	7	8	7	7
	Oil products (mg/l)	0.03	0.05	0.09	0.05
	SAE**	0.025	0.031	0.025	0.029
	DDT	No	No	No	No
	Hydro chemical UG a/? mcg/l	No	No	No	No
	Fenols (mg/l)	0.004	0.006	0.005	0.008
	Total nitrogen (mg/l)	0.370	0.420	0.456	0.592
	Total hardness (mg eqv/l)	4.00	4.52	5.28	5.4
	ORP***	224	200	211	240
	Pb	No	No	No	No
	V	No	No	No	No
	Mo	No	No	No	No
	Al	3.4	4.2	3.6	3.0
	Mn	3.2	3.5	3.3	3.1
	Tg	2.0	1.6	1.4	1.9
	Bi	No	No	No	No
	BOR*- Biochemical Oxygen Requirement				
	SAE**- Surface Active Elements				
	ORP***- Oxidation Rehabilitate Potencial				

Table 12 - Analysis of Water Quality in 1991 of River Kura at the Town of Mingechevir

	Date	4/2/91	3/4/91	11/6/91	2/8/91	10/8/1991	12/4/1991
IONS CONTENTS MG/L	Temperature	13.2	9.2	19.2	24.2	16.0	12.0
	Suspended substance mg/l	364	412	92	23	106	154
	Oxygen	10.03	10.29	8.8	7.88	7.99	10.26
	BOR* 5mg/l	1.18	1.62	1.47	2.05	1.73	0.73
	CO2	5.4	2.9	0.9	1.2	1.3	2.4
	pH	7.78	8.07	8.50	8.30	8.24	8.05
	Ca^{2+}	70.9	71.9	69.3	64.9	68.0	69.4
	Mg^{2+}	9.2	9.2	19.7	25.9	23.2	19.0
	NH^{4+}	0.04	0.05	0.09	0.23	0.02	0.03
	Na+K+	706	96.5	56.5	56.2	55.0	47.8
	$HCO^{-}3$	188.9	180.0	183.1	140.3	134.2	140.3
	CL^{-}	31.8	44.2	40.5	39.1	45.9	33.5
	$SO^{2-}4$	191.1	177.5	170.8	142.4	227.8	73.5
	$NO2^{-}$	0.006	0.007	0.016	0.003	0.002	0.003
	NO3	1.49	1.51	1.32	2.21	1.36	1.31
	Sum of Ions (mg/l)	531.5	592.7	519.6	539.3	525.3	492.6
CHEMICAL ELEMENTS	$PO4^{3-}$ (mg/l)	0.117	0.038	0.095	0.096	0.075	0.076
	Si (mg/l)	4.4	1.3	1.9	6.5	3.5	4.0
	Fe (mg/l)	0.13	0.15	0.17	0.17	0.13	0.09
	Zn^{2+} (mkg/l)	10	8	7	17	8	5
	Cu^{2+}(mkg/l)	16	10	5	12	10	8
	Oil products (mg/l)	0.33	0.07	0.19	0.12	0.08	0.06
	SAE**	0.03	0.02	0.04	0.05	0.03	0.02
	DDT						
	Gekha Chlor Ciclo Geksan a/? mcg/l						
	Fenols mg/l	0.006	0.009	0.009	0.009	0.010	0.005
	Total nitrogen (mg/l)	0.077	0.026	0.055	0.066	0.04	0.055
	Total hardness mg eqv/l	4.31	4.36	5.09	5.38	5.31	5.02
	ORP***						
	Pb	0.0	0.0	0.0	0.0	0.0	0.0
	V	0.0	0.0	0.0	3.5	0.0	0.0
	Mo	0.0	0.0	0.0	2.4	0.0	0.0
	Al	4.1	5.1	4.3	8.3	3.3	6.3
	Mn	6.0	5.5	4.2	4.4	2.7	4.7
	Tg	3.7	3.7	6.2	5.3	4.3	3.0
	Bi	2.1	2.4	0.0	0.0	0.0	2.3
	BOR*- Biochemical Oxygen Requirement						
	SAE**- Surface Active Elements						
	ORP***- Oxidation Rehabilitate Potencial						

Table 13 - Analysis of Water Quality in May 1960 in the Mingechevir reservoir at Vertical No. 3

	Date	**Depth**	**Depth**	**Depth**	
		1 m	**24 m**	**47 m**	
IONS CONTENTS MG/L	Temperature	19.9	13.5	10.7	
	Suspended substance (mg/l)				
	Oxygen				
	BOR* 5 (mg/l)				
	CO2				
	pH				
	Ca^{2+}	47.6	52.7	54.2	
	Mg^{2+}	10.8	11	11.1	
	NH^{4+}				
	Na+K+	22	25.2	24.80	
	$HCO^{-}3$	145	160.0	157.0	
	CL^{-}	14	15	16.8	
	$SO^{2-}4$	66.3	72.1	75.0	
	$NO2^{-}$	0.088	0.054	0.084	
	NO3				
	Sum of Ions (mg/l)	306	336	339.0	
CHEMICAL ELEMENTS	$PO4^{3-}$ (mg/l)	0.018	0.094	0.014	
	Si (mg/l)	6.4	6.2	6.4	
	Fe mg/l	0.72	0.90	0.56	
	Brutality	9.27	10	10.2	
	Color	24	17	0	
	Oxygen	3.4	6	2.3	

Table 14 - Analysis of Water Quality in 2000
in the Alazan River at 1.7 km below the Junction of Agrichay River

	Date	5/2/00	5/4/00	9/7/00	8/10/00
IONS CONTENT (mg/l)	Temperature	10.0	13.0	18.0	18.0
	Suspended substance (mg/l)	64	193	159	402
	Oxygen	10.04	9.24	7.82	7.19
	BOR* 5 (mg/l)	1.19	1.37	1.71	2.56
	CO2	3.0	2.8	0.6	0.7
	pH	8.08	8.11	8.5	8.43
	Ca^{2+}	54.3	59.3	39.6	60.6
	Mg^{2+}	17.4	10.6	9.4	5.9
	NH^{4+}	0.03	0.02	0.04	0.08
	Na+K+	40.1	38.5	25.70	50.8
	$HCO^{-}3$	189.9	200.1	106.8	115.9
	CL^{-}	18.8	8.2	10.0	14.8
	$SO^{2-}4$	103.4	88.3	85.2	153.9
	$NO2^{-}$	0.013	0.020	0.010	0.007
	NO3	1.29	1.36	1.55	1.15
	Sum of Ions (mg/l)	425.2	406.4	278.3	403.1
CHEMICAL ELEMENTS	$PO4^{3-}$ (mg/l)	0.003	0.002	0.005	0.007
	Si (mg/l)	3.8	4.4	7.2	6.6
	Fe (mg/l)	0.06	0.08	0.07	0.10
	Zn^{2+} (mkg/l)				
	Cu^{2+}(mkg/l)	4	8	4	3
	Oil products (mg/l)	0.02	0.018	0.02	0.01
	SAE**	0.019	0.008	0.025	0.020
	DDT	No	No	No	No
	Hydro chemical UG a/? (mcg/l)	steps	No	No	No
	Fenols (mg/l)	0.002	0.001	0.005	0.004
	Total nitrogen (mg/l)	0.318	0.533	0.833	0.362
	Total hardness (mg eqv/l)	4.14	3.83	2.75	3.51
	ORP***	238	240	192	200
	Pb	No	No	No	No
	V	steps	steps	1.1	
	Mo	steps	No	0.9	
	Al	2.6	2.7	2.8	
	Mn	2.9	3.3	3.0	
	Tg	2.4	3.6	2.6	
	Bi	0.8	No	steps	

BOR*- Biochemical Oxygen Requirement
SAE**- Surface Active Elements
ORP***- Oxidation Rehabilitate Patencial

Table 15 - Analysis of Water Quality in 1991
in the River Alazan below Junction of Agrichay River

	Date	2/2/91	10/4/91	8/6/91	4/8/91	6/10/91	5/12/91
IONS CONTENTS (mg/l)	Temperature	2.4	4.6	16.4	26.2	14.9	3.5
	Suspended substance (mg/l)	199	235	971	24	120	175
	Oxigen	12.75	12.10	9.24	7.19	9.15	12.70
	BOR* 5 (mg/l)	0.88	1.24	1.22	1.92	1.45	0.70
	CO2	1.6	2.1	0.9	0.9	1.0	0.9
	pH	8.35	8.20	8.36	8.32	8.38	8.60
	Ca^{2+}	46.7	35.2	45.2	40.7	44.1	71.8
	Mg^{2+}	22.8	17.5	15.3	17.6	16.4	9.2
	NH^{4+}	0.04	0.07	0.09	0.06	0.02	0.03
	Na+K+	55	64.2	21.8	38.9	23.0	33.4
	$HCO^{-}3$	156.6	146.4	122.0	133.8	134.2	152.6
	CL^{-}	16.6	12.8	11.0	16.2	21.3	26.7
	$SO^{2-}4$	160.4	137.8	94.9	111.0	75.9	112.3
	$NO2^{-}$	0.002	0.007	0.011	0.009	0.002	0.005
	NO3	1.92	2.0	1.52	2.02	1.85	1.92
	Sum of Ions (mg/l)	465.6	422.9	317.1	367.2	323.1	414.6
CHEMICAL ELEMENTS	$PO4^{3-}$ (mg/l)	0.044	0.041	0.091	0.081	0.106	0.073
	Si (mg/l)	8.5	6.6	2.8	2.9	6.1	4.9
	Fe (mg/l)	0.07	0.11	0.17	0.13	0.09	0.07
	Zn^{2+} (mkg/l)	3	5	9	4	4	5
	Cu^{2+}(mkg/l)	5	8	12	12	7	9
	Oil products (mg/l)	0.03	0.07	0.04	0.05	0.05	0.06
	SAE**	0.01	0.02	0.03	0.02	0.03	0.02
	DDT	0.000	0.000	0.000	0.000	0.000	0.000
	Gekha Chlor Ciclo Geksan a/? mcg/l	0.002	0.002	0.000	0.001	0.004	0.000
	Fenols (mg/l)	0.006	0.003	0.006	0.006	0.007	0.004
	Total nitrogen (mg/l)	1.96	2.08	1.63	2.09	1.87	1.96
	Total hardness (mg eqv/l)	4.21	2.2	3.53	3.49	3.55	4.34
	ORP***						
	Pb	0.0	0.0	0.0	0.0	0.0	0.0
	V	0.0	0.0	0.0	1.6	0.0	0.0
	Mo	0.0	0.0	0.0	3.0	0.0	0.0
	Al	3.8	4.9	5.0	4.3	2.3	3.8
	Mn	2.6	4.7	3.6	6.3	3.7	4.2
	Tg	2.6	3.3	5.5	7.4	2.6	2.2
		1.4	2.0	2.0	0.0	0.0	1.9
	BOR*- Biochemical Oxygen Requirement						
	SAE**- Surface Active Elements						
	ORP***- Oxidation Rehabilitate Potential						

Figure 1 – Mingechevir Reservoir Sediment Map

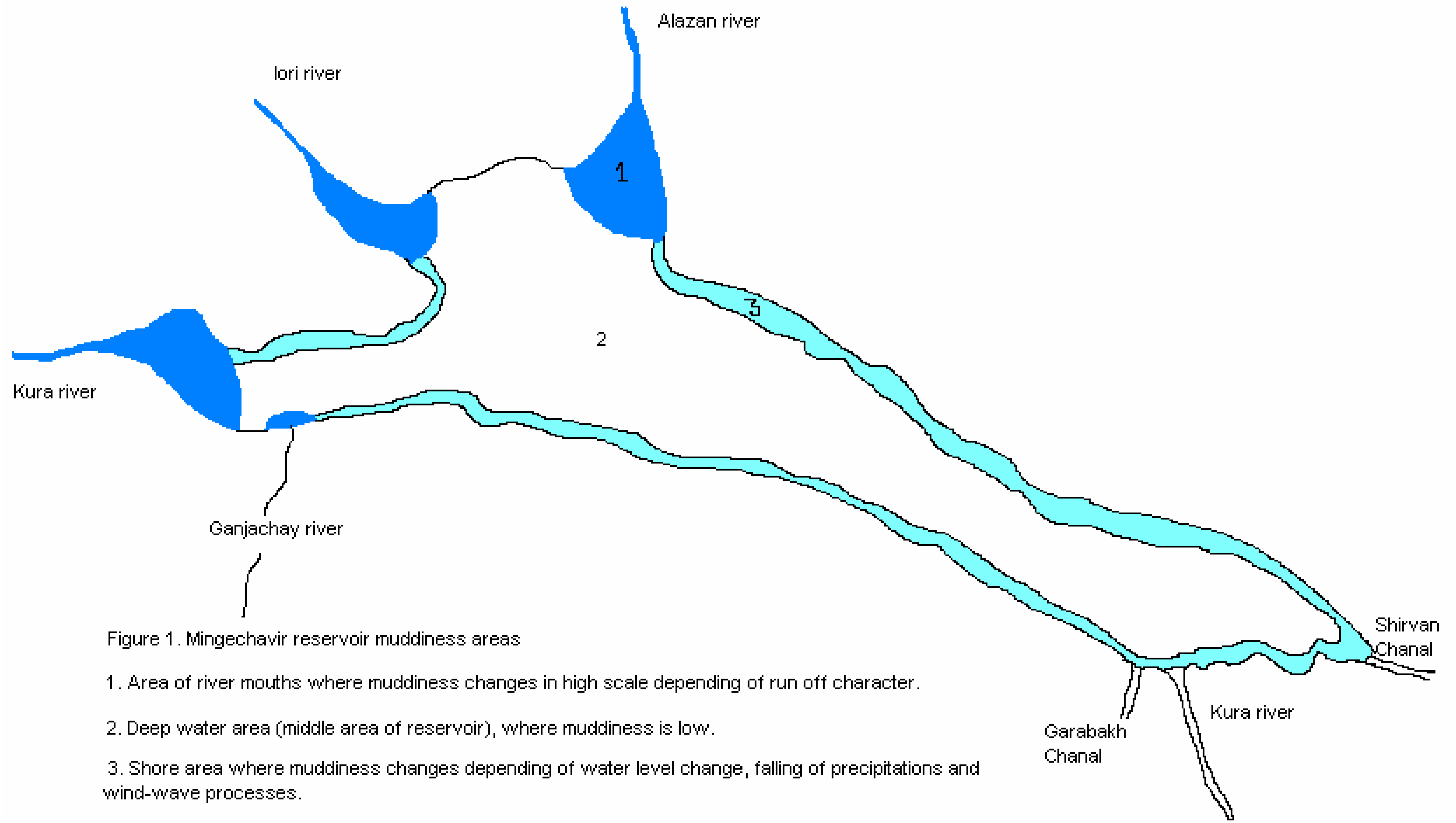
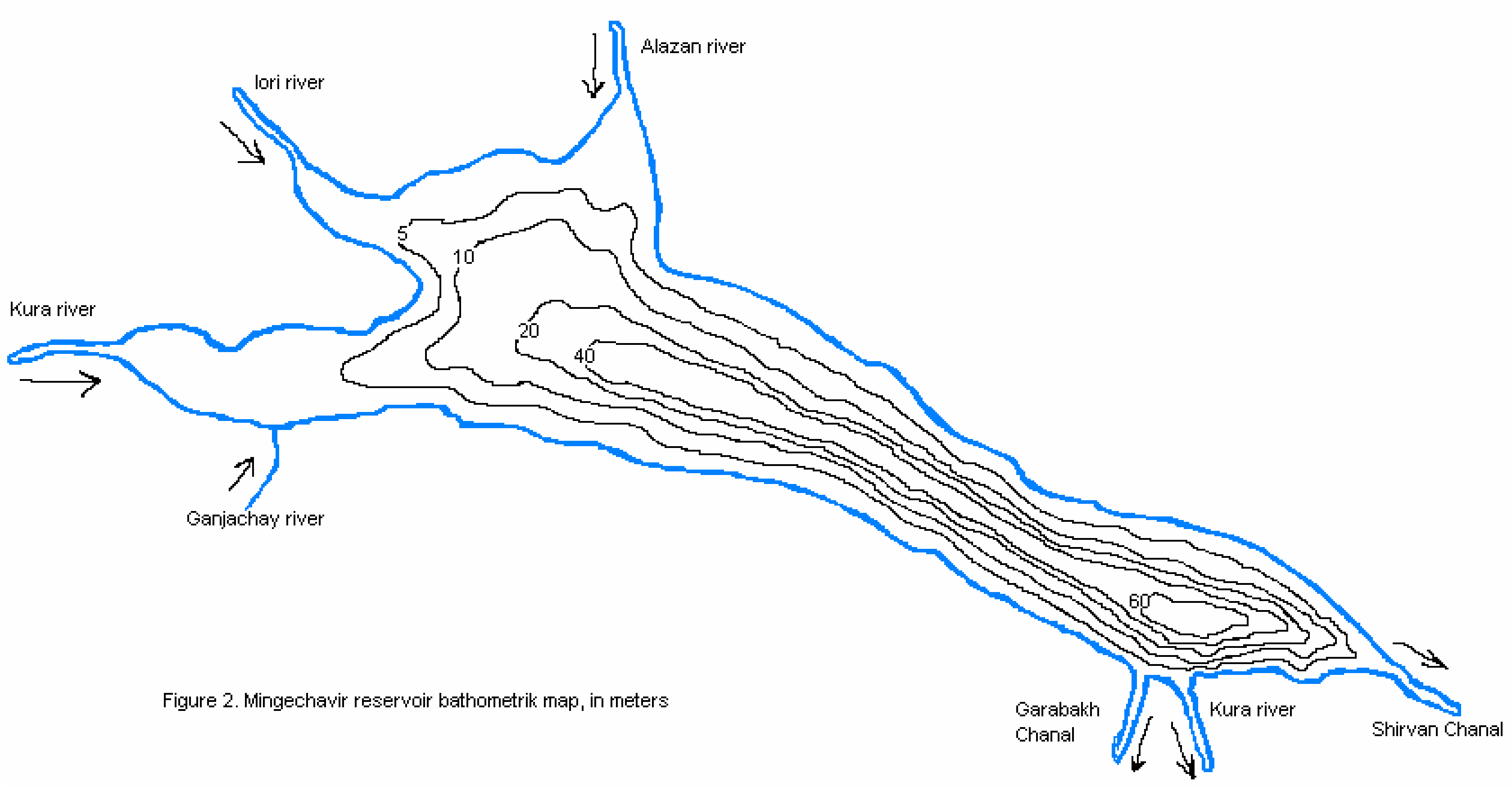


Figure 2 – Mingechevir Reservoir Bathometric Map



Development *Alternatives*, Inc.

14 Paliashvili Street, Tblisi 380079 Georgia
AUA Center Building; 9 Alex Manukian Street, Suite 207; Yerevan 375070 Armenia
Caspian Business Center; 40 Jafar Jabbarli Street, Suite 604; Baku 370000 Azerbaijan