Table- 1 Calculation of Design Capacity

Year	[1] Population	[2] Rate of Population increase	[3] Rate of Population Population Served	[4] Population served	[5] Water demand	[6] Ratio of Water Leakage	[7] Capacity of all pumping stations	[8] Population inflow	[9] Water demand of population inflow	[10] Total water demand	[11] Maximum daily supply	[12] Maximum hourly supply	[13] Design water supply	[14]
	Persons	%	%	Persons	m^3/day	%	L/sec	Persons	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	L/sec
2003	168,736													
2004	170,876					44.0								
2005	172,626					43.0								
2006	174,401					40.9								
2007	176,569			163,068	54,791	41.7	1,728	29,600	1,776	56,567	70,709	95,457	163,734	1,895
2008	178,335	1.0	92.0	164,068	55,127	40.9	1,728	29,896	1,794	56,921	71,151	96,054	162,528	1,881
2009	180,118	1.0	92.9	167,330	56,223	39.4	1,728	30,195	1,812	58,035	72,544	97,934	161,607	1,870
2010	181,919	1.0	93.8	170,640	57,335	37.9	1,728	30,497	1,830	59,165	73,956	99,841	160,775	1,861
2011	183,738	1.0	94.7	174,000	58,464	36.4	1,728	30,802	1,848	60,312	75,390	101,777	160,027	1,852
2012	185,575	1.0	95.6	177,410	59,610	34.9	2,138	31,110	1,867	61,477	76,846	103,742	159,358	1,844
2013	188,359	1.5	96.5	181,766	61,073	33.4	2,138	31,577	1,895	62,968	78,710	106,259	159,548	1,847
2014	191,184	1.5	97.4	186,213	62,568	31.9	2,138	32,051	1,923	64,491	80,614	108,829	159,808	1,850
2015	194,052	1.5	98.3	190,753	64,093	30.4	2,138	32,532	1,952	66,045	82,556	111,451	160,131	1,853
2016	196,963	1.5	99.2	195,387	65,650	28.9	2,138	33,020	1,981	67,631	84,539	114,128	160,518	1,858
2017	199,917	1.5	100.0	199,917	67,172	27.4	2,138	33,515	2,011	69,183	86,479	116,747	160,809	1,861

< Calculation condition >

Supply unit	336	L/person*day
Peak factor of daily maximum	1.25	
Peak factor of hourly maximum	1.35	
Existing pump capacity	1,728	L/sec
New pump capacity	2,138	L/sec
Population inflow in daytime	29,600	Persons(2007)
Supply unit for population inflow	60	L/person*day

< Calculation method >

[1]=Population in previous year*(1+[2]/100)
[2]=Design value
[3]=Actual or Design value
[4]=[1]*[3]/100
[5]=[4]*336L/1000
[6]=Actual or Design value
[7]=Existing capacity and design value
[8]=Population in previous year*(1+[2]/100)
[9]=60L*[8]/1000
[10]=[5]+[9]
[11]=[10]*1.25
[12]=[11]*1.35
[13]=[12]/(1-[6]/100)
[14]=[13]/24/60/60

[3]: By 2017, it increases to 100% in the time series.
[6]: It is actual value by 2008.
From 2009 to 2017, It improves 1.5% every year.
The value of 1.5% is average rate of reduction of leakage from 2007 to 2009.

Table-2 Accual Lekage Volume

Year	[1] Distributed amount		[2] Lekage volume		[3] Effective water amount		[4] Leakage rate
	m^3/year	m^3/day	m^3/year	m^3/day	m^3/year	m^3/day	%
2004	38,615,000	105,795	17,002,000	46,581	21,613,000	59,214	44.0
2005	38,319,000	104,984	16,464,000	45,107	21,855,000	59,877	43.0
2006	39,804,000	109,052	16,272,000	44,581	23,532,000	64,471	40.9
2007	41,282,000	113,101	17,221,000	47,181	24,061,000	65,920	41.7
2008	42,874,000	117,463	17,545,000	48,068	25,329,000	69,395	40.9
2009	31,931,000	87,482	12,134,000	33,244	19,797,000	54,238	38.0

Average rate of reduction of leakage from 2007 to 2009: 1.5% per year

Table-3 Design water supply without improvement of leakage

Year	Ratio of Water Leakage	Maximum daily supply	Design water supply	
	%	m^3/日	m^3/day	L/sec
2007	41.7	95,457	163,734	1,895
2008	40.9	96,054	162,528	1,881
2009	40.9	97,934	165,709	1,918
2010	40.9	99,841	168,936	1,955
2011	40.9	101,777	172,212	1,993
2012	40.9	103,742	175,536	2,032
2013	40.9	106,259	179,795	2,081
2014	40.9	108,829	184,144	2,131
2015	40.9	111,451	188,580	2,183
2016	40.9	114,128	193,110	2,235
2017	40.9	116,747	197,541	2,286

Table-4-1 Population in the area with interruption in water supply

Year	Population served	No-water population	Rate of no-water population
	Persons	Persons	(%)
2009	167,330	23,911	14.3

Table-4-2 Estimated population in the area with interruption in water supply (2012)

Population served	177,410	人
Population in the area with interruption in water supply: 177,410 X 14.3% =	25,370	人

Table-5 Calculation of design water supply considered for the aging of existing equipments (1)

Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Design capacity of existing pump	Current capacity of existing pump	Pump capacity of Mareza 2		Design capacity of all pumping station	Design water supply	
			Existing	New		without leakage	with leakage prevention
	L/sec	L/sec	L/sec	L/sec	L/sec	L/sec	L/sec
2009	2,093	1,677	544		1,677	1,918	1,870
2010	0	1,655	536		1,655	1,955	1,861
2011	0	1,633	528		1,633	1,993	1,852
2012	0	1,611	520	960	2,051	2,032	1,844
2013	0	1,589	512	960	2,037	2,081	1,847
2014	0	1,567	504	960	2,023	2,131	1,850
2015	0	1,545	496	960	2,009	2,183	1,853
2016	0	1,523	488	960	1,995	2,235	1,858
2017	0	1,500	480	960	1,980	2,286	1,861

<Calculation method>

[2]=The value in previous year -(1677-1500)/8

[3]=The value in previous year -(544-480)/8

[4]=Total capacity of the renewed Mareza 2

[5]=[2] (Year 2009-2011), [2]-[3]+[4] (Year2012-2017)

[6]=Refer to the value in the table-3

[7]=Refer to [14] in the table-1

[1]:The value of 1,677 is actual value.

[2]:The value of 544 is actual value and 480 is the assumued value. It is assumed that value of [2] reduces to 480 from 544 in 8 years.

Table-6 Calculation of design water supply considered for the aging of existing equipments (2)

Year	[1]	[2]	[3]	[4]	[5]	[6]
	Capacity of the existing pumping stations without Mareza2	Pump capacity of Mareza 2		Design capacity of all pumping stations	Design water supply	
		Existing	New		without leakage	with leakage prevention
	L/sec	L/sec	L/sec	L/sec	L/sec	L/sec
2009	1,133	544	-	1,677	1,918	1,870
2010	1,119	536	-	1,655	1,955	1,861
2011	1,105	528	-	1,633	1,993	1,852
2012	1,091	-	960	2,051	2,032	1,844
2013	1,077	-	960	2,037	2,081	1,847
2014	1,063	-	960	2,023	2,131	1,850
2015	1,049	-	960	2,009	2,183	1,853
2016	1,035	-	960	1,995	2,235	1,858
2017	1,020	-	960	1,980	2,286	1,861

<Calculation method>

[1]=1,677-[2]

[2]=Value in preevious year -(544-480)/8

[3]=Total capacity of the renewed Mareza 2

[4]=[1]+[2] (Year 2009-2011), [1]+[3] (Year 2012-2017)

[5]=Refer to the value in the table-3

[6]=Refer to [14] in the table-1

[1]: The value of 1,677 is actual value.

[2]: Refer to [3] in the table-5

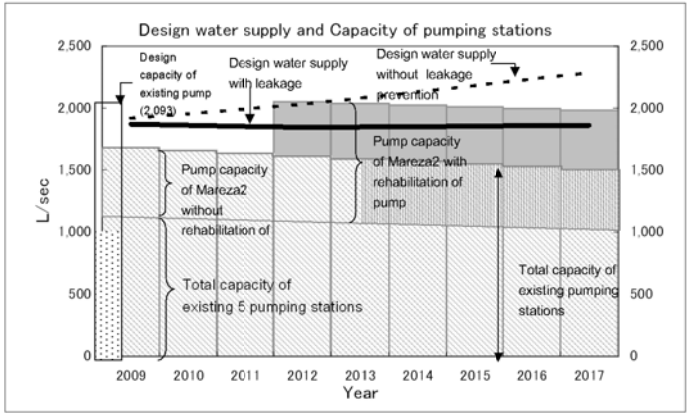
[3]: Total capacity of the renewed Mareza 2

Table-7 Estimated value of reduction of pump capaity in 2017

Pump station	Pump No.	Pump			Motor		Design capacity	Actual capacity*	Age	Assumed reduction rate of pump capacity in 2017**	Assumed pump capacity in 2017**
		Type	Maker	Country of origin	Maker	Country of origin	L/sec	L/sec		%	L/sec
Mareza 1 (Old)	P3	CP182/3	Jugoturbina	Croatia	SERVER	Serbia	375	375	Less than 10 years	10%	338
	P4	VPN250-2R	Jastrebac	Serbia	SERVER	Serbia					
	P5	VPN250-2R	Jastrebac	Serbia	SERVER	Serbia					
	P6	4.8BO34-30/4	Jugoturbina	Croatia	SERVER	Serbia					
Mareza 2 (New)	P1	VO23/20-III	Litostroj	Slovenia	SERVER	Serbia	960	544	More than 20 years	25%	480
	P2	VO23/21-III	Litostroj	Slovenia	SERVER	Serbia					
	P3	VO23/22-III	Litostroj	Slovenia	SERVER	Serbia					
	P4	VO23/23-III	Litostroj	Slovenia	SERVER	Serbia					
Zagoric	P1	VO17/16-IV	Litostroj	Slovenia	SERVER	Serbia	300	300	Less than 10 years	10%	270
	P2	VO17/17-IV	Litostroj	Slovenia	SERVER	Serbia					
	P3	UPA200B-130/7B	KSB	Germany	KSB	Germany					
	P4	UPA200B-2 5 0 B/250- 5 E	KSB	Germany	KSB	Germany					
Cemovsko polije	P1	E10S55/4K	Caprari	Italy	Caprari	Italy	375	375	Less than 10 years	10%	338
	P2	E8S64/7A	Caprari	Italy	Caprari	Italy					
	P3	TV103-3SN KMC7502D	Vogel	Germany	Vogel	Germany					
	P4	E14S50/2AB 2 5 0 - 5 E	Caprari	Italy	Caprari	Italy					
	P5	UPA250B250/5E	KSB	Germany	KSB	Germany					
Milje	P1	E8S64/7A	Caprari	Italy	Caprari	Italy	70	70	Less than 10 years	10%	63
	P2	E4XH/20MCK410	Caprari	Italy	Caprari	Italy					
	P3	FZ658/12-SD	Lowara	Italy	Lowara	Italy					
Tuzi 1											
Tuzi 2											
Tuzi 3	P1	E6S55/9AMC625	Caprari	Italy	Caprari	Italy	13	13	Less than 10	10%	12
Dinosa		NR850	Wilo		Wilo						
Total							2,093	1,677			1,500

* The data is produced from PWS.

**Design capacity



Appendix 6: Socio-Condition Survey

The aim of survey is to grasp information on social condition in order to consider the relevance and necessity of proposed project components and the PDM's indicators for the Project. The outline of survey is shown in Table-1.

Table-1 Outline of Socio-Condition Survey

Items	Contents
Target Area	Central Podgorica, Momisici, Tolosi, Vrela Ribnicka, Dybabel
No. of Samples	106 samples
No. of Interviewers	5 persons
Survey Period	From 27th May to 2nd June, 2009 (5 days)
Respondent	Families in the target area
Questionnaire	Questionnaire is shown in the "Questionnaire of Socio-Condition"

Based on the information gathered from Podgorica Water Supply and Sewerage, the Study team selected the area with low water pressure and high water pressure to carry out this survey.

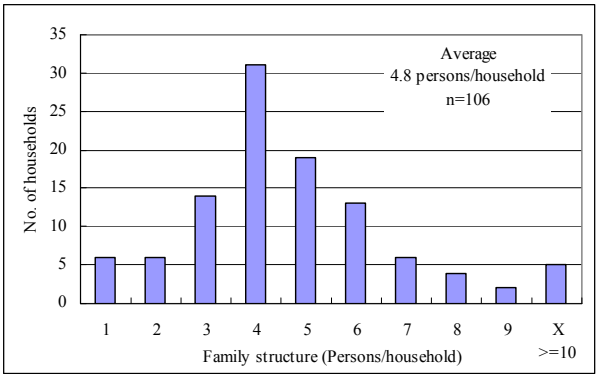


Figure-1 Average family size

1) Family structure

Based on the result of survey, average family size is 4.8 persons per household. (The range of persons in family varies from 1 to 15.)

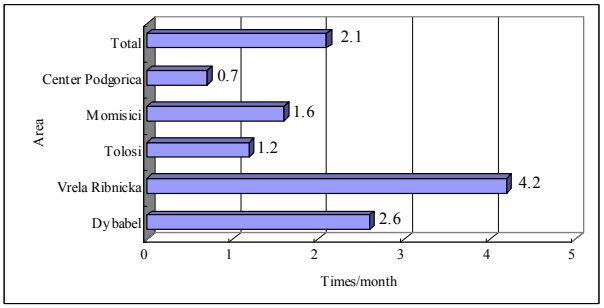
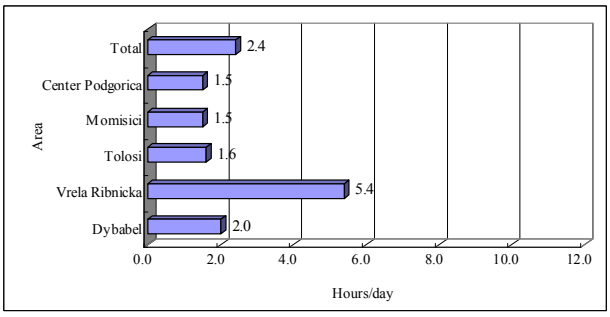


Figure-2 Frequency of interruption in water supply

2) Current condition of water supply

<Interruption in water supply>

On average, the frequency of interruption in water supply is 2 times per month, and number of areas with interruption in water supply for 2 hours or more is 2 as shown in Figure-2 and Figure-3. These two areas are deemed to face serious level of interruption in water supply.



The socio-condition survey was carried out in June 2009. In summer season, especially in the month of August, when air temperature gets very high, the water demand reaches to the highest level and the number of people who are affected by the interruption in water supply is estimated to increase due to lack of water supply capacity.

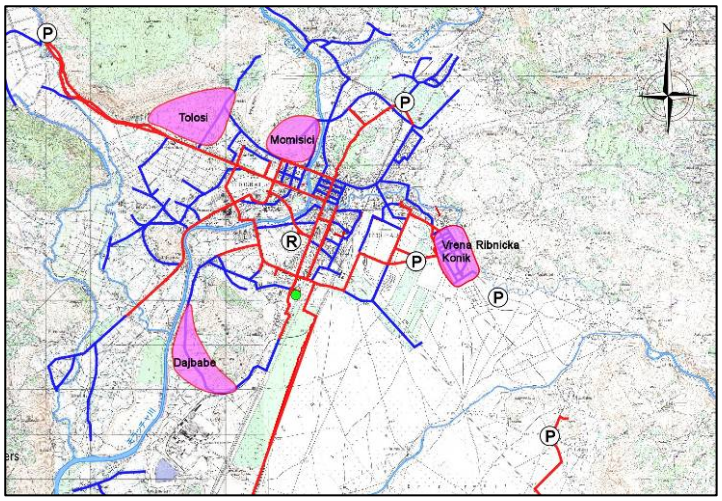
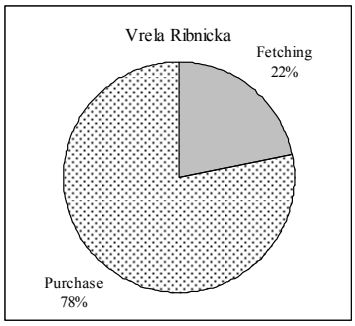


Figure-4 Areas of interruption in supply

Figure-4 shows area of interruption in water supply identified through socio-economic survey. Figure-5 and Figure-6 show alternative water sources and detail on impacts due to water supply interruption in Vrena Ribnicka, the area where the impact is most significant.



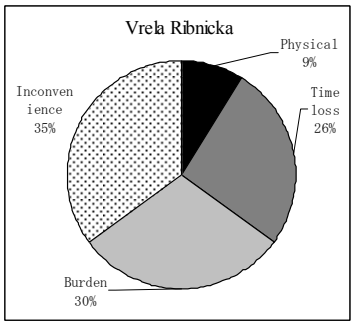


Figure-5 Alternative water source (Left)
Figure-6 Damage of interruption in supply (Right)

In case of interruption in water supply, affected people manage drinking water either through purchase of water bottle or through fetching water from neighborhoods because many of the households are not equipped with their own storage tanks. These measures are limited only to the case of drinking water. People use toilet in their office or park and they avoid using water for washing during interruption in water supply.

<Water use>

Figure-7 shows per capita daily water consumption. The daily water consumption in the area where interruption in water supply occurs more frequently is smaller than the area where number of occurrences of interruption is low. In Podgorica city, there is only one zone (within target area) where average

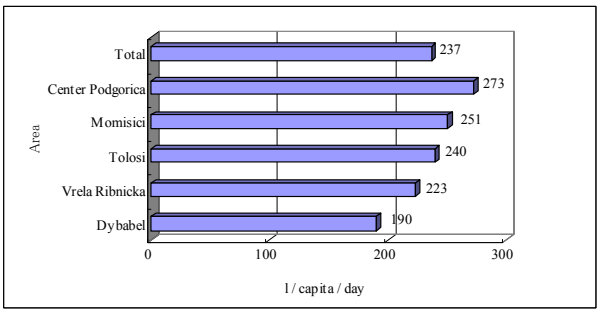


Figure-7 Water consumption

daily water consumption reaches to 273 L/c/d. In most of the target areas, water consumption is about 10% to 30% lower than the average. Average water consumption in Podgorica city is little higher compared to 260L/c/d in Belgrade, Serbia. However, the minimum water demand for daily life in Podgorica city is estimated as 250L/c/d. Therefore, available water supply in 3 areas (Tolosi, Vrela Ribnicka and Dybabel) is limited when compared to average water consumption in Podogorica city. Figure-8 shows existing level of water pressure. The topography of Podgorica city is plain and difference in elevation is very small. According to the information from Podgorica Water Supply and Sewerage, the target of direct water supply is up to 4th floor only and the possibility of occurrence of interruption in water supply due to lack of pump head and topographic condition is low. However, except for Central Podgorica, where water pressure is high, interruption in water supply due to low water pressure is observed in 4 areas. This is because water is supplied in these areas in insufficient amount and at low pressure due to poor management of pump operation and valve position and lack of valves. To deal with this situation, distribution management should be carried out based on adequate distribution network calculation.

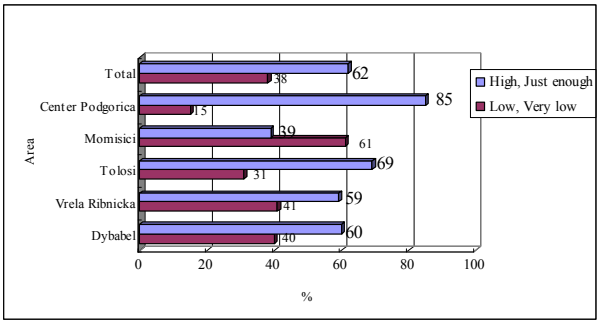


Figure-8 Water pressure

Figure-9 shows water uses in the target area. The water consumption for shower, bathing and washing is large. During interruption in water supply, people respond by purchase of water bottle for drinking. However, lack of sufficient amount of water in these urban areas results into limitation of water supply for other water uses and thereby causes poor living condition. The reply to question related to this is observed to have wide variation. In order to figure out more detail on water uses, it is necessary to investigate on frequency of each water uses, and corresponding water consumption at a time.

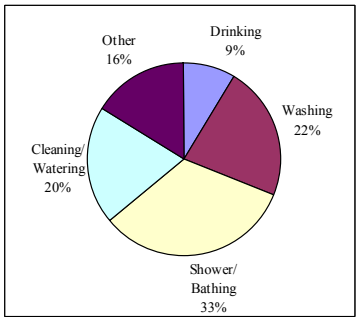


Figure-9 Water use

Figure-10 shows the level of purchase of water bottle. In Central Podgorica where frequency of interruption in water supply is little, the rate of purchase of water bottle is low and it is high in the other

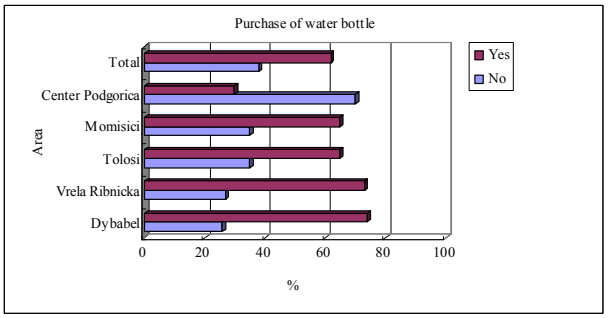


Figure-10 Situation for purchase of water

areas. In Vrela Ribnicka and Dybabel where frequency of interruption is more than 2 times and period of interruption in water supply is more than 2 hours, the level of water bottle purchase is high and people often purchase water bottle.

<Water quality>

Figure-11 shows condition of water quality. In all target areas, most of respondents feel that water quality level is "Good" or "Acceptable". Especially, in Central Podgoria, Momisici and Tolosi, more than 50% of respondents expressed the water quality to be "Good". Figure -12 shows the results of responses on taste and smell for water supply. In Vrela Ribnicka and Dybabel, more than 60% of respondents replied that they experience smell of chlorine in supplied water, and therefore, proper management for residual chlorine should be considered. The presence of excess residual chlorine in supplied water causes a bad impression of water quality. In other areas, no marked comment about water quality has been observed.

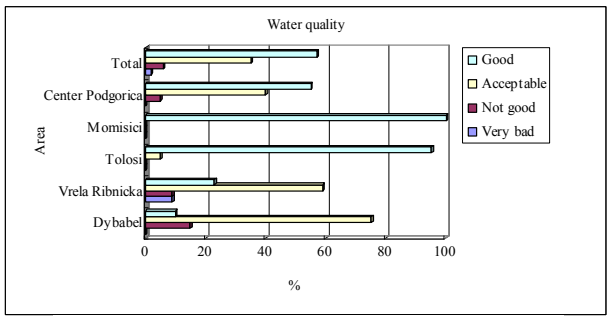


Figure-11 Water quality

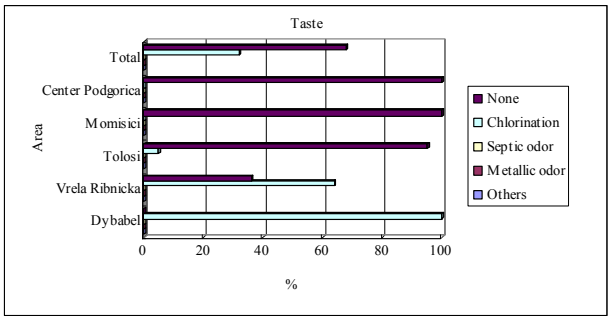


Figure-12 Condition of taste and smell of water supply

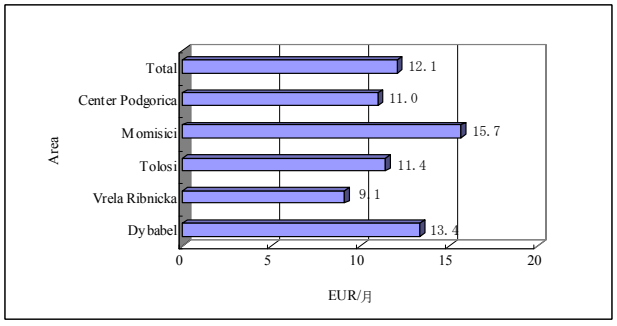


Figure-13 Monthly water charge

<Water charge>

Figure-13 shows monthly water charge. The average of monthly water charge in the target areas is 12.1 EUR/month.

Figure-14 shows the ratio of monthly water charge as a part of total expenditure of household. In the target areas, 80% of people spend less than 5% of their total household expenses as water charge. Therefore, it is assumed that among the domestic expenses, water

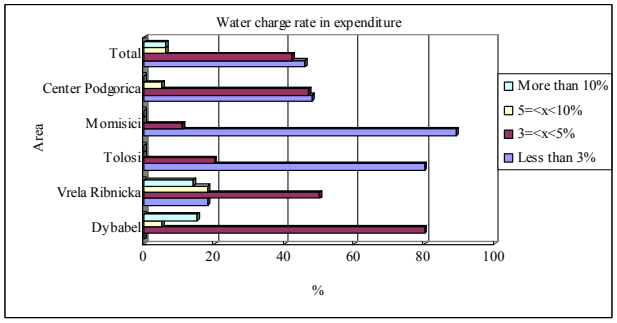


Figure-14 Water charge rate in expenditure

charge is not a burden. However, many households have agreement with water vendor for supply of 20 litter bottle as alternative water source in case of water supply interruption and for this they need to pay on average about 20 EUR every month, for a family size of 4-5 persons. This causes burden to domestic expenses and it also becomes physical and mental burden for urban people. Therefore, it is a serious problem in the city that has administrative responsibility of water supply.

Figure-15 shows the method of payment of water charge. Most of respondents pay their water charge in PWS's office or branch office of PWS after receiving their monthly invoice.

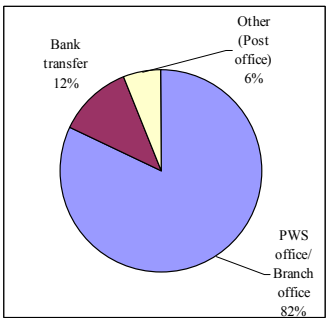


Figure-15 Payment method of water charge

Figure-16 shows impression of the users on the level of water charge. Approx. 60% of respondents expressed that existing water charge is "Cheap" or "Reasonable". However, in Vrela Ribnicka and Dybabel, where frequency of interruption in water supply is high, the people expressed that the water rate is "Expensive" and "Very expensive" compared to other 3 areas. Monthly water charge seems to be reasonable, however, it is indicated that people are unsatisfied with poor services of water supply.

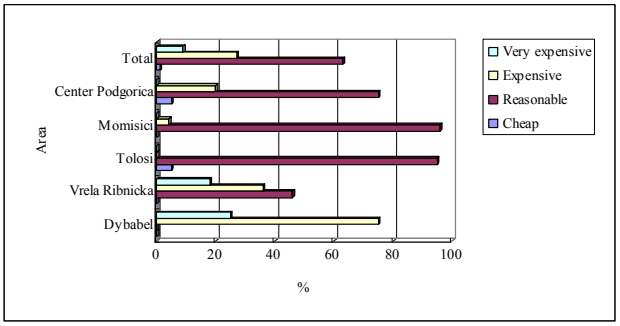


Figure-16 Impression of water charge

Table-2 Result of socio-condition survey (1)

Sections	No.	Questions		Unit	Area					Total
					Dybabel	Vrela Ribnicka	Tolosi	Momisici	Center Podgorica	
Number of Respondents				Persons	20	23	20	23	20	106
Section 1 Interviewee's Information	1-1	Sex	Male	No.	19	21	13	15	9	77
				%	95	91	72	83	45	78
			Female	No.	1	2	5	3	11	22
				%	5	9	28	17	55	22
			Total	No.	20	23	18	18	20	99
				%	100	100	100	100	100	100
		Age		Average	56.9	55.9	55.1	67.5	51.4	57.6
Section 2 Family Structure	2-1	Total number		Persons	4.3	4.9	4.4	5.9	4.4	4.8
		Male		Persons	2.4	2.6	2.2	2.9	1.9	2.4
		Female		Persons	1.9	2.3	2.2	3.0	2.5	2.4
Section 3 Water Abailability	3-1	Experience	Yes	No.	20	22	18	23	11	94
				%	100	96	90	100	55	89
			No	No.	0	1	2	0	9	12
				%	0	4	10	0	45	11
			Total	No.	20	23	20	23	20	106
				%	100	100	100	100	100	100
	3-2	Frequency		times/month	2.6	4.2	1.2	1.6	0.7	2.1
	3-3	Hours		hours/day	2.0	5.4	1.6	1.5	1.5	2.4
	3-4	Alternative	Water truck	No.	0	0	0	0	0	0
				%	0	0	0	0	0	0
			Water tank	No.	0	0	2	1	0	3
				%	0	0	11	4	0	3
			Fetching	No.	8	5	4	9	1	27
				%	40	22	22	39	17	30
			Purchase	No.	10	18	12	13	5	58
				%	50	78	67	57	83	64
			Well	No.	1	0	0	0	0	1
				%	5	0	0	0	0	1.5
			Others (Waiting)	No.	1	0	0	0	0	1
				%	5	0	0	0	0	1.5
			Total	No.	20	23	18	23	6	90
				%	100	100	100	100	100	100
	3-5	Damage	Physical	No.	0	2	0	0	1	3
				%	0	9	0	0	12.5	4
			Time loss	No.	13	6	7	8	1	35
				%	65	26	44	47	12.5	42
			Burden	No.	2	7	9	8	1	27
				%	10	30	56	47	12.5	32
			Inconvenience	No.	5	8	0	1	4	18
				%	25	35	0	6	50	21
			Others (Waiting)	No.	0	0	0	0	1	1
				%	0	0		0	12.5	1
			Total	No.	20	23	16	17	8	84
				%	100	100	100	100	100	100

Table-3 Result of socio-condition survey (2)

Sections	No.	Questions		Unit	Area					Total
					Dybabel	Vrela Ribnicka	Tolosi	Momisici	Center Podgorica	
Section 4 Water consumption and Water use	4-1	Consumption		m^3 / capita	190	223	240	251	273	237
	4-2	Pressure	High	No.	1	0	2	0	9	12
				%	5	0	11	0	45	12
			Just enough	No.	11	13	11	9	8	52
				%	55	59	58	39	40	50
			Low	No.	7	6	6	14	2	35
				%	35	27	31	61	10	34
			Very low	No.	1	3	0	0	1	5
				%	5	14	0	0	5	4
			Total	No.	20	22	19	23	20	104
				%	100	100	100	100	100	100
	4-3	Water use	Drinking	%	8	12	6	6	14	9
			Washing	%	18	29	15	17	31	22
			Bathing	%	44	36	20	21	47	33
			Cleaning	%	10	13	37	30	8	20
			Others (Cleaning)	%	20	10	22	26	0	16
			Total	%	100	100	100	100	100	100
	4-4	Water tank	Yes	No.	14	16	13	15	6	64
				%	74	73	65	65	30	62
			No	No.	5	6	7	8	14	40
				%	26	27	35	35	70	38
			Total	No.	19	22	20	23	20	104
				%	100	100	100	100	100	100
Section 5 Water quality	5-1	Quality	Good	No.	2	5	19	23	11	60
				%	10	23	95	100	55	57
			Acceptable	No.	15	13	1	0	8	37
				%	75	59	5	0	40	35
			Not good	No.	3	2	0	0	1	6
				%	15	9	0	0	5	6
			Very bad	No.	0	2	0	0	0	2
				%	0	9	0	0	0	2
			Total	No.	20	22	20	23	20	105
				%	100	100	100	100	100	100
	5-2	Taste	None	No.	0	8	19	23	23	73
				%	0	36	95	100	100	68
			Chlorination	No.	20	14	1	0	0	35
				%	100	64	5	0	0	32
			Septic odor	No.	0	0	0	0	0	0
				%	0	0	0	0	0	0
			Metallic odor	No.	0	0	0	0	0	0
				%	0	0	0	0	0	0
			Others	No.	0	0	0	0	0	0
				%	0	0	0	0	0	0
			Total	No.	20	22	20	23	23	108
				%	100	100	100	100	100	100
	5-3	Color	None	No.	20	17	20	23	18	98
				%	100	77	100	100	90	93
			Red	No.	0	0	0	0	0	0
				%	0	0	0	0	0	0
			Turbidity	No.	0	5	0	0	2	7
				%	0	23	0	0	10	7
			Others	No.	0	0	0	0	0	0
				%	0	0	0	0	0	0
			Total	No.	20	22	20	23	20	105
				%	100	100	100	100	100	100

Table-4 Result of socio-condition survey (3)

Sections	No.	Questions		Unit	Area					Total
					Dybabel	Vrela Ribnicka	Tolosi	Momisici	Center Podgorica	
Section 6 Water charge	6-1	Water charge	Water charge	EUR/month	13.4	9.1	11.4	15.7	11.0	12.1
	6-2	Method	Branch office	No.	19	10	18	23	13	83
				%	100	45	100	100	68	82
			Bank account	No.	0	9	0	0	3	12
				%	0	41	0	0	16	12
			Others (Post office)	No.	0	3	0	0	3	6
				%	0	14	0	0	16	6
			Total	No.	19	22	18	23	19	101
				%	100	100	100	100	100	100
	6-3	Rate	More than 10%	No.	3	3	0	0	0	6
				%	15	14	0	0	0	6
			5=<x<10%	No.	1	4	0	0	1	6
				%	5	18	0	0	5	6
			3=<x<5%	No.	16	11	4	2	9	42
				%	80	50	20	11	47	42
			Less than 3%	No.	0	4	16	17	9	46
				%	0	18	80	89	48	46
			Total	No.	20	22	20	19	19	100
				%	100	100	100	100	100	100
	6-4	Feel	Very expensive	No.	5	4	0	0	0	9
				%	25	18	0	0	0	9
			Expensive	No.	15	8	0	1	4	28
				%	75	36	0	4	20	27
			Reasonable	No.	0	10	19	22	15	66
				%	0	46	95	96	75	63
			Cheap	No.	0	0	1	0	1	2
				%	0	0	5	0	5	1
			Total	No.	20	22	20	23	20	105
				%	100	100	100	100	100	100

Survey No.: _____

SOCIO-CONDITION SURVEY

Questionnaire

Interviewer: _____, Interviewed date: _____/_____, 2009

Town: _____

1. Botum
2. Daybabel
3. Tolosi
4. Momisici
5. Center Podgorica

SECTION 1 Interviewee's Information

1-1 Name of Interviewee _____

Sex: M / F Age: _____

SECTION 2 Family Structure

2-1 Total number of household member _____ persons

(Male:____persons, Female:____persons)

SECTION 3 Water Availability

3-1 Experiences of interruption in supply

Has your family ever experienced interruption in supply?_____

Code for answer: 1. Yes
2. No

3-2 Frequency of interruption in supply

How often does your family experience interruption in supply in a month ?

_____Times

3-3 Average hours of interruption in supply

_____Hours

3-4 Alternative water source

When it is interruption in supply, where does your family get drinking water from ?_____

Code for answer: 1. Water truck from corporation
2. Individual water tank for storage of water supply
3. Fetching water from supply area
4. Purchase of bottled water
5. Own well
6. Others_____

3-5 Damages caused by interruption in water supply

When it is interruption in supply and you get water from where you answered in "3-4", what kind

of damage did you have at that time ?_____

Code for answer: 1. Physical condition defectiveness (diarrhea)
2. Time loss by fetching water
3. Increase of burden for domestic account by purchase of drinking water
4. Inconvenience of daily life (Shortage of shower water, washing water)
5. Others_____

SECTION 4 Water consumption and Water use

4-1 Water consumption (Please check invoice from Podgorica Water and Sewerage Corporation)

How much water does your family use last month? Please see the invoice from corporation.

_____m^3/month

4-2 Pressure of water supply

How does your family feel the pressure of water supply in your house connection?_____

Code for answer: 1. High
2. Just enough
3. Low
4. Very low

4-3 Water use

What is rate of each water consumption by water use ?

Drinking and Cooking	_____%
Washing	_____%
Bathing and Shower	_____%
Cleaning and Watering	_____%
Others _____	_____%
Total	100 %

4-4 Water tank

Do you buy water bottle for drinking?

Code for answer: 1. Yes (Capacity_____L/month)
2. No

SECTION 5 Water quality

5-1 How do you feel water quality for domestic use?

Code for answer: 1. Good quality
2. Not perfect, but basically acceptable
3. Not good
4. Very bad

5-2 Taste and smell

How is taste and smell of water supply ?

Code for answer: 1. None
2. Smelling of chlorination
3. Septic odor
4. Metallic odor
5. Others_____

5-3 Color

How is color of water supply ?

Code for answer: 1. None
2. Red water
3. Turbidity
4. Others_____

SECTION 6 Water charge

6-1 Water charge

How much is your family spending for water use ?

_____EUR/month

6-2 Method of payment of water charge

How does your family pay for water charge ?

Code for answer: 1. Payment at branch of Podgorica Water and Sewerage Corporation
2. Pulling down from bank account
3. Others_____

6-3 Rate of water charge in monthly expenditure

How much is your family spending on water for domestic use in a month?

Code for answer: 1. More than 10%
2. 5 =< x < 10%
3. 3 =< x < 5%
4. Less than 3%

6-4 How do you feel water charge?

Code for answer: 1. Very expensive
2. Expensive
3. Reasonable
4. Cheap

Appendix 7: Water Hammer Analysis

Water Hammer Analysis on New Water Transmission Pipeline (800mm ϕ)
from Mareza 2 Pump Station to Ljubovic Reservoir (20,000 m^3)

Under this Project the water distribution pumps in Mareza 2 pump station are replaced. Meanwhile, PWS is going to construct the new reservoir of 20,000 m^3 at Ljubovic and to lay the new water transmission pipeline from Mareza pump stations to Ljubovic reservoir by use of finance related to EC. When these projects are completed, water transmission system is switched so that water transmission is made through the said pipeline from Mareza 2 pump station.
Although Mareza 2 pump station has two air chambers and one air compressor for the water hammer prevention facilities at present, they are not used. This is because the existing water transmission pipeline has both the function of water transmission and it of water distribution concurrently. When system is switched to water transmission and all the pumps in Mareza 2 pump station shut down with power failure or miss operation, there is possibility that water hammer occurs in the water transmission pipeline. Accordingly in case that the said air chambers and air compressor are restored and used for the said water transmission pipeline, this effectiveness for water hammer prevention was studied for reference.

This study was made for both the case having non water hammer prevention facilities and it having the said water hammer prevention facilities. Both cases are approached as follows;

① to confirm whether the maximum increasing pressure at all pumps shutdown does not exceed the maximum working pressure of the said pipeline by calculating the maximum increase pressure at all pumps shutdown.
② to confirm whether the minimum decreasing pressure at all pumps shutdown does not make water column separation in the said pipeline by calculating the minimum deceasing pressure at all pumps shutdown.

The result of study is summarized the table below. As a result of it, it was confirmed that the existing water hammer prevention facilities could be applied to the said pipeline. For details of the study, refer to the attached data.

Table Result of Study on Water Hammer

	Case of non water hammer prevention facilities	Case of the existing water hammer prevention facilities
1. Pressure occurring at all pumps shutdown -Maximum increasing pressure in pipeline -Minimum decreasing pressure in pipeline	 1.1739 MPa (11.970 kgf/cm^2) -0.4436 MPa (-4.523 kgf/cm^2)	 0.9379 MPa (9.564 kgf/cm^2) -0.0419 MPa (-0.428 kgf/cm^2)
2. Maximum working pressure in pipeline	0.9807 MPa (10 kgf/cm^2)	Same as left
3. Water column separation	Yes	No
4. Applicability of pipeline	No, this is because the maximum increasing pressure exceeds the maximum working pressure and water column separation occurs.	Yes

WATER HAMMER ANALYSIS REPORT

1. PURPOSE : To examine Water Hammer Phenomena at trip of all operating pumps

2. METHOD : Easy Transient Analysis Program (Easy TRAP)

3. CRITERIA : Minimum allowable negative pressure is -0.058842 MPa (-6m)

4. BASIC CONDITIONS

(1) Main Pump

Pump service	:	Transmission
Pump EBARA Model	:	400 VY2M
No. of installed pumps	:	4 sets
No. of operating pumps	:	3 sets
Rated pump capacity (Q)	:	19.2 m^3/min
Rated pump total head (HT)	:	90 m
Rated speed of rotation (N)	:	1470 min^{-1}
Rated pump efficiency (ηP)	:	77 %

(2) Motor and GD^2

Motor output	:	400 kW
Motor type	:	Squirrel cage
Motor voltage	:	6000 V
Motor frequency	:	50 Hz
No. of pole	:	4 P
Motor GD^2	:	15.3 kg m^2
Pump GD^2	:	15.9 kg m^2

(3) Valve

1) Check Valve

Valve bore	:	400 mm
Valve type	:	Ordinary check

2) Discharge Valve

Type of Discharge Valve	:	
Discharge Valve Bore	:	
Valve Closing Time	:	

(4) Pipeline

1) Discharge Pipeline

Pipe No.	:	1
Pipe material	:	Steel
Pipe diameter (D)	:	800 mm
Pipe thickness (t)	:	8 mm
Value of K/E	:	0.01
Wave speed (a)	:	1007.63 m/sec
Pipeline length (L)	:	8910 m
Loss co-efficient (C)	:	160
Pipeline loss (Hf)	:	21.85 m

(5) Operating Conditions

Flow condition	:		Design capacity
Flow capacity (QT)	:		57.6 m^3/min
Suction water level	:	NWL	32.5 EL m
Discharge water level	:	NWL	99 EL m
Actual head (Ha)	:		66.5 m

Pipeline loss (Hf)	:	21.848 m
Pump station loss (Hp)	:	1.652 m
Pump capacity ratio	:	100%
Pump head ratio	:	100%

5. CALCULATION RESULTS WITHOUT COUNTERMEASURE (CASE 1)

	Distance from PS (m)	Elevation (EL m)
Minimum Pressure -0.4436 MPa	8464.5 m	64.0 EL m
Maximum Pressure : 1.1739 MPa	0.0 m	32.0 EL m

Water Column separation will occur. Countermeasures are necessary.
Maximum pressure should be checked by Customer whether it is within allowable pressure of the pipeline.
Maximum and Minimum Pressure Line are shown as attached herewith.

6. RECOMMENDED WATER HAMMER PROTECTION DEVICES

(1) Installation of air chamber

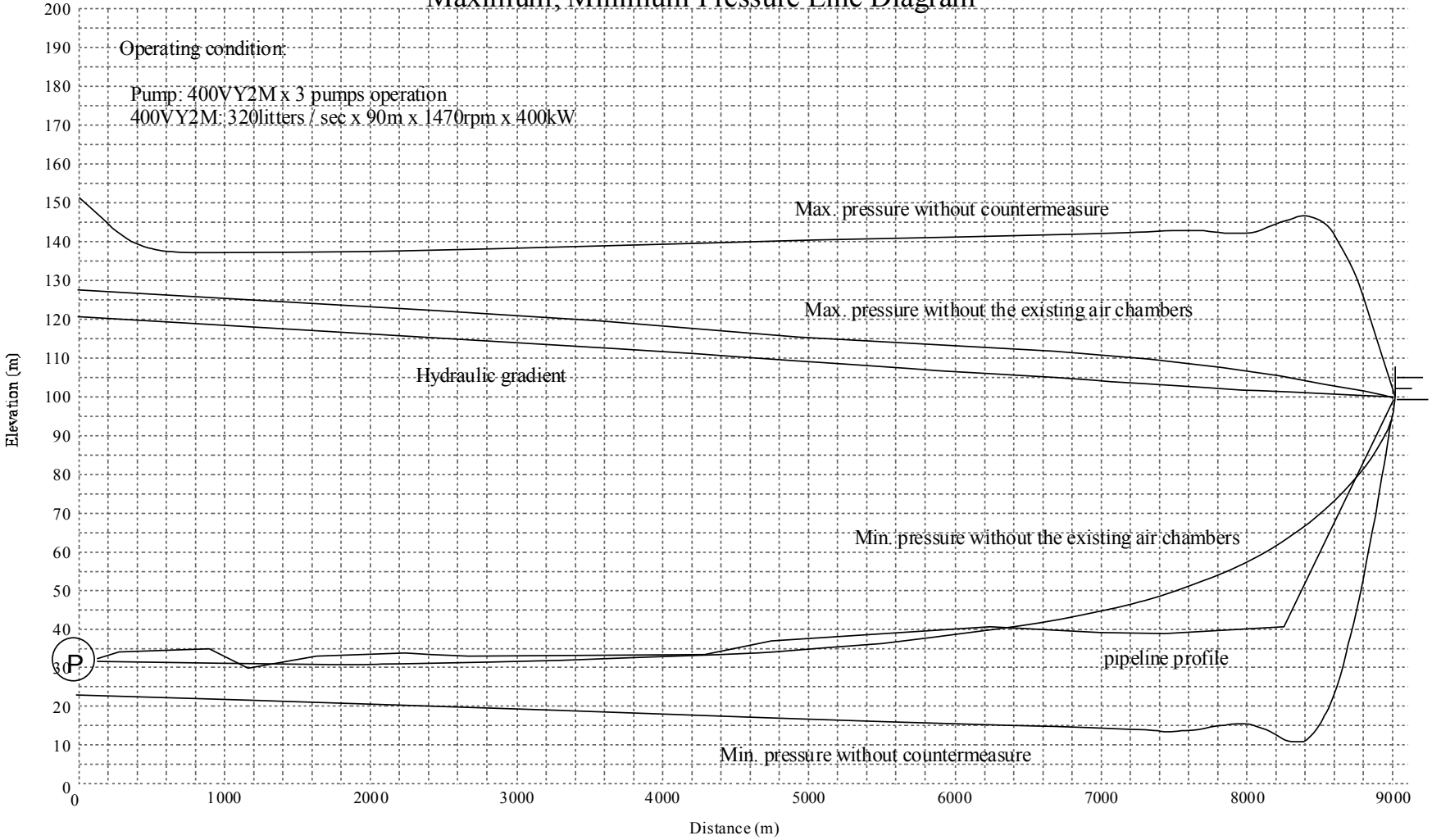
Air chamber volume	:	16.0 m^3
Location from pump station	:	0 m
Installed elevation	:	32.5 EL m
Air chamber volume	:	16.0 m^3
Location from pump station	:	0 m
Installed elevation	:	32.5 EL m

7. CALCULATION RESULTS AFTER PROTECTION DEVICES ARE INSTALLED (CASE 2)

	Distance from PS (m)	Elevation (EL m)
Minimum Pressure -0.0419 MPa	8869.6 m	95.8 EL m
Maximum Pressure : 0.9379 MPa	0.0 m	32.0 EL m

Pressure in the pipeline will become negative.
However, water column separation will not occur.
Maximum pressure in the pipeline is within allowable range.
Maximum and Minimum Pressure Lines are shown as attached herewith.

Maximum, Minimum Pressure Line Diagram



Appendix 8: Drawings for distribution network

Table-1 List of drawings

DWG No.	Title
1	Key plan for distribution network
2	Distribution network (Map-1)
3	Distribution network (Map-2)
4	Distribution network (Map-3)
6	Distribution network (Map-4)
7	Distribution network (Map-5)
8	Distribution network (Map-6)

NO.	DATE	APPROVED	REVISION

NOTE:

JAPAN INTERNATIONAL COOPERATION AGENCY

THE PREPARATORY SURVEY II ON THE PROJECT FOR URGENT REHABILITATION OF WATER SUPPLY SYSTEM IN THE CAPITAL CITY OF PODGORICA IN MONTENEGRO

Key plan for distribution network

DATE	APPROVED
	CHECKED
	DRAWN
SCALE	DWG. NO.
1:8000	(1)

NO.	DATE	APPROVED	REVISION

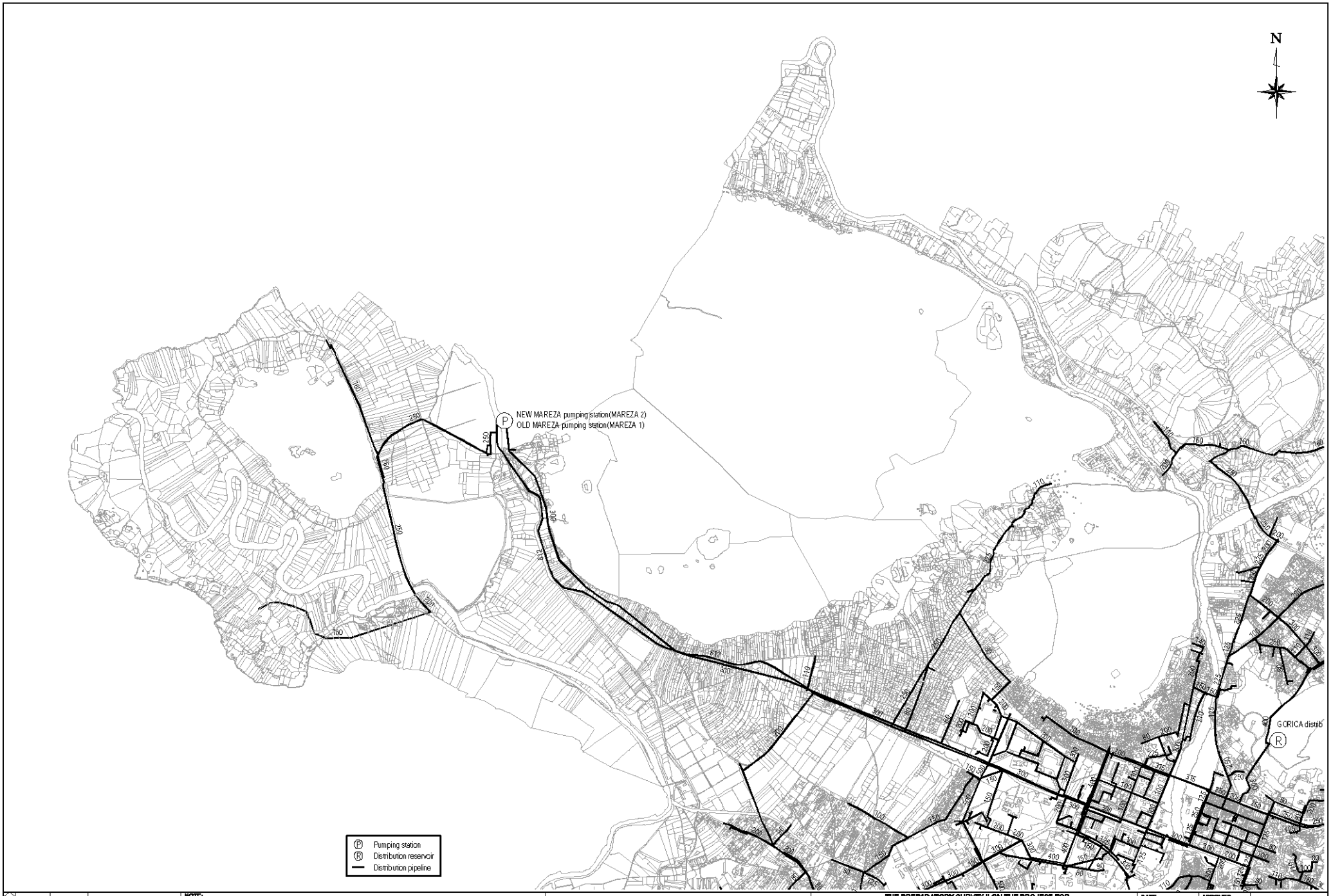
NOTE:

JAPAN INTERNATIONAL COOPERATION AGENCY

THE PREPARATORY SURVEY II ON THE PROJECT FOR
URGENT REHABILITATION OF WATER SUPPLY SYSTEM
IN THE CAPITAL CITY OF PODGORICA IN MONTENEGRO

Distribution network (Map-1)

DATE	APPROVED
	CHECKED
	DRAWN
SCALE 1:3000	DWG. NO. (2)



NO.	DATE	APPROVED	REVISION

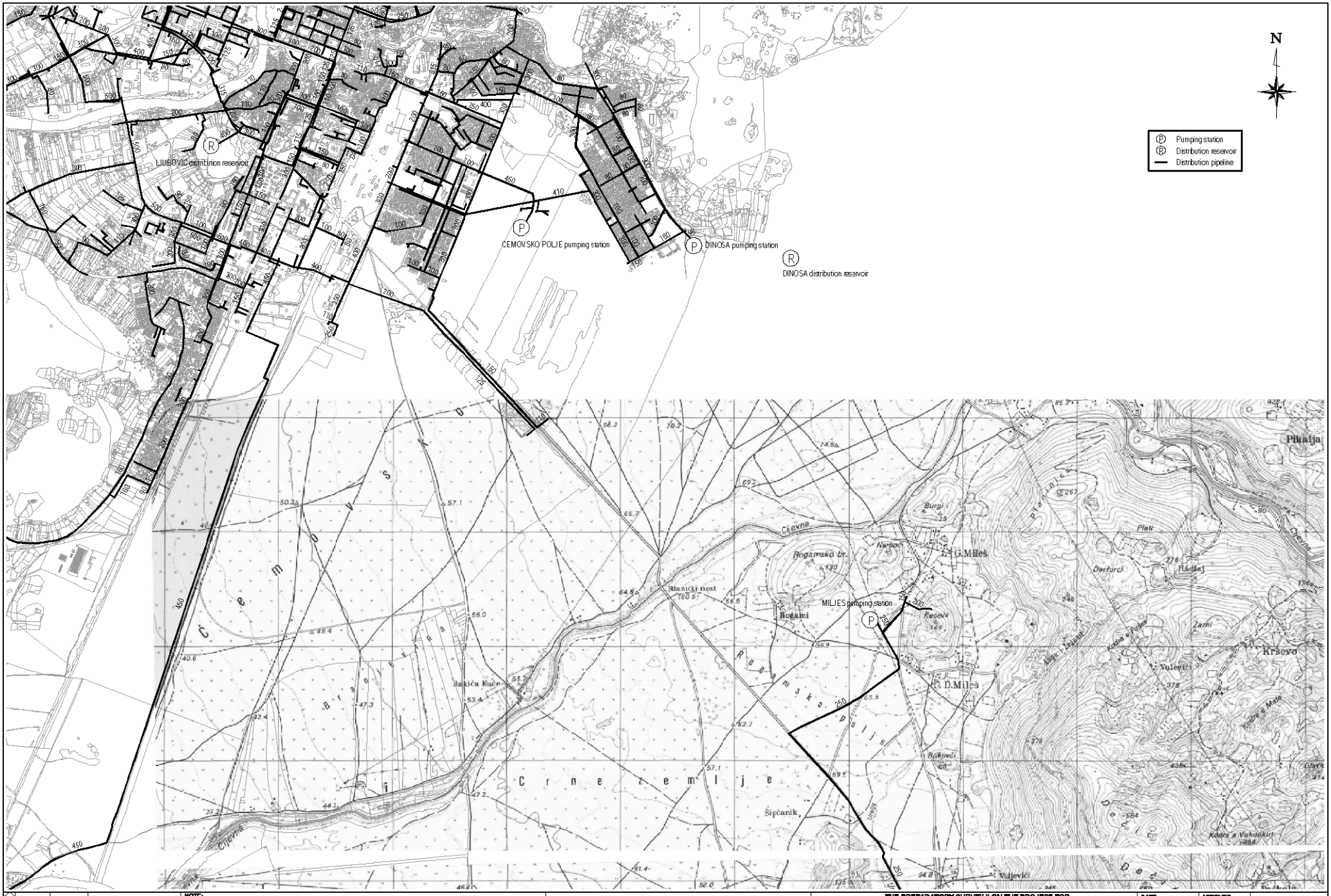
NOTE:

JAPAN INTERNATIONAL COOPERATION AGENCY

THE PREPARATORY SURVEY II ON THE PROJECT FOR
URGENT REHABILITATION OF WATER SUPPLY SYSTEM
IN THE CAPITAL CITY OF PODGORICA IN MONTENEGRO

Distribution network (Map-2)

DATE	
APROVED	
CHECKED	
DRAWN	
SCALE	1:3000
DWG. NO.	(3)



NO.	DATE	APPROVED	REVISION

NOTE:

JAPAN INTERNATIONAL COOPERATION AGENCY

THE PREPARATORY SURVEY II ON THE PROJECT FOR URGENT REHABILITATION OF WATER SUPPLY SYSTEM IN THE CAPITAL CITY OF PODGORICA IN MONTENEGRO

Distribution network (Map-3)

DATE	APPROVED
	CHECKED
	DRAWN
SCALE: 1:3000	DWG. NO.: (4)