

Consulting Service Report for Examination of Plants
On
Belgrade Central Waste Water Collection and Treatment Project
In
Republic of Serbia

March, 2010
Japan Consulting Institute
Mitsui Consultants Co., LTD.



This work was subsidized by Japan Keirin Association
Through its Promotion funds from KEIRIN RACE
<http://ringring-keirin.jp/>

Table of Contents

Chapter 1 Introduction	1
1-1. Name of the Project:	1
1-2. Background and Necessity of the Project	1
1-3. Outline and method of this advisory service.....	2
1-4. Current situation of Republic of Serbia	3
1-5. Current situation of Belgrade City	4
Chapter 2 Current situation of Belgrade Central Waste Water Collection and Treatment and necessity of Improvement	7
2-1. Current situation of Belgrade waste water collection and treatment	7
2-1-1.Collection systems	7
2-1-2.Sewage system.....	8
2-1-3.Pumping station	8
2-1-4.Organization of sewerage system development.....	10
2-2. Effluent Standard of Republic of Serbia	11
2-2-1. Example of effluent standards	11
2-2-2. Legislation concerning water pollution in Serbia.....	11
2-2-3. Effluent standard of EU	14
2-2-4. Necessity of Belgrade Central Waste Water Collection and Treatment.....	14
Chapter 3 Planning of construction of sewerage system in Belgrade	15
3-1.Collection system.....	15
3-2. Population	18
3-3. Planned hydraulic load of the WWTP Veliko Selo	19
3-4.Planned water quality.....	20
3-5. Treatment process	22
3-6. Plant staging.....	25
Chapter 4 Environmental aspect of the project.....	26

4-1. National sustainable development strategy	26
4-2. Movement toward EU accession	27
4-3. Items to be achieved by the host county (including the implementation agencies and related organization) for the implementation of the project.....	27
Chapter 5 Suggestions from the results of the survey	29
5-1. Feasibility study	29
5-2. Technical assistance of Japanese technology on operation and maintenance of Advanced Treatment of Waste Water	30
5-3. Recommendation of utilization of ODA Loan	30
Chapter6. Further Approach.....	33

Chapter 1 Introduction

1-1. Name of the Project:

Belgrade Central Waste Water Collection and Treatment Project

1-2. Background and Necessity of the Project

The Republic of Serbia, where the River Danube flows 588 km in the country, decided to join and became full membership of the International Commission for the Protection of the Danube River (ICPDR) in August 2003 and since then has participated in international cooperative challenge to protect the water quality of the international river, Danube and to secure safe navigation of the river. ICPDR is an international commission established in October 1998 for the purpose of protection of water quality, prevention of flood and security of safe navigation of the Danube River and now consists of fourteen (14) countries where the River Danube flow or who have sources of water to the River Danube, as well as European Union. ICPDR conducts multi-national monitoring of the Danube water quality and pointed out that the main cause of pollution of the river is hydroelectric power plants constructed and operated at various points of the river and waste water discharge without treatment by large cities along the river.



Photo1-1. Panoramic View of Danube at the suburb of Belgrade

As a member of ICPDR , the Republic of Serbia has been planning several waste water improvement projects at large cities on the Danube River, such as the capital city, Belgrade, Novi Sad, etc. In accordance with the government policy, the master plan of Belgrade city incorporates the waste water treatment project to improve the quality of waste water discharged to the Danube River. The project has, however, never been realized due to lack of necessary fund.

The present government of Serbia maintains the policy to accelerate to join EU. Joining EU,

Serbia must observe EU Standard for waste water quality and the improvement of sewage system will become inevitable.

For the water supply of Belgrade city, various countries have given the city grant programs to improve the quality of water supply system of the city. The grant programs amount to approximately 30 Million Euro since the year 2000. Among those grant programs, the largest grant program was “SCADA, remote control, PS reconstruction” given by JICA, Japan in the year 2006, which amounts to 7.9 Million Euro. For the sewage system of the city, however, only the grant programs by EU and Germany for study expenses amounting to 0.9 Million have been given to the city.

The master plan of sewage system improvement at Belgrade is now being prepared by Belgrade Land Development Public Agency (LDA) with cooperation of Water Institute Jaroslav Cerni. This is funded by the city budget and is expected to be completed by the end of April 2010.

Under such circumstances, in July 2009, the government of Serbia submitted to Japanese government the official request of ODA loan for this important project, “Belgrade Central Sewage System Improvement project”, together with another project, “Flue Gas Desulphurization Project for Nikola Tesla-A Power Station”. The feasibility study of the latter project has been conducted and completed by Japanese consultants’ team in February 2010 and Japanese government is evaluating the project. For the former project, the feasibility study shall still be required for Japanese government to evaluate the project.

1-3. Outline and method of this advisory service

In response to the request by the government of Serbia, Japan Consulting Institute (JCI) conducted the advisory service for the Belgrade Central Sewage System Improvement Program for the purpose of:

- (i) Collection of information on the situation of the existing sewage system at Belgrade,
- (ii) Outlining whole project which consists of waste water treatment plant to be newly built, rehabilitation of the existing pump stations, construction of new pump station, additional sewage networks, etc.,
- (iii) Defining scope of works to be covered by Japanese ODA loan, and
- (iv) Advice on the most feasible technical solution of the project.

The consultants' team was dispatched to Belgrade for local survey mission for site visits of the existing sewage facilities and planned site of waste water treatment plant and interviews with related local organizations during the period from February 24 to March 5, 2010. This advisory service report was made based on the result obtained during the local survey mission and analysis using by the consultants' in-house data.

1-4. Current situation of Republic of Serbia

The Republic of Serbia had been the largest republic of the former Yugoslavia and played the leading role in the field of politics, economy, education, cultures, etc. in the former Yugoslavia. After the civil wars in the 1990s and independences of the other republics, the former Yugoslavia was replaced by the state union of Serbia and Montenegro in the year 2003. The state union of Serbia and Montenegro ceases to exist following the independence of Montenegro from the state union, and the Republic of Serbia became an independent state in the year 2006. In 2008, Albanians in Kosovo and Metohija province of Serbia declared independence from the Republic of Serbia which the government of Serbia continues to refuse. The international community is still divided over the issue: some countries are against Kosovo independence, some have recognized it.

Serbia is a parliamentary republic. The Serbian parliament has 250 seats. Prime Minister is elected for the terms of four (4) years and the President is elected to serve a five (5) year term. The most recent parliamentary election took place in January 2007 and the presidential election in January 2008. The current President is Mr. Boris Tadic of the Democratic Party, and the prime minister is Mirko Cvetkovic forming governing coalition of Democratic Party with Socialist Party of Serbia.

Serbia's population in 2008 came to approximately 9,850,000 including Kosovo and 7,350,000 excluding Kosovo. According to World Bank statistics, Gross National Income (GNI) excluding Kosovo was 41.9 Billion US Dollar equivalent and 5,700 US Dollar per capita in 2008, while the data including Kosovo is not available. The country's majority ethnic is Serbs with minority ethnic, Albanians, Hungarians, Bosniaks, Roma, etc. Orthodox Christianity is the major religion in Serbia. The situation of economy becomes better; Economic growth in 2008 is 5.6%, Inflation rate in 2008 is 12.7% (World Bank statistics) and Jobless rate in 2008 is 14% (Serbian government statistics).

Serbia takes up an area of 88,361km² including Kosovo. The country borders Bosnia and

Herzegovina, Croatia, Hungary, Romania, Bulgaria, FYR Macedonia, Albania and Montenegro. The Midzor peak at Stara Planina is the highest in Serbia at 2,156m. The Danube River flows 588km through the country, the Sava River 206km, and the Drina River forms most of the border with the west (220km). Another Serbian river is the Great Morava (185km), created by the confluence of the Western Morava (308km) and the Southern Morava (295km).



Fig.1-1. Serbia in Europe

1-5. Current situation of Belgrade City

Belgrade is the capital and largest city of Serbia. With a population of 1,630,000 (Official estimate 2007), Belgrade is the third city in Southeastern Europe, after Istanbul and Athens. Its name in Serbian language, Beograd translates to White City.

One of the oldest cities in Europe, Belgrade's wider city area was the birthplace of the largest prehistoric culture in Europe. In the long history, Belgrade had experienced a lot of wars and invasions of foreign countries, its possession had been frequently changed. Since the establishment of the former Yugoslavia, Belgrade city has been the capital of the republic. Belgrade is the central economic hub of Serbia and the capital of Serbian education and science.

Belgrade has the status of a separate territorial unit in Serbia, with its autonomous city government. Its territory is divided into 17 municipalities, each having the own local council. It covers 3.6% of territory of Serbia and 24% of the country's population lives in the city.

Belgrade lies 116.75 meters above sea level and is located at the confluence of the Danube and Sava Rivers, at coordinates 44°49' 14" North and 20°27' 44" East.



Photo1-2. Panoramic view of confluence of Danube and Sava at Belgrade

After the World War II, New Belgrade (Novi Beograd) was built on the left bank of the Sava River, merging Belgrade with Zemun. The city has an urban area of 360km², while together with its metropolitan area covers 3,223km².

Belgrade has a mild continental climate. The year-round average temperature is 11.7°C, while the hottest month is July with an average temperature of 22.1°C and the coldest month is January with an average temperature of -2.3°C.

Current mayor is Mr. Dragan Djilas of Democratic Party. The civil assembly of Belgrade has 110 councils who are elected for four-year terms.

The city is divided into 17 municipalities. The most of the municipalities are situated on the southern side of the Danube and Sava Rivers, in the Sumadija region. Three municipalities, Novi Beograd, Zemun and Surcin are on the northern bank of the Sava in the Syrmia region, and the municipality of Palilula, spending the Danube, is in both of Sumadija and Banat region.



Fig.1-2. Municipalities of Belgrade

Belgrade is the most economically developed part of Serbia, being the home of National Bank and the bases of many notable companies both domestic and foreign. Over 35% of Serbia's GDP is generated by the city, which also has 34% of Serbia's employed population.

Chapter 2 Current situation of Belgrade Central Waste Water Collection and Treatment and necessity of Improvement

2-1. Current situation of Belgrade waste water collection and treatment

2-1-1. Collection systems

Construction of the sewage system in Belgrade started 100 years ago. In 1905, sewage network that is a part of the central system was constructed. Until the Second World War, 24% of today's sewage system was constructed. After the Second World War sewage construction followed development and expansion of the city in New Belgrade and Zemun as well as in direction Zeleznik – Zarkovo –Cukarica, Topcider river and Kumodraz creek valley.

Today, Belgrade sewage covers area of 13,500 ha, where 40% is combined sewage and 60% is separate sewage. Status of the Belgrade sewage network is:

- In central area 75% of fecal network and 65% of rain network
- In wide city area 54% of fecal network and 74% of rain network
- Sewage channel length – 1,380 km
- Collectors length – 205 km
- House connections -52,000 peaces
- Street gutters -32,000 peaces

Rivers Sava and Danube are recipients for collected fecal and rain water. Over 37 discharge points exists (over 50% is for rain water). Estimated discharge flow in rivers Sava and Danube is:

- 200,000,000m³/year of fecal water
- 60,000,000m³/year of rain water

34 sewage PS (Pump Stations) exist in Belgrade sewage system with total installation capacity of 53,000 l/s. PS are pumping 57,000 m³/h of fecal water and 133,000 m³/h of rain water, or more than 120,000,000 m³/year (about 320,000 m³/d) of waste water. Installed power of sewage PS is about 8,600 kW.

2-1-2.Sewage system

In view of the geographical aspects and population density, Belgrade sewage system is divided in 5 independent sewage systems.

- Central sewage system
- Ostruznica sewage system
- Banat sewage system
- Batajnica sewage system
- Bolec sewage system

These are illustrated as shown in fig.2-1.

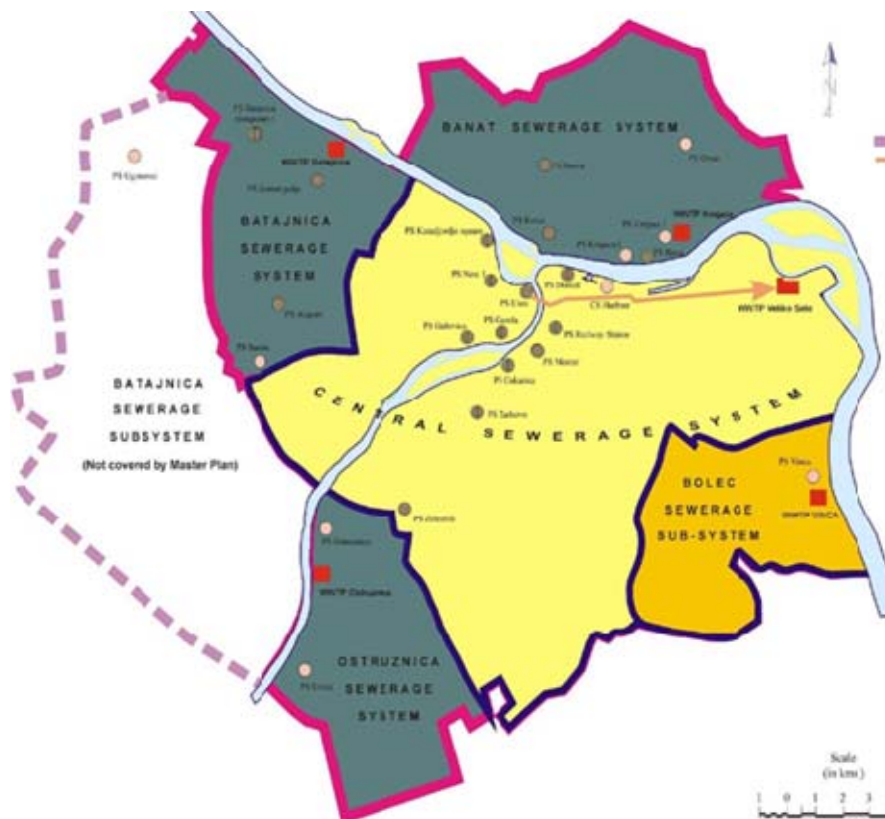


Fig.2-1. Belgrade sewage system

2-1-3.Pumping station

In the storm weather, 70% of sewage is discharged as rain water by the pumps for rain water discharging, while 30% is discharged by waste water pump.

Photo2-1 shows the pump for rain water discharge.Photo2-2 shows the pump for waste water discharge.Photo2-3 shows control panel in the city. Central control station of all pumping stations in the city is installed at the Mostar pumping station as shown in photo2-3.



Photo 2-1. Pump facility for storm discharge



Photo2-2. Pump facility for waste water discharge

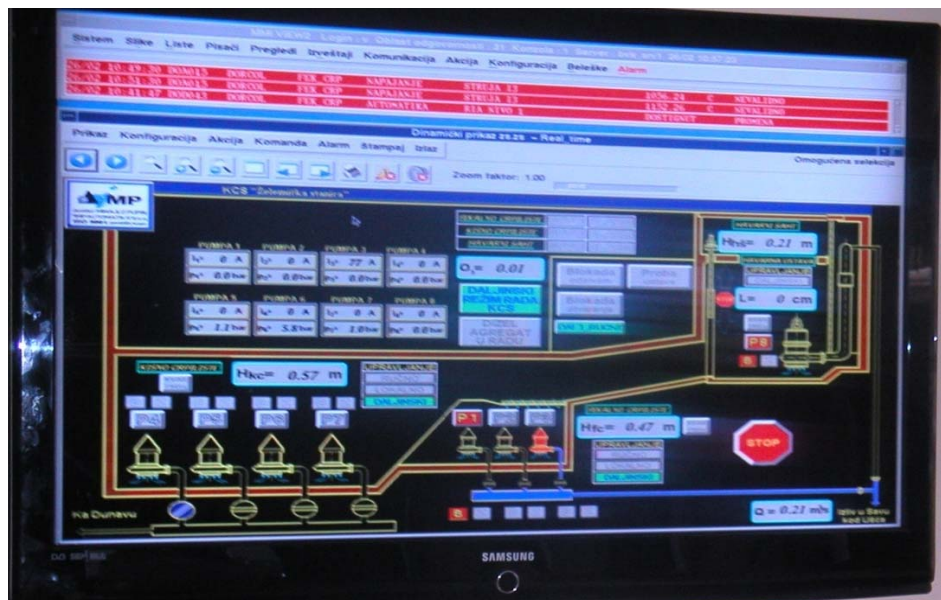


Photo2-3. Control panel of pump stations

2-1-4. Organization of sewerage system development

The organization which is in charge of sewerage development is Land Development Agency (here in after referred as LDA), and the organization in charge of maintenance of water way and sewerage system is Belgrade Waterway and Canalization (Beogradski Vodovod I Kanalizacija; here in after referred as BVK). The organization of LDA is shown in fig.2-2.

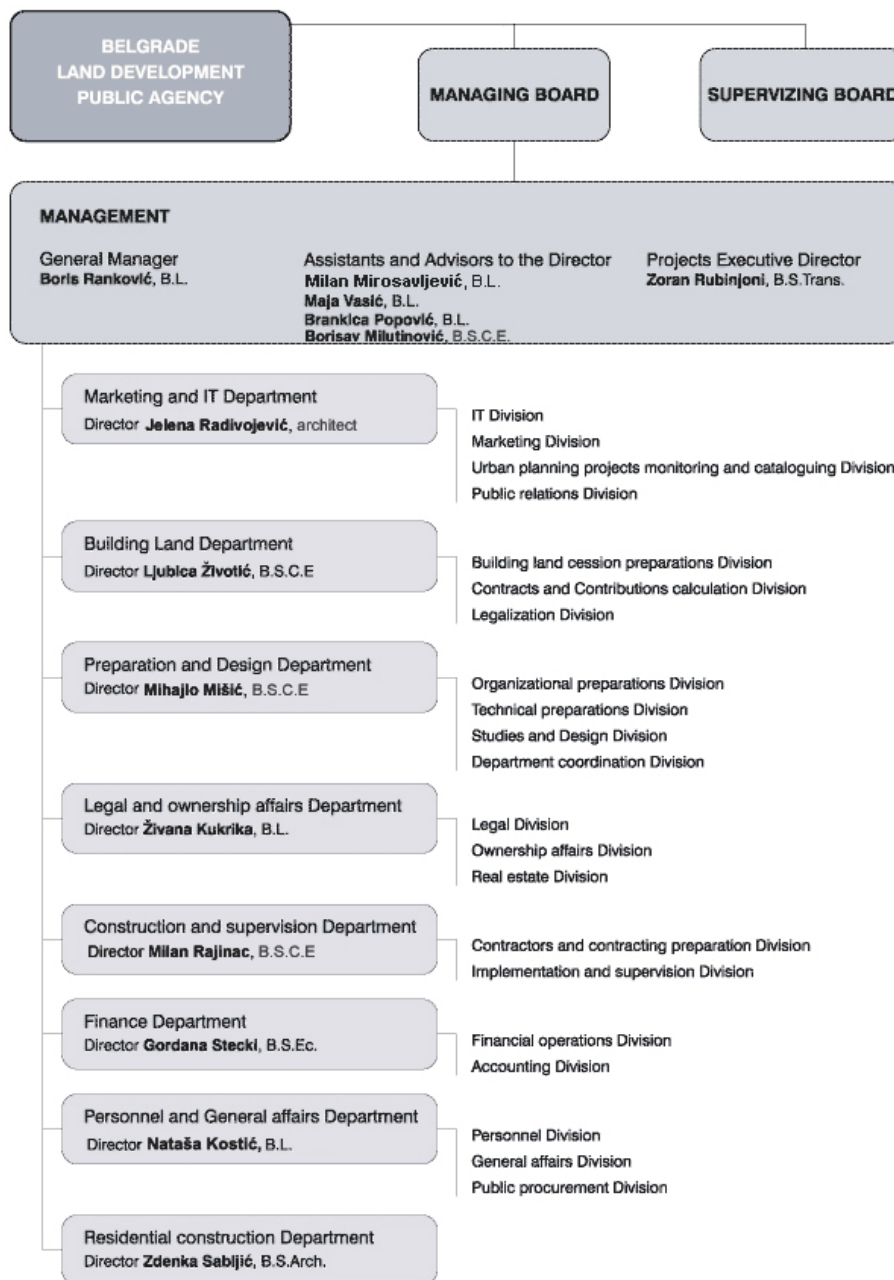


Fig.2-2. Organization of LDA

2-2. Effluent Standard of Republic of Serbia

2-2-1. Example of effluent standards

The example of effluent standards of other countries is illustrated in table2-1.

Table2-1. The example of effluent standards of main countries

Item	Standard (mg/l)	
	IFC ¹⁾	Japan ²⁾
BOD	30	160
COD	125	160
SS(PE2,00 – 10,000)	50	200
SS (PE>10,000)		
N(PE10,000 – 100,000)	10	120
N (PE > 100,000)		
P(PE10,000 – 100,000)	2	16
P (PE > 100,000)		

1) IFC Environmental, Health, and safety Guidelines, GENERAL EHS GUIDELINES)

2) Water Pollution Control Law

2-2-2. Legislation concerning water pollution in Serbia

Legislation concerning water pollution in Serbia is based exclusively on quality of receiving water after mixing with effluents. This kind of approach does not exist anymore in Western Europe and North America since long time ago and system has been improved by appropriate requirements of effluent quality and/or minimal removal efficiency for certain parameters.

By-law Of Water Courses (Official Gazette of the Republic of Serbia No.5/68) specified four classes according to their pollution level and their purpose. The by-law does not address mineral and thermal water. The classes are:

- Class I: water, that, in natural state or after disinfection, can be used for drinking water supply, food industry and fish (salmonidae) breeding.
- Class II: water appropriate for bathing, recreation, water sports, less fine

fish(cyprinidae) breeding, including water that, after basic treatment methods(coagulation, filtration, and disinfection), can be used for drinking water supply and food industry.

- Class III: water that can be used for irrigation and industries except food industry.
- Class IV: water that can be used only after special treatment.

Water courses falling into class II that are not crossing borders with neighboring countries are subdivided into two subclasses:

- Subclass IIa : water that, after basic treatment methods(coagulation, filtration and disinfection), can be used for drinking water supply, bathing and food industry.
- Subclass IIb : water that can be used for water sports, recreation, less fine fish(ciprinides) breeding, and cattle drinking.

Water classes are defined according to the following parameters and their limit values are as shown on table 2-2:

The improvement of effluent standard is achieved by appropriate requirements of effluent quality and/or minimal removal efficiency for certain parameters. The organization related to environment and legal system is working to improve the legal system. Until completion, the effluent from the new WWTP will be governed by EU standard.

Table.2-2. Definition of water quality classes (Official Gazette of the Republic of Serbia 5/68)

№	parameter	Class I	Class II	Class IIa	Class IIb	Class III	Class IV
1	Suspended solids in dry condition (mg/ℓ), maximum	10	30	30	40	80	—
2	Total dry solids in dry condition (mg/ℓ), maximum	350	1000	1000	1500	1500	—
3	pH value	6.8-8.5	6.8-8.5	6.8-8.5	6.8-8.5	6.0-9.0	—
4	Dissolved oxygen(mg/ℓ), minimum (not applicable to ground water and natural lakes)	8	6	6	5	4	0.5
5	Five-day biochemical oxygen demand (mg/ℓ), maximum	2	4	4	6	7	—
6	Saprobity index after Libman(not applicable to groundwater and natural lakes)	oligo-saprobic	beta-meso-saprobic	beta-meso-saprobic	beta-alpha-meso-saprobic	alpha-meso-saprobic	—
7	Biological production	oligo-trophic	eutrophic	eutrophic	—	—	—
8	Most probable number of coliform bacteria in 100 ml of water, maximum	none	none	none	none	none	—
9	Visible	none	none	none	none	none	none
10	Detectable	none	none	none	none	—	—
11	Detectable odour	none	none	none	none	—	—

2-2-3. Effluent standard of EU

Effluent standard of EU for urban waste water treatment plant is shown on table2-3.

Table 2-3. Effluent standard of EU for urban waste water treatment plant

Item	Standard(mg/l)
BOD	25
COD	75
SS (PE2,000–10,000)	60
SS (PE>10,000)	35
N (PE10,000–100,000)	15
N (PE>100,000)	10
P (PE10,000–100,000)	2
P (PE > 100,000)	1

2-2-4. Necessity of Belgrade Central Waste Water Collection and Treatment

The necessity of Belgrade Central Waste Water Collection and Treatment is obviously significant as a full member country of ICPDR and the country which has target to join EU. Therefore, LDA is developing their own plan to construct Waste Water Treatment Plant (herein after WWTP). The new WWTP will satisfy effluent standards of EU.

Chapter 3 Planning of construction of sewerage system in Belgrade

LDA has feasibility study and preliminary design for WWTP Veliko Selo. The technical report is as follows.

3-1. Collection system

LDA is developing their own planning of sewerage improvement as shown on fig.3-1. The progress of each section is as shown on table 3-1. At the same time, they are in progress of land acquisition for the construction of waste water treatment plant.

According to the plan, waste water which is currently discharged to the Rivers Sava and Danube without any treatment should be collected by the trunk sewer and be transported to the new waste water treatment plant as shown on fig.3-1.

LDA defines No.9 as “Interceptor” and other drainages from section No.1 to 10 as “Collectors”. No.13 is WWTP Veliko Selo.

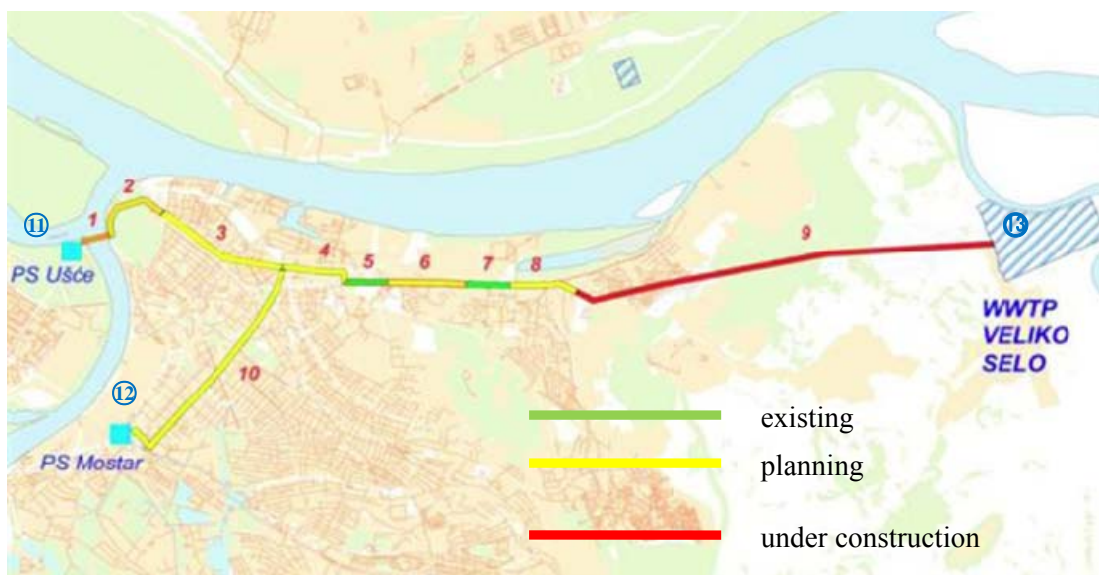


Fig.3-1. Construction Plan of trunk sewer

The existing sewerage facilities in Belgrade are as shown in table 3-1.

Table 3-1. The existing sewerage facilities in Belgrade

№	Section	Present situation
1	Syphon under the Sava River	planning
2	Usce-T.Koscuska	planning
3	T.Koscuska-V.Dobrnjca	planning
4	V.Dobrnjca-Pancevo bridge	planning
5	Tunnel karaburma	existing
6	Tunnel karaburma	planning
7	Vojvode Micka- "Minel"	existing
8	"Minel" - Rospi Cuprija	planning
9	Tunnel Visnjica	constructing
10	Hinta Pomoc-Venizelosova	planning
11	PS Usce(new)	planning
12	PS Mostar reconstruction	planning
13	WWTP Veliko Selo	planning

Photo3-1 shows site of WWTP Veliko Selo and photo3-2 to 3-4 show the construction of Interceptor.



Photo3-1.Site of WWTP Veliko Selo



Photo3-2. Boring machine for tunneling



Photo3-3. Concreting



Photo3-4. Assembling iron reinforcing bar for segments of Interceptor

3-2. Population

In the census since 2002, total number of inhabitants has been presented by the Municipalities . The table 3-2 shows number of inhabitants living in the area of the Central sewage system, of which number of inhabitants was estimated by Statical Office of the Republic of Serbia, especially for requirements of Central sewage system calculation for future analysis.

The population equivalents are given in table 3-3.

Table 3-2. Number of inhabitants

Basin	Area (ha)	Inhabitants		
		2015	2021	2031
Zemun and New Belgrade	5,457	361,229	370,394	379,654
Zeleznik Basin(makis)	6,636	107,973	106,855	109,526
Banovo Brdo	377	37,692	36,768	37,687
Topcider Basin	8,433	146,398	145,750	149,394
Senjak	173	9,823	9,872	10,119
Mokroluski Basin	3,234	218,875	222,232	227,788
Sava Basin	318	48,254	48,387	49,579
Danube Basin	428	51,146	51,506	52,794
Bulburder Basin	741	113,051	113,035	115,864
Karaburma	398	33,362	32,744	33,563
MirijevoBasin	1,019	62,570	37,736	6,429
Visnjica	774	11,303	11,586	11,876
Total	27,988	1,201,640	1,216,865	1,247,288

(Master Plan of Beograd)

Table 3-3. Number of population equivalent

	2015	2021	2031
Number of inhabitants connected to the sewer system including the number of employees in industry	789,265	1,216,865	1,247,288
Number of population equivalents for industrial waste water	231,520	396,660	406,577
Total	1,020,785	1,613,525	1,653,865

3-3. Planned hydraulic load of the WWTP Veliko Selo

LDA is designing WWTP Veliko Selo as follows.

(1) Hydraulic calculation

Hydraulic calculation for each basin was performed based on:

- Number of inhabitants (data from Statistical Office of Republic Serbia)
- Specific water consumption : inhabitants + industry (analysis)
- Volume of water that comes in to the sewage (reference data from BVK)
- Infiltrated water in to the sewage (reference data from BVK)
- Percentage of connected consumers on the sewage network (existing and future dynamic plans of construction by BVK)
- Dilution in rain period (criteria from BVK)
- Coefficient of irregularity (reference data and recommendation from BVK)

Calculation of hydraulic load on WWTP was done for dry and rain period. The study was performed based on the following assumptions:

- Specific consumption in 2021:
- inhabitants: 150 ℓ /cap/day
- employee: 50 ℓ /cap/day
- industry: 1.50 ℓ /ha/ of area under industry object (acc. to the Belgrade GUP area under industry object is 830.4 ha)
- $(1.5 \times 830.4 \times 86400)/121865=90$ ℓ /cap/day
- Consumed Water that comes to the sewage : 80%
- Infiltrated water : adopted 30%
- Specific waste water inflow : $(150+50+90) \times 0.80 \times 1.30=302$ ℓ /cap/day

(2) Summary of hydraulic calculation

Summary of wastewater flows to WWTP Veliko Selo is given in the table 3-4 and 3-5.

table 3-4. Maximum daily flow to WWTP Veliko Selo

Max. Daily Flow					
Year	2001	2011	2015	2021	2031
$Q_{\text{max day}}^{\text{dry}} \text{ m}^3/\text{d}$	376,113	398,378	427,522	463,409	474,995
$Q_{\text{max day}}^{\text{wet}} \text{ m}^3/\text{d}$	644,111	686,775	736,278	808,466	828,679

table 3-5. Average daily flow to WWTP Veliko Selo

Average Daily Flow					
Year	2001	2011	2015	2021	2031
$Q_{\text{ave day}}^{\text{dry}} \text{ m}^3/\text{d}$	289,317	306,442	328,863	356,468	365,381
$Q_{\text{ave day}}^{\text{wet}} \text{ m}^3/\text{d}$	495,470	528,289	566,368	621,897	637,445

3-4.Planned water quality

(1) Wastewater

The measurement of the raw waste water quality is monitored in eight outlets from pumping stations, of which results are shown on table 3-6.

table 3-6. water quality monitored at the pumping station

Item	Water quality(in average)
pH value	7.8
TSS(mg/ ℓ)	226.9
BOD(mg/ ℓ)	130.1
PO_4^{3-} (mg/ ℓ)	4.7
NO_2^- (mg/ ℓ)	0.11
NO_3^- (mg/ℓ)	3.8
Chloride ion(mg/ ℓ)	123.7

From the monitored results, quality requirement for WWTP Veliko Selo is determined as shown on table 3-7.

Table 3-7. Determined municipal wastewater quality

Constituent	Concentration(mg/l)
BOD ₅	264
COD	616
SS	297
T-N	52
T-P	9

(2) Effluent standard

Effluent standard will be governed by EU standards.

Table 3-8. Effluent standards for design for the WWTP Veliko Selo

Parameter	Value(mg/l)
BOD ₅	25
COD	125
SS	35
T-N	10
T-P	1

3-5. Treatment process

In order to fulfill the strict standard of EU, activated sludge process is so studied as to achieve removal of both organic and inorganic materials and nitrogen. The mechanism of activated sludge process which removes BOD and N is expected as follows.

(1) The activated sludge process for BOD removal

Activated sludge is suspension of microorganisms, both active and dead, in wastewater consisting of entrapped and suspended colloidal and dissolved organic and inorganic materials.

In the activated sludge process, wastewater enters into a reactor basin where microbial flocculation particles are brought into contact with the organic components of the wastewater.

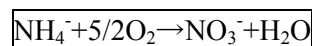
The organic matter serves as a carbon and energy source for microbial growth. Contents of the reactor basin are referred to as mixed liquor suspended solids (MLSS) or mixed liquor volatile suspended solids (MLVSS) and are components of the most part of microorganisms, inert and non – biodegradable suspended matter.

The activated sludge system is used to achieve carbonaceous BOD removal.

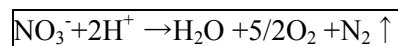
(2) The activated sludge process for nitrification and de-nitrification

The nitrification and de-nitrification steps can be carried out in a single tank with a sequential aeration. The reactions are as follows:

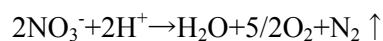
Nitrification



De-nitrification



The nitrate flow to be denitrified is ensured by the recirculation of mixed liquors. The dimensioning of the anaerobic zone is established on the basis of the quantity of nitrogen to denitrify and the speed of de-nitrification, respective of the consumption per hour of anoxia per gram of VMS contained in the biologic zone. The de-nitrification is given by the following equation:



The stoichiometry of the preceding equation enables us to recover 2.8mg of O₂ by reduction of 1 mg nitrogen nitric. To achieve nitrification process, following conditions should be met:

- sufficient oxygen supply
- minimum sludge age(SRT)
- sufficient carbon source should be available

To achieve high rates of de-nitrification, an anoxic zone at the aeration tank inlet with sludge recirculation from the sedimentation tank should be implemented. De-nitrification stage reduces nitrates to nitrogen gas. The purpose of de-nitrification is to remove nitrogen and recover the oxygen from the nitrates. Following conditions should be fulfilled for de-nitrification:

- proper nitrification first should be achieved
- anoxic conditions

For combined nitrification/de-nitrification process following conditions should be met:

- The sludge age shall be sufficient to allow the development of nitrifying bacteria
- The sufficient potential for de-nitrification
- The mass of nitrifying microorganisms shall be sufficient for amount of nitrogen to nitrify

From above investigation, LDA has determined basic design criteria for the activated sludge process with nitrification/de-nitrification

Table3-9. Design criteria of activated sludge process

Parameter	Unit	Standard value	Chosen value
MLSS	g/m ³	3000-4000	3000
oxygen requirement	kgO ₂ BOD	1.5-2.5	2.0
Design temperature	°C		12
Type of aeration			Fine bubble aeration
Side depth	m	4.5-7.5	5
Recycling ratio	%	20-100	100

(3) Phosphorus removal on rapid sand filters

In the raw wastewater 2/3 of the total phosphorus contents is in the form of phosphates and 1/3 in the form of orthophosphates. It was envisaged that alumina sulfate is used for the precipitation of phosphorus. Alum sulfate is foreseen for precipitation of phosphorus for this stage of project implementation. If economic reasons impose it, it is quite possible to use ferric chloride in next phase of project implementation. Alum – sulphate will be dosed before sand filters.

In addition to the phosphate elimination, the tertiary filtration permits to reduce the SS as well as the BOD₅ and the COD remaining in the treated water (Reduction of the BOD₅:45% to55%, considers: reduction of the SS:60% to74 %,considers: 65 %; Reduction of the COD : 0.55, SS,considers:30 %.

Table3-10. Design criteria of Rapid sand gravity filters

Parameter	Unit	Value
Filtration Velocity	m/h	12.0
Filtration area per unit	m ²	94
Effective size of the sand	mm	0.8
Bed height	m	1.0
For 95%phosphorus removal- Alum to Phosphorus ratio (Al/Phosphorus)		2.3-1

3-6. Plant staging

Due to the fact that main parts of sewerage system are under construction, for establishment of the plant staging , the following steps for development area are foreseen:

- Start Horizon June 2005.
- Construction of INTERCEPTOR from connection of Tonnel Hinta promoc – Venizelosova to the location of WWTP Veliko Selo:2005 – 2015
- Construction of Tonnel Hinta pomoc – Venizelosova
- Finally construction of WWTP “ Veliko Selo”:2015 -2021
- Reconstruction of PS “Usce”and siphon under Sava river: -2015
- Construction of new sewage network and reconstruction of the existing one:2005-2031

From the viewpoint of finance and dynamism of construction, there is an option for phasing whole construction:

Phase I – up to 2015

- WWTP construction
- Interceptor construction (from connection of Tonnel Hinta Pomoc to the location of WWTP)
- Tunnel Hinta Promoc – Venizelosova construction – 65% of inhabitants connected (all basins except Zemun and New Belgrade and Danube basin)
- Construction of siphon under Sava

Phase II – 2015 – 2121

- Final construction of Interceptor – 97% of basins are connected on WWTP.

According to the plan developed by LDA, they divide into the facility which will be undertaken by Serbian side, and covered by Japanese ODA , as shown on table3-11.

Table3-11.The Construction of Facilities classification

Scope	Facilities	Remarks
Undertaken by Serbian side	Collector:2,3,4,6,8 Interceptor:9	table3-1.
To be covered by Japanese ODA	Siphon:1 Collector:10 Reconstruction of PS:Usce, Mostar Construction of WWTP:Veliko Selo	- ditto -

Chapter 4 Environmental aspect of the project

4-1. National sustainable development strategy

Due to that the modern world is facing with common responsibility and the necessity of harmonizing its development with the needs of people and nature and with the awareness that the earth must be preserved for both present and the future generations, the Republic of Serbia has established “National sustainable development strategy” in 2008. The Belgrade Central Waste Water Collection and treatment Project is consistent with National Sustainable development strategy. In the water section, sustainable strategy is developed as follows:

Sustainable development requires optimal management, preservation and enhancement of water quality and rational use of water. The sectional policy objectives for sustainable use of water resources are:

- To harmonize national water legislation with the EU legislation, especially to implement the EU Water Framework Directive;
- To increase access to quality water by connecting the population to public water supply systems;
- To reduce losses in water supply systems;
- To improve water quality in reservoirs intended for water supply;
- To improve the quality of water in water courses, primarily by building new WWTP and more efficient operation of existing waste water treatment plants; and through controlled use of fertilizers and pesticides;
- Rehabilitation and clean up of polluter water courses;
- Introducing full-cost recovery prices for water and services through the “polluter/user pays” principle;
- Adequate institutional and territorial organization of the water sector;
- defining the legal status and property transformation of water management enterprises;
- Resolving the problems of municipal waste water through PPP for bigger towns and through public investments for smaller settlements;
- Introducing the regulatory function;
- Providing for public participation and participation of users in all stages of decision-making in the water sector.

The adoption of a new Law on Water and other laws and regulations to ensure harmonization

with the EU Water Framework Directive, as well as creating economic conditions for its implementation, are a priority. The introduction of a regulatory function to the water sector is the greatest need in the field of public water supply and sewerage services, and it should be provided through: setting standards and prices for provision of public services, measurements and control of company performance and fines, primarily the control of reducing network losses and through investing revenues generated through increased prices into the rehabilitation of infrastructure. A separate action plan needs to be developed for the construction of waste water treatment plants, after establishing an inventory (register) of polluters and after adopting regulations and standards for their consistent implementation.

4-2. Movement toward EU accession

The countries wishing to be the members of the EU are provided with the standards (Copenhagen Standards) that require the EU obligations and objectives to be accepted). Serbia wishing to join the EU is now confronting with the problem how to meet these Standards. The environmental policy is required to ensure creation of the laws and ordinances meeting the Acquis Communautaire (hereafter called "EU Acqui") as the overall system of the EU laws. In response to this requirement, the national resolution of the Republic of Serbia was passed in 2004 to ensure that the legal structure of Serbia would conform to the EU Acqui in future and the target fiscal year would be 2017.

The EU Acqui includes reference to the environmental law. More than 200 references are found in the legal framework (directive, provision, law, resolution, etc.) for the water pollution, water utilization, air pollution, waste management, chemical management and nature protection.

4-3. Items to be achieved by the host county (including the implementation agencies and related organization) for the implementation of the project

The study team suggests that the following items should be achieved by the host country.

(1) Notes of project

The republic of Serbia joined and became full membership of the International Commission for the Protection of the Danube River (ICPDR) in August 2003 and has participated in international cooperative challenge to protect the water quality of the international river, Danube. The project contributes to reduction of waste water pollutants from Belgrade to the Danube,

since the recipient water course of treated wastewater from WWTP Veliko Selo is the Danube.

(2) Sludge utilization program derived from WWTP

Usually, waste activated sludge and captured particulates on rapid sand bed are thickened and dewatered, then dumped to the dump site. However, waste activated sludge will be recycled and reused as soil improver. Therefore, scheme of sludge utilization should be investigated with organizations relating to agricultural land management.

(3) Implementation of environmental impact assessment

WWTP Veliko Selo contributes to reduction of the water pollutant and does not belong to the nature that would increase the environmental impact. Thus, the objective of EIA is different from that of the EIA for constructing an ordinary construction. Further, at an interview with the Ministry of Environment and Spatial Planning, it was confirmed by their comment that the Veliko Selo is the facility that is subject to assessment in accordance with the current environmental assessment law in Serbia. The EIA for this project should be conducted in apparel with the Feasibility Study. Since the construction of WWTP Veliko Selo is deemed to be national project, EIA approval by competent authority should be inevitable. EIA is to be conducted by LDA and is to be approved by Ministry of Environment and Spatial Planning.

(4) Others

Since the treated wastewater discharged is governed by standard of EU. Not only the effluent from Veliko Selo, but also the quality of Danube river is monitored according to the ICPDR program.

Chapter 5 Suggestions from the results of the survey

5-1. Feasibility study

From the results of the survey, we found that the sewerage development plan by LDA contains both new construction of collectors and use of the existing collectors, therefore, needs careful coordination of various works planned like patchworks. We suggest that the feasibility study (herein after F/S) including following items should be conducted as soon as possible.

1) Appropriate wastewater collection system

According to the sewerage development plan by LDA, they have a plan to transport wastewater from Zemun and New Belgrade under the Sava River by siphon. Conventional siphon has caused many troubles derived from precipitated sludge. To avoid these problems, two option should be studied in the F/S.

One is to separate Zemun and New Belgrade from Central sewage system. This option will avoid siphon construction and keep sewage gravitational flow. As shown on table3-2, around 360 thousand to 380 thousand inhabitants live in these areas, and occupy around 20% in area and around 30% in habitants of Belgrade. Therefore, if new site for WWTP is available, plan of separation may be feasible. However, it will need review of city developing plan and sewerage developing plan.

Another is to adopt improved model of siphon, for example, controls diameter of siphon by air compression to avoid sludge precipitation by controlling sewer flow rate. If this type of siphon is adapted to this Project, the design and technical specifications shall be carefully reviewed, taking the past references of troubles into consideration.

Since sewerage system is basically gravitational, the technical analysis will be required how to keep the gravitational flow, by separation of Zemun and New Belgrade or adoption of improved type of siphon. The system to be adapted to this project should be determined depending on the results of F/S.

2) Approval of validity of sewage flow by drawing the longitudinal section of Collector and Interceptor to WWTP Veliko Selo

At the particular part, the longitudinal section of collector has been drawn. But, some of them drawn in the past are too old, does not cover the part from PS Usce or Mostar to WWTP Veliko Selo and contains the existing collectors. To approve validity of the sewerage development plan from the viewpoint of sewage flow, drawing of complete longitudinal section is necessary.

3) Management of advanced treatment

WWTP Veliko Selo is planned to implement advanced treatment process to remove N and P as well as BOD₅. BOD₅ removal and Nitrogen removal is performed by activated sludge process. However, the performance of the process depends on SRT and DO management.

4) Sludge reuse

Waste sludge could be applied to farmland. Waste sludge from Phosphorus removal contains aluminum used as coagulant. However, sludge which contain aluminum inert phosphate in the soil. So, if the sludge is applied to farmland, ferric chloride is appropriate.

5-2. Technical assistance of Japanese technology on operation and maintenance of Advanced Treatment of Waste Water

Due to the limiting conditions of water resources in Japan, Japan has developed advanced wastewater treatment technology, especially improvement of operation and maintenance technology at the existing wastewater treatment plants. And Japan developed comprehensive fix nitrifying bacteria technology as palette for management of activated sludge to accelerate nitrification. Therefore, Japanese technology for advanced wastewater treatment is competitive in international market. Japanese engineers are able to support BVK and other related organizations in charge of operation and maintenance of wastewater treatment plant with advanced treatment process, since this project is the first introduction of such technology to Serbia.

5-3. Recommendation of utilization of ODA Loan

“The main policy of official development assistance (ODA) for the fiscal year 2009” issued by International Cooperation Bureau of Ministry of Foreign Affairs (MOFA) of Japanese government in April 2009 stated that one of the most targeting area of ODA for west Balkan countries is water supply and sewage among various infrastructure constructions. The policy

also indicated that ODA loan and technology assistance shall be preferably utilized for those countries, in view of relatively higher national income of those countries.

This project is recognized as one of the most significant environmental projects by Serbia who is targeting to join EU, and is in conformity with Japanese government’s ODA policy. Serbia is categorized as upper middle income European country by DAC List (GNI per capita \$3,706~ in 2007) of OECD. It would be highly recommendable if Serbia could overcome this environmental issue using Japanese ODA loan of favorable conditions and it would become very important step for Serbia to join EU.

It is recommended that the various activities currently conducted by various organizations in Serbia should be well coordinated and be consolidated to a complete project. Also recommended is the classification of each part of the project to the scope to be covered by Japanese ODA and the scope which Serbian side will undertake by their own fund as shown in table 5-1 and fig.5-1.

Table 5-1. The scope of the project to be covered by Japanese ODA and Serbian side

Scope	Facilities	Remarks
Undertaken by Serbian side	Collector:2,3,4,6,8 Interceptor:9	table3-1.
To be covered by Japanese ODA	Siphon:1 Collector:10 Reconstruction of PS:Usce, Mostar Construction of WWTP:Veliko Selo	- ditto -
Total of Japanese ODA	152.1 million Euro	

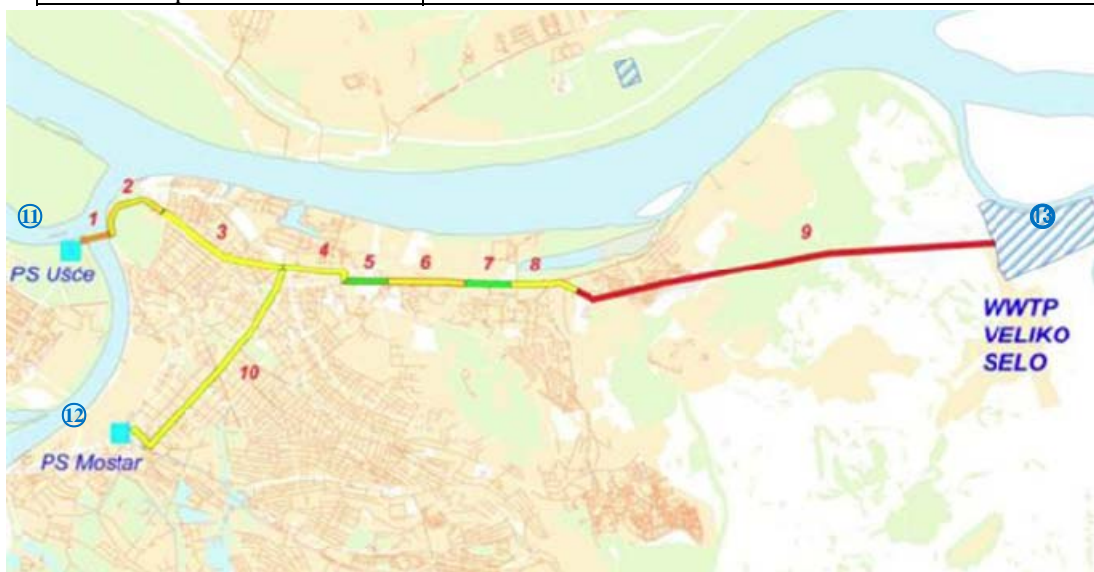


Fig.5-1. Construction Plan of trunk sewer

For further evaluation of the project as candidate of Japanese ODA loan, it is inevitable that the feasibility study should be conducted for in-depth analysis of the project. At Serbian side, the monitoring of progress of environmental impact assessment for approval of building permit as well as resolution of land acquisition issue of the planned project site will be required. For execution of loan agreement, Serbian parliament's ratification will be required for sovereign guaranty and approval of city assembly will be also required for City's execution of loan agreement. Since the annual budget of Belgrade city should incorporate the expenses that Serbian side should bear for the project, which is subject to city assembly's approval. Sovereign guarantee for that portion will be also required, in order to secure the project completion.



Photo5-1. Meeting with LDA



Photo5-2. Meeting with BVK

