JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF PUBLIC WORKS AND TERRITORIAL PLANNING
ROMANIA

THE FEASIBILITY STUDY

ON WASTEWATER TREATMENT
ALONG THE DANUBE RIVER DOWNSTREAM REACH
IN ROMANIA

FINAL REPORT

MAIN REPORT

January 2000

PACIFIC CONSULTANTS INTERNATIONAL
In association with
NIHONSUIDO CONSULTANTS CO.,LTD.

Foreign Currency Exchange Rates Applied in the Study

Currency	Exchange Rate/US$
Romanian Lei (ROL)	15,756
Japanese Yen (¥)	122.00
Euro	0.95266
German Mark (DM)	1.8838

(Average rate of June 1999)

Note: Following numerical notations are adopted in the Report:
Decimal marker : "." (Period)
Digit separator : "," (Comma)

PREFACE

In response to a request from the Government of Romania, the Government of Japan decided to conduct the Feasibility Study on Wastewater Treatment along the Danube River Downstream Reach in Romania and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Akira Takechi of Pacific Consultants International (PCI) and composed of staff members of PCI and Nihon Suido Consultants Co., Ltd. to Romania, three times between January 1999 and January 2000. In addition, JICA set up an advisory committee headed by Mr. Osamu Fujiki, Osaka Prefectural Government, between January 1999 and January 2000, which examined the Study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Romania, and conducted field surveys in the study area. Upon returning to Japan, the team conducted futher studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Romania for their close cooperation extended to the team.

January, 2000

Kimio Fujita
President
Japan International Cooperation
Agency

THE FEASIBILITY STUDY ON WASTEWATER TREATMENT ALONG THE DANUBE RIVER DOWNSTREAM REACH IN ROMANIA

January, 2000

Mr. Kimio Fujita

President

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The Feasibility Study on Wastewater Treatment along the Danube River Downstream Reach in Romania". This report has been prepared by the Study Team in accordance with the contracts signed on 18 January 1999 and 13 May 1999 between the Japan International Cooperation Agency and the Joint Study Team of Pacific Consultants International and Nihon Suido Consultants Co., Ltd.

The report examines the existing conditions of the seven cities in the study area, presents the results of feasibility studies on wastewater treatment plants in Tulcea, Galati, and Braila, and presents the results of basic studies on wastewater treatment plants in Calarasi, Giurgiu, Turnu Magurele, and Drobeta Turnu Severin.

The report consists of the Summary, Main Report, and Supporting Report. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, results of the feasibility studies, results of basic studies for the four cities, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Romania, and also to Romanian officials and individuals for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the implementation of wastewater treatment plants along the Danube River downstream reach, and that friendly relations of both countries will be promoted further by this occasion.

Yours faithfully,

Akira Takechi

Team Leader

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ABBREVIATIONS

Organizations

EBRD	European Bank for Reconstruction and Development
ISPA	Instrument for Structural Policies for Pre-accession
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
MOF	Ministry of Finance
MPWTP	Ministry of Public Works and Territorial Planning
MWFEP	Ministry of Water, Forestry and Environmental Protection
DLPA	Department of Local Public Administration

General

LIBOR	London Inter-bank Offered Rate
WTP	Willingness to Pay
ROL	Romanian Lei

Technical Terms

WWTP	Wastewater treatment plant
EIA	Environmental Impact Assessment
TDH	Total dynamic head
BOD_5	Biochemical oxygen demands, 5-day, 20℃
COD	Chemical oxygen demands
Cl^-	Chlorine ion
DO	Dissolved oxygen
F/M	Food-to-microorganism ratio
MPN	Most probable number
MLSS	Mixed liquor suspended solids
pH	The reciprocal of the logarithm of the hydrogen-ion concentration
SRT	Sludge retention time
SS	Suspended solids
T-N	Total nitrogen
T-P	Total phosphorous
TSS	Total suspended solids
VSS	Volatile suspended solids
As	Arsenic
Cr^{6+}	Chromium, hexavalent

Units

mm	millimeter
cm	centimeter
m	meter
km	kilometer
mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
km^2	square kilometer
ha	hectare
ml	milliliter
l	liter
m^3	cubic meter
mg	milligram
g	gram
kg	kilogram
t	ton (1,000 kg)
W	watt
kW	kilowatt
m^3/d	cubic meter per day
m^3/h	cubic meter per hour
m^3/m	cubic meter per minute
m^3/s	cubic meter per second
l/d	liter per day
l/s	liter per second
mg/l	milligram per liter
lcd	liter per capita per day
$m^3/m^2/d$	cubic meter per square meter per day

PART I: GENERAL

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The countries of the Danube River basin and interested international institutes met in Sofia in September 1991 to draw up an initiative to support and reinforce national actions for the restoration and protection of the Danube River – the Environmental Program for the Danube River Basin – known as the Danube Environmental Program. The countries set up a task force and a program coordination unit, and the Strategic Action Plan for the Danube River Basin was drafted by the task force in 1991 as an essential early step towards addressing the Danube Basin's environmental problems. The Strategic Plan identified a development of wastewater treatment as one of priority actions to be taken to achieve the target.

In line with the Plan, seven (7) cities, namely Tulcea, Galati, Braila, Calarasi, Giurgiu, Turnu Magurele and Drobeta Turnu Severin, located along the Danube River were selected as higher priority cities in the nationwide development of wastewater treatment. While wastewater collection systems are considerably developed in the selected cities, none of them have proper treatment facilities. They are discharging wastewater to the Danube River without proper treatment. Situations have been well recognized, thus most of the cities have prepared a plan for the construction of wastewater treatment facility.

In the mean time, Romania, which intends to join EU in the nearest future, undertakes various institutional adjustments to meet the EU Directives that describe common standards among EU member countries. The development of wastewater treatment is required by one of the EU Environmental Directives and, thus has a high priority in the government policy.

Both the state and municipal governments have been keen to realize the plans, however, they have not succeeded it because of lack of financial sources in the both governments. Under the present situation, the realization is considered to be possible only by utilizing financial instruments of foreign financial agencies judging from budget constraints of the both governments.

Foreign financial agencies strictly require a feasibility of the project implementation in many aspects, such as technical, financial, economic, social, and environmental aspects, at least. However, the existing plans are not provided with enough information to confirm the feasibility in these aspects.

On these backgrounds, this study entitled "the Feasibility Study on Wastewater Treatment along the Danube River Downstream Reach in Romania" (hereinafter "the Study") was conducted to provide feasibility studies, which can confirm the feasibility in those aspects, and the methodology to enable the cities to access the international financial instruments.

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are;

i) to conduct a basic study on wastewater treatment in the selected seven (7) cities,

ii) to conduct a feasibility study for wastewater treatment of the targeted three (3) cities, Tulcea, Galati and Braila, among the selected seven (7) cities, and

iii) to carry out technology transfer to the Romanian counterpart personnel in the course of the Study.

1.3 STUDY AREA

The study area covers seven (7) cities along the Danube River, namely Tulcea, Galati, Braila, Calarasi, Giurgiu, Turnu Magurele, and Drobeta Turnu Severin, as shown in *Figure I.1.1*. Basic studies were conducted at the seven cities, while feasibility studies were conducted at three targeted cities, namely Galati, Braila, and Tulcea.

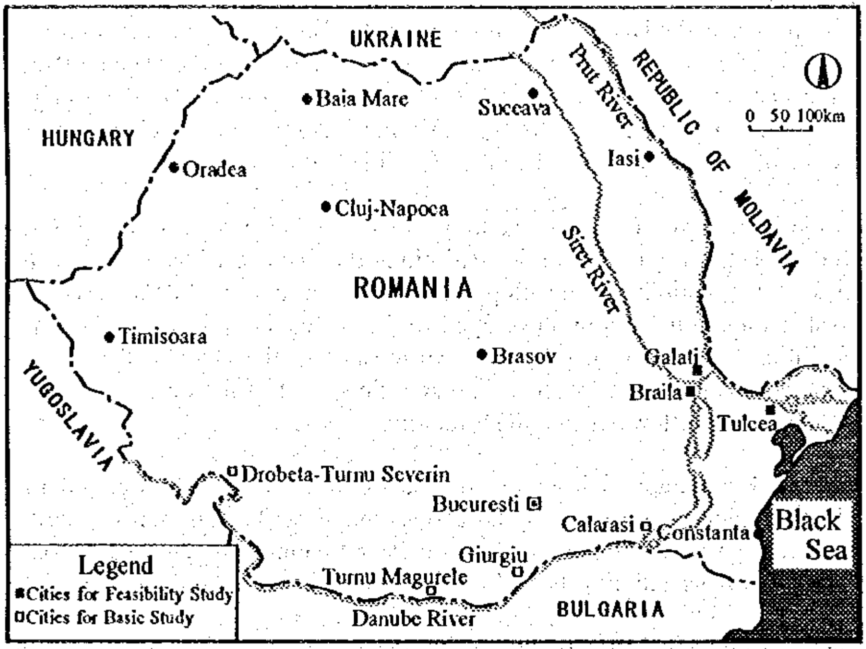


Figure I.1.1 Study Area

1.4 STUDY ORGANIZATION

The whole organizational scheme is shown in *Figure I.1.2*. JICA set up a study team (the JICA Study Team) to conduct the Study and organized an advisory committee to examine the Study. Ministry of Public Works and Territorial Planning (MPWTP), the Romanian executing agency of the Study, organized a steering committee consisting of relevant ministries and the seven cities, and chaired the committee. The relevant ministries include the Ministry of Finance (MOF), the Ministry of Water, Forest and Environment Protection (MWFEP), and the Department of Local Public Administration of the government (DLPA), at least. The Steering Committee organized a counterpart team to work with the JICA Study Team. Members of each organization are as shown in *Table I.1.1*.

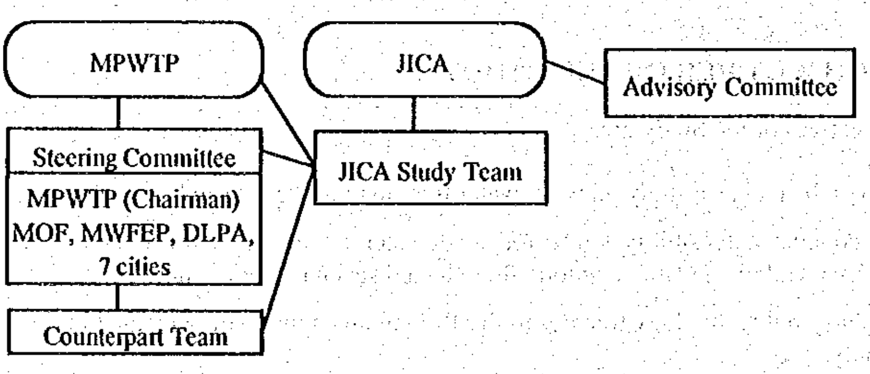


Figure I.1.2 Study Organization

Table I.1.1 Members of Study Organizations

JICA Study Team		
Team Leader	:	Mr. Akira TAKECHI
Sewerage Planning	:	Dr. Harutoshi UCHIDA
Sewerage Facility Planning (1)	:	Mr. Shohei SATA
Sewerage Facility Planning (2)	:	Mr. Toru KIMURA
Sewerage Facility Planning (3)	:	Mr. Yuichi HASHIMOTO
Construction Planning/Cost Estimation	:	Mr. Ryo MATSUMARU
Mechanical/Electrical Planning	:	Mr. Yasuo MOTO
Economical/Financial Analysis	:	Mr. Naomichi ISHIBASHI
Management/Institution/O&M	:	Mr. Satoshi KOJIMA
Natural Environment	:	Mr. Tatsuo MOROTOU
		Dr. Jun LIU
Study Administration	:	Mr. Kyoichi SUGIMOTO
JICA Advisory Committee		
Chairman of the Committee	:	Mr. Osamu FUJIKI
Committee Member	:	Mr. Satoshi FURUYAMA
Romanian Steering Committee		
Chairman of the Committee	:	Mr. Laszlo Borbely (MPWTP)
Committee Member	:	Ms. Jeni IONITA (MPWTP)
Committee Member	:	Mr. Liliana MARA (MWFEP)
Committee Member	:	Mr. Marin COJOC (MOF)
Committee Member	:	Mr. Aurelian NEBEL (DLPA)
Committee Member	:	Mr. Pamfil TAPAI / Vice Mayor (City of Turnu Magurele)
Committee Member	:	Mr. Octavian BEZNEA / Vice Mayor (City of Calarasi)
Committee Member	:	Mr. Marin AXENTE / Vice Mayor (City of Galati)
Committee Member	:	Mr. Constantin MOCANU/ Vice Mayor (City of Tulcea)
Committee Member	:	Mr. Anton LUNGU / Mayor (City of Braila)
Committee Member	:	Mr. Constantin CRETESCU / Vice Mayor (City of Drobeta Turnu Severin)
Committee Member	:	Mr. Gabriel MARCOCI / Vice Mayor (City of Giurgiu)
Counterpart Team		
Ms. Georgeta VASILACHE		Special Inspector, MPWTP
Mr. Constantin GHEORGHE		Expert, MWFEP
Ms. Otilia FROLU		Expert, MOF
Mr. Ion TITEL		Director, R.A. SAGO (City of Turnu Magurele)
Mr. Marcel NUTU		Director, S.C. APA CANAL S.A. (City of Calarasi)
Mr. Podaru NITA		Dirctor, S.C. APATERM S.A. (City of Galati)
Mr. Dumitru DUDUCA		Director, S.C. ACET S.A. (City of Tulcea)
Mr. Romeo FINDRIHAN		General Director, R.A. APTERCOL (City of Braila)
Mr. Octavian BOSOANCA		Genral Director, S.C. SECOM S.A. (City of Drobeta Turnu Severin)
Mr. Constantin IONESCU		General Director, S.C. AQUA TERM S.A. (City of Giurgiu)

1.5 SCHEDULE OF THE STUDY

The study was commenced in January 1999 and completed in January 2000 with submission of the Final Report. Overall time schedule of the Study is presented in the figure below.

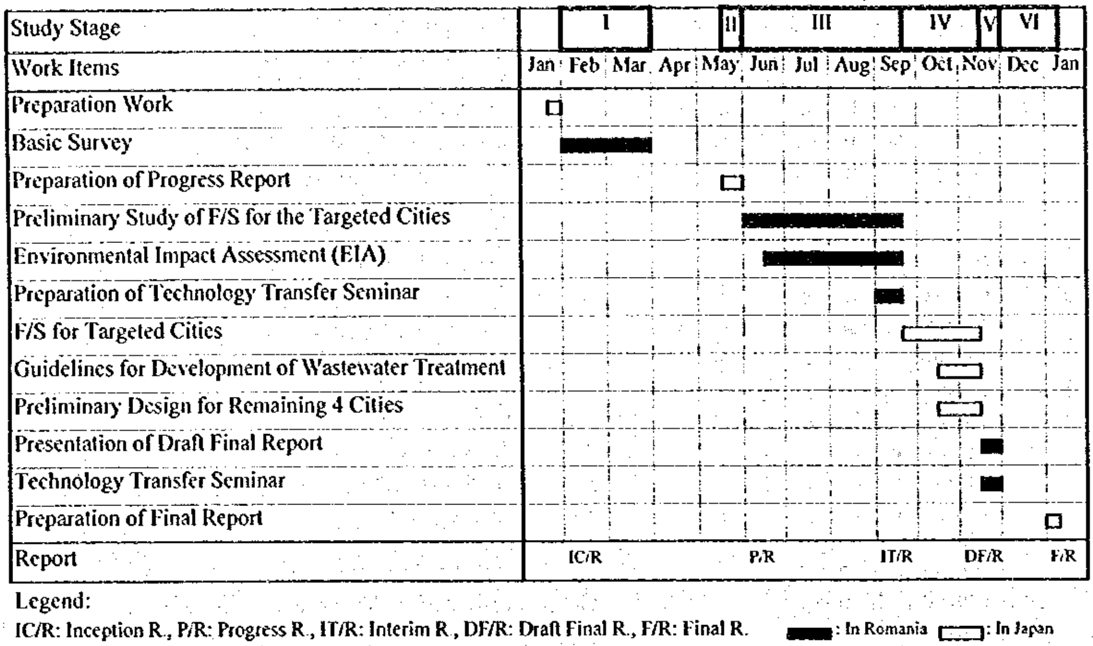


Figure I.1.3 Time Schedule of the Study

1.6 CONTENTS OF THE REPORT

This report was prepared as a final report, presenting whole results of the Study. Final Report comprises of following reports:

- Summary
- Main Report
- Supporting Report

Main Report and Supporting Report are composed of two (2) parts. The first part (Part I) describes matters common for all the seven (7) cities in the study area, and the second part (Part II) describes matters specific for each city. Four (4) kinds of Part II, *i.e.* for F/S of Tulcea WWTP, for F/S of Galati WWTP, for F/S of Braila WWTP, and for basic studies for four (4) cities, were prepared.

Main Report and Supporting Report have five (5) versions by cities, including a version contains all of the four kinds of Part II. Their contents by versions are as follows.

Table I.1.2 Contents of Main and Supporting Reports by Versions

Version	Contents
Combined	Part I, Part II for Tulcea, Part II for Galati, Part II for Braila, Part II for Four Cities
Feasibility Study for Tulcea WWTP	Part I, Part II for Tulcea
Feasibility Study for Galati WWTP	Part I, Part II for Galati
Feasibility Study for Braila WWTP	Part I, Part II for Braila
Basic Study for Four Cities	Part I, Part II for Four Cities

CHAPTER 2 INSTITUTIONAL CONSIDERATION

2.1 GENERAL

The development of wastewater treatment has been a field having a higher priority in Romanian government's policies, which is one of the EU applicable countries, as well as the wastewater treatment in the study area has high priority from a view point of the restoration and protection of the Danube River. These situations are well recognized, thus most of the cities in the study area ever have a plan to construct a wastewater treatment plant (WWTP). A major reason that none of those plans have been realized is considered to be a financial burden for the cities, which is responsible for the arrangement of an investment cost for the construction, and a budget constraint of the state government, which was responsible to subsidize local public works. A financial viewpoint, therefore, could be one of key factors that strongly affect the realization of proposed projects in the Study.

On the other hand, there were considerable changes in the institutional framework around the wastewater management recently. They are related to a privatization of wastewater management undertakers, abolition of state subsidy to local public works, local government's initiatives in the investment to local public works and utilization of external and subsidiary loans.

Therefore, institutional strategies to realize the projects shall be fully compatible to the new institutional framework.

2.2 ADMINISTRATION OF PUBLIC WORKS

2.2.1 Competence of Local Administrative Authorities

Romanian administrative structure consists of three levels, namely, state level, county level, and local level. Administrative authority of county and local levels is summarized below.

	Deliberative authority	Executive authority
County level	County council	President of county council
Local level	Local council	Mayor

Local public services are duties of the local administrative authority. The services include at least following services.

- Water supply
- Wastewater management
- Solid waste management
- District heating
- Local public transport

In the study area, relevant city councils and mayors are responsible for wastewater treatment.

2.2.2 Approval of Local Public Investments

An execution of a local public investment financed by the local budget and loans needs a registration of the investment in an investment plan of the local government and the local council's approval on the investment plan as an annex to the local budget. For the registration in an investment plan, an approval on the feasibility study of the investment according to the law is requisite.

Requirements for the content of feasibility study are described in the technical norm No.784/34N. It should be noted that the technical norm requires all the necessary permissions and agreements with relevant authorities to be obtained during the feasibility study stage. These permissions and agreements include environment agreement and permit as well as permissions for gas, electricity, and telecommunication supply and so on. It might be a reflection of Romanian tradition to contract a feasibility study and a detailed design as one package. In Japan as well as in most EU countries, necessary permissions for construction are obtained based on detailed design.

Approval process on the feasibility study varies depending on financial sources and amount of the investment. If the financial source of an investment is exclusively covered by a local budget or any loans contracted directly by a local administrative authority, the feasibility study of the investment can be approved by the local council. Otherwise, along with ex-ante agreement of the Ministry of Finance, the feasibility study should be approved by an authority as follows.

Table I.2.1 Approval Authority of Feasibility Study

Approval authority	Executive body of investment			
	County*	City	Town	Commune
Mayor (President of county council*)	< 2	< 2	< 2	< 2
Council	2 ~ 80	2 ~ 45	2 ~ 35	2 ~ 25
The state government	> 80	> 45	> 35	> 25

(As of 1 January 1999, Unit: Billion Lei)
Note) Criteria of investment amount may be revised every three (3) months considering an inflation.

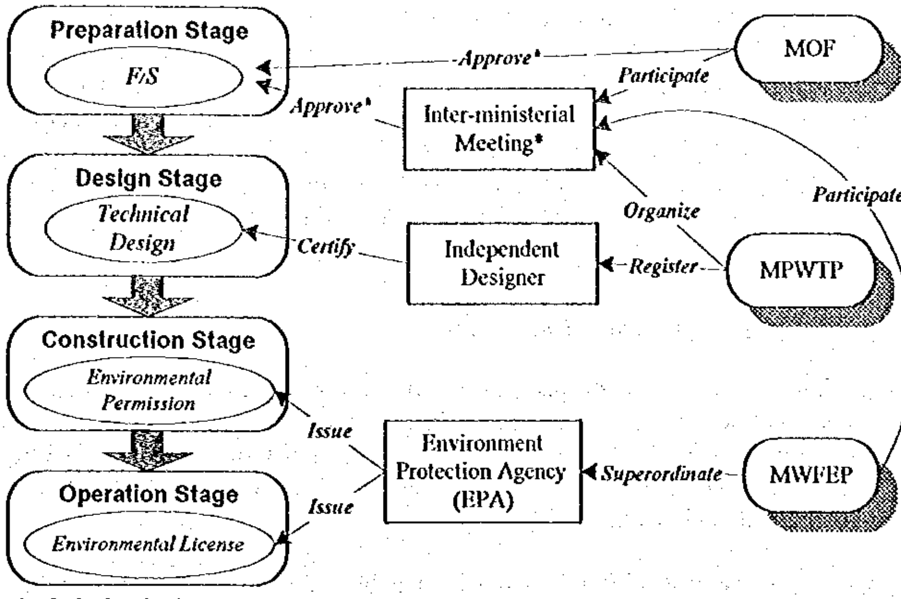
2.2.3 COMPETENCE OF THE STATE ON LOCAL PUBLIC WORKS

In addition to approval process for large scale investment, the state government controls local public investment by means of quality assurance and permission procedures.

For the quality assurance of construction works, all designs and drawings should be checked, singed, and sealed by the independent inspector registered by MPWTP.

Environmental Protection Agency (EPA), a subordinate organ of MWFEP, is designated as the issuer of an environment permission and an environment license. The environment permission is requisite for construction works. Similarly, environment license is requisite for operation of the constructed facilities. The environmental protection law No.137/95 describes environmental permitting procedure. The law obligates an environment impact assessment to obtain environment permissions or licenses for the projects listed in the Appendix No. II of the law. Projects related to wastewater treatment installations are listed there.

These public works administration procedures are illustrated in *Figure I.2.1*.



*) Only for the large scale investment

Figure I.2.1 Schematic Flow of Public Works Administration Procedure

2.3 PRIVATIZATION OF PUBLIC SERVICE SECTOR

2.3.1 HISTORY OF PRIVATIZATION

Privatization of public service sector started soon after political change of 1989. The first step was an enactment of the law No. 15/90 concerning reorganization of state economic units to Regia Autonomas (financially independent public corporation) or commercial companies. The law allows public service sectors to transform either a Regia Autonoma or a commercial company. Majority chose a Regia Autonoma, however, there were some cases to be commercial companies. Among seven (7) cities in the study area, only Drobeta Turnu Severin chose a commercial company.

Second step of the privatization process was issuance of a series of governmental urgent ordinances related to commercialization and privatization of Regia Autonomas in 1998. Here the commercialization means transformation of Regia Autonomas into commercialized companies of which shares are owned by relevant local councils, and the privatization means transferring the shares to the State Ownership Fund (SOF) followed by selling the shares to private sector by SOF. Currently, except the case of Drobeta Turnu Severin, each local council in the study area has not transferred the shares of public service companies to SOF. Privatization process applied in Romania can be illustrated as shown below.

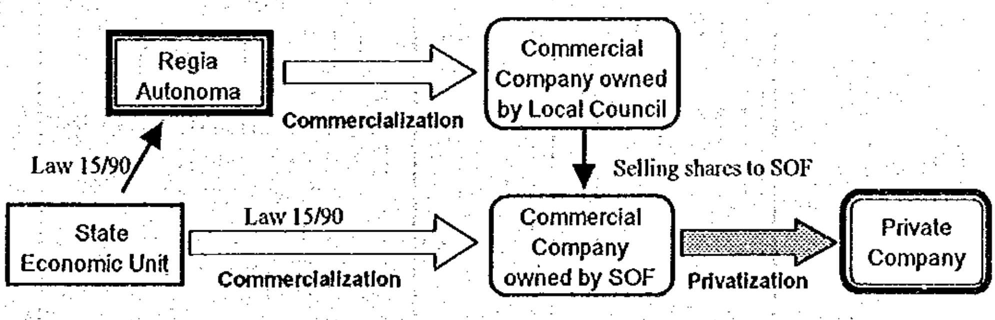


Figure I.2.2 Privatization Process in Romania

Privatization of public services may result in higher efficiency of the service and lighter financial burden on local administrative authorities. However, progress of privatization of public services is far behind against the Romanian government's expectation. One of the main reasons is uncertain stipulation concerning ownership of relevant assets. Most public service companies recognize that they will render their services based on concession contract with relevant local council, however, they have no chance to conclude an actual contract without clear definition of their asset. To solve this problem, the public patrimony law and the concession law were recently enacted in 1998.

2.3.2 OWNERSHIP OF SEWERAGE FACILITIES

The public patrimony law No.213/98 specifies two types of public assets, i.e. inalienable public assets and private public assets. Inalienable public assets can not be transferred or sold but private public assets can be. The law is annexed with a list of inalienable public assets. According to the list, sewer networks and wastewater treatment plants with related installations and lands are inalienable public assets.

However, there remains a possibility to transfer inalienable public assets to private public assets. The article 10 of the public patrimony law describes how this transfer can be achieved. It is stipulated that the transfer from the public domain to private domain can be done through a governmental decision or a decision of local administrative authorities, unless the decision breaches the Constitution.

2.3.3 PROSPECT OF PRIVATIZATION IN ROMANIA

The most likely prospect of the privatization process within the present legislative framework is as follows:

- Construction, extension, or large-scale rehabilitation of sewerage facilities will be exclusively done by local councils.
- Operation companies will render operation and maintenance service based on a concession contract, which is based on the lease of facilities from the local council.

This scenario may not be preferable from the viewpoint of privatization, on the other hand, it may be advantageous to apply financial assistance of international financial sources.

2.4 PROPOSED OPERATIONAL STRUCTURE OF SEWERAGE SERVICE

Based on the most likely prospect of the privatization process, the following operational structure of the sewerage service is proposed for a financial analysis of the Study.

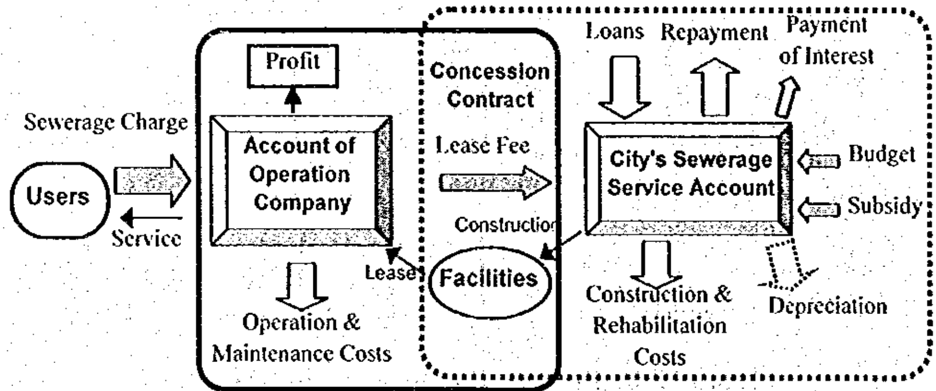


Figure I.2.3 Operational Structure of the Sewerage Service

In the proposed structure, an operation company, which will be established on the present commercial company or Regia Automona by selling shares to the State Ownership Fund and finally to private sectors, renders operation and maintenance of the sewerage service based on a concession contract with a city council, and collects sewerage charges from users. In general, concession contracts may cover transfer or lease of various rights, such as rights of trade, ownership, operation, and management. Since details of the concession contract to be applied in each city have not became clear, it is set out that the concession contract in the proposed structure covers only the lease of facilities necessary for the services, and that the lease fees are paid from the operation company to the city council.

2.4.1 Account of the Operation Company

For the privatization purpose, the operation company needs certain level of profits so as to attract private investors. Under the structure shown in *Figure I.2.3*, the profits of the operation company would be represented as follows.

Profits = Collected Sewerage Charge – (O & M costs + Lease fee + Corporate Tax)

The O & M costs are determined by actual works. The lease fee could be determined in the concession contract usually so as to cover all the costs required to obtain lease objects. The tax could be fixed at a certain rate of the profits. The required sewerage charge will be set so as to ensure required level of the profits.

In the sewerage charge fixed by this manner, users bear all the costs required for the sewerage services, including capital costs. While this meets a beneficiary-payment principle, this may cause a heavy financial burden to the users. In addition, the beneficiary of the sewerage service may be not only users of the sewerage services but also other people who enjoy effects of the water quality improvement by the sewerage development. Furthermore, if the sewerage development has a political aim to fulfil the EU directives as an EU applicable country, it would be justified that the public sectors, such as the state and the municipalities, bear some of the costs. Therefore, a case to introduce subsidy, which reduces the amount of the lease fee, will be considered in the financial analysis.

2.4.2 Account of the City Council

The city council is responsible for the construction of the sewerage facilities including procurement of the capital costs and depreciation of relevant assets. The capital costs will be procured through its own budget, loans, and subsidies from the state or other authorities. Sources of repayment and payment of interests of the loans would be its own budget, the lease fee, and the subsidies.

2.5 FINANCIAL SOURCES FOR LOCAL PUBLIC WORKS

2.5.1 Local Budgets

In old regime, local public authorities obtained their budget via the state government. The more projects they applied, the more budget the state distributed. One of the serious problems was that distributed budgets from the state were earmarked for each of all applied projects, which resulted in severe deficit to required project costs. Furthermore, there was quite large time lag between application and distribution of the state subsidies to the local budget.

The local public finance law No. 189/98, coming into force on 1st of January 1999, transferred the competence of income tax collection from the state to the local administrative authorities. The income tax collected by a local administrative authority distributed among the state budget, the budget of county in which the local administrative authority locates, and the local budget.

The proportion of this distribution can be modified annually by the state budget law. Currently it is 50%, 15%, and 35% to the state, county, and local, respectively. At the same time subsidies from the state budget have been drastically diminished. Hearing with seven cities in the study area showed that almost no state subsidies are allocated to the local budget in 1999.

Under the new regime, for most local administrative authorities the local portion of income tax is major current revenue. The law provides local governments with competence to make their investment plans based on estimated revenue. In other words, the local governments can intensively invest their budget to certain important project as they wish. It makes implementation of their investments more effective and realistic.

2.5.2 Utilization of External Loans

(1) External Loans Contracted by Local Administrative Authorities

The local public finance law provides the local administrative authorities with a competence to contract internal or external loans, under following provisions:

- Total of the annual installments, which consist of repayment, interests, and commissions incurred by the loans, is less than 20 % of the total current revenue of the local budgets.
- The installments incurred by the loans shall be reimbursed by the local budgets.

Furthermore, an approval of the Commission for the authorization of loans is prerequisite to external loans contracted by the local administrative authorities. The law stipulates that the Commission shall be made up of representatives of following authorities:

- The local administrative authority
- The state government
- The National Bank of Romania

(2) External Loans Guaranteed by the State

Concerning the state guarantee for external loans, the public finance law merely says that the state government may offer guarantees to external loans contracted by local administrative authorities, under the provisions of the public debt law.

The public debt law No. 81/99, coming into force on 10th of May 1999, deals with the matters related to external loans and the state guarantees. The law allows local administrative authorities to apply state external loans for financing the investment in the field of infrastructure development and social services. Under same criteria, the state guarantees can be issued for external loans to finance selected investment projects. For issuing the state guarantees, not only the inter-ministerial committee but also the Export-Import Bank of Romania participates in the appraisal procedure.

In the past, the Ministry of Finance obliged to pay not a few bad debts of local governments and now is careful for examining the repayment capability of applicant local governments. This repayment capability can be proved by the cash-flow statement which shows the total annual installments will never exceed 20% of the current revenue, according to the Ministry of Finance.

The state government establishes a maximum external debt level every year. Romanian government concluded a loan agreement with IMF (International Monetary Fund) in August 1999. The conditionality imposed by IMF contains restriction of external loans. It will probably depress the maximum external debt levels for a couple of years, however, a drop of the level will not be so significant.

2.5.3 SPECIAL FEES FOR LOCAL PUBLIC SERVICES

The local public finance low allows local councils to charge special fees for their public services. The tariff of these special fees shall be calculated to cover, at least, the invested funds and the operation and maintenance cost of the services.

The special fees should be collected exclusively from the beneficiary of the service. The special fees are determined, collected, and distributed only by own bodies of the local councils.

2.6 EXTERNAL FINANCIAL SOURCES

Financial arrangement for the WWTP construction will rely on external financial sources. Financial analysis in this study would adopt options to utilize several possible external financial sources.

Considering facts that Romania is an EU applicant country, and that this study is being implemented under the technical cooperation by the government of Japan, , EBRD (European Bank for Reconstruction and Development) loan, ISPA (Instrument for Structural Policies for Pre-accession) grant scheme, and JBIC (Japan Bank for International Cooperation) loan would be adopted as the options for the external financing sources.

2.6.1 EBRD LOAN

EBRD is to help mobilize domestic and foreign direct investment, to support private sector development by;

- providing loans and equity to create/modernize/expand private companies,
- strengthening financial institutions, and
- developing the public infrastructure needed to support the private sector.

Public sector can be covered by EBRD financing through its second and third activities. For financing public sectors, EBRD requires a sovereign guaranty, otherwise applies private sector lending terms. Lending terms differ between the public sector loan and the private sector loan. Typical terms are as follows.

Table I.2.2 Typical Lending Terms of EBRD

Sector	Interest Rate	Payment Period	Grace Period	Remarks
Public	LIBOR+1%	15	2~3	Sovereign guaranty
Private	LIBOR+2~6%	5~7	1~1.5	Negotiable

Note: LIBOR = London Inter-bank Offered Rate

There are 47 EBRD projects in Romania as of the end of 1998. Among them, 14 projects are of the public sector and 33 projects are of the private sector. A total portfolio counts USD 1,561 million with 51% of the public and 49% of the private. EBRD has guidelines for the distribution of portfolio between the public and private sectors, *i.e.* 40% and 60% respectively. Therefore, there is less possibility to finance further public sector projects in Romania.

Meanwhile, EBRD welcomes the implementation of Local Public Finance Law 189/98 from a viewpoint of the promotion of decentralization. To support local public projects, EBRD likely introduces a new scheme to finance those projects directly. The scheme is expected to provide a new finance source to local administrative authorities responsible for the implementation of local projects such as the construction of wastewater treatment plants. However, since the new scheme may apply the terms for the private sector, it would be not easy for the local administrative authorities to utilize the new scheme.

2.6.2 ISPA

ISPA is a new pre-accession aid of the European Union (EU) established by the Council Regulation (EC) No.1267/1999 (hereinafter the ISPA Regulation) in June 1999.

Pre-accession aids are EU's aid tools for 10 EU applicant countries, *i.e.* Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. Originally PHARE was established as the sole pre-accession aid in 1989. In 1999 ISPA and SAPARD (Support for Agricultural and Rural Development) were newly established to strengthen supports for infrastructure development. ISPA aims to support investment projects in fields of environment protection and transport infrastructure improvement.

It is proposed to grant Euro 3 billion per year as pre-accession aids, of which breakdown is Euro 1.5 billion by PHARE, Euro 1.0 billion by ISPA, and Euro 0.5 billion by SAPARD, during the period from 2000 to 2006.

An allocation of ISPA money between beneficiary countries will be decided by the European Commission (EC) based on the population, per capita GDP in purchasing power parities, and surface area of each beneficiary country. It is said that the annual allocation for Romania will be Euro 200 million. This allocation might be modified taking into account of implementation of the investment supported by ISPA in previous year.

ISPA provides mainly two (2) forms of assistance, namely non-repayable direct assistance and repayable assistance. Non-repayable direct assistance is so called grant. Repayable assistance is a grant for managing authority or another public authority who loan the grant money to executive bodies of the investment projects in the fields of environment protection and transport infrastructure improvement. Under repayable assistance, reimbursed money to the managing authority or another public authority shall be reapplied for the same purpose.

ISPA assistance can cover up to 75 % of initial investment cost born by public bodies or bodies regarded as equivalent to public bodies. In case of repayable assistance the rate of assistance shall be reduced from 75 %.

According to the ISPA Regulation the eligible projects for ISPA assistance shall satisfy following requirements:

- In case of environmental field, the project enables the beneficiary countries to comply with the requirements of Community environmental law and with the objectives of the Accession Partnerships.
- In case of transport infrastructure field, the project promotes sustainable mobility and enables the beneficiary countries to comply with the objectives of the Accession Partnerships.
- Total project cost exceeds Euro 5 million.

The Accession Partnership is a kind of action program clarifying the priority areas in which large efforts should be made to realize EU accession. To complement it, each applicant country prepares own National Program for the Adoption of the Acquis, which gives detailed program for adopting the 'acquis communautaire' (the European Communities' legislation framework).

The ISPA Regulation also requires that a balance be struck between environmental projects and transport infrastructure projects.

2.6.3 JBIC Loan

JBIC (former OECF) is Japanese bilateral financing organ for ODA (Official Development Assistance) to foreign countries. It is widely recognized in the world for having helped develop infrastructures in developing countries.

There are two routes to provide loans: one is a yen loan which is the government to government loans, and another is overseas investment/financing to the private sector. In both cases, the currency is Japanese yen. Typical lending terms for both cases are as shown in *Table I.2.3*.

Table I.2.3 Typical Lending Terms of JBIC

Sector	Interest Rate	Repayment Period	Grace Period	Remarks
Public	Construction : 2.7% Consulting : 2.3%	30 years	10 years	Joint financing is desirable.
Private	2.0%	15 - 20 years	5 - 10 years	Sovereign guaranty is preferable.

In 1998, JBIC (then OECF) signed agreements to provide Romania with yen loans to the road and harbor projects. The lending terms for the two projects are as shown in the upper column of *Table I.2.3*. The loans used to the foreign portion of the capital cost, but today the percentage of the capital cost to which the loans are applicable is determined case by case (usually 70% to 80%). According to JBIC, joint financing with other international financial organs is desirable.

In the case of overseas investment/financing to the private sector, the lending terms are directly influenced by the domestic situation surrounding investment/financing by the Japanese government. At the present moment they are as shown in *Table I.2.3*. In providing loans, JBIC needs bank guaranty to protect its creditor's position. If sovereign guaranty can be arranged, there is no problem. Loans will be provided to 70% of the capital cost, the balance being born by the debtor.

2.7 PROPOSED FINANCIAL ARRANGEMENT

In the present regime, it is possible for the city councils to utilize both external loans contracted by themselves or through the state. The utilization of the external loans contracted by themselves would be more preferable from a viewpoint of local councils' initiatives in local public works, which is one of aims of the local public finance law. However, it seems practically difficult for the councils to access those loans. In general, external loans without state guarantee apply lending terms for a private sector, which would be too heavy financial burden to the city councils. This is the reason why it is assumed that the councils apply external loans through the state.

In case of the external loan through the state, the repayment capability of the council must be proved with such a manner that the total annual installments never exceed 20% of the current revenue.

On the other hand, the sound financial condition of the operation company is crucial for success of the project. Since the abovementioned privatization process may take a couple of years, at least, an actual financial arrangement would be done based on the existing operational structures, *i.e.* Regia Autonoma or commercialized company. Whether the operational company will have been privatized or not at the commencement of the project, the early establishment of the proposed operational structure is required to secure its repayment capability.

Thus, the financial feasibility of the project was evaluated from financial conditions of both the city council and the operation company.

CHAPTER 3
CONCEPTS OF PRELIMINARY ENGINEERING

3.1 GENERAL

This chapter presents concepts of a preliminary engineering adopted in feasibility study for wastewater treatment facilities. The concepts have been elaborated based on the results of field surveys, review of existing plans, and studies conducted throughout the course of the present study. These concepts are adopted to feasibility studies for Tulcea, Galati and Braila, and some of the contents comprise "the guide to feasibility study" for the four cities.

Generally, a preliminary engineering design in a feasibility study for a facility construction project gives a technical basis to evaluate a feasibility of the proposed project. Information to be provided by the preliminary engineering design would include planning basis of the facility design, type of facilities, layout, structure, size and quantity of required facilities, type, capacity and quantity of required equipment, construction methods and costs, and operation and maintenance methods and costs. Also, the preliminary engineering design provides information to be taken into account in a detailed design to be conducted when the project is implemented.

It should be noted that the preliminary engineering is used for the evaluation of a technical feasibility of the project, but not to be used at the stage of actual implementation of the project or actual construction works. Since a feasibility study and a detailed design of projects are used to be contracted as one package in Romania, designing in Romanian feasibility studies is so in detail. It is more common manner to separate a feasibility study and a detailed design internationally. As the projects by this feasibility study are supposed to be implemented by the external loans from international financing organizations as mentioned in the previous chapter, a required grade of the engineering is the one to satisfy requisites for evaluation of the project feasibility.

3.2 SCOPE OF PRELIMINARY ENGINEERING

Judging from the objectives of the Study, major facilities to be provided with the preliminary engineering are a wastewater treatment plant but sewer networks are excluded from the scope. However, interceptors (or trunk mains), which transfer sewage from the sewer networks to the wastewater treatment plant, would be included in the scope, if necessary.

3.3 TARGETS OF WASTEWATER TREATMENT

The norm NTPA 001, concerning limits of pollutant loads in wastewater discharged in water resources, issued by MWFEP in 1997, requires that the WWTP effluent quality comply with the requirements shown in *Table I.3.1*.

The effluent requirements for the WWTP proposed by the Study should follow these requirements. It is apparent that advanced treatments will be required to meet the criteria for nutrient materials, such as total nitrogen (T-N) and total phosphorous (T-P). This could increase the construction costs, consequently make the implementation of the project difficult. It would be not realistic to propose to construct total facilities that treat wastewater to the requirements. It would be rather realistic to propose two stage construction; in the first stage, to construct facilities to treat wastewater to meet the requirements except the nutrient materials and in the second stage to construct an additional treatment (an advanced treatment) as expansion of the facilities to meet the requirement for the nutrient materials.

Table I.3.1 Pollutant Load Limits in Wastewater Discharged to Water Resources (NTPA001) (Sheet 1/2)

Item No.	Quality Indicator	Units	Admissible	Methods of Analysis
A. Physical Indicators				
	Temperature	°C	30°C	-
B. Chemical Indicators				
	Hydrogen ion concentration (pH) For Danube River	Unit pH	6.5 – 8.5 6.5 – 9.0	STAS 8619/3-90
	Total suspended matter(T.S.M.)	mg/dm^3	60.0	STAS 6953-81
	Biochemical oxygen demand in 5 days (BOD)	mg/dm^3	20.0	STAS 6560-82
	Chemical oxygen demand – potassium hypermanganate method (COD-Mn)	mg/dm^3	40.0	STAS 9887-74
	Chemical oxygen demand – potassium dichromate method (COD-Cr)	mg/dm^3	70.0	STAS 6954-82
	Ammonium nitrogen (NH_4^+)	mg/dm^3	2.0	STAS 8683-70
	Total nitrogen (N)	mg/dm^3	10.0	STAS 7312-83
	Nitrates (NO_3^-)	mg/dm^3	25.0	STAS 8900/1-71
	Nitrites (NO_2^-)	mg/dm^3	1.0	STAS 8900/2-71
	Sulfides and hydrogen sulfide(H_2S)	mg/dm^3	0.1	STAS 7510-66
	Sulphites (SO_3^{2-})	mg/dm^3	1.0	STAS 7661-89
	Phenols carried by water vapors	mg/dm^3	0.05	STAS 7167-92
	n-Hexane extracts	mg/dm^3	5.0	STAS 7587-66
	Oil products	mg/dm^3	1.0	STAS 7877-87
	Phosphates (PO_4^{3-})	mg/dm^3	4.0	STAS 10064-75
	Total phosphorus (P)	mg/dm^3	1.0	STAS 10064-75
	Anion active synthetic, biodegradable detergents	mg/dm^3	0.5	STAS 7576-66
	Arsenic	mg/dm^3	0.05	STAS 7885-67
	Aluminum (Al^{3+})	mg/dm^3	8.0	STAS 9411-83
	Calcium (Ca^{2+})	mg/dm^3	300	STAS 3662
	Lead (Pb^{2+})	mg/dm^3	0.2	STAS 8637-79
	Cadmium (Cd^{2+})	mg/dm^3	0.1	STAS 7852-80
	Trivalent chrome (Cr^{3+})	mg/dm^3	1.0	STAS 7884-91
	Hexavalent chrome (Cr^{6+})	mg/dm^3	0.1	STAS 7884-91
	Total iron (Fe^{2+} Fe^{3+})	mg/dm^3	5.0	STAS 8634-70
	Copper (Cu^{2+})	mg/dm^3	0.1	STAS 7795-80
	Nickel (Ni^{2+})	mg/dm^3	0.1	STAS 7987-67
	Zinc (Zn^{2+})	mg/dm^3	0.5	STAS 8314-87
	Mercury (Hg^{2+})	mg/dm^3	0.005	STAS 8014-79
	Silver(Ag)	mg/dm^3	0.1	STAS 8190-68
	Florides (F^-)	mg/dm^3	0.5	STAS 8910-71
	Molybdenum(Mo^{2+})	mg/dm^3	0.1	STAS 11422-84
	Selenium (Se^{2+})	mg/dm^3	0.1	STAS 12663-88
	Manganese (Mn^2+)	mg/dm^3	1.0	STAS 8662-70
	Magnesium (Mg^{2+})	mg/dm^3	100.0	STAS 6674-77
	Cobalt (CO_2^+)	mg/dm^3	1.0	STAS 8288-69
	Cyanide (CN^-)	mg/dm^3	0.05	STAS 7685-79
	Free chlorine (Cl_2)	mg/dm^3	0.05	STAS 6364-78
	Chlorides (Cl^-)	mg/dm^3	500.0	STAS 8663-70
	Residue filtered at 105°C	mg/dm^3	2,000.0	STAS 9187-84

Table I.3.1 Load Limits of Pollutants in Wastewater Discharged to Water Resources (NTPA001) (Sheet 2/2)

Item No.	Quality Indicator	Units	Admissible	Methods of Analysis
C. Bacteriological indicators				
	Total coliform bacteria	Nr/100 cm^3	1 mil	STAS 3001-91
	Fecal coliform bacteria	Nr/100 cm^3	10,000	STAS 3001-91
	Fecal streptococci	Nr/100 cm^3	5,000	STAS 3001-91
	Salmonella	Nr/100 cm^3	N.D.	STAS 3001-91

*) Discharged wastewater temperature shall not exceed 2-5 degrees higher than the receiving water or 30°C.

**) Surface water to which wastewater is discharged should not be used for irrigation purpose.

***) Total heavy metal ions concentration shall not exceed 1 mg/dm^3, the individual values being those provided in the table. In the localities where no wastewater treatment plant is provided, the water in water distribution network containing zinc higher than 0.5 mg/dm^3 will be accepted also at wastewater discharge into the water courses.

****) Analysis method will be the one corresponding to the standard in force.

The JICA Study Team thinks that to start wastewater treatment, even it is incomplete, is much better than to wait without wastewater treatment until the time when a complete one can be constructed. Therefore, in the Study, the requirements for T-N and T-P are set out as ultimate requirements and are not applied to the proposed facilities.

3.4 DETERMINATION OF DESIGN BASIS

Such design bases as wastewater flow and characteristics, which are essential factors of facility design, exist in each city and they have been used in previous feasibility studies and sewerage development plans. Since most of sewerage facilities designed and being constructed are based on those bases, it may cause discontinuity, if the design bases determined in the Study far differ from the existing ones. It would be more practical to adopt the existing design bases, keeping compatibility with the existing facilities.

However, as long as information given to the JICA Study Team, some of these bases do not have enough justifiable background. Therefore, in the Study, the existing design bases were reviewed by using available data having solid bases, the results of field survey in the Study and data in literatures.

Following design bases were reviewed.

Table I.3.2 Reviewed Design Basis

Population	- Total administrative population - Service population of public water supply and sewerage system
Design Flow	- Wastewater generation - Average daily flow - Maximum daily flow - Maximum hourly flow - Wet weather flow
Wastewater Characteristics	- Wastewater pollution loads estimates - Design influent quality for the proposed WWTP

The design bases were reviewed and updated by the following process as shown below. First, the present conditions concerning design basis were analyzed based on the data and information provided by city councils, the public water companies, and related organizations. The survey results of wastewater quantity and quality were also used to understand the present conditions of wastewater generation and pollution loads. Second, the design bases proposed in the latest sewerage plan were reviewed.

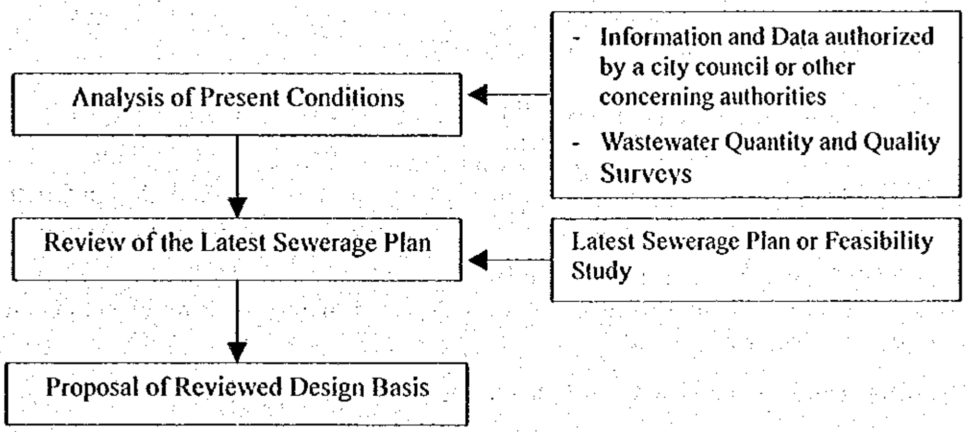


Figure I.3.1 Process for Reviewing Design Basis

3.5 INTERCEPTOR SYSTEM

Interceptors are to transfer the wastewater to WWTPs by collecting wastewater from existing outfall sewers or trunk mains. In the course of the Study, it was confirmed that there existed trunk mains, which collected most of the wastewater from sewer networks in some cities, or construction of such trunk mains was going on. Therefore, the proposed projects utilize those existing or being constructed trunk mains as much as possible to transfer the wastewater to WWTP.

According to the above idea, the preliminary engineering for the interceptors covers following scopes:

Tulcea: Interceptor sewers from the existing trunk mains to WWTP,
Connections of the existing outfall sewers to the existing trunk mains,
A transfer pumping station, and
Connections to the pumping station.

Galati: An interceptor sewer from the existing most upstream outfall sewer to WWTP,
Connection of the existing outfall sewers to the interceptor sewer, and
Structures to divert the excess wastewater.

Braila: An interceptor sewer from the most downstream point of the existing trunk mains,
Connection of the existing outfall sewers to the interceptor sewer, and
Structures to divert the excess wastewater.

The interceptor facility designs were made by the following criteria, which basically correspond to the Romanian Standards.

Table I.3.3 Criteria for Interceptor Facility Design

Item	Criteria
Pipe connection method	Crown connection
Minimum velocity	0.6 m/s
Maximum velocity	3 m/s
Earth covering	1 m. it can be less than it with proper reinforcement in special case
Manhole spacing	
Sewer diameter 800 mm or smaller	60 m
Sewer diameter from 800 – 1500 mm	75 m
Sewer diameter over 1500 mm	150 m

3.6 WASTEWATER TREATMENT PLANT

Specific plant design objectives include the following:

- The plant effluent quality shall meet the discharge criteria to the Danube River and its tributaries as set forth by the NTPA 001;
- Plant facilities are to be designed in principle based on the "National Design Criteria for Wastewater Treatment Plant Facilities," as promulgated by the Romanian Government;
- Plant facilities will be built now on the land owned or acquired by the Cities, and may be expanded later as required to meet future unexpected increased flows or enforcement of more stringent control standards;
- The plants can accommodate the estimated wastewater flows up to the year 2010;
- The plants will provide preliminary, primary and secondary treatment processes;

- The process should be operationally simple and provide the WWTP with low operational and maintenance costs; and
- The plants do not present many hazards to the surrounding community.

The design principles for the WWTP plans expressed here set the basis for the preliminary engineering design for 2010, along with the future plant expansion and upgrading, and set down the philosophy that should be used for the detailed design of WWTP and related facilities.

The preliminary engineering for WWTP cover the following points:

- Process concepts;
- Process control;
- Operation and maintenance;
- Current design;
- Expansion and upgrading to meet the future effluent requirement; and
- Economical use of existing wastewater facilities.

Among the above, process concepts are a major point of the preliminary engineering for WWTP. The next section deals with selection of treatment process of the WWTP.

3.7 SELECTION OF TREATMENT PROCESS

Purpose of the selection of the treatment process is to select the most proper treatment process that treat wastewater to meet the effluents requirements, considering construction and operation/maintenance costs, operation flexibility, expandability, operation methods and popularity in areas.

This section presents processes and results of selection of the treatment process to be adopted in the preliminary engineering.

3.7.1 PLANT EFFLUENT REQUIREMENTS

The effluent quality is basically to comply with the requirements of the NTPA 001. However, as discussed in the previous section of this chapter, the feasibility study proposes two stage water quality target, considering a reality in possibility of project implementation under present situations around the state's and municipalities' financial conditions.

Among the water quality requirements specified in the NTPA 001, indicators other than indicators relating to organic matters, nitrogenous matters and phosphorous matters and all the bacteriological indicators can be achieved by a conventional wastewater treatment as far as influent does not contain extremely high concentration of those indicators. And there were no evidence that wastewater from any of cities could contain high concentration of any of such indicators. Therefore, in the preliminary engineering of the wastewater treatment plant, the effluent requirements are set out as follows:

BOD : 20 mg/l or less SS : 60 mg/l or less

Meanwhile, the NTPA 001 refers to the EU Directives, thus they are requirements that the future wastewater treatment has to achieve. Therefore, the study is to propose the advanced treatment for the requirements for T-N and T-P that can be constructed as expansion of the existing facility and also be catered in treatment plant sites confirmed at present. In this case, following requirements are adopted for the preliminary designed of the advanced treatment:

T-N : 10 mg/l or less T-P : 1 mg/l or less

3.7.2 SELECTION OF SECONDARY TREATMENT PROCESS

(1) General

The minimum requirements for the WWTP process of the three cities are to achieve the pollutant removal efficiencies of the secondary treatment level. In view of the effluent quality requirements (20 mg BOD_5/l, 60 mg SS /l), any treatment processes with BOD_5 and SS removal efficiencies of 70 percent or lower (primary treatment processes, trickling filters, etc.) can hardly meet such requirements.

(2) Biological Method and Physical-chemical Method

As the possible secondary treatment processes meeting with such effluent requirements, biological and physical-chemical processes are reviewed as to the accruing advantages and disadvantages. In general, the physical-chemical treatment processes require significant quantities of chemicals and produce large volume of sludge, whereas those by biological treatment processes do not. For these reasons, the biological treatment processes are more economical than physical-chemical processes.

The majority of public wastewater treatment plants used elsewhere in Romania are of the conventional activated sludge methods. In particular, on account of the facts that the stringent effluent quality standards are enforced to the region's receiving water bodies, it is evident that the activated sludge method or equivalent is the minimum requirement for the public wastewater system.

(3) Comparison of Alternative Processes

For the possible secondary treatment process, the following two (2) candidate processes have been selected.

- Conventional activated sludge (CAS)
- Oxidation ditch (OD)

For comparison of the two processes, an imaginary WWTP of 100,000 m^3/day treatment capacity is planned for each process, and compared each other for particular features such as land requirements; capital, and operation and maintenance costs; complexity of operation and maintenance; sludge production; organic removal efficiency, etc., as shown below.

Table I.3.4 Comparison of Biological Process

Items of Comparison	Conventional Activated Sludge	Oxidation Ditch
Design fundamentals		
Primary clarifier overflow rate	50 m^3/m^2/day	
Aeration time	8 hr	24 hr
Final clarifier overflow rate	25 m^3/m^2/day	10 m^3/m^2/day
Operational Parameters		
MLSS in aeration tank	1500 - 2000 mg/l	3000 - 4000 mg/l
Return sludge ratio	25 – 50 %	100 - 200 %
Required Area	12,100 m^2 (100%)	50,000 m^2 (475%)
Operation and Maintenance costs		
Sludge circulation	100%	300%
Air blow	100%	100%
Excess Sludge	100%	75%
Others	- Requires much control works to keep normal operation.	- Requires less operation works. - Requires larger land area. - Requires higher operation costs

* Based on an imaginary plants with 100,000m^3/day of treatment capacity

Required land area include necessary spaces such as parking, roads, buffer zones, etc. Spaces will be planted with shrubs and trees to landscape the area and to reduce the odors and noise from plant facilities. The OD requires more than 4 times wider area than the CAS does.

Capital costs: Capital costs of civil works, electrical and mechanical equipment, utilities and other facilities have been estimated for each process. The CAS process costs slightly higher than the OD process: however, the costs for electrical and control equipment appear to differ not so significantly from the OD processes because these costs are governed in general by the power loading of the plant rather than treatment process itself.

Operation and maintenance: Operation and maintenance costs of the WWTP comprise those for electricity and other energy, operation and maintenance labor, supplies and maintenance materials, raw materials, chemicals, administration and staff, etc. The OD system requires less complex operation and maintenance procedures than in the CAS system, however, the O/M costs of the CAS process are generally higher than the OD process.

Operation flexibility: The CAS process isn't resistant to shock organic or toxic loadings, while the OD method is in general resistant to such loading. Although the treatment cost per unit volume of sewage by the oxidation ditch system may be more or less the same as the CAS, the OD system is generally more appropriate to be used for rather small scale plants, and have not much experience to operate large scale treatment plants like those for the three cities.

(4) Proposed Process

The above discussions and alternative analyses have led to the conclusions that the conventional activated sludge process is most suitable method for WWTPs of the three city.

The proposed treatment processes for WWTPs consist of the following components.

- Preliminary Treatment: screening and degritting,
- Primary Treatment: sedimentation,
- Secondary Treatment: conventional activated sludge, and
- Sludge Treatment: anaerobic digestion and dewatering.

The expected BOD and SS removal efficiencies of the conventional activated sludge process are at around 90 percent when the system is properly operated. The expected pollutants removal efficiencies and qualities by the primary, secondary and overall processes are as summarized in the following table.

Table I.3.5 Expected Pollutants Removal Efficiency and Wastewater Quality

Parameter	Removal Efficiency (%)			Wastewater Quality (mg/l)		
	Primary treatment	Secondary treatment	Overall removal	Raw wastewater	Primary effluent	Secondary effluent
BOD_5	30	85	89.5	170	119	18
SS	40	80	88.0	170	102	20

Note: Wastewater qualities are of representative values.

(5) Study on Aeration Time of Conventional Activated Sludge Process

Design standards of the conventional activated sludge method in Romania and Japan are summarized in *Table I.3.6.*

There are no significant differences between the two standards as to primary and final sedimentation tanks, however, as to aeration tank the differences are rather significant.

Table I.3.6 Romanian and Japanese Standard Design Criteria for Conventional Activated Sludge Method

Institution	Item	Unit	Parameter	
			Japan	Romania
Primary sedimentation	Hydraulic Flow Rate			
Tank	-separate system	m^3/m^2.day	35-70	26,5
	-combined system		25-50	-64.8*)
	Settling time			1.5-2 (Qd)
*)suspended solid	-separate system	hour	>1.5 (Qd)	>1.0 (Qh)
initial concentration	-combined system		>0.5 (Qh)	>0.5 (Qh)
200-300mg/l	Effective water depth	m	2.5-4.0	
Qd :Max daily flow	- radial horizontal			1.6-2.5
Qh:Max hourly flow	-Longitudinal horizontal			1.8-2.95
	weir loading	m3/m.day	250 (Qd)	1440 (Qd)
Aeration reactor tank	MLSS	mg/l	1500-2000	3300
	BOD−SS Loading	BOD-kg/ MLSSkg-day	0.2-0.4	0.3
	Return sludge ratio	%	25-50	100
	Effective water depth	m	4-6	2-6
	Hydraulic retention time	hour	6-8	2-3
Romanian standard	A−SRT	day	3-6	
*)Discharge conditions	(Aerobic sludge retention			
BOD5<20mg/l	time)			
Finally settling tank	Hydraulic Flow Rate	m^3/m^2.day	20-30	16.8-28.8
	Settling time	hour	3-4 (Qd)	3.5-4.0 (Qd)
	Effective water depth	m	2.5-4.0	
	- radial horizontal			2.5-3.5
	-Longitudinal horizontal			2.4-3.3
				192 (Qd)
	weir loading	m^3/m.day	150 (Qd)	
Disinfection	Contact time	minutes	15	
	Chlorine dosing rate			
	-Biological treatment	mg/l	2-4	
	-Primary treatment		7-10	

The Study applies 6-hour aeration time to the aeration tank design, which follows the Japanese standards, based on the following reasons.

- As the return sludge ratio is set as low as 50 %, expenses for return sludge pumps and operation are less costly; and
- This system makes operation easy because of the low MLSS concentration. Should bulking occurs in aeration tanks, the return sludge ratio can be increased as a remedial measure to as high as 100 % to recover the aeration function to normal.

The civil works by the Romania Standards is less costly than that by the Japanese Standards, but the total cost including the equipment and operation cost for the project period by the Japanese Standards is apparently lower than that by the Romanian Standards.

3.7.3 FUTURE PROCESS UPGRADE AND EXPANSION

Effluent of the conventional activated sludge process normally containing about 20 to 50 mg/l of BOD_5, 20 to 40 mg/l of T-N and 8 to 15 mg/l of T-P, as well as minor amount of other constituents. These materials serve as nutrients for the natural biota in the receiving water. To meet the ultimate requirements for the effluent, advanced treatment could be required.

(1) Comparison of Candidate Advanced Treatment Processes

In order to compare advantages and disadvantages of different processes, several most possible advanced treatment processes were first selected and evaluated in their treatment performance, costs, land requirements, flexibility and ease of operation and maintenance. Then, less advantageous alternative processes were screened out from further evaluation.

The alternative combinations of processes thus selected are of the following four scenarios of typical combinations.

Table I.3.7 Alternative Scenario of Advanced Treatment

Scenario-1	BOD and SS removal	Conventional activated sludge, oxidation ditch.
Scenario-2	BOD, SS and T-N removal	Recirculation nitrification-denitrification, Step feed, multi-stage nitrification-denitrification.
Scenario-3	BOD, SS and T-P removal	Anaerobic-aerobic activated sludge.
Scenario-4	BOD, SS, T-N and T-P removal	Anaerobic-anoxic-aerobic.

The T-P removal may be difficult, as the aerated grit chambers and oil traps will be provided ahead of the WWTP system and cannot maintain the influent under anaerobic conditions. Hence, biological removal of phosphorus (needs anaerobic condition) is hardly achievable. For this reason, the phosphorus removal is to be performed by chemical precipitation process.

(2) Recirculation Nitrification-Denitrification Process

The "Recirculation Nitrification-Denitrification Process" consists of reaction tanks that are divided into two separated zones, namely anoxic (denitrification) and aerobic (nitrification) zones. The wastewater and the return sludge go over the anoxic zone, and also a part of nitrified mixed liquor in aerobic zone is returned to the anoxic zone.

In the aerobic zone, the entering ammonia nitrogen is oxidized to nitrite nitrogen and/or nitrate nitrogen, and in the anoxic zone, oxidized nitrogen is converted to nitrogen gas by oxidation reaction of organic matters in the influent wastewater. *Figure I.3.2* shows the process.

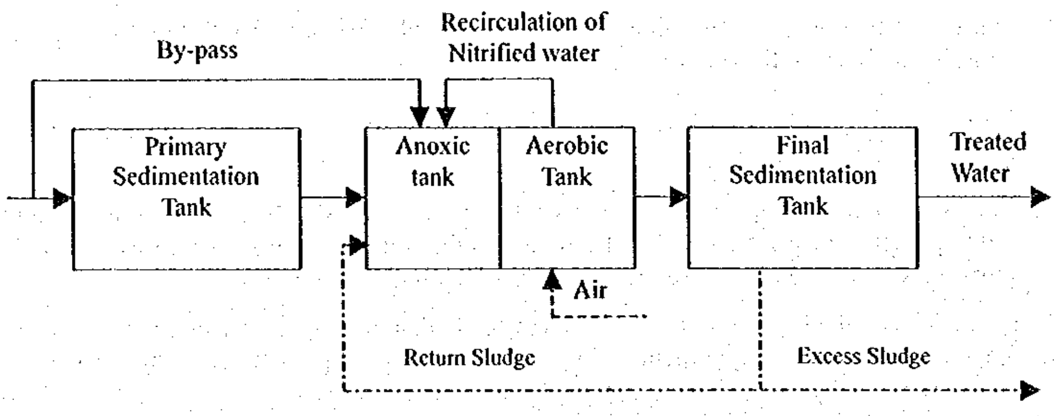


Figure I.3.2 Recirculation Nitrification-Denitrification Process

For the average water quality of urban wastewater, annual average removal efficiency of total nitrogen is expected to be 60 ~ 70% for the primary sedimentation tank effluent, and BOD and SS removal efficiencies exceed the conventional activated sludge process.

Characteristics of the recirculation nitrification-denitrification process are as follows:

- For total nitrogen design removal efficiency of 60 ~ 70%, the capacity of reaction tanks is larger than conventional activated sludge process,
- It is necessary to divide the reaction tank,
- It is necessary to provide some equipment (pumps) in order to recirculate a nitrified liquor,
- In order to ensure food to microorganisms in aerobic zone, in case of rainfall or for initial operation, it is necessary to provide a channel to by-pass the primary sedimentation tank,
- MLSS concentrations of 2,000 ~ 3,000 mg/l (higher than conventional activated sludge process) are to be maintained in the aeration tanks. In designing of final settling tanks, lower overflow rate and an effective water depth should be considered, and
- Provide a scum breaker device in anoxic tanks.

Design fundamentals of the recirculation nitrification-denitrification process are shown bellow:

Table I.3.8 Design Fundamentals

Items of water quality	Reaction tank influent water quality	Design quality of treated wastewater
BOD (mg/l)	130	10
SS (mg/l)	70	5
T-N	36	12
Temperature (°C)	13 °C	

The land requirements for the advanced treatment plants will be about 1.5 times larger than those for the secondary treatment plants. The capital, and operation and maintenance costs of the advanced treatment process will be about 1.5 times and 1.8 times larger than the secondary plants, respectively.

Removal of T-N from 30 to 10 mg/l are more expensive than that of BOD from 150 to 20 mg/l.

(3) Conclusions and Recommendations

Conclusions concerning the advanced treatment are as follows.

- Biological removal of phosphorus is hardly achievable because the aerated grit chambers and oil traps, which will be installed ahead of the biological treatment process, cannot maintain the influent under anaerobic conditions. For this reason, the phosphorus removal will be performed by chemical precipitation process.
- T-N removals will be achieved by the recirculation nitrification-denitrification method.
- It seems ambitious to invest a huge amount of costs for advanced treatment at present only for removing small amount of nitrogen and phosphorus. The capital costs will be double the secondary treatment costs.
- The upgrading of the treatment process shall be made only when the situations become to require that. The conventional activated sludge process alone could solve significantly the current river water contamination problems. It is considered more realistic to defer the construction of the advanced treatment process until the next stage, to allow enough time to further study the real environmental situations.
- The WWTP plan under the present study should include the possible layout plans and land requirements for additional the future upgrading.