2. Water Conservation

2.1 Effects of Water Conservation

2.1.1 Outline

The following beneficial effects can be obtained from the water conservation.

① Reduction in the volume of pollutants discharged into rivers

② Reduction in the pollution load requiring treatment by the WWTP

③ Improvement in the management of enterprises

Below is a simple description of these effects.

2.1.2 Reduction in the Volume of Pollutants Discharged into Rivers

① Reduction in the volume of pollutants generated in factories

It is rare that water conservation directly reduces the volume of pollutants. For water saving, however, working conditions and production processes must be improved. As a result, it is expected that the amount of pollutants discharged may be reduced.

② Reduction in the volume of pollutants in treated wastewater

After the industrial effluent is treated by the WWTP or by treatment equipment on-site at the factories in order to bring the water quality up to the emission standards, the treated water is discharged into rivers. When water is saved and the drainage volume is decreased, the volume of pollutants discharged into rivers will be decreased to a comparable degree since the water quality of treated water is constant.

2.1.3 Reduction in the Pollution Load Requiring Treatment by the WWTP

For the reasons described above in 2.1.2.①, water saving not only reduces the volume of pollutants requiring treatment by the WWTP, but also the pollution load.

Even if the volume of industrial effluent is increased and exceeds the WWTP's treatment capacity due to increased industrial production in the future, the circumstances can be improved by promoting water saving.

2.1.4 Improvement in the Management of Enterprises

This survey clearly showed that, for each of the factories surveyed, the ratio of the cost of industrial water and effluent to the shipping price is much higher than the corresponding ratios for factories in the same industry in Japan.

Promotion of water conservation is an effective way of decreasing the ratio and improving the management of enterprises for the time being.

It was also clarified that, with the present rates on industrial water and effluent, economical use of industrial water can be reduced by about 20%. This indicates that the management of enterprises can be improved by the promotion of water saving.

The ratio of the cost of industrial water and effluent in the shipping price must be compared with the corresponding ratios in countries other than Japan, particularly those of the countries in Europe. However, as the ratios are exclusive materials of enterprises, they are not published in Japan or any other foreign countries. The ratios used here for comparison are exclusive data possessed by the Water Reuse Promotion Center.

2.2 Recommendations on Water Conservation

2.2.1 Recommendations to the national government and cities

As mentioned above, the water conservation is expected to bring about much effect. Therefore, the water conservation must be propelled as a policy, and the national government and cities are requested to indirectly assist enterprises which are obliged to implement conservation.

Specifically, We recommend that the national government and cities take the following measures:

① Technical assistance to enterprises

Experts in water conservation must be positioned in the national government or cities to energetically advise and instruct enterprises.

② Financial assistance to enterprises

In principle, enterprises must implement water conservation with their own funds, but great benefit can be gained by providing a financing system with low interest rates such as that implemented in Japan in order to reduce the burden on enterprises.

③ Establishing a sewage rating system which does not hinder water conservation

As almost all industrial effluent is discharged to the WWTP, a sewage rating system which makes it disadvantageous to implement water conservation from an economic viewpoint (for example, a system under which the rate for unit waste volume increases with decreases of drainage volume) would not be favorable.

In relation to the above ②, several types of financial assistance given to enterprises in Japan are described below.

① Low-interest rate financing system for equipment for water conservation.

This is a system under which the national or local governments finance a certain percentage of the cost of equipment installed in enterprises at a rate lower than that of open market, with several limits set according to the plant site and facilities installed.

② Incentive taxation system for energy-conserving equipment

When an enterprise installs equipment which are certified by the national government as energy conserving equipment, a certain percentage of the installation cost is deducted from the taxes.

2.2.2 Recommendations to Enterprises

As all of our concrete recommendations and general technical guidance are presented in the report and attachments, only a few very fundamental recommendations will be given here.

① Enterprises must understand that the cost of industrial water and effluent have a substantial effect on their finances.

As mentioned previously, the ratio of the cost of industrial water and effluent in the shipping price is comparatively high. It is important to fully recognize this point and aggressively propel the water conservation.

② Correctly determine the volume of industrial water used and the volume of effluent,and make a complete balance of water.

As indicated in 1.1, the factories surveyed did not adequately manage the volume of industrial water used. Of the 9 factories which use well water and river water, water meters were installed in only 3. Of the factories to which tap water is supplied through the common water meter, 2 factories had not installed water meters of their own.

This recommendation was already made in 1.1, but as it is the most fundamental item for water conservation, we repeat it here.

③ Whenever possible, try to accurately ascertain the minimum volume of water and lowest limit of water quality required for a certain purpose.

The simplest way to save water is not to use it, supplying only the minimum volume of water required for a certain purpose. To reclaim the water used, it is imperative that the quality of the reclaimed water is above the lowest required level.

It is technically very difficult to ascertain the above-mentioned values. Execution of the above requires close cooperation of water-treatment engineers and production engineers. Even in Japan, execution is extremely rare, and limited to cases when there is an urgent need for water saving, for example, at times of drought.

④ Study concrete methods of water conservation, determine the most applicable method, confirm its economy, and begin execution.

One must be careful in confirming economy. It is essential to obtain a correct written estimate from the manufacturer of the equipment.

⑤ Water balance must be remade in accordance with the change in the operation of factories.

As water balance changes constantly, establish a certain remaking method and remake the balance periodically and regularly.

As water balance indicates a factory's production processes and production states, normally it is not presented to outsiders. It is not known, therefore, how water balance is actually remade. In the factories located in the areas which often suffer from droughts, water balance is remade even in normal times to promote water saving in preparation for future water shortages.

If the assistance of external experts can be obtained for executing the above ② to ⑤, we expect that it will be possible to compensate for the shortage of technical knowledge on the factory side and transfer the technology.

3. The WWTP

3.1 Setting of Rates

Before making any recommendations to the WWTP, let us rearrange the results of the simulation on the system to set sewage rates indicated in the preceding Chapter 3.2.1. First of all, the following principles are established as a fundamental policy in setting the system of WWTP rates.

(1) The total treatment cost of the WWTP must be covered by the rates paid by users.

(2) Average total treatment cost shall be 160 SIT/m^3, and this rate shall be increased or decreased depending on the degree of pollution and the volume of industrial effluent.

(3) The indexes expressing the degree of pollution shall be COD, BOD, and SS (pollutants which the WWTP cannot treat, and phosphorus and nitrogen, which the WWTP plans to remove in the future, will not be taken into consideration). Based on the above principles, the calculation equation of the rate per $1m^3$ is decided as follows.

$$\text{Rate (SIT/m}^3) = A \cdot (COD + 2 \cdot BOD + 2 \cdot SS)/5 + B$$

Having decided the rate calculation equation as above, it is now necessary to select one of two policies in setting a charging system. One policy is to set only a charging system and leave everything else to the principle of free economy. The other policy is to set a certain limit on the pollutant load of effluent, and let factories remove compulsorily the pollutant load which exceeds the limit. In Japanese sewage systems, a limit is set on the pollutant load and this limit is considered an effective measure for the reduction of pollutants. As every country has its own circumstances, however, judgment must be made accordingly.

Following are charging systems considered recommendable from the results of the surveys mentioned in the preceding chapters:

(1) To leave the actions of enterprises to the principle of free economy, two methods can be applied. One is managing household effluent and industrial effluent with separate charging systems. In this case, the rate calculation equation will be:

$$\text{Rate (SIT/m}^3) = 0.4 \cdot (COD + 2 \cdot BOD + 2 \cdot SS)/5 + 90$$

The average rate of 20 factories surveyed will be 164 SIT/m^3, with 4 of the factories out of the 20 applying preliminary treatment. Total amount invested by factories will be 195 million SIT, and as for the reduction of pollutant load implemented by this investment, COD will be reduced by 1,963kg/d, BOD by 944kg/d, and SS by 548kg/d.

(2) It is said that Maribor City will charge 80 SIT on $1m^3$ of household effluent uniformly. When this is taken into consideration, the above-mentioned method may be perceived as unfair since, in this case, the charge on the industrial effluent of low-pollutant load could potentially be less than 80 SIT/m^3. The other method is to apply the charging system used for household effluent to industrial effluent of low-pollutant load, and to charge the industrial effluent with high-pollutant load according to the amount of the load. The rate calculation equation will be:

$$\text{Rate (SIT/m}^3) = 0.8 \cdot (COD + 2 \cdot BOD + 2 \cdot SS)/5 + 20$$

The number of factories which apply preliminary treatment is 5 including SVILA, whose industrial effluent is large in volume, and the average rate will be 160/m^3. The total amount invested will be 238 million SIT, and as for the reduction of pollutant load implemented by this investment, COD will be reduced by 2,413kg/d, BOD by 1,244kg/d, and SS by 458kg/d.

(3) To set a limit (COD:600mg/l, BOD:300mg/l,SS:300mg/l) on the pollutant load of the industrial effluent discharged to the WWTP, the following rate calculation equation can be applied:

Rate (SIT/m^3) = 0.5· (COD + 2·BOD + 2·SS) + 70

In this case, the average rate will be 163/m^3·, with 5 factories applying preliminary treatment. A total of 220 million SIT will be invested by the factories, with the reduction of the pollutant load implemented by the investment totaling 2,011kg/d for COD, 981kg/d for BOD, and 541kg/d for SS.

Three representative cases have been outlined above, and the characteristics of each case have been outlined in the preceding 3.2.1. There is another conception focusing in the reduction of load on the WWTP. The relation between load reduction and the investment amount required for the reduction is indicated in Fig. 3.2.1. According to the figures, SS reduction efficiency is almost constant regardless of the amount invested. Investment is very effective in the reduction of COD, with the reduction staying proportional to the amount invested until it reaches 240 million SIT, where the COD begins to show saturation. BOD has the same tendency as COD, but investment has less of an effect. Since there are more than one charging system equations for the same investment amount and reduction efficiency, both the investment effect and the characteristics of the calculation equations need to be taken into account in setting a calculation equation. Before any concept is applied, many cases, as well as their administrative, economic, and political implications, must be studied, and a sound judgment must be made. As a diskette with the calculation program (FORTRAN) is attached, please make use of it in the actual implementation.

It should be noted here that a calculation equation of rates concretely reflects the policies of the administration authorities, and that the method of estimating the result of the policies was established by this survey.

We present below the measures which, based on the results of the above study, the city authorities will have to take.

To begin with, the system to be adopted by the WWTP will have to be decided. As mentioned in the preceding Chapter 3.2.1, the total system to treat all of the effluent of Maribor City comprises both the WWTP and factories. Thus, the total system cannot be optimized unless the WWTP's system is determined beforehand.

Secondly, discussion will have to be held on how to allot the treatment of factories' pollutant load (COD, BOD, SS) to the WWTP and factories. As a result of this survey, it is estimated that almost all the factories will discharge their effluent to the WWTP under the current emission standards. If the city authorities are to request factories to reduce pollutant load of the effluent led to WWTP, they will have establish some regulations or set a charging system which necessitate the preliminary treatment of the effluent at the factories. In such a case, they will be able to make use of the relation of the pollutant reduction volume, the amount invested, and the charging system clarified by this survey.

Thirdly, note that the above-mentioned estimation of preliminary treatment is based on the economic calculation by the computer program, and not on the judgment of factories. Therefore, it will be necessary to discuss the estimation result with factories and confirm or amend the estimation.

When the above three items are cleared, it becomes possible to decide how to configure the total system. Please note that this recommendation is given based on the present condition. It is not possible to decide on a future system unless estimations on the industrial effluent of Maribor City in future are prepared. Incidentally, in Japan, a sharp increase in the demand for industrial water was estimated at the time of high growth, but in reality, the increase in substantial demand for industrial water was relatively slight due to the promotion of water reuse. Further, although in principle a factory's pollutant load is proportional to the production amount, change might be brought about to the industrial structure, so estimation will have to be made prudently.

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3.2 Removal of CODcr

The effluent of textile-dyeing factories accounts for about 20% of the total effluent led to the WWTP. As the effluent of textile-dyeing factories contains a large quantity of refractory COD component, there is a possibility that the WWTP's emission standard 100mg/L cannot be attained. That is why the removal of CODcr must be studied. For your reference, some recommendations based on actual examples in Japan are given below.

1) Characteristics of wastewater

The effluent from 5 textile dyeing factories (M-1, S-1, S-2, S-3, S-4) accounts for a high percentage of the wastewater for the whole of Maribor city, all of which will be led to the WWTP. The industrial effluent from these companies accounts for 20% in water volume, and 11% in the amount of CODcr. On the other hand, the industrial effluent of the 5 food and chemical factories (M-4, M-6, M-7, S-6, A-5), whose CODcr concentration is high, accounts for 5.3% in water volume and 11% in the amount of CODcr in the total wastewater.

The ratio of the above two types of industrial effluent put together accounts for 25% in water volume and 22% in the amount of CODcr (Table 3.2.1).

Table 3.2.1 Comparison of Total Wastewater, Textile Dyeing Industrial Effluent, and Other Effluent

		CODcr	
	m^3/d	mg/l	kg/d
(1) Total Water Volume (to be treated at the WWTP)	36,600	691	25,517
(2) Effluent of 20 Factories Surveyed	11,558	500	5,784
(3) Effluent of Textile Dyeing Factories (5 factories)	7,342	387	2,838
Textile Dyeing/Total x 100, %	20		11
(4) Effluent of Food and Chemical Factories with High CODcr Concentration (5 factories)	1,938	1,400	2,710
Food and Chemical/Total x 100, %	5.3		11
(5) (3) + (4)/Total x 100, %	25		22

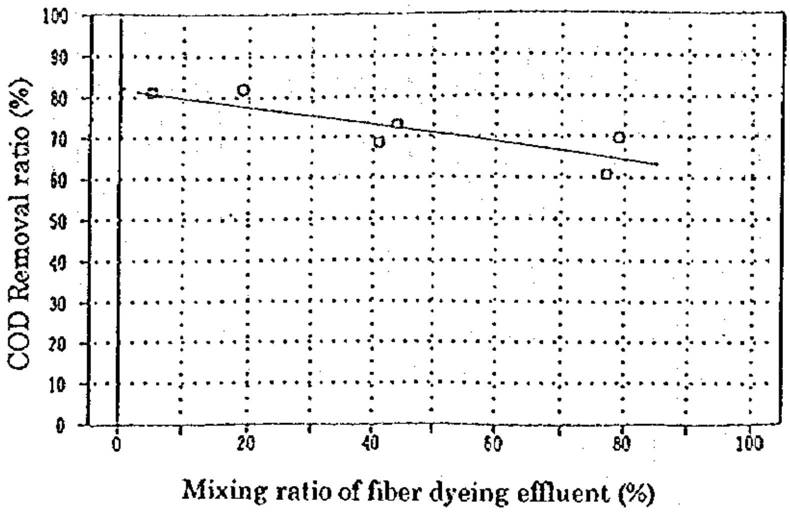
Notes: (1) Total water volume is quoted from the proposal made by Maribor City.
(2) The effluent of 20 factories surveyed was calculated from Table 1.1.2 of Chapter IV.
(3) The values of the effluent of 5 textile dyeing factories (M-1, S-1, S-2, S-3, S-4)

⑤ BOD/COD is low.

As refractory COD is contained in the effluent, the COD removal ratio in biological treatment will be low. In selecting the treatment system of the WWTP, this point must be taken into account.

(2) Matters demanding special attention in the removal of CODcr

When aerobic treatment is applied to the general household effluent mixed with textile dyeing effluent, the COD removal ratio decreases with the increase of the mixing ratio. This is confirmed by the records in Japan. The data are indicated in Fig. 3.2.1.



Source : Nippon Jogesuido Sekkei Co., Ltd.

Fig. 3.2.1 Relation of the Ratios of Water Volume Received and the COD_{Mn} Removal

From the above data, which covers exclusively the COD_{Mn} removal ratio, the removal ratio for CODcr is estimated to be a little lower. We are afraid, therefore, that it would be very difficult to reduce the 691mg/l CODcr contained in the raw effluent indicated in the proposal of the WWTP project to 100mg/l by treatment. When A2O system is applied and coagulant is added, the removal ratio will increase a little. Even in that case, the best result will be reduction from 500mg/l to 100mg/l COD. Consequently, textile dyeing factories may be obliged to install pretreatment equipment to remove some CODcr in advance. This point must be taken into account in studying the treatment processes of the WWTP.

3) Effluent of food and chemical factories of high CODcr concentration

As the effluent of food factories contains components which can be decomposed easily by biological treatment, it is estimated that its CODcr removal ratio will be higher than that of textile dyeing effluent. Its CODcr concentration is, however, very high, and the absolute volume is equal to that of textile dyeing effluent. This point must also be taken into account in studying the treatment processes of the WWTP.

Depending on the circumstances, it might be necessary to let the factories whose effluent contains a large quantity of CODcr apply preliminary treatment to reduce the volume of CODcr.

When the conceptual design of preliminary treatment equipment to reduce pollutant load was worked out for each factory, reduction in the volume of CODcr was estimated. Please make use of our data as references.

4. Measures Required of the Government

4.1 Fundamental Policy

Observation of regulatory standards is the first and minimum step we must take for the prevention of pollution, preservation of the environment, and minimization of the influence of business activities on the environment. For this purpose, four main pillars -framework, talent, technology, and funds-- must be set into balance.

Although standards for discharging industrial effluent to rivers and WWTP emission standards were both established in 1996, environmental pollution will keep progressing if enterprises fail to observe these standards and the government does not exercise proper management and instruction.

To propel preservation of the environment efficiently, it is essential not only to carry out personnel development on both the administration side and the factory side, but also to build up a financial incentive system in order to accelerate investment in environmental measures, and to encourage engineering companies to acquire the abilities to work as consultants to factories and design and install treatment equipment.

4.2 Personnel Development

To implement the measures to prevent water pollution, it is necessary to acquire a wide range of technologies and knowledge related to the mechanism of the generation of pollution, dispersion of pollutants, health damage, pollution-preventing measures, measuring methods, etc.

When experts with these technologies and knowledge are posted in the central government, local cities, and enterprises, environmental measures can be propelled efficiently.

To foster environmental experts as quickly as possible, it is important to establish an organization which handles the issues of the environment and personnel development exclusively under the leadership of the central government. Ideally, such an organization should have the following features:

1) Positioning

An organization under the direct control of the central government must take part in the organization, and the participation of persons from the private sector must be solicited in order to obtain wide-range cooperation.

2) Main function

① Promotion of environmental technology:

Offer training courses to disseminate knowledge of the mechanism of the generation of pollution, dispersion of pollutants, health damage, pollution-prevention measures, measuring methods, etc.

② Establishment of an expert qualification system:

Test those who have finished the above courses and qualify those who have passed the test as experts.

③ Production of texts on environmental technology:

Produce texts which contain all the knowledge required for experts, both for use in training courses and for distribution.

④ Propagation of the measures the government takes for the preservation of the environment

3) Funds for the establishment of the organization

Funds must be raised from far and wide; from the central government, local cities, industrial groups, enterprises, etc.

4) Management

In principle, the organization must be on a self-paying basis, but appropriation of national subsidies and membership fees from industrial groups for management must also be studied.

4.3 Incentive Systems for Investment in Environmental Measures

Enterprises regard the burden of the cost for environmental measures as negative investment which does not contribute to production.

The investment is, however, indispensable for the coexistence of the enterprises with society. Establishment of a taxation system and a financial incentive system which will accelerate the investment of enterprises in environmental measures is now required. The following systems are recommendable:

1) Tax reduction and exemption system for the installation of environment-preserving equipment

Establish and apply a cost depreciation period reduction system, and a fixed property taxes reduction and exemption system to the enterprises which have installed environment-preservation equipment in connection with wastewater treatment and rationalization of water use.

2) Low-interest rate financing system for investments in environment-preservation equipment

As environment-preservation equipment related with wastewater treatment exerts pressure on the finance of enterprises, governmental financial agencies are requested to establish a low-interest rate financing system or a system of grants-in-aid for paying interest to ease the pressure.

One possible option is the use of environmental taxes (for example, carbon taxes or taxation on the use of tap water and rivers, excess charges on sewage pollution, etc.) as the financial source for the above systems.

Appropriation of fines imposed on exceeding the standards for discharging effluent to public water bodies to finance the systems is inevitable for a certain period, but it must be noted that if such appropriation is continued as a permanent system, enterprises will feel unfairly treated and their will to invest in environmental measures may decrease.

4.4 Promotion of Engineering Companies

Slovenia appears to have a shortage of water-treatment engineering companies and the capacity of the existing companies has not been sufficiently developed due to the absence of any demand for wastewater-treatment technology in previous years.

Engineering companies earn money by offering professional knowledge to enterprises, and the enterprises can promote efficiency by acquiring technologies they presently lack. Engineering companies and enterprises are, so to speak, related like two wheels of a car.

Independent promotion of engineering companies requires much time and labor. To bring about an early promotion, it is advisable to pursue cooperation with foreign countries in the acquisition and propagation of technology.

VI. Current Condition and Model Systems of Factories and Economic Evaluation

VI. CURRENT CONDITION AND MODEL SYSTEMS OF FACTORIES AND ECONOMIC EVALUATION

1. General Summary

1.1 Outline

In Chapter I, the following items are described with regard to the model factory group (seven factories) , the secondary beneficiary factory group (seven factories) and the tertiary beneficiary factory group (six factories).

① Analysis (including water quality analysis) of and comment on the current condition of water supply and waste water
② Model system for water conservation and economic evaluation of model system
③ Model systems for waste water treatment and pretreatment and economic evaluation of model systems
④ Financial analysis on selected model factories

Financial analysis shall be carried out on three factories: M-1 (Svila), M-2 (Marles) and M-6 (Kosaki). These factories were selected because they are situated close to the river and the factories themselves requested selection.

In 1.-General Summary, the common items in water conservation, waste water treatment, pretreatment and the financial analysis are indicated.

In 2.-Design Conditions, design conditions that are common to each factory are indicated for especially important waste water treatment and pretreatment model systems.

In 3., 4. and 5., the above items (analysis of current condition of water supply and waste water; economic evaluation of water conservation model systems; economic evaluation of waste water treatment and pretreatment model systems, etc.) are indicated for all factories in the model factory group, the secondary beneficiary factory group and the tertiary beneficiary factory group.

Tables 1.1.1, 1.1.2 and 1.1.3 show lists of each of the factories in the model factory group, the secondary beneficiary factory group and the tertiary beneficiary factory group respectively.

Fig. 1.1.1 shows the locations of each of the factories.

• Reasoning behind selection of the target factories

As is shown in Table 1.1.4, seven target factories have been selected: one in the textile and dyeing sector, one in the furniture manufacturing sector, one in the machine sector and four in the foodstuffs sector. In consideration of the fact that the main industries in Maribor are textile and dyeing, foodstuffs and machines, factories possessing large water consumption volumes and waste water pollution loads were selected to represent these sectors.

The four factories in the foodstuffs sector were selected to represent the different areas of alcohol (beer, wine), meat products and dairy products. Thus, the seven selected factories can be said to be representative of industry in Maribor today.

The 13 factories in the secondary factory group and tertiary factory group break down into four in the textile and dyeing sector, five in the machine sector, two in the foodstuffs sector and two in the chemicals sector. These factories were selected for their large pollution loads, second only to the pollution loads of the model factories. Four factories were selected from the textile and dyeing sector because this is a high water-consuming industry and is a representative industry of Maribor.

The tertiary factory group was added during the survey stage in order to gain a better understanding of industrial waste water volumes and pollution loads over a wider range of factories. Factories (not included among the model factories and secondary factory group) with large pollution loads or water consumption levels were selected as tertiary factories.

The total 20 selected target factories are, as is described later, responsible for discharging approximately 80% of all the industrial waste water that is generated in Maribor.

Table 1.1.1 Outline of the Model Factories

No.	Name (Abbreviation)	Industry	Main Products: Products Quantity	Capital 1000SIT. Area m² & Employee	Water Source & Consumption m³/d	Waste Water is discharded to
M-1	SVILA TEKSTILNA TOVARNA, d.d. (SVILA)	Textile (Knittng)	Viscose 1000m/y Rayon 6,687 Polyester 330	Capital 2,142,875 Area 15,611 Employee 490	Well Water 1,587	Drava River
M-2	MARLES HOLDING, d.d. MARLES POHISTVO, d.o.o. (MARLES)	Furniture	Kitchien Element 96,552 Pieces/y	Capital 1,509,109 Area 20,000 Employee 482	Well Water 298	Drava Riyer
M-3	LIVARNA Maribor ARMAL (ARMAL)	Machine & Metal Processing	Pipe Fittings 184t/y Sanetary Fittis. 719t/y Heating Fittings 88t/y	Capital 182,287 Area 12,015 Employee 380	City Water 372	Public Sewerage
M-4	STAJERSKA PIVOVARNA, d.d. (PIVOVARNA)	Food (Brewery)	Beer 6,000 kl/y Soft Drinks 5,000 kl/y Juce 8,000 kl/y	Capital 130,000 Area 40,000 Employee 170	Well Water 411	Public Sewerage
M-5	VINAG VINARSTOV-SADJARTVO (VINAG)	Food (Wine Cellar)	Wine 5,000 kl/y	Capital Area Employee 400	City Water 71	Public Sewerage
M-6	KOSAKI TOVARNA MESNIH IZDELKOV (KOSAKI)	Food (Slaughter Hause)	Cows 11,500 head/y Pigs 43,000 head/y	Capital Area 22,534 Employee 100	City Water 365	Public Sewerage
M-7	MARIBORSKA MLEKARNA, d.o.o. MM MARIBORSKA MLEKARNA, d.o.o. (MLEKARNA)	Food (Dairy)	Milk 16,393 Ton/y Cheese 3,153 Ton/y Yogurt 1,508 Ton/y	Capital 808,790 Area 14,000 Employee 286	City Water 476	Public Sewerage

Table 1.1.2 Outline of the Secondary Beneficiary Factories

No.	Name (Abbreviation)	Industry	Main Products: Products / Quantity	Capital 1000SIT. Area m² & Employee	Water Source & Consumption m³/d	Waste Water is Discharged to
S-1	Tovarna Volnenih tkanin MERINKA, p. o. (TVT MERINKA) (MERINKA)	Textile (Dyeing)	Wool Fabric 650,000m/y Stoking 20,000,000 Pieces/y	Capital Area 33,430 Employee 613	Well Water 760 City Water 425 Total 1,185	Public Sewerage
S-2	Tekstilna Tovarna TABOR, d. o. o. (TABOR)	Textile (Dyeing)	Mixture Fabric 3,140,216 m²/y	Capital 1,005,895 Area Employee 400	Well Water 1,158 City Water 93 Total 1,251	Drava River
S-3	Mariborska tekstilna tovarna Melje, d. d. (MTT MELJE), d. d. Tovarna tkanin MELJE, d. o. o. (MTT)	Textile (Dyeing)	Cotton 7,140,000 m²/y Mixture Fabric 3,060,000 m²/y	Capital 1,369,568 Area Employee 750	Well Water 731 City Water 538 River Water 1707	Public Sewerage
S-4	Tovarna sukancev in trakov TSP, p. o. (TSP)	Textile (Dyeing)	Sewing Thread 182.3 Ton/y	Capital 637,588 Area 9,038 Employee 198	Well Water 29 City Water 36 River Wate 278	Public Sewerage
S-5	METALNA, STROJE-GRADNJA, KONSTRUKCI-JE MONTAZA IN STORI-TVE, d. d. (METALNA)	Machine & Metal Procss.	Power Plant, Cranes, Pro-cess Equipments, etc. Steel Handled 1,000t/m	Capital Area 300,000 Employee 2,100	City Water 212	Public Sewerage
S-6	MERKATOR-SLOSAD d. d. (SLOSAD)	Food (Drink)	Concentrated Fruit Juice 1,800 Ton/y Cherries in Alcohole 400	Capital Area 23,000 Employee 90	Well Water 15 City Water 20 Total 35	River
S-7	INTES MLIN TESTENINE (INTES)	Food (Miller)	Wheat Flour 26,399 Ton/y Pasta 3,565 Ton/y	Capital Area Employee 180	City Water 162	Public Sewerage

Table 1.1.3 Outline of the Tertiary Beneficiary Factories (1/2)

No.	Name (Abbreviation)	Industry	Main Products Products / Quantity	Capital 1000SIT, Area m² & Employee	Water Source & Consumption m³/d	Waste Water is Discharged to
A-1	TVT-Tovarna Vozil in toplotne tehnike-Boris Kidric-TIRNA VOZILA (TVT)	Machine & Metal Proces-sing	Rolling Stocks Reparing Diesel Locomotives 5 Diesel Coach 20-30 Unit Electric Coach 10 Unit	Capital 448,000 Area 37,000 Employee 553	Well City 517 River 103 Total 620	Sewerage
A-2	ELEKTROKOVINA-SVETILA (SVETILKE)	Machine & Metal Proces-sing	Lighting Tool Units Interal Use 643,145 Industrial Use 282,316 Outdoor Use 9,450	Capital 1,000,000 Area Employee 266	Well City 130 River Total	Sewerage
A-3	PRIMAT-Tovarna kovinske opreme (PRIMAT)	Machine & Metal Proces-sing	Safty Safe 1,220 t Metal Wardrobe 727 t Annual Shipment 884,567 1,000 SIT	Capital Area 17,366 Employee 220	Well City 109 River Total	Sewerage
A-4	ELEKTROKOVINA Elektromotorji (ELKO)	Machine & Metal Proces-sing	Pumps 10,484 Sigle Phase Motor 8,246 Three Phase Motor 38,683 Annual Shipment 920 MSIT	Capital 882,795 Area 49,421 Employee 252	Well City 155 River Total	Sewerage

Table 1.1.3 Outline of the Tertiary Beneficiary Factories (2/2)

No.	Name (Abbreviation)	Industry	Main Products Products Quantity	Capital 1000SIT, Area m² & Employee	Water Source & Consumption m³/d	Waste Water is Discharged to
A-5	HENKEL ZLATOROG (HENKEL)	Chemical Industry	Washing Powder 16,000 t Cosmetics 6,640 t Annual Shipment 8,317,517 1,000 SIT	Capital 5,817,130 Area 28,200 Employee 575	Well City 339 River 312 Total 651	Sewerage
A-6	SWATY Tovarna umetnih brusov (SWATY)	Chemical Industry	Grinding Wheels. Vitri- fied Bond 667t, Resin B. 465t,Reinforced R.B.1 Kt Diamond & CBN 44 KCarats	Capital 2,124,000 Area 39,779 Employee 451	Well City 149 River Total	Sewerage

Table 1.1.4 Each Factories VS Classified Industry

	Machine & Metal Processing	Food	Textile	Furniture	Chemical Industry	Total
Model Factories	1	4	1	1	—	7
Secondary Beneficiary Factories	1	2	4		—	7
Tertiary Beneficiary Factories	4	—	—	—	2	6
Total	6	6	5	1	2	20

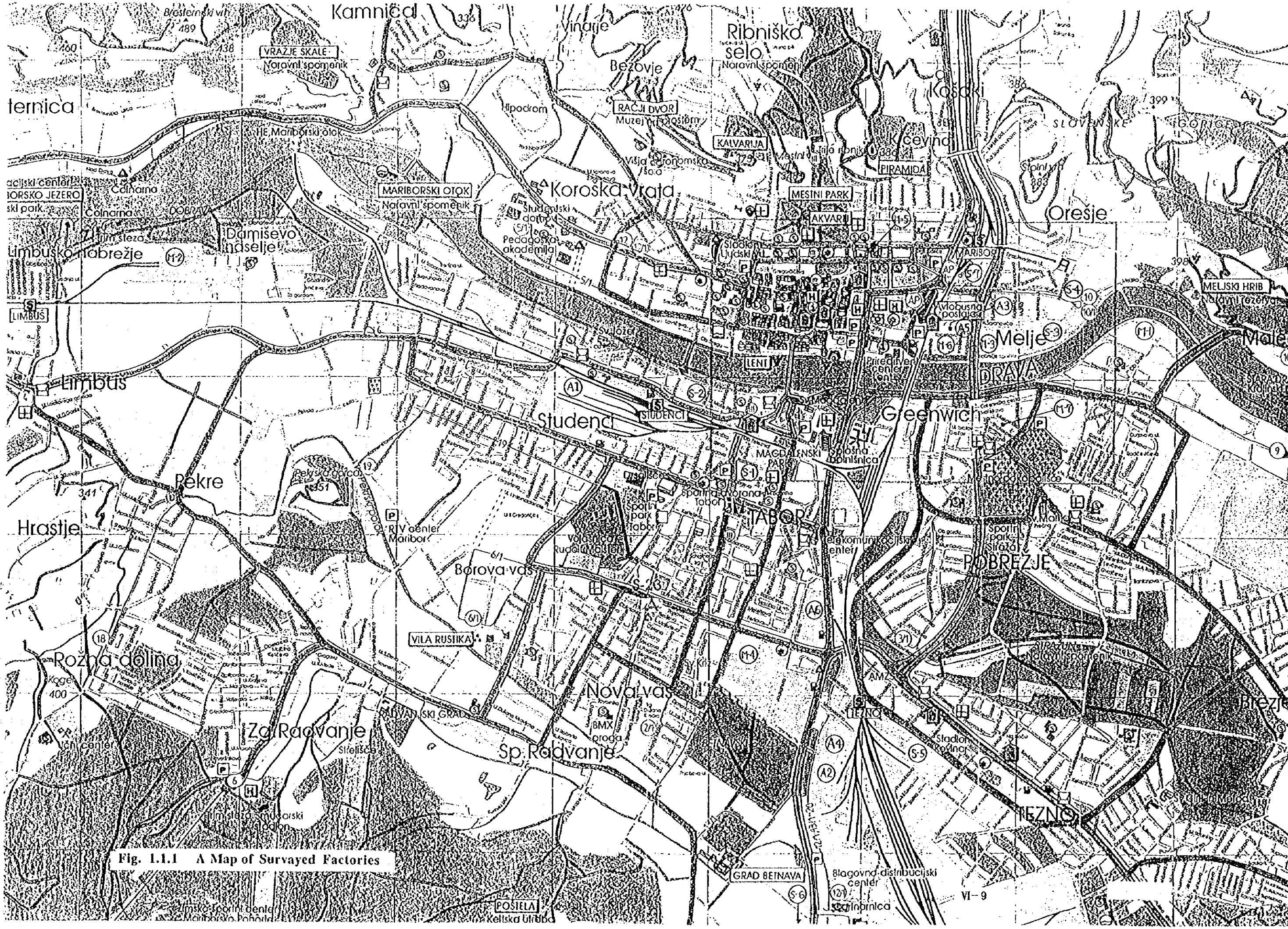


Fig. 1.1.1 A Map of Survayed Factories

1.2 Water Conservation

As described in the analysis of individual factories, the control of water consumption at the subject factories is far from efficient. Many of the factories do not measure the total water consumption volume. Given this situation, It is almost meaningless to examine water conservation. The first step towards carrying out water conservation is to conduct close control of the water supply.

Feasible ways of water conservation are examined here, assuming that the water consumption level indicated in the questionnaire is correct, in order to provide examples of how a water conservation plan can be advanced.

The results of a questionnaire survey and visiting survey are used to establish and analyze the present conditions of water consumption, followed by examination of the present conditions of water conservation efforts. A water conservation plan can then be formulated based on the analysis and examination results. A water conservation plan has the following structure.

① Outline of plan
② Specifications of equipment
③ Rough estimation of required cost
④ Technical comment
⑤ Economic evaluation

The cost consists of the equipment cost and operation cost and is accounted for in local currency (SIT). The figures given are fairly rough estimates as they are calculated to roughly examine the relative advantages of conservation spending, i.e. conservation cost, vis-a-vis the current water supply and drainage cost. When water conservation is, therefore, really on the agenda, more detailed examination, planning and estimation are required.

The technical comment mainly means examination of the suitability of the preconditions for the water conservation plan.

In the economic evaluation, the cost of water conservation is compared to the cost (water supply and drainage expenses, charges and taxes, etc.) without water conservation to determine whether or not conservation is economically advantageous.

Not all of the water conservation plan described here are economically advantageous but are included as conservation examples. Finally, changes of the total water consumption volume and unit consumption of water are given along with a general review of the water conservation if the presentation of such figures is deemed necessary.

1.3 Pretreatment and Waste Water Treatment

1.3.1 Pretreatment

1) Pretreatment that satisfies WWTP discharge standards

A conceptual design was carried out at each of the model factories to determine the kind of treatment systems the factories would need to install if they were to follow the Slovenia national factory waste water discharge standards established in 1996. Simple treatment systems were proposed for each of the secondary and tertiary beneficiary factories without carrying out conceptual design.

2) Pretreatment for reduction of the pollution l oad

Because the current WWTP discharge standards contain hardly any regulations on pollutants other than heavy metals, there is a risk that operation of the WWTP may be harmed in future if the factories continue discharging in the way they do now. Thus, it is necessary for the factories to install appropriate pretreatment systems in order to reduce pollution loads prior to discharge.
For this reason, except for a few factories not requiring consideration, conceptual design was carried out on a number of pretreatment cases set according to pollution load reduction volumes in each of the factories within the model factory group, the secondary beneficiary factory group and the tertiary beneficiary factory group.

Pretreatment systems, as a rule, were designed based around physical and chemical treatment methods (biological treatment was considered in unavoidable cases), and the equipment and running costs in each case were calculated. Here, care was taken to reduce the treatment cost as much as possible.

The conceptual design was carried out in accordance with the design conditions described later in section 2. The design procedure is the same as that used in the design of the waste water treatment systems at each model factory, however, regarding the pretreatment system cost, because this was estimated to grasp the general costs of various equipment combinations, estimate values are shown for the equipment cost and the treatment cost.

1.3.2 Waste Water Treatment

In each of the model factories, conceptual design was carried out on waste water treatment facilities that would satisfy standard values in the case of waste water discharge into rivers. Regarding the secondary beneficiary factories, simple treatment systems were proposed without going through the conceptual design process.

1.4 Assumptions For Financial Analysis

Regarding three factories such as Svila, Marles and Kosaki among seven Model Factories, comparative analysis for waste water treatment is conducted for two cases, the discharge to sewerage and the discharge to river.

As Maribor city plans to start operation of waste water treatment plant (WWTP) in 2005, the waste water treatment system is assumed to be constructed in 2004 and become operational in 2005.

In this section, common assumptions applicable to the three factories are described.

1.4.1 Capital Requirements

1) Basic assumptions

(1) Currency and exchange rate

The Deutsche Mark is used as the basic currency in this analysis and other currencies are converted into Deutsche Mark at the following exchange rate effective on June 19, 1996 indicated by the authorities in Maribor in the second on site survey.

1 Deutsche Mark (DEM) = 89.89 Slovenian Tolar (SIT)

(2) Pricing level

All the costs and prices as used in the analysis are fixed at the price prevailing in June, 1996 as said above, and no price escalation after the date is assumed.

(3) Project life

The project life for the analysis is sixteen years consisting of one year for construction and fifteen years of operation.

2) Capital requirements

In addition to the plant construction cost estimated based on the conceptual design in the next section, other costs and expenses forming part of the capital requirements are described.

(1) Land cost

Each factory has an adequate site required for the plant construction, and no land cost is appropriated. In addition, no site development cost is also appropriated because of minimal amount.

(2) Physical contingency

This is the cost to secure the unexpected cost exceeding the capital requirement which may arise due to unforeseeable factors or imperfect estimation at the time of this calculation.

At the time of the third site survey, this survey mission entrusted local engineering company to cross-check the cost data which was estimated by the mission considering local conditions, consequently, it was ascertained that there was no difference on estimation.

From the above reason, no physical contingency is appropriated at this stage.

(3) Price contingency

This is the cost to meet the increase in price which may arise in the future, but this cost is not considered since the analysis is made on the basis of the fixed price as mentioned in 1.4.1 1), (2).

(4) Import duty

Based on the discussion with the authorities in Maribor, import duty on imported equipment and machinery is not considered at this stage.

(5) Sales tax

Sales tax of 5% is imposed on both foreign and domestic equipment and machinery, and services.

(6) Pre-operating expenses

The expenses include the costs incurred in the tasks for project preparation directly undertaken by the implementing body.

The expenses during the test run period are included in the plant construction cost, and the initial charges of chemicals and agents are regarded to be included in the above expenses.

(7) Interest during construction

The source of funds for the project has not yet determined. However, in accordance with the assumption concerning the financing plan mentioned in paragraph 1.4.2, it is assumed that loan will be available from a domestic financial institution. The loan is assumed to be incurred on the average during the construction period.

(8) Initial working capital

No initial working capital is appropriated because of minimal amount.

(9) Capital requirements

The capital requirements represent the sum of the above-mentioned costs and expenses.

1.4.2 Financing Plan

It is assumed that the capital requirements estimated in paragraph 1.4.1 for the construction of waste water treatment system will be provided with the following condition.

1) Debt-equity ratio

The debt-equity ratio on each factory will be separately established.

2) Financing conditions on long-term loan

For the purpose of the study, it is assumed that domestic loan will be financed under the following conditions.

(1) Interest: Interest rate on each factory is separately established on a DEM base.
(2) Grace period: Construction period
(3) Repayment: Equal annual installments for 10 years after grace period

3) Other condition

If a cash shortage occurs during the operation period, this is generally to be met by short-term loan, however, the project is assumed to be compensated by the overall profit of the factory. Accordingly, interest on short-term loan is not considered in the waste water treatment cost.

1.4.3 Waste Water Treatment Cost

1) Variable cost

Variable costs include chemicals and agents, electricity, water and sludge disposal. Regarding supplies and utilities required newly for waste water treatment, the prices shown in section 2.5 to 2.6 are used.

2) Fixed cost

Fixed cost include personnel cost, maintenance cost, sewage charge, pollution tax, depreciation and amortization, and interest on long-term loan.

(1) Personnel cost

Personnel cost on each factory will be separately established.

(2) Maintenance cost

Maintenance cost is assumed to be 5% of the plant construction cost excluding civil and building.

(3) Sewage charge

In case of discharge to sewerage, with the implementation of WWTP, the sewage charge is imposed at 160 SIT/m^3(1.78 DEM/m^3), so that financial

financial analysis is performed. The charge is established taking account of the costs of the construction, operation and maintenance in WWTP. It is a tentative price for the analysis at this time and would be changed in future if many parameters are changed.

(4) Pollution tax

Pollution tax is imposed at state and local level. The local tax is imposed at 40.75 SIT/m3(0.45 DEM/m3) for all the water use.

On the other hand, the state tax is not paid if effluents are treated below standard value. In the analysis, no state tax is assumed in the cases of discharge into the river and sewerage system, however, the government charge for all the water use is imposed at the range of 3.2 to 4.8 SIT/m3.

(5) Depreciation and amortization

The plant construction cost is depreciated using the following method.

Equipment and machinery	:	15 years straight line method
Civil and building	:	40 years straight line method

Furthermore, interest during construction is amortized over 15 years under the straight line method.

(6) Other treatment cost

The interest on long-term loan mentioned in paragraph 1.4.2 is covered by this cost. However, in view of the nature of the project, the following costs are not considered in the analysis.

Interest on short-term loan
Income tax

1.4.4 Waste Water Treatment Fee

In the analysis, the unit cost per volume of waste water treated as of 2010 when long-term loan is half repaid is assumed to be equivalent to a waste water treatment fee throughout the operation period. The above unit cost covers variable cost, direct fixed cost, depreciation and amortization as well as half of interest on long-term loan.

1.4.5 Method on Financial Analysis

In accordance with the assumptions mentioned heretofore, the following financial statements required for the financial analysis are prepared.

Waste water treatment cost statements
Funds flow statements including Financial Internal Rate of Return (FIRR) calculation

Based on the results of the above financial statements, financial analysis is performed using the following method.

1) The economical advantages in the cases between the discharge to sewerage and discharge to river are based on the comparison of waste water treatment cost.

For the comparative analysis purpose, the value as of 2010 is regarded as the average cost of the project.

The standard cost method used by the analysis assumes the average cost of the project to be close to the average of the costs to be obtained from year-by-year cost calculations during the operation period. Generally, it can be effectively used for the selection of a project scheme and cost analysis focusing on composition of cost elements.

In relation to the above, the following assumptions are established on the items to be taken account of in the initial stage of operation.

(1) The treatment volume from the first year of operation shall be equal to the existing waste water volume.
(2) The factories concerned shall acquire the waste water treatment technology prior to the introduction of the model systems.
(3) The frequency of parts replacement for the maintenance of equipment is low in the initial operating stage but increases in line with the deterioration of equipment over time. In this analysis, taking into account costs in similar projects, repair costs shall be counted as average values throughout the period of operation.

2) The FIRR shall be used rather than profitability, in order to gauge the impact of fluctuations in major factors.

In the analysis, the plant construction cost and chemicals are taken up as the factors.

FIRR is one of the effective methods to assess profitability on investment made by a project. In the analysis, however, the waste water treatment fee as a major revenue source of the project is determined under rough assumptions, making the FIRR obtained and its comparison less meaningful. Nevertheless, since major elements of the project subject to this analysis are assumed to incur during different periods, the degree of change in FRR can be compared on an objective basis.

3) Debt service ratio (DSR) on long-term loan is used as a method for analyzing the soundness on funds flow.

DSR is an indicator to measure the soundness for financial position, and is calculated by the following formula.

$$DSR = \frac{\text{Profit after tax} + \begin{array}{c}\text{Depreciation}\\ \text{\& Amortization}\end{array} + \begin{array}{c}\text{Interest on}\\ \text{long-term loan}\end{array}}{\begin{array}{c}\text{Repayment on}\\ \text{long-term loan}\end{array} + \begin{array}{c}\text{Interest on}\\ \text{long-term loan}\end{array}}$$

It is a general consensus that DSR is a safety value of 1.15 or higher at each year.

In the analysis, the value as of 2010 is regarded as an average of the project as same in item 1), while DSR is used in order to understand the impact on funds flow, especially in case of the reduction of cost.

1.5 Preconditions for Economic Evaluation

Except for the three factories on which financial analysis was carried out (Svila, Marles, Kosaki), simple economic evaluation for the case of equipment installation was carried out on the other factories based on the following conditions.

(1)	Depreciation period	: equipment	15 years
		: building, civil engineering	40 years
(2)	Interest	: 10%/annum	
(3)	Depreciation method	: uniform depreciation	

2. Model Factories

2.1 M-1 SVILA TEKSTILNA TOVARNA d.d.

2.1.1 Factory Outline

Capital	: 2,142,875 Thousand SIT (1995)
Total factory area	: 15,611m^2
Number of employees	: 490
Working conditions	: 7.7 hr/day (paying 8 hr), 252 days/year
Products	: Rayon textile, Polyester textile, Polyamide textile, Mixed textile
Annual production	: 6,686,805m, 329,578m, 481,236m, 119,411m
Annual sales	: 2,404,476 Thousand SIT

2.1.2 Water Conservation

(1) Recycling of indirect cooling water of oil cooler for turbine generator

(a) Plan outline

At present, the indirect water of the oil cooler is not recycled. Water temperature at the outlet is about 20℃. Waste water is to be recycled.

(b) Basic condition

		Present	plan
Water quantity (m^3/d)		64	64
Operation time (h/d)		24	12
Water quantity (m^3/h)		2.53	5.0
Water temperature ℃	inlet	12	25
	outlet	20	35
Recovery rate %			95
Reduced water (m^3/d)			60.8
Cooling load (Kcal/h)		20,270	50,000
Annual operating days : 208			

(c) Cost estimates

- Facility cost 1,750 (thousand SIT)
- Operation costs 66.4 (thousand SIT/y)
- Necessary costs 29.8 (SIT/m^3)

(2) Conservation of air conditioning water

The amount of water for the air conditioner is not specifically controled. It is probably used more than necessary. Water quantity can be controled with the installation of a flow controller.

- Facility cost 500 (thousand SIT)
- Operation costs 0
- Necessary costs 7.5 (SIT/m^3)

(3) Reclamation of waste water

i. Selection of source water

According to Basic Guideline ①, waste water of a color which is difficult to remove, should not be used. The following may be considered for source water :

ii. Water quality of source water and reclaimed water

The water quality of source water should be determined based on the quality and the quantity of effluent and its hourly fluctuations with regard to the desired quality of reclaimed water.

The desired quality of reclaimed water depends how it is to be used (e.g., rinsing water of dyeing process). The quality required for some purposes is not always known, however. Then it is necessary to by experiment to determine the required quality.

iii. Treatment capacity and reclamation process

Water source→pH control→Two stage biological treatment (Trickling filter, Submerged bio-filter)→Coagulation and sand filtration→ Activated carbon absorption→Recovered water

(c) Estimated costs

- Facility cost 160,000 (thousand SIT)
- Operation costs 8,669 (thousand SIT/y)
- Necessary costs 234.8 (SIT/m^3)

(4) Summary of water conservation plan

No.	Contents of Water Conservation Plan	Saving amount m^3/day	Cost per recovered SIT/m^3
1	Recycling of indirect cooling water for oil cooler by cooling tower	60.8	29.8
2	Saving of air conditioning water by flow regulator	32	7.5
3	Reclamation of dyeing waste water by high degree process	500	234.8
	Total	592.8	201.4

2.1.3 Pre-treatment and Waste Water Treatment

1) Waste water treatment

In the event of direct discharge to the river, the color, NH4-N and P must be strictly regulated.

Waste water treatment flow

(waste water)→Collecting pit (present)→Stabilization tank→Neutralization tank → Aeration tank → 1st Sedimentation tank → Aeration tank → 2nd Sedimentation tank→Anaerobic tank→Aeration tank→Coagulation tank→3rd Sedimentation tank→Sand filter→Ozonizing tube→Activated carbon adsorber →Treated water tank→Discharge to the river

(coagulated sludge) →Sludge storage tank→Sludge dehydrator→Cake hopper→Truck

Reasons for selection of waste water system

① A separate emission standard is established for the textile factory.
② In cases of direct discharge to the river, the emission standard of the textile industry is particularly strict regarding the color and P. Ozone treatment and activated carbon absorption are then needed so that BOD, COD, SS, and oil will clear the standard.

③ Chemical coagulation separation may be considered as a candidate of the primary treatment. But since the BOD standard is 30mg/l, biological treatment is more appropriate. N-NH_3 is easily decreased by the standard activated sludge treatment, which requires anti-forming facility, since bubbles are produced by the influence of the active surface agent

④ P is removed by coagulation sedimentation. Sand filtration is essential to post treatment.

⑤ Activated carbon adsorption works better than the ozone process for the completion of bleaching. The ozone process precedes the activated carbon adsorption, in order to lower the adsorption load of activated carbon. At the stage when the color is thick, the ozone process works well. Although it is possible for the ozone process alone to clear the color regulation, activated carbon adsorption is used for the completion of bleaching. Since the function of activated carbon adsorption is not to lower COD but to enhance the bleaching, it should be kept to a minimum.

2) Pretreatment that satisfy WWTP discharge standards, and waste water treatment

Discharge into the sewerage system requires a pretreatment system, since the pH of dyeing waste water sometimes exceeds the regulation value. Equip the existing water collecting pit with neutralization facilities of pH controlling, chemical injection, stirring, etc., as a pretreatment system. Other types of waste water may be discharged without treatment.

The following compares two cases with regard to dyeing waste water :

Case A.

Equip the existing water pit with neutralization facilities of pH controlling, chemical injection, stirring, etc. The advantage is the low cost of the facility. Chemical costs, chemical replenishment work, etc. are necessary.

Case B.

Install a stabilization tank equivalent to 1/3 day capacity. The advantage is that neutralization chemicals are not needed.

3) Pretreatment for reduction of the pollution load

① Case 1: pH adjustment and coagulating sedimentation treatment of total waste water; dewatering and external disposal of sludge

In this case, the existing facilities from the water collecting pipes to the water collection pit can be used as they are. Because all the waste water is treated, the scale of facilities is large and cost of chemicals high. The color can be reduced to extremely low levels. Regarding the effect in terms of reduced sewage charge due to the reduction in pollution load, although the COD Mn will fall significantly, because the reduction in COD Cr will be small and the BOD and COD values are not very high to start with, it is estimated that the saving in sewage charges gained from reduction of the pollution load would not be very high and would not be enough to cover the pretreatment cost.

② Case 2: coagulating sedimentation treatment of thick colored waste water only; dewatering and external disposal of sludge

In this case, new facilities for treating only the concentrated waste water need to be installed in addition to the existing ones from the water collecting pipes to the water collecting pit. These installation works would prove very difficult in reality. However, once those works are completed, because the waste water volumes to be treated are small, equipment and running costs could be significantly reduced.

Furthermore, color could be efficiently removed from the waste water and, due to the dilution effect of other water, it is estimated that color could be reduced to sufficiently low levels to enable the treated water to satisfy river discharge standards.

③ Case 3: coagulation treatment of thick colored waste water only, followed by direct discharge

In this case, there is no separation and removal of floc that adsorbs the waste water color (Case 2), but the treated water is discharged as it comes out of the system. Although the SS value increases, the color discharge standards are satisfied and the method is the least expensive of the three.

Table 2.1.1 Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quan-tity m3/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	SS mg/L ( )	color (1/m)	T-N mg/L (kg/d)	T-P mg/L (kg/d)
*1 (for design) Raw total wastewater	1,500	500 (750)	300 (450)	40 (60)	30	20 (30)	10 (15)
*2 Case-1 Treated total wastewater	1,500	300 (450)	200 (300)	30 (45)	3	20 (30)	1 (1.5)
*3 Thick wastewater (Raw water)	400	800 (320)	400 (160)	100 (40)	60	20 (8)	10 (4)
*4 CASE-2 Treated thick wastewater	400	400 (160)	200 (80)	30 (12)	3	20 (8)	1 (<1)
*5 CASE-3 Treated thick wastewater	400	400 (288)	200 (80)	300 (120	3	20 (8)	1 (<1)
*6 Case-3' Mixed total discharge	1,500 Design base	200 (300)	100 (150)	100 (150	2	20 (30)	1 (2)

Notes) * 1 : quality of total waste water (design value of model system)
* 2 Case 1 : case where total waste water undergoes pretreatment
* 3 water quality when colored waste water from the dyeing process only is separated
* 4 Case 2 : case where colored waste water only undergoes pretreatment
* 5 Case 3 : case where colored waste water only undergoes pretreatment and there is no floc separation
* 6 : total waste water when treated colored waste water is mixed with other waste water

Table 2.1.2 Equipment and Running Costs of the Treatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³	Running Cost SIT/m³	Total treatment cost SIT/m³
CASE-1	154,400,000	40	107	147
CASE-2	55,000,000	15	88	103
CASE-3	43,200,000	12	70	82
Discharge to River	506,117,000	144	404	548

Case 1: case where total waste water undergoes pretreatment
Case 2: case where colored waste water only undergoes pretreatment
Case 3: case where colored waste water only undergoes pretreatment and there is no floc separation

4) Conclusion

Rather than treating all the waste water, it is more economic to collect only the concentrated waste water and treat it by coagulation. If it is possible to discharge the treated water without separating and removing floc which adsorbs the colored matter, the system can be made even more economic.

2.1.4 Financial Analysis

Technical comment was carried out on the case of river discharge (Case 1) and two cases of sewerage system discharge (Cases 2-A and 2-B), and financial analysis was carried out based on the results of this.

In addition to the aforementioned plant construction cost, the capital requirement based on the preconditions stated in 1.4.1 will come to 6,267,000 DEM (Case 1), 168,000 DEM (Case 2-A) and 413,000 DEM (Case 2-B). It is assumed that all the capital requirement are acquired through a long-term loan and that the rate of interest is 12%.

In accordance with said preconditions, breakdowns of the waste water treatment cost and funds flow statements for the basic cases were prepared, and those results are outlined below.

Regarding the waste water treatment cost, the cost including depreciation and interest payments in the sewerage system discharge case is almost the same as now (2.4 DEM/m^3) and 4.4 DEM/m^3 cheaper than the cost in the case of direct river discharge (6.8 DEM/m^3).

Regarding funds flow, the debt service ratio on long-term loan (DSR) is less than 1.00 in all the cases, indicating that there is a shortage of cash to repay the loan.

Next, sensitivity analysis was carried out to gauge the effect of fluctuations in the cost of plant construction and chemicals, the two major cost elements in the project. It was found that in Case 1, there is a higher sensitivity to the chemicals cost rather than plant construction cost, whereas the opposite was found to be true in Case 2-A.

Furthermore, a case study was carried out on the case where it is assumed that a low interest loan can be obtained. In all the cases, if it is assumed that an interest rate of 6% can be obtained, it is possible to expect an effect that is equivalent to a 20% reduction in the plant construction cost.

As a result of the above analysis, it was found that the case of sewerage system discharge is more economically advantageous than the case of direct river discharge.

Regarding sewerage system discharge, two technically different cases were presented. As the waste water treatment cost in each case was found to be the same, the decision on which system to adopt shall be left to the factory.

In recent years, textile exports have dropped and the financial standing of the factory has become difficult. In these circumstances, it is thought that being able to utilize low interest loans in the future would help ease the burden placed on the factory's funds.

2.2 M-2 MARLES HOLDING, d.d. MARLES POHISTVO d.o.o.

2.2.1 Factory Outline

(1) Outline

Marles Holding Maribor d.o.o. is a group company in the housing sector which carries out all processes from general timber sawing through to veneer manufacture, wooden furniture making and wooden building construction. Within the group, Marles Zaga d.o.o. carries out timber manufacture, Marles Hise d.o.o. is in charge of wooden building construction, Marles Pohistvo d.o.o. manufactures wooden furniture and Marles Storitive provides services to the overall group.
30% of the painted furniture (tables, chairs, shelves, kitchen tops, etc.) produced at Marles Pohistvo d.o.o. is exported to countries such as Austria, and so on.

(2) Scale

Capital	:	1,509109, SIT
Total factory area	:	20,000m^2
Number of employees	:	482
Products	:	Wooden Furniture
Annual production	:	96,552 台
Working conditions	:	8 hr/day (paying 8 hr), 239 days/year

2.2.2 Water Conservation

(1) Implementation of water usage control

In the current situation, the amount of water pumped from the well is not measured and there is practically no control of water usage at all. A flow meter must first be fitted in the well and the control of water usage must be implemented throughout the whole factory. These are the basic conditions for water conservation.

(2) Recycling of indirect cooling water for air compressor

(a) Outline of plan

The indirect cooling water used in the compressor is currently discharged after being used only once. The plan is to recycle this waste water for further use by means of a cooling tower.

As the water temperature at the outlet is unknown, it has been assumed as 20℃. Moreover, the plan here was compiled assuming the amount of water entered on the questionnaire to be correct.

(b) Basic conditions

The basic conditions are indicated in Table 3.2.6.

		Present	plan
Water quantity (m^3/d)		45	45
Operation time (h/d)		8	8
Water quantity (m^3/h)		5.6	5.6
Water temperature ℃	inlet	15	25
	outlet	25	35
Recovery rate %			95
Saving quantity (m^3/d)			42.8
Cooling load (Kcal/h)		56,000	56,000
Annual operating days :		239	239

(c) Rough estimation of required cost

- Equipment cost 1,883 (thousand SIT)
- Operating cost 89.1(thousand SIT/y)
- Required cost 39.5(SIT.m^3)

(d) Economic evaluation

① In the current situation, because 62.9 SIT/m^3 is being spent on water usage and waste water matters, the use of water recycling is clearly advantageous. Moreover, according to state and municipal regulations, this cost should come to approximately 57 SIT/m^3.

② In the future case where waste water comes to be discharged into the sewerage system, an additional sewage charge of at least 100 SIT/m^3 will come to be charged. Thus, the use of water recycling would become even more advantageous.

2.2.3 Waste Water Treatment and Pretreatment

1) waste water treatment for river discharge

(1) Treatment system

After treating washing waste water from the painting booths and gluing machines by coagulating sedimentation, the treated water is mixed with domestic waste water and regenerated waste water from the softener and is treated further by contact aeration. Coagulating sedimentation is again carried out and the treated water is mixed with cooling water from the compressors and boiler water and finally discharged.

(2) Waste water treatment cost

The treatment cost per 1 m^3 of waste water is 915 SIT/m^3.
The breakdown of this unit treatment cost is shown in Table 2.2.1.
Therefore, the treatment cost per 1m^3 of all of the waste water is as follows :

$$(①+②+③+④) \div (304\ m^3/day \times 239\ days/year) = 238\ SIT/m^3$$

Table 2.2.1 Classification of the Treatment Cost per 1m³ of Waste Water

Items		Contents	Cost (SIT/year)
Depreciation period	Equipment	62,779,000 SIT ÷ 15 years	① 4,185,267 SIT/year
	Buildings, Civil works	30,000,000 SIT ÷ 40years	② 750,000 SIT/year
Rate of interest	92,779,000 x 0.05		③ 4,638,950 SIT/year
Running cost			④ 7,699,000 SIT/year
(① + ② + ③ + ④) ÷ 18,881			915 SIT/m³

2) Pretreatment that satisfy WWTP discharge standards, and waste water treatment

(1) Treatment system

Treatment of washing waste water from the painting booths and gluing machines by coagulating sedimentation is carried out. (Case-1)

(2) Waste water treatment cost

The treatment cost per 1 m^3 of waste water is 2,055 SIT/m^3.
The breakdown of this unit treatment cost is shown in Table 3.2.17.
Therefore, the cost of treating one cubic meter of all of the waste water is as follows.

$$(①+②+③+④) \div (304\ m^3/day \times 239\ days/year) + 176.56\ SIT/m^3 = 240\ SIT/m^3$$

Table 2.2.2 Classification of the Treatment Cost per 1m³ of Waste Water

Items	Contents		Cost (SIT/year)
Depreciation period	Equipment	16,155,000 SIT ÷ 15 years	① 1,077,000 SIT/year
	Buildings, Civil works	7,800,000 SIT ÷ 40years	② 195,000 SIT/year
Rate of interest	23,955,000 x 0.05		③ 1,197,750 SIT/year
Running cost			④ 2,108,000 SIT/year
(① + ② + ③ + ④) ÷ 2,227.48			2,055 SIT/m^3

3) Pretreatment for reduction of thepollution load

(1) Treatment system

After treating washing waste water from the painting booths and gluing machines by coagulating sedimentation, the treated water is mixed with domestic waste water and regenerated waste water from the softener and is treated further by contact aeration. (Case 2)

(2) Quality and pollution load of the waste water

The quality, volumes and pollution loads of waste water and treated water are shown in Table 2.2.3.

(3) Equipment cost and treatment cost

The equipment cost and treatment cost in Case 1 and Case 2 are shown in Table 2.2.4.

Table 2.2.3 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	Quantity m³/d	pH	CODcr mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Booth & Gluing	Raw Waste Water	1.32	7	10,600 (14.0)	2,880 (3.80)	5,150 (6.80)	735 (0.97)	2.7 (0.004)
	Case-1			5,300 (7.00)	2,010 (2.65)	30 (0.04)	735 (0.97)	2.0 (0.003)
	Case-2			120 (0.16)	25 (0.03)	30 (0.04)	10 (0.01)	6.2 (0.008)
Domestic	Raw Waste Water	70	7	400 (28.0)	200 (14.0)	50 (3.5)	40 (2.8)	7 (0.49)
	Case-2			120 (8.4)	25 (1.75)	30 (2.1)	10 (0.7)	6.2 (0.43)
Compressor	Raw Water	45		– ( )	– ( )	– ( )	– ( )	– ( )
Boiler	Raw Water	182		– ( )	– ( )	– ( )	– ( )	– ( )
Total Waste Water	Raw Waste Water	298	7	141 (42.0)	60 (17.8)	35 (10.3)	13 (3.8)	1.5 (0.46)
	Case-1			117 (35.0)	56 (16.7)	22 (6.7)	12 (3.7)	1.5 (0.43)
	Case-2			28 (8.51)	1 (0.30)	6 (1.82)	2 (0.61)	1.0 (0.30)
	Discharge to River			28 (8.51)	1 (0.30)	6 (1.82)	2 (0.61)	1.0 (0.30)

Table 2.2.4 Equipment and Running Costs of the Treatment System

	Equipment Cost SIT	Depreciation & Interest SIT/m³ ①	Running Cost SIT/m³ ②	Total Treatment Cost SIT/m³ ①+②
Case-1	23,955,000	34	29	63
Case-2	44,000,000	96	78	174
Dicharge to Rever (Design Base)	92,779,000	132	106	238

4) Conclusion

If water is discharged to the WWTP, it will be necessary to add 176.56 SIT/m^3 to the waste water treatment cost shown in Table 3.2.3. Thus, the least expensive method is discharge into the river.

However, the treated waste water in the case of river discharge only satisfies standards because it is diluted with boiler blow water and compressor cooling water. In the future, it is foreseen that, due to developments in manufacturing technology, changes in the times and demands from customers, etc., the facilities and raw materials used in production will change. Moreover, if water conservation advances further, the volumes of such diluting water from the boiler and compressors will fall. If such developments should occur in the future, it will become necessary to make improvements to the waste water treatment system for discharging into the river.

In view of the above, it is considered that discharging waste water to the WWTP upon first carrying out pretreatment by coagulation is the most advisable measure at the current time. If, however, WWTP discharge standards are reviewed or a charge system established according to pollution loads is adopted in future, it may become necessary to consider the next level of pretreatment, or, in the event of much harsher standards being laid down, the introduction of river discharge.

2.2.4 Financial Analysis

Financial analysis was carried out on the case of river discharge (Case 1) and the case of sewerage system discharge (Case 2).
In addition to the aforementioned plant construction cost, the capital requirement based on the preconditions stated in 1.4.1 will come to 1,111,000 DEM (Case 1) and 284,000 DEM (Case 2). It is assumed that 50% of the capital requirement will be obtained from self capital and that the remainder are acquired through a long-term loan where the rate of interest is 10%.
In accordance with said preconditions, breakdowns of the waste water treatment cost and funds flow statements for the basic cases were prepared, and those results are outlined below.
Regarding the waste water treatment cost, the cost including depreciation and interest payments in the sewerage system discharge case is 2.9 DEM/m^3, which is slightly higher than the cost in the case of direct river discharge (2.8 DEM/m^3).
Regarding funds flow, the debt service ratio on long-term loan (DSR) is just above 1.00 in both cases, indicating that there is enough cash to repay the loan.
Next, sensitivity analysis was carried out to gauge the effect of fluctuations in the cost of plant construction and chemicals, the two major cost elements in the

project. It was found that in both cases, there is a higher sensitivity to the plant construction cost rather than the chemicals cost.
Furthermore, a case study was carried out on the case where it is assumed that a low interest loan can be obtained. In both cases, if it is assumed that an interest rate of 5% can be obtained, it is possible to expect an effect that is equivalent to a 10% reduction in the plant construction cost.

As a result of the above analysis, it was found that this factory was the only one of all the model factories where the waste water treatment costs are the same in the cases of both river discharge and sewerage system discharge.
As with the other model factories, sewerage system discharge is one option. However, potential advantages to be gained from carrying out river discharge include the following: 1) potential investment opportunity regardless of WWTP operation in the event where surplus funds are generated, 2) no more obligation to pay the current sewage charge, and 3) the ability to reduce the financial burden more than in the case of sewerage system discharge in the event where low interest funding can be exploited.
The decision on whether to adopt river discharge or sewerage system discharge is one that should be made upon giving careful consideration to future economic trends.

2.3 M-3 LIVARNA Maribor ARMAL

2.3.1 Factory Profile

(1) Background

MARIBORSKA LIVARNA MARIBOR, p. o., originated as a Christian church bell producing company in 1952, and later expanded to include a variety of copper processed products.

Almost completely destroyed during World War II, the company nevertheless soon resumed production of welding rods for copper ware, faucets, showers, etc.

In 1974, following an amendment of the law (still in effect), it was partitioned into the following five companies :

① AKLIMAT (Producer of aluminum radiators)
② PREDELAVA BAKRA (Producer of copper alloys)
③ ARMAL (Producer of faucets, flush toilet mountings, and castings for heaters and air conditioners)
④ VZDRZEVANJE (Supplier of utilities and maintenance for group company)
⑤ MLM (Exporter and marketer of group company products)

The five companies operate in cooperation as the MARBORSKA LIVARNA MARIBOR group. Our survey, however, focused on the electro-plating factory of the ARMAL d.o.o., since its waste water is largely polluted.

(2) Scale

Capital	:	182,287,000 SIT		
Total factory area	:	12,150 m^2		
Number of employees	:	380		
Products	:	water faucets, flush toilet bases, heating and air conditioning castings		
Annual production	:	184.4	719.2	88
		68.7		
Working conditions	:	256 days/year, 8 hours/day		

2.3.2 Water Conservation

(1) To reuse indirect cooling water of PEC reclamation system for the waterproof test of final products.

(a) Outline of Plan

The indirect cooling water of PEC reclamation system is not at present recycled. The temperature of water at the outlet is about 25°C, with no change in water quality. This effluent is to be reused for waterproof test of final products in the assembly plant of the same building.

(b) Basic conditions

	Water quantity (m^3/d)	Operation time (h/d)	Water quantity (m^3/h)	Operation days quantity (d/y)	Water saving (m^3/d)
Present PEC reclamation system	100	16	6.25	229	
Present waterproof test facility	49	8	6.13	235	
Amount of reused water and time period	(49)	(8)	(6.25)	(229)	(48)

(c) Cost estimate

- Facility cost 750 (thousand SIT)
- Operation cost 0 (Same as at present)
- Required cost 7.99 (SIT/m^3)

(2) To reuse indirect cooling water of PEC reclamation system as direct cooling water for casting plant.

(a) Outline of plan

The indirect cooling water of the PEC reclamation system is used only once.

(b) Basic conditions

	Water quantity (m^3/d)	Operation time (h/d)	Water quantity (m^3/h)	Operation days (d/y)	Water saving quantity (m^3/d)
Present PEC reclamation system	100	16	6.25	229	
Present casting cooling water	96	21.6	4.44	202	
quantity of reusing water and the period	(71)	(16)	(4.44)	(202)	(71)

(c) Cost estimate

- Facility cost　　2,300 (thousand SIT)
- Operation cost　　58.2 (thousand SIT/y)
- Required cost　　30.79 (SIT/m^3)

(3) Comment and evaluation of Case 1 and Case 2

(a) Technical comment

① Since the indirect cooling water for TEC reclamation system is used only once, the water temperature at the outlet is about 25°C, with no change in water quality.

② The plans for the effluent reuse (Cases 1 and 2) differ to a certain extent in water quantity, operation time, and operation days. But these problems can be technically solved to create an effective means of water conservation.

(b) Economic evaluation

The cost per unit of recovered water in this water reuse plan is about 8 SIT/m^3 (Case 1), and about 31 SIT/m^3 (Case 2).

The costs are examined under the following conditions :

① Case 1 and 2 are economically feasible, because the present cost of water and effluent is about 200SIT/m^3.

② Since over 100SIT/m^3 is expected for future sewage charges, both Case 1 and Case 2 have good returns.

③ The facility cost of Case 2 is only about 0.1% of annual sales. The company is thus advised to take these plans into consideration.

2.3.3 Pretreatment for Reduction of the Pollution Load

Because a waste water treatment system is already in place and the quality of total waste water satisfies both river and WWTP discharge standards, there is no need to install a waste water treatment and pretreatment system.

2.3.4 Model Case

Basic plating processes shall be assumed to be copper plating, nickel plating and chrome plating, and the chemicals used shall be the same types to give the plating plant some general character. Because ARMAL d.o.o generates 30 m3 of waste water every day and operates for 256 days per year, a plating plant that complies with these conditions shall be assumed and examination shall be carried out on two cases: the case where waste water treatment and regeneration treatment are carried out and the case where waste water undergoes simple treatment.

1) Waste water treatment and regeneration treatment

(1) Treatment system

Washing waste water from copper, nickel and chrome plating and washing waste water that contains acidic and alkaline liquid shall be treated for regeneration by means of ion exchange resin. However, cyanide waste water and shall undergo oxidation, chrome waste water shall undergo reduction and acidic and alkaline waste water and heavy metals shall undergo pH adjustment before being discharged. As for B-type waste water, this shall undergo coagulating sedimentation and treatment by B adsorptive resin before being discharged.

(2) Waste water treatment and regeneration treatment costs

The breakdown of the treatment cost per cubic meter of water is shown in Table 2.3.1.

Table 2.3.1 Details of treatment cost per 1m³

Items	Contents		Prices
Repayment years	Equipment	195,192,000 SIT÷15 years	①13,012,800 SIT/year
	Buildings, Civil works	48,125,000 SIT ÷40years	② 1,203,125 SIT/year
Interest	243,317,000 x 0.05		③12,165,850 SIT/year
Operating costs			④23,185,000 SIT/year
(① + ② + ③ + ④) ÷ 38,400			1,291 SIT/m³

2) General waste water treatment in plating plants

(1) Treatment system

It is general for cyanide waste water to undergo oxidation, chrome waste water to undergo reduction and acidic and alkaline waste water and heavy metals to undergo pH adjustment before being discharged.

(2) Waste water treatment cost

The equipment cost and treatment cost of a general waste water treatment system in a plating plant are shown in Table 2.3.2.

Table 2.3.2 Equipment and Running Costs of the Treatment System

	Equipment Cost SIT	Depreciation & Interest SIT/m³ ①	Running Cost SIT/m³ ②	Total Treatment Cost SIT/m³ ①+②
Pretreatment	35,000,000	480	350	830

3) Current pollution load

The existing pollution load is shown in Table 2.3.3.

Table 2.3.3 Volume, Quality and Pollution Load of Waste Water

Kind of Waste Water	Quantity m³/d	pH	CODcr mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Total Waste Water (Livarna Group)	1,193		20 (23.9)	8 (9.5)	– (–)	– (–)	– (–)
Total Waste Water (Armal d.o.o.)	372		20 (7.44)	8 (2.98)	– (–)	– (–)	– (–)

4) Conclusion

It is not necessary to install a waste water treatment system and pretreatment system. However, the quality of water treated by the plating waste water treatment system shows levels of heavy metals in excess of standard. Because a number of causes and countermeasures can be considered for this, it is desirable to improve the treatment system in a rational manner upon clarifying the causes.

2.4 M-4 STAJERSKA PIVOVARNA, d.d

2.4.1 Factory Outline

(1) Outline

Capital	:	130,000,000 SIT
Factory complex area	:	40,000 m^2
Employees	:	170
Products	:	Beer, soft drinks, juice
Annual production (hl)	:	60,000 (beer), 50,000 (soft drinks), 80,000 (juice)
Operating conditions	:	216 days/year, 8 hours/day

2.4.2 Water Conservation

(1) Implementation of water usage control

In the current situation, the amount of water pumped from the wells is not measured and there is practically no control of water usage at all. Flow meters must first be fitted in the wells and the control of water usage must be implemented throughout the whole factory. These are the basic conditions for water conservation.

(2) Change of bottle washing machines to the water saving type

(a) Existing bottle washing machines

There are currently two bottle washing machines: one large double end type and one small single end type, but the washing system is the same in both.

The volume of water used for washing by the bottle washing machines is unclear. However, if the aforementioned measurements are correct, it is estimated that 350 m^3/day of water is used when both machines are operating.

Based on this assumption, it works out that approximately 1.5 liters of water is used to wash one bottle. Compared to the amount of water used by recent bottle washing machines, this is a fairly high value.

(b) Outline of plan

The plan is to replace the existing bottle washing machines with the type that uses less water (water saving type). However, in view of the extremely high price (in excess of 10 million SIT) of bottle washing machines, it is thought that this cannot be carried out straightaway. In the event where the existing machines are scrapped in the future, it would be desirable to replace them with water saving models.

The features of this machine in terms of water usage are as follows.

① Make-up water (new water) is only supplied for the final water rinse, and recovered water is used in all the other rinses.

② The flow of water starts from the final water rinse and passes through the second water rinse, the first water rinse, final soak tank and pre-washing. This is a counter current with respect to the flow direction of the bottles, and the washing process is known as multistage counter-current washing.

Approximately 0.4 liters of water is used to wash one bottle, representing a large improvement over the estimated amount of water used in the existing machines (approximately 1.5 liters per bottle). This is, however, an estimate for a large capacity machine, and it is reckoned that around 1.0 liter per bottle would be used in a smaller capacity machine. Having said that, there is no doubt that a large water saving could be achieved.

(c) Technical comment

A water saving bottle washing machine not only allows water to be saved on, it has a high washing effect and also makes the handling of peeled-off labels easy.
With the existing bottle washing machines, it is considered that much labor and water is used in the handling of peeled-off labels following the end of the washing. Thus, it is estimated that adoption of a water saving type bottle washing machine would lead to great savings both in water and labor.

(d) Economic comment

As it is difficult to obtain accurate values relating to the amount of water saved and the prices of water saving bottle washing machines, it is not easy to comment on the economic feasibility of this method. Examination is, however, made based on the following assumptions.

- Amount of water saved : 120 m^3/day (approx. 1/3 of water used by bottle washing machine)
- Future sewage charges and water costs : 217 SIT/m^3
- Annual operating days : 216 days

Based on these assumptions, it is estimated that the profit achieved as a result of water saving can be approximately 5,625,000 SIT per year. Because it is thought that the running costs of a new bottle washing machine would not be more than at present, it is imagined that such profits would be used to cover the depreciation costs of the machine. The depreciation conditions are assumed as follows.

- Depreciation method : Equal depreciation over 15 years
- Rate of interest : 10% per annum
- Equipment maintenance cost : 5% of equipment cost per year

Calculating the equipment cost of the machine equivalent to the profit gained (5,625,000 SIT/year) based on these assumptions, it works out to approximately 33,700,000 SIT.

If one also takes into account the above-mentioned savings that can be made in water usage and labor by introducing a water saving bottle washing machine, it is considered that an economic effect could be gained.

2.4.3 Waste Water Treatment and Pretreatment

1) Waste water treatment for river discharge

(1) Waste water treatment cost

Treatment Cost per m^3 of Waste Water (Table 2.4.1)

Table 2.4.1

Item	Contents		Cost (SIT/m^3)
Depreciation	Machinery	79,823,000 SIT ÷ 15 years ÷ 155,520 m^3/year	① 34
	Building, civil engineering	109,750,000 SIT ÷ 40 years ÷ 155,520 m^3/year	② 18
Interest	189,573,000 SIT x 0.05 ÷ 155,520 m^3/year		③ 61
Running cost			④ 110
Total Treatment cost ① + ② + ③ + ④			223

(2) Conclusion

In the case of river discharge, because the discharge standards are so harsh (especially T-P: 2.0 mg/L), the equipment cost and running cost are both expensive.

As a result, it would be disadvantageous for this factory to independently install waste water treatment facilities at this point in time.

2) Pretreatment that satisfy WWTP discharge standards

Judging from the results of analysis, the quality of final waste water, is within standard values set for discharge into the WWTP. Thus, there is no need to install pre-treatment equipment.

3) Pretreatment system for reduction of the pollution load

(1) Volumes, quality and pollution loads of waste water and treated water

The result of the examination carried out on Case-1, Case-2 and Case-3 are shown in Table 2.4.2.

Table 2.4.2 Waste and Treated Water Quality and Pollutant Load

Kind of waste water	Quan-tity m3/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	PH	SS mg/L (kg/d)	T-N mg/L (kg/d)	T-P mg/L (kg/d)
*1 Raw thick waste water	400	1400 (560)	400 (160)	7	100 (40)	14.4 (5.8)	8.3 (3.3)
*2 Treated thick waste water							
Case-1	400	300 (120)	80 (32)	7	100 (40)	14.4 (5.8)	8.3 (3.3)
Case-2	400	560 (224)	80 (32)	7	164 (66)	10 (4)	5 (2)
*3 Total waste water (Raw water)	720	890 (641)	260 (187)	Ave 7.4	76 (55)	12 (8.6)	6 (4.3)
CASE-1	720	249 (201)	74 (59)	7	76 (39)	12 (6.2)	6 (3.1)
CASE-2	720	424 (305)	82 (59)	7	113 (81)	9.4 (6.8)	4.2 (3)
CASE-3	720	400 (288)	74 (53)	7	114 (82)	8 (5.8)	3.6 (5)
*4 Discharge to River	720 Design base	120 (86)	25 (18)	Ave 7.8	80 (58)	-	2. (1.4)

Notes Case 1: Raw thick waste water is pretreated by an aerobic system
Case 2: Raw thick waste water is pretreated by an aerobic system
Case 3: Total waste water is pretreated by aerobic system
*1: Water quality of concentrated liquid in total waste water
*2: Water quality of raw thick water treated in each case
*3: Quality of total waste water when treated raw thick waste water is mixed with other waste water
*4: Water quality in the case of river discharge

(2) Equipment cost and treatment cost

The equipment and treatment costs in each case are shown in Table 2.4.3.

Table 2.4.3 Equipment and Treatment Costs of Treatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³	Running Cost SIT/m³	Total treat-ment cost SIT/m³
CASE-1	39,300,000	36	81	117
CASE-2	35,960,000	33	28	61
CASE-3	43,500,000	40	31	71
Discharge to River	189,573,000	113	110	223

(3) Conclusion

Costs are dramatically reduced because coagulation and sedimentation equipment for T-P treatment and chemicals are unnecessary, and because the lowered removal rate of BOD and COD reduces equipment costs.

2.5 M-5 VINAG VI NARSTVO-SADJARSTVO

2.5.1 Factory Outline

1) Outline

This winery is located in the center of Maribor. Squeezed fruit juice that is carried in by tank lorry is brewed and matured in underground tanks, and the resulting wine is then bottled and shipped.

Factory complex area	:	
Employees	:	400
Operating conditions	:	8 hours/day, 251 days/year
Products	:	Wine (white, red)
Annual production	:	5,000 m^3

2.5.2 Water Conservation

1) Current condition of water usage and water conservation

(1) Features of water usage

① The city water supply is the sole water source, and flow meters are used to measure the volume of consumption.

② Almost all of the water (approximately 86%) is used for washing. The rest is used for miscellaneous purposes, boiler water and for the evaporative condenser used in the ammonia refrigerator.

③ The washing water is used in a bottle washing machine (1) and in the washing of filters and tanks, etc.

④ The recovery of boiler water is being conducted quite effectively (estimated rate of recovery is approximately 80%).

(2) Current condition of water conservation

① Partial water saving can be witnessed in the retrieval of boiler water, the adoption of a refrigerator evaporative condenser and the adoption of a CPI, etc.

② Water usage management is not sufficient. Many of the hoses used for floor and equipment washing do not have hand control valves attached to their ends.

③ Although the bottle washing machine (largest consumer of water) is the water saving type, the volume of water it uses is rather large at 1.5 liters per bottle.

④ With 40,000-50,000 bottles being washed per day (approximately 10,000 bottles per hour), even considering that the washing machine is a small model, the water consumed is too great.

2) Comment and assessment

(1) Technical comment

① The flow of bottles through the bottle washing machine and along the conveyor belt is not very smooth, and this is thought to be one reason for the poor washing efficiency.

② It is estimated that approximately 20 m^3 of water a day could be saved on by renewing the bottle washing machine and conveyor belt. However, the investment required for this would be around 50,000,000 SIT, and it is clear that the resulting water conservation alone could not make this proposition economically feasible. Therefore, it is desirable that water saving equipment be installed when the proper time comes for investment into equipment improvement and renewal at the factory.

③ The most important thing now with regard to water saving is to raise the awareness of managers and operators towards the issue.

④ Hand control valves should be attached to the ends of washing hoses. The investiment required for this would be around 10,000 SIT/piece.

(2) Economic comment

① Because it is important for the present that water usage be reduced through higher awareness among managers and operators, it is impossible to make any economic comment.

2.5.3 Waste Water Treatment and Pretreatment

1) Waste water treatment for river discharge

(1) Waste water treatment cost

(1) Treatment cost per m^3 of waste water (Table 2.5.1)

Table 2.5.1

Item	Contents		Cost (SIT/m^3)
Depreciation	Machinery	48,089,000 SIT ÷ 15 years ÷ 22,590 m^3/year	① 142
	Building, civil engineering	33,125,000 SIT ÷ 40 years ÷ 22,590 m^3/year	② 37
Interest	81,214,000 SIT x 0.05 ÷ 22,590 m^3/year		③ 179
Running cost			④ 353
Total Treatment cost ① + ② + ③ + ④			711

(2) Conclusion

In the case of river discharge, because the discharge standards are so harsh (especially T-P: 2.0 mg/L), the equipment cost and running cost are both expensive. Moreover, because the treatment volume is so small and the annual operating days are few (216 days/year), the cost per unit treatment volume is high.

As a result, it would be highly disadvantageous for this factory to independently install waste water treatment facilities at this point in time.

2)Pretreatment system that satisfy WWTP discharge standards

In view of the fact that an equalization treatment system is installed and analysis of waste water found it to be within WWTP discharge standards, there is no need to install a pretreatment system.

3)Pretreatment system for reduction of the pollution load

(1) Volumes, Quality and Pollution Loads of Waste Water and Treated Water (Table 2.5.2)

Table 2.5.2 Waste and Treated Water Quality and Pollutant Load

Kind of waste water	Quntity m^3/d (kg/d)	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	PH	SS mg/L (kg/d)	T-P mg/L (kg/d)
Total Raw waste water (After neu-tralization)	90	750 (68)	510 (46)	Ave 7.8	90 (8)	17 (1.5)
Pretreated water (Discharge to WWTP)	90	220 (20)	100 (9)	7	172 (15)	10 (0.9)
Treated water (Discharge to River)	90	120 (11)	25 (2.3)	7	80 (7)	2 (0.2)

(2)Equipment and treatment costs

Table 2.5.3 Equipment and Treatment Costs of Treatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³ ①	Running cost SIT/m³ ②	Total Treatment cost SIT/m³①+②
Pretreatment	24.630.000	112	114	226
Discharge to River	81.214.000	358	353	711

(3) Conclusion

Costs are dramatically reduced, because coagulation and sedimentation equipment for T-P treatment and chemicals are unnecessary, and because the lowered removal rate of BOD and COD reduces equipment costs.

2.6 M - 6 KOSAKI TOVARNA MESNIH IZDELKOV

2.6.1 Factory Profile

Factory area	:	22,534m^2
Number of employees	:	100
Working conditions	:	5 hrs./day, 250 days/year
Products (livestock)	:	Beef cattle, Pork (pigs)
Annual production	:	11,500 (head), 43,000

2.6.2 Water Conservation

1) Current conditions of water usage and conservation

(1) Features of water usage

① City water is the only source. Quantity is measured by a flowmeter.

② Most water (96%) is used for washing and product treatment. The remainder is for cooling, boiler and miscellaneous purposes.

③ Washing water and product treatment water is used for washing meat, floors and meat carving instruments.

(2) Present state of water conservation

① Cooling water of the ammonia refrigerators (3 units) is reduced by adopting evaporative condensers (3 units).

② Boiler feed is used to produce hot water by direct steam injection.

③ After bloodletting, products are washed as they pass through a hot water tank (1 unit).

④ The floor and carving tools are washed with water using a high pressure jet cleaner and hose with hand control valve. Some hoses are not equipped with hand control valves, however.

2) Technical evaluation of water conservation

(1) Technical comment

① Water for washing and product processing accounts for about 96% of water consumption; about twice that of Japan, on average. But since the two production systems differ, no simple conclusions may be drawn.

② Sanitary reclamation of washing water and product processing waste water is impossible. While it is possible to use recovered water for cooling or other purposes, it is not economically feasible, since the quantity is negligible.

③ Because cleaning and product processing are both manually operated, water consumption may be significantly reduced by encouraging workers to save water.

(2) Economic comment

① Nothing specific is noted here, except the importance of reducing water consumption by fostering awareness in the company of the need for water conservation.

2.6.3 Waste Water Treatment and Pretreatment

1) Present conditions

All waste water is discharged into the sewerage system from waste water pits installed in three locations.

Waste water from the meat factory is discharged through the oil separators installed in two of the above three locations.

Without pretreatment, oil in waste water may not clear regulations for sewerage discharge. The existing oil separators function adequately in this regard and no more separators are necessary.

2) Waste water treatment

Waste water treatment system flow

(waste water)→Collecting pit (present)→Stabilization tank→Neutralization tank → Anaerobic tank → Aeration tank → 1st. Sedimentation tank → Coagulation tank→2nd. Sedimentation tank→Sand filter→Ozonizing tube→ Activated carbon absorber→Treated water tank→Discharge to the river

(coagulated sludge)→Sludge storage tank→Sludge dehydrator →Cake hopper→Truck

Reasons for waste water treatment system

① The slaughterhouse falls under the general category of emission standards. Since the factory's waste water pollutants are basically organic, the activated sludge treatment system that is adopted by the public treatment center serves well here.

② There are strict regulations concerning direct discharge to the river of N and P. This problem is solved by a waste water system designed so that N, P, BOD, COD, SS, and oil may clear emission standards.

③ NH_4-N is easily reduced by activated sludge treatment. NOH_3-N, converted from NH_4-N, is removed by anaerobic denitrification.

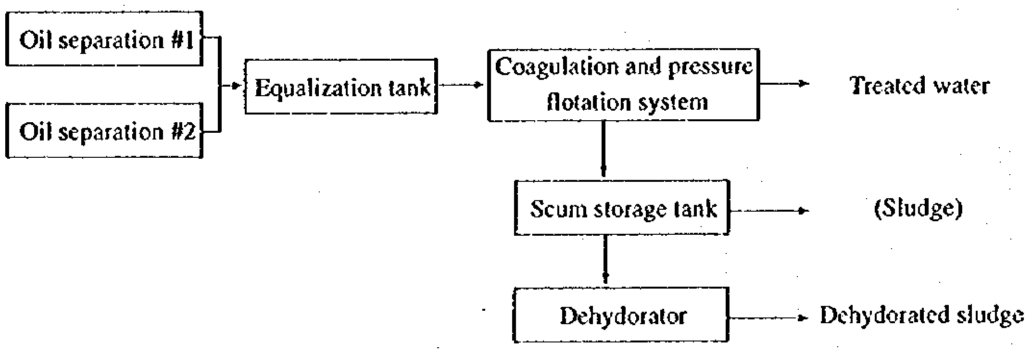
④ P is removed by coagulation and sedimentation.

⑤ Emission standards for SS and COD are such that sand filter and activated carbon absorption are unnecessary.

⑥ Since waste water from the slaughter house fluctuates greatly in concentration and quantity over time, treatment is stabilized by installing a stabilization tank of daily capacity. The oil load is reduced by placing an oil separator in the collecting pit. Effluent can be sent directly to the stabilization tank bypassing the above process. This reduces the amount of time in removing scum. A pressure floatation tank is also necessary.

3) Pretreatment for reduction of the pollution load

In the case where further reduction of the pollution load is demanded, coagulation and pressure flotation shall be added. In order to avoid placing too great a load on the waste water treatment plant, which will utilize biological treatment methods, physical rather than biological pretreatment methods shall be employed. The reason why coagulation and pressure flotation is chosen ahead of coagulation sedimentation is due to consideration of the removal of oil and fat, the inherent nature of which is to float anyway.



Case 1: oil separator only

Oil separation can sufficiently be handled by the existing separator. Regarding the treatment of floating oil and fat, a collection specialist currently comes to collect it once per week for delivery as a raw material to a soap factory. The present treatment cost (or income) is zero.

Case 2/3: addition of coagulation and press flotation system

Nighttime personnel expenses can be eliminated by making the system operate for less than 12 hours per day. The next choice is whether or not to use a dehydorator. If there is no dehydorator, not only will the equipment cost naturally be cut, but the operating effort and cost of coagulant for dehydoration will also be unnecessary.

Case 3: addition of fixed floor catalytic oxidation and biological treatment system

In the case where further reduction of COD and BOD is required, biological treatment shall be carried out.

Anaerobic biological treatment is often adopted in cases of high pollution load, however, this does not work well when there are high levels of oil and fat. It is advantageous to carry out aerobic biological treatment after conducting coagulation and pressure flotation, when the pollution load of the water is low. Because SS levels are low, fixed floor catalytic oxidation and biological treatment is highly suited.

Table 3.6 Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quan-tity m3/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	Fat mg/L ( )	SS mg/L (kg/d)	T-N mg/L (kg/d)	T-P mg/L (kg/d)
*1 Case-1 Oil separator	400	1,500 (600)	800 (320)	60 (24)	600 (240)		20 (8)
*2 CASE-2/3 + Coagulation & floatation	400	800 (320)	400 (160)	20 (8)	< 30 (12)		< 2
*3 CASE-4 + Contact Oxidation	400	250 (80)	100 (40)	10 (4)	< 30 (12)		< 2

Note) * Case 1: case where oil separation is carried out as pretreatment
* Case 2: case of further adding coagulation and press flotation (with dewaterer)
* Case 3 (with no dewaterer)
* Case 4: case where catalytic oxidation is added to Case 2

Table 3.7 Equipment and Running Costs of the Treatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³	Running Cost SIT/m³	Total treat-ment cost SIT/m³
CASE-1	exsited	0	0	0
CASE-2	50,000,000	55	85	140
CASE-3	43,000,000	48	72	120
CASE-4	80,000,000	88	100	188
to River	296,076,000	299	266	565

4) Conclusion

Table 3.6.10 shows the water quality that can be obtained from pretreatment and the estimated cost of the system. The same figures in the case of a system of waste water treatment for direct river discharge are also shown for reference. In the case of direct river discharge, the waste water treatment cost becomes very expensive due to the strict discharge standards. In fact, the treatment cost in this case is so expensive that it cannot even be compared with the sewage charge in the case of sewerage system discharge.

Treatment by coagulation and pressure flotation does cause remarkable reduction in the pollution load, however, the treatment cost is roughly the same as the standard sewage charge. Unless a progressive charge system, in which the sewage charge becomes twice as high as the standard charge when pollution loads are high, is established, a pretreatment system designed to reduce the pollution load would not be economically feasible. In another word, so long as the additional sewage charge is small, it is more economic to discharge into the sewerage system and accept the higher sewage charge.

2.6.4 Financial Analysis

As a result of the technical comment, it was found that in the case of sewerage system discharge (Case 2), no additional waste water treatment costs will arise because the existing oil separator can be used and pretreatment is not required. Therefore, financial analysis shall concentrate on the case of river discharge (Case 1).

In addition to the aforementioned plant construction cost, the capital requirement based on the preconditions stated in 1.4.1 will come to 3,665,000 DEM (Case 1). It is assumed that capital requirement are acquired through a long-term loan and that the rate of interest is 12%.

In accordance with said preconditions, a breakdown of the waste water treatment cost and funds flow statements were prepared, and those results are described below.

Regarding the waste water treatment cost, the sewerage system discharge case does not involve any additional treatment cost, but it is necessary to pay 2.29 DEM/m^3 for the sewage charge and the pollution tax. In the case of river discharge, on the other hand, the combined cost of depreciation and interest payments is 7.63 DEM/m^3, which is 5.34 DEM/m^3 more expensive.

Regarding funds flow in Case 1, the debt service ratio on long-term loan (DSR) is less than 1.00, indicating that there is a shortage of cash to repay the loan.

Next, sensitivity analysis was carried out to gauge the effect of fluctuations in the cost of plant construction and chemicals, the two major cost elements in the project. It was found that in Case 1, there is a higher sensitivity to plant construction cost rather than the chemicals cost.

Furthermore, a case study was carried out on the case where it is assumed that a low interest loan can be obtained. In Case 1, if it is assumed that an interest rate of 6% can be obtained, it is possible to expect an effect that is equivalent to a 20% reduction in the plant construction cost.

As a result of the above analyses, it is concluded that it would be economically advantageous for this factory to adopt the case of sewerage system discharge, which involves no pretreatment, rather than the case of direct river discharge.

2.7 M-7 MARIBORSKA MLEKARNA, d.o.o.MM MARIBORSKA MLEKARNA, d.o.o.

2.7.1 Factory Outline

(1) Outline

Mariborska Mlekarna p.o. is an integrated manufacturer of milk and fermented milk packed in paper cartons and various cheeses, etc. The volume of raw milk it uses has been increasing at a rate of approximately 3.5% every year, and it is able to produce a wide range of products in small quantities through the use of modern and hygienic production equipment. Some of its products are exported to Croatia and other countries.

(2) Scale

Capital	:	808,790,000 SIT
Total factory area	:	14,000m^2
Number of employees	:	286
Products	:	Milk, Cheese, Fresh Cheese, Fermentation Milk
Annual production (kg)	:	16,393,777 2,066,470 1,086,857 1,507,745
Working conditions	:	7 hr/day (paying 8 hr), 365 days/year

2.7.2 Water Conservation

(1) Technical examination

① In consideration of the current condition of water conservation described above, it is necessary to grasp as accurately as possible the water usage situation on each area of equipment and investigate whether or not the current water usage levels are appropriate.

By optimizing equipment water usage through making some slight investments in the equipment based on the survey results, a water saving of approximately 10-15% (approximately 50 m^3/day) could be achieved.

② The staff and equipment investment required to achieve water conservation, and the resulting water saving effect are supposed as follows.

Engineers	:	2
Period	:	1 year (spending 50% of time on current work and 50% on water conservation)

Facility cost : 1,000,000 SIT (hand control valves, piping parts, instrumentation, etc.)

Water conservation : 50 m^3/day

③ The engineers (two) and period (one year) shall be limited and, following the implementation period, the engineers will revert back to their normal duties and water saving will be carried out as a routine practice based on the use of manuals, etc.

(2) Economic examination

① The trial calculation of the economic effect based on the above conditions is shown below.

(a) Investment in one year

Personnel expenses : 3,000,000 x 2 engineers x 50% = 3,000,000 SIT/year

Equipment cost : 1,000,000 SIT/year

Total : 4,000,000 SIT/year

(b) Forecast water saving effect

50 m^3/day x 200 SIT/m^3 x 365 days = 3,650,000 SIT/year

It can be seen that the investment can be retrieved inside one year, showing that it would be economically feasible to carry out water conservation.

2.7.3 Waste Water Treatment and Pretreatment

1) Waste water treatment for river discharge

(1) Treatment system

Upon equalizing waste water from the manufacturing process, this is mixed with domestic waste water and regenerated waste water from the softener to undergo treatment by the anaerobic/aerobic (AO) method. The treated water from this finally undergoes coagulating sedimentation before being mixed with cooling water for discharge.

(2) Waste water treatment cost

The treatment cost per 1 m^3 of waste water is 217 SIT/m^3.

The breakdown of this unit treatment cost is shown in Table 2.7.1.

Therefore, the cost of treating one cubic meter of all of the waste water is as follows.
(①+②+③+④) ÷ (474 m^3/day x 365 days/year) = 208 SIT/m^3

Table 2.7.1 Breakdown of Treatment Cost per 1 m^3 of Waste Water

Items		Contents	Cost	
Depreciation period	Equipment	9,995,000 SIT÷15 years	① 6,666,333	SIT/year
	Buildings, Civil works	48,125,000 SIT÷40years	② 1,203,125	SIT/year
Rate of interest	148,120,000 x 0.05		③ 7,406,000	SIT/year
Running cost			④ 20,718,800	SIT/year
(①+②+③+④) ÷ 165,710			271	SIT/m^3

2) Pretreatment for WWTP discharge

(1) Treatment system

Waste water from the manufacturing process and regenerated waste water from the softener undergo equalization treatment before being discharged.

(2) Waste water treatment cost

The treatment cost per 1 m^3 of waste water is 76 SIT/m^3.
The breakdown of this unit treatment cost is shown in Table 2.7.2.
Therefore, the cost of treating one cubic meter of waste water is as follows.
(①+②+③+④) ÷ (474 m^3/day x 365 days/year) + 176.56 SIT/m^3
= 205 SIT/m^3

Table 2.7.2 Breakdown of Treatment Cost per 1 m^3 of Waste Water

Items		Contents	Cost	
Depreciation period	Equipment	10,958,000 SIT÷15 years	① 730,533	SIT/year
	Buildings, Civil works	2,647,000 SIT÷40years	② 66,175	SIT/year
Rate of interest	13,605,000 x 0.05		③ 680,250	SIT/year
Running cost			④ 3,394,000	SIT/year
(①+②+③+④) ÷ 68,620			71	SIT/m^3

3) Pretreatment for reduction of the pollution load

(1) Pretreatment system

a. Case 2

It is forecast that biological treatment will be adopted in the WWTP, however, the operation of this could be made difficult if the waste water contains too much oil and fat. Therefore, it is necessary to install a pretreatment system to carry out oil separation, and it is general for press flotation to be adopted for this. Press flotation shall be assumed as Case 2.

b. Case 3

Here, treated water from Case 2 shall be treated by the UASB method of anaerobic biological treatment in order to reduce BOD and COD.

c. Case 4

Here, treated water from Case 2 shall be treated by the biological filtration method of aerobic biological treatment in order to reduce BOD and COD.

(2) Waste water quality and pollution load

The quality, volumes and pollution loads of waste water and treated water are shown in Table 2.7.3.

(3) Equipment cost and treatment cost

The equipment and treatment costs in Cases 1-4 are shown in Table 2.7.4.

Table 2.7.3 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	Quantity m³/d	pH	CODcr mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	FAT mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Waste water from manufacturing process	Raw Waste Water	175	7	5,700 (998)	2,000 (300)	930 (163)	300 (52.5)	11 (1.9)
	Case-1			5,700 (998)	2,000 (300)	930 (163)	300 (53.5)	11 (1.9)
	Case-2			2,850 (499)	1,000 (175)	30 (5.25)	10 (1.75)	11 (1.93)
	Case-3			570 (100)	100 (17.5)	30 (5.25)	10 (1.75)	10 (1.75)
	Case-4			1,900 (333)	100 (17.5)	30 (5.25)	10 (1.75)	10 (1.75)
Car Washing	Raw Waste Water	35	7	2,100 (73.5)	450 (15.8)	650 (22.8)	500 (17.5)	130 (4.55)
	Case-3			570 (20)	100 (3.50)	30 (1.05)	10 (0.35)	10 (0.35)
	Case-4			1,900 (66.5)	100 (3.50)	30 (1.05)	10 (0.35)	10 (0.35)
Domestic	Raw Waste Water	231	7	400 (92.4)	200 (46.2)	50 (11.6)	– ( )	– ( )
Total Waste Water	Raw Waste Water	476	5	2,443 (1163)	866 (412)	414 (197)	147 (70)	14 (6.45)
	Case-1		7	2,443 (1163)	866 (412)	414 (197)	147 (70)	13 (6.45)
	Case-2		7	1,397 (665)	464 (221)	13 (6.41)	6 (2.96)	10 (4.93)
	Case-3		7	446 (212)	141 (67.1)	38 (17.9)	4.4 (2.1)	4.4 (2.1)
	Case-4		7	1,032 (491)	473 (225)	38 (17.9)	4.4 (2.1)	4.4 (2.1)
	Discharge to River		7	119 (56.8)	25 (11.8)	40 (18.9)	4.4 (2.1)	2.0 (0.95)

Table 2.7.4 Equipment and Running Costs of Treatment Systems

		Equipment Cost SIT	Depreciation & Interest SIT/m^3 ①	Running Cost SIT/m^3 ②	Total Treatment Cost SIT/m^3 ①+②
Pretreatment	Case-1	13,605,000	8	20	28
	Case-2	19,000,000	34	31	65
	Case-3	40,000,000	50	102	158
	Case-4	36,000,000	47	49	106
Dicharge to Rever (Design Base)		148,120,000	88	120	208

4) Conclusion

If river discharge standards are aimed for, it is necessary to treat the total waste water and install a coagulating sedimentation system for removing the P content. Consequently, the waste water treatment system would be expensive in terms of both equipment and running costs. If WWTP discharge standards are aimed for, because the waste water does not contain harmful substances, it is only necessary to consider a pretreatment system for reducing the pollution load of organic substances.

Depending on movements in WWTP discharge standards, it may be necessary to advance step by step the examination of a coagulation flotation treatment system for removing oil and fat content and biological treatment systems for reducing pollution loads (especially COD). In readiness for such occasions, it is desirable to adopt a biological treatment method in which it is possible to increase the removal rate through simply altering the mode of operation.

3. Secondary Beneficiary Factories

3.1 S-1 Tovarna volnenih tkanin MERINKA, p.o. (TVT MERINKA)

3.1.1 Factory Profile

1) General

MERINKA is the largest woolen textile factory in Slovenia. The factory imports and processes slivers for yarn dyeing, cloth dyeing, and textiles. About 80% of the products is exported to North America. The factory is also a subcontractor for foreign companies, processing stockings with sewing ; dyeing; finishing, and packaging. Materials and processing facilities are furnished by other companies; MERINKA provides only place and labor. Overall the factory is well managed.

Total factory area	:	333,430m^2	
Products	:	Woolen fabrics	Stockings
Annual production	:	650,000m	20,000,000pairs
Annual sales	:	11,000,000DM	4,000,000DM (Processing charge only)
Number of employees	:	ca. 330	ca. 280
Working conditions	:	3 shifts	1 shift

3.1.2 Water Conservation

(1) Technical comment

① Considering the above, the precise amount of water consumption for each facility must be measured to determine whether or not domestic and air conditioning water consumption is proper.

With a small facility investment bases upon survey results, water consumption can be brought to a proper level and thereby reduced 10-15% (approx. 50m^3/d) in each facility.

② Estimated facility and labor costs for water conservation, and the anticipated results, are as follows :

Engineer	:	1
Period	:	1 year (concurrent with present work, engagement rate 50%)

Facility cost : 2,000 thousand SIT (plumbing parts, piping parts, instruments, etc.)

Water conservation : $50m^3$/day

③ The number of engineers should be limited to one and the working period to one year. After his task is finished, water conservation will be continued to be practiced in daily work, according to the operation manual.

(2) Economic comment

① Cost estimates based on above premises :

(a) Annual investment

Labor cost : 3,000,000 SIT x 1 engineer x 50% = 1,500 (thousand SIT/y)

Facility cost : 2,000

Total : 3,500 (thousand SIT/y)

(b) Anticipated water saving:

$50m^3$/d x 200SIT/m^3 x 240d/y = 2,400 (thousand SIT/y)

According to the above, investment should be recovered in about 1.5 years. It will be therefore economically feasible.

3.1.3 Pretreatment and Waste Water Treatment

1) Present situation

① All waste water is discharged into the sewerage system.

② The most current water quality analysis indicates that a pretreatment system for sewerage system discharge is unnecessary.

③ Direct river discharge is uneconomical due to the factory's distance from the river.

2) Pretreatment for reduction of the pollution load

Judging from the coagulator test results, it is difficult to separate and treat the concentrated waste water from dyeing. Coagulation sedimentation treatment shall be carried out on the total waste water.

Table 3.1.1 S-1 Merinka Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quan-tity m³/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	SS mg/L ( )	color (1/m)	t-Fat mg/L (kg/d)	t-P mg/L (kg/d)
*1 Raw total wastewater	1,200	650 (780)	150 (180)	40 (48)	37	30 (36)	3
*2 Case-1 Coagulation & sedimentation	1,200	350 (420)	80 (96)	< 30	< 3	< 20	< 1

(Note) * 1: quality of total waste water
* 2: when total waste water undergoes pretreatment (coagulating sedimentation)

Table 3.1.2 S-1 Merinka Equipment and Running Costs of the Pretreatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³	Running Cost SIT/m³	Total treat-ment cost SIT/m³
CASE-1	143,800,000	47	105	152

3.2 S-2 Tekstilna tovarna TABOR, d.o.o.

3.2.1 Factory Profile

Capital	: 1,005,895 (thousand SIT)
Number of employees	: 400
Products	: Polyester-based mixed fabrics
Annual production (1995)	: 3,140,216m^2
Annual sales	: 940,725 SIT (processing charge only)
Working conditions	: 3 shifts, 249 days/year

3.2.2 Water Conservation

1) Present state of water conservation and use

(1) Uses of water

① Water is supplied from city water and well water. City water is used for domestic water and well water for production processes, after undergoing quantity measurement.

Well water is pumped up from two wells, each having pressure control, and is directed to the main pipe for distribution to production processes. No storage tank is used.

② Most (about 85%) of the water is used for dyeing process rinsing and product processing.

③ Air conditioning water is make up water for the temperature control in the spinning and textile factory. The quantity is small, because there are few installed facilities (spinning machines, weaving machines, etc.); therefore the heating load is low.

(2) Present state of water conservation

① Well water is supplied from two wells. The water is distributed after pressure control, thereby avoiding unnecessary water pumping.

② The main equipment of the dyeing process is as follows :

(a) Cloth dyeing :

Winch type	8 sets (5 are for pre-washing)
High pressure	2 sets, Small tester of the same system 1set liquid flow type

Jet type 2 sets (with heat recovery system for its waste water)
Pad type 1 set (Not in present use)

(b) Yarn dyeing : Dyeing tank (2) and drying tank (1) 2 sets

(c) Cotton dyeing : Atmospheric tank 2 sets

③ The water consumption of the dyeing rinsing and product processing is about 78m^3/thousand m^2, equivalent to that of a Japanese dyeing factory. Water consumption varies with kind and quality of products, however, and simple conclusions cannot be drawn from this comparison alone.

④ Boiler feed is recovered at the rate of approximately 60%.

⑤ Air conditioning water is recycled through the sand filter. Its make up water is supplied to the sand filter tank without water flow control.

2) Examinations and evaluations

(1) Technical evaluation

① Since the operation rate of the factory is low, it is difficult to draw conclusions on the present state of water conservation based on this survey.

② However, since water consumption varies with kind and quality of products, simple conclusions cannot be drawn from this comparison alone.

③ The University of Maribor has proposed various system improvement policies for electricity, water , steam, dye, waste water, etc. Improvements will be made when financing concerns are cleared.

(2) Economic examination

The situation is as mentioned above, with no additional remarks of note.

3.2.3 Waste water treatment and Pretreatment

1) Present conditions

① The charcoal filter is working effectively.

② The charcoal filter, as a pretreatment system, has sufficient capacity for sewerage system discharge.

③ As a treatment system, it has insufficient capacity for direct river discharge.

2) Pretreatment for reduction of the pollution load

The effects of the charcoal filtration are recognized actually, though the pollution load of the inlet waste water is rather low. Color and COD are reduced by half. However, because the BOD and oil and fat content are reversed, it cannot be said that this alone is confirmation of the effect. Having said that, the quality of the waste water on the day of the survey would have satisfied even the discharge standards for direct river discharge, needless to say the standards for discharge into the sewerage system. This treatment method is a most interesting one and is worthy of careful observation in the future.

3) Reduction of water consumption and cost through waste water treatment and pretreatment

It is possible that, if concentrated waste water from dyeing is separated and decolored separately, washing water that is currently used in large quantities for dilution can be reduced and the resulting cost lessened. With this in mind, testing of separation by coagulating sedimentation was carried out.

Samples of waste water from the cloth dyeing machines (most highly concentrated waste water) and from the final discharge outlet (for comparison purposes) were taken. The results of jar testing are shown in Table 4.2.4.

From the results, it can be seen that the effects of coagulation treatment are large. Moreover, good discoloring can be achieved by using an inorganic coagulant and not cation polymer. The test conditions are equivalent to the case of ideal batch treatment. Because the factory batch operates three dyeing machines, it would be possible to design a waste water treatment system for batch mode operation, however, in terms of ease of operation, it is more practical to perform automatic operation by monitoring the water level in a storage tank.

4) Outline of treatment system and pretreatment system

Case 0 : direct discharge into the river of total waste water in its present state

Case 1 : adding treatment by coagulating sedimentation to reduce the water usage to 1/3 before directly discharging into the river

Case 2 : treating colored water only by coagulating sedimentation, and thus reducing water usage to 1/3

In Case 1, coagulating sedimentation treatment is added upstream of the existing carbon filtration system.
In Case 2, piping and a storage tank are newly installed to collect only concentrated waste water from the dyeing machines, and water from this is automatically fed to the coagulating sedimentation system through a method where the water level in the tank is monitored.

Table 3.2. S-2 TABOR Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quan-tity m3/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	SS mg/L ( )	color (1/m)	T-N mg/L (kg/d)	T-P mg/L (kg/d)
*1 Case-0 total water	1,200	100 (120)	25 (30)	< 30	3	23 (28)	< 2
*2 three times concentrated	400	300 (120)	75 (30)	80	9	70 (28)	2
*3 Case-1 coagul-sedim'n	400	100 (40)	25 (10)	< 30	< 3		< 1
*4 thick color wastewater	40	3,000 (100)	750 (30)	100 (2)	60	600 (24)	10
*5 Case-2 coagul-sedim'n	40	1,000 (40)	250 (10)	< 30	7		2
*6 CASE-2' mixed total	400	100 (40)	25 (10)	< 30	< 3		< 1

(Note) *1: quality of total waste water
*2: total waste water when water usage is reduced to 1/3
*3: Case 1: case of coagulating sedimentation treatment of waste water that reduces water usage to 1/3
*4: water quality when colored waste water from the dyeing process is separated
*5: Case 2: pretreatment (coagulating sedimentation) of colored waste water only
*6: Case 2: total waste water when treated colored waste water is mixed with other waste water

Table 3.2.S-2 Tabor Equipment and Running Costs of the Pretreatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³	Running Cost SIT/m³	Total treatment cost SIT/m³
CASE-1	50,000,000	55	80	135
CASE-2	18,000,000	20	35	55

The running cost has been calculated for the case of a treatment volume of 400 m^3/d.
Case 1 : case of coagulating sedimentation treatment of waste water that reduces water usage to1/3
Case 2 : pretreating (by coagulating sedimentation) only colored waste water before mixing with other waste water

In Case 1, the daily treatment cost will be as follows: 400 x 135 = 54,000 SIT. However, because this method will allow a water saving of 800 m^3 to be achieved, the system will balance out if the total cost of well water is 65 SIT/m^3.

In Case 2, the daily treatment cost will be as follows: 400 x 55 = 22,000 SIT. The system will achieve a balance if a daily water saving of 800 m^3 can be achieved.

5) Conclusion

The existing waste water quality practically satisfies the standards for river discharge.

As the factory has free use of the well under its possession, it adopts a policy of conducting ample dilution before discharging. If a waste water treatment system is to be introduced, in place of the current system of water dilution, to reduce water consumption and cost, it would be best to separate only the colored waste water from the dyeing process and treat it by coagulating sedimentation. The resulting treated water could then be passed through the existing charcoal filtration process together with the other waste water, and then be discharged into the river.

3.3 S-3 Mariborska tekstilna tovarna Melje, d.d. (MTT MELJE), d.d., Tovarna tkanin MELJE, d.o.o.

3.3.1 Factory Profile

Capital	:	1,369,568 thousand SIT
Number of employees	:	750
Working conditions	:	8 hrs./day
Products	:	Cotton fabric Polyester blends
Annual production (1995)	:	7,140,000m 3,600,000m

3.3.2 Water Conservation

(1) Implementation of water usage control

The quantity of pumped well water is not measured, which implies a lack of water consumption control. A flow meter, the basis of water conservation, should first be installed for the purpose of water consumption control in the factory.

Since water quantity indicated in the questionnaire is not precise, it is irrelevant to discussions of ways to save water.

(2) Recycling of indirect cooling water for air compressor

(a) Outline of plan

Indirect cooling water is at present used only temporarily for the air compressor. Water temperature at the outlet is about 22℃. The waste water is to be recycled by the cooling tower.

(b) Cost estimate

- Facility cost 1,900 (thousand SIT)
- Operation cost 94.4 (thousand SIT/y)
- Required cost 33.8 (SIT/m^3)

(c) Economic evaluation

The anticipated cost of water recycling in this system is 34 SIT/m^3. But when city water is used, the cost exceeds 200 SIT/m^2, and recycling of water is economically feasible.

(3) Reclamation of waste water

(a) Reclamation plan

i. Selection of source water

Colored waste water which is not easily decolorized should be avoided. Waste water may be selected from the following:

① Effluent of cooling water
② Colorless waste water of pre- rinsing and bleaching processes.

ii. Quality of reclaimed water

The minimum required quality of reclaimed water is determined by function (e.g., dyeing rinsing water). Actually, the quality of usable water is often unknown by function In that case, it must be checked by experiment.

iii. Reclamation process

Water source→pH control→Two stage biological treatment (Trickling filter, submerged bio-filter)→Coagulation and sand filtration→Activated carbon absorption→Recovered water

(b) Economic comment

① The cost for reclamation of water is quite high, probably exceeding 200 SIT/m^3.

② The necessary costs included in water reclamation, are the costs of facilities to collect recovered waster water, storage tanks to temporarily hold waste water and recovered water, facilities to supply recovered water (piping, pump, etc.), and others.

In light of the above, the anticipated cost of water reclamation is high.

③ A charge of about 160 SIT/m^3 is expected in the future when the WWTP is built. But if there is a tax for water use (about 41 SIT/m^3) water reclamation may be economically feasible under certain conditions.

3.3.3 Pretreatment and Waste Water Treatment

1) Present condition

① Of the 8 sewage outlets, 6 are currently used. All outlets merge at the most downstream outlet. According to the most recent data, the pH sometimes exceeds emission standards, and pretreatment is necessary. A neutralization tank is less expensive than a large stabilization tank.

② The overall capacity of water related systems is excessively large. These facilities should also be examined in regard to the current consolidation and reduction of the production system.

2) Pretreatment for reduction of the pollution load

Because each plant in MTT is not installed with a water supply flow meter, the volume of water consumption at each plant is unclear. It is even difficult to measure the quality and volume of waste water from each plant because there are no discharge pits and the discharge system consists largely of conduits. Under these circumstances, it is impossible to plan a pretreatment system over all MTT.

For reference purposes, a pretreatment system shall be introduced as follows for the case of the cloth dyeing plant only, from which good coagulation results were obtained.

Table 3.3. S-3 MTT Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quan-tity m^3/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	SS mg/L ( )	color (1/m)	t-N mg/L (kg/d)	t-P mg/L (kg/d)
*1 Wastewater from Printing	400	230 (90)	150 (60)	60 (12)	40	16 (36)	1
*2 Case-1 Coagulation & sedimentation	400	120 (50)	80 (30)	< 30	< 5		< 1

(Note) * 1: quality of waste water from the printing plant
* 2: when waste water is pretreated (by coagulating sedimentation)

Table 3.3. S-3 MTT Equipment and Running Costs of the Pretreatment System

	Equipment cost SIT	Depreciation & Interest SIT/m³	Running Cost SIT/m³	Total treatment cost SIT/m³
CASE-1	50,000,000	55	80	135

The running cost has been calculated for the case of a treatment volume of 400 m^3/d.

3) Conclusion

In total, all the plants of MTT consume thousands of cubic meters of water every day. If a waste water treatment system for direct river discharge is to be built, the treatment unit cost would be cheaper if all the waste water was handled together, however, if a pretreatment system for discharge into the sewerage system is adopted, it is often more economical to treat waste water that has a high pollution load separately.

First of all, it is necessary to gain an understanding of the actual water consumption at each plant within the group.

3.4 S-4 Tovarna sukancev in trakov TSP, p.o.

3.4.1 Factory Profile

Capital	: 637,588 Thousand SIT		
Total factory area	: 9,038m^2		
Number of employees	: 198		
Products	: Sewing thread	Ribbons	Belt fabric
	Polyester 95%	Mixed cotton 5%	
Annual production	: 182,300kg		
Annual sales	: 470,950 SIT		
Working conditions	: 8 hours/day		

3.4.2 Water Conservation

(1) Implementation of water usage control

As said previously, water conservation is currently practiced to a certain extent. But since well water is free, water conservation control is not enough.

However, there are plans to reduce expensive river water and to increase well water usage. If well water is used and discharged into sewage, more than 100 SIT/m^3 (for tax and sewage fees) will be required. When the WWTP is built in the future, the cost is expected to exceed 100SIT/m^3. Well water use should not be increased without considering these factors.

(2) Reclamation of waste water

(a) Reclamation plan

i. Selection of source water

Colored waste water which is not easily decolorized should be avoided. The following may be selected :

① Colorless waste water of the pre-washing and dyeing processes
② Relatively less colored rinsing waste water of dyeing process.

The water of ① is presumably of small quantity. The water of ② is needed to ensure a large amount of recovered water.

ii. Quality of reclaimed water

The minimum required quality of reclaimed water is determined by purpose (eg. rinsing water of dyeing process). But the quality of usable water by function is often unknown. Then it must be checked by experiment.

iii. Reclamation process

Water source→pH control→Two stage biological treatment (Trickling filter, submerged bio-filter)→Coagulation and sand filtration→Activated carbon absorption→Recovered water

(b) Economic evaluation

① The anticipated cost for water reclamation is quite high, probably in excess of 200 SIT/m^3.

② Costs included in water reclamation are facilities to collect waste water and recovered water; storage tanks to temporarily hold waste water and recovered water, facilities to supply recovered water (piping, pump, etc.), and others.

In light of this, the anticipated cost of water reclamation is high.

③ A charge of about 160 SIT/m^3 is expected in the future when the WWTP is built. But if a tax for water use (about 41 SIT/m^3) is charged, water reclamation may be economically feasible under certain conditions.

3.4.3 Pretreatment and Waste Water Treatment

1) Present conditions

① A heat exchanger for cooling waste water (preheating of make up water) and neutralization system are both installed.

② According to analyzed data of the last three years, emission standards for sewage discharge are cleared even without these facilities.

③ Direct river discharge is clearly uneconomical.

2) Pretreatment for reduction of the pollution load

Based on the coagulation test results, comparison shall be carried out on the following two alternative pretreatment systems.

Table 3.4. S-4 TSP Quality and Pollution Loads of Waste Water and Treated Water

Kind of wastewater	Quan-tity m3/d	CODcr mg/L (kg/d)	BOD mg/L (kg/d)	SS mg/L ( )	color (l/m)	T-N mg/L (kg/d)	T-P mg/L (kg/d)
*1 Raw total wastewater	200	400 (80)	200 (40)	40 (8)	30	15 (3)	1
*2 Case-1 Coagulation & sedimentation	200	250 (50)	80 (16)	< 30 (<6)	< 3		
*3 Thick wastewater (Raw water)	40	2,000 (80)	900 (36)	50 (2)	80	45 (2)	5
*4 CASE-2 Coagulation only	40	1,300 (52)	500 (20)	500	7		2
*5 CASE-2' Mixed total discharge	200	300 (60)	120 (24)	100	< 3		< 1

(Note) * 1: quality of total waste water
* 2: Case 1: case of pretreatment (coagulating sedimentation) of total waste water
* 3: quality of only colored waste water separated from the dyeing processes
* 4: Case 2: pretreatment (just coagulating sedimentation) of colored waste water only
* 5: Case 2: total waste water when treated colored waste water is mixed with other waste water

Case 1: pretreatment (coagulating sedimentation) of total waste water
COD and BOD fall and the reduction in SS and color is great.
If 200 m^3 of waste water is collected and treated by coagulation every day, floc separation will be necessary.

Case 2: pretreatment (coagulation only with no floc formation) of colored waste water only
SS will increase but coloration will almost completely disappear.
In the case where only 40 m^3/d is treated by coagulation, even if the waste water is discharged without forming floc that adsorbs the colored matter, because the final effluent will be diluted five times by the other waste water, the increase in the SS value will not be too extreme.

Table 3.1. S-4 TSP Equipment and Running Costs of the Pretreatment System

	Equipment cost SIT	Depreciation & Interest SIT/m^3	Running Cost SIT/m^3	Total treat-ment cost SIT/m^3
CASE-1	40,000,000	120	105	225
CASE-2	10,000,000	30	25	55

3) Conclusion

The present waste water would satisfy discharge standards in the case of discharge into the sewerage system. In the event where reduction of water coloration becomes necessary due to additional requirements, it would be best to separate only the colored waste water from the dyeing processes and carry out treatment by coagulation. Fortunately in the case of TSP, because the dyeing machines are on the second floor and the waste water piping is on the first, it is relatively easy to switch over to piping for colored waste water only and install a water storage tank.

3.5 S-5 METALNA, STROJE-GRADNJA, KONSTRUKCI-JE, MONTAZA IN STORITIVE, d.d.

3.5.1 Factory Outline

(1) Outline

Metalna, Strojegradnasa, Konstrukcije, Montaza Instoritive, d.d. is a major heavy industrial company within Slovenia. It used to be a state factory possessing a work force of 4,200, however, divided between the 12 companies of the Metalna group. 10 of those companies, possessing a combined work force of 2,000, are located in Maribor, and the other two companies, with a combined work force of 500, are in Kriska.

The factory's main products are all forms of hydraulic generator (not including turbines), construction and transportation equipment such as cranes and rings., etc., and various industrial machinery for the chemicals, paper, food and dye sectors, etc.

With the cooperative operating setup of the group behind it, the company is currently being active on the international stage. Participation of the iron working division is anticipated in future WWTP construction.

(2) Scale

Capital	:	23,000 DM
Total factory area	:	300,000 m^2
Number of employees	:	2,100
Products	:	hydraulic generators, construction and transportation instruments, industrial machines
Working conditions	:	8 hr/day (paying 8 hr), 250 days/year

3.5.2 Water Conservation

(1) Technical comment

① Because the current control of water usage cannot be described as sufficient, it is necessary to put into effect a much stricter control system by first attempting to grasp the volumes of water used in each area.

② It is possible for the cooling water currently being used in one-through to be recycled by the cooling tower. However, consideration does need to be given to the following points.

- Maximum allowed water temperature required for cooling and the minimum water temperature that can be obtained in the summer from the cooling tower.

- As the machinery that requires cooling is thought to be dispersed throughout the factory, the ability to group it and carry out the recycled use of water.

(2) Economic comment

① In order to carry out the sufficient control of water usage, in addition to the installation of flow meters, etc., more control staff are needed. The volume of water saving required to balance the extra personnel expenses created by this is calculated in Table 4.5.4 based on set preconditions.

Case	Preconditions				Water Saving where Expenses Can be Recovered	
	Operating Days (days/year)	Personnel Expenses Unit Rate (1000 SIT/year)	Required Staff	Costs Relating to Water Usage and Waste Water (SIT/m³)	Volume of Water Saving (m³/day)	Rate of Water Saving (%)
Now	250	3,000.0	2 x 0.5	213	56.3	26.6
*Future	250	3,000.0	2 x 0.5	310	38.7	18.2

*Note : In the case where a WWTP is completed.

It would be difficult to recover the additional costs in the current situation. However, the economic feasibility of the future case is high.

② In the case of recycle using cooling water by the cooling tower, the cost per unit of recycled water would not exceed 100 SIT/m³ (roughly 30-40 SIT/m³), and indeed this proposition would be economically feasible even now.

3.5.3 Pretreatment

1)Pretreatment that Satisfy WWTP Discharge Standards, and Waste Water Treatment

(1) Treatment system

Waste water from the painting booths is treated by coagulating sedimentation before being discharged.

(2) Waste water quality and pollution load

The quality, volumes and pollution loads of waste water and treated water are shown in Table 3.5.1.

Table 3.5.1 Volumes, Quality and Pollution Loads of Waste Water

Kind of Waste Water	Case	Quantity m³/d	pH	CODcr mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Varnishing	Raw Waste Water (1)	10	8.7	1,440 (14.4)	300 (3)	85 (0.85)	20 (0.2)	5 (0.05)
	Pre-Treatment (2)	10	7	1,152 (10.5)	240 (2.4)	30 (0.3)	20 (0.2)	5 (0.05)
Total Waste Water	Raw Waste Water (3)	212	8.2	85 (18.0)	50 (10.6)	30 (6.36)	30 (6.36)	2 (0.42)
	Raw Waste Water (1+3)	222	7	146 (32.4)	62 (13.6)	32 (7.21)	30 (6.56)	2 (0.47)
	Pre-Treatment (2+3)	222	7	128 (28.5)	59 (13.0)	30 (6.66)	30 (6.56)	2 (0.47)

(3) Equipment cost and treatment cost

The equipment and treatment costs of the pretreatment system are shown in Table 3.5.2.

Table 3.5.2 Equipment and Running Costs of the Treatment System

		Equipment Cost SIT	Depreciation & Interest SIT/m³ ①	Running Cost SIT/m³ ②	Total Treatment Cost SIT/m³ ①+②
Pretreatment	Case-1	24,000,000	52	43	95

2) Pretreatment for reduction of the pollution load

Because waste oil from cutting is consigned for treatment to an outside sub-contractor, there is no waste water with a high pollution load. Consequently, there is no need to install a pretreatment system for reducing the pollution load.

3) Conclusion

Judging from the water quality measurements, there is no need to install a pretreatment system for general waste water. However, in the case of waste water generated in the painting booths washing, it would be desirable to perform pretreatment before discharging to the WWTP.

3.6 S-6 MERKATOR-SLOSAD, d.d.

3.6.1 Factory Outline

(1) Outline

Merkator-Slosad d.d. is a manufacturer of natural fruit juices, fruit soft drinks, sarcocarp drinks, fruit syrups, cherries soaked in alcohol and frozen fruits, etc. Its raw materials include strawberries, apples, cherries, and so on. The factory possesses freezer equipment that enables it to operate throughout the year, however, production of cherry juice reaches a peak in the first three weeks of June and production of apple juice reaches a peak between September and November.

(2) Scale

Capital	:	23,000 DM
Total factory area	:	300,000 m^2
Number of employees	:	90
Products	:	concentrated juice, cherries steeped in alcohol, frozen fruit
Annual sales(t)	:	1,800 400 150
Working conditions	:	8 hr/day (paying 8 hr), 250 days/year

3.6.2 Water Conservation

(1) Features of water usage

① The factory relies on city water and well water as its water sources. The amount of city water used is measured, but the well water is not, and the figures given on the questionnaire were estimated based on production volumes. The volumes used of each source are extremely small.

② Well water is used in boilers and for the washing of equipment. Because the quality of the well water is low, it cannot be used as potable water. Furthermore, the amount of well water that can be lifted is limited and it would be difficult to increase the current volume.

③ Water from the city water is mainly used as cooling water in refrigerator, and some is used for domestic purposes.

(2) Current condition of water conservation

① Condensate water which is generated in the concentration process of fruit juice is used to wash the raw materials. Moreover, much of this washing water is recycled.

② Cooling water for the refrigerator is recycled by the evaporative condenser.

(3) Comment

Because water conservation is already being practiced to a satisfactory degree and only very small volumes of water are being used, there is no room to carry out further water saving.

3.6.3 Pretreatment

1) Pretreatment for WWTP discharge

(1) Treatment system

Waste water undergoes equalization before being discharged (Case 1)

(2) Waste water quality and pollution load

The quality, volumes and pollution loads of waste water and treated water are shown in Table 3.6.1.

(3) Equipment cost and treatment cost

The equipment and treatment costs in Case 1 are shown in Table 3.6.2.

2) Pretreatment for reduction of the pollution load

(1) Treatment system

The waste water is discharged after undergoing equalization and anaerobic treatment. An anaerobic treatment system that does not involve heating the waste water has been selected. This is because, as a treatment system, it is sufficient to achieve an organic material removal rate of around 50%.

(2) Waste water quality and pollution load

The quality, volumes and pollution loads of waste water and treated water are shown in Table 3.6.1.

(3) Equipment cost and treatment cost

The equipment and treatment costs in Case 1 are shown in Table 3.6.2.

Table 3.6.1 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	Quantity m³/d	pH	CODcr mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Pre-treatment	Raw Waste Water	40	5	4,300 (172)	1,400 (56)	500 (20)	50 (2)	5 (0.2)
	Case-1	40	7	4,300 (172)	1,400 (56)	500 (20)	50 (2)	5 (0.2)
	Case-2	40	7	2,150 (86)	700 (28)	250 (10)	15 (0.6)	2 (0.08)

Table 3.6.2 Equipment and Running Costs of the Treatment System

		Equipment Cost SIT	Depreciation & Interest SIT/m³ ①	Running Cost SIT/m³ ②	Total Treatment Cost SIT/m³ ①+②
Pretreatment	Case-1	1,500,000	13	10	23
	Case-2	12,000,000	125	15	140

3) Conclusion

There is no need to install a pretreatment system.

Because the waste water contains harmful substances, there is room to examine a pretreatment system for reducing the pollution load of organic substances. If the WWTP discharge standards are revised or a system of charges according to the pollution load is adopted in the future, it is considered that additional equipment can be added on in a phased manner to the system in Case 2 in order to improve the removal rate.

3.7 S-7 INTES MLIN TESTENINE

3.7.1 Factory Outline

(1) Outline

Intes Mlin Testenine was established in Slovenia 130 years ago and is currently the second largest milling factory in the country. In the past, it made all conceivable products from flour milled from wheat and it had a work force of 1,000, however, the bread factory was made into a separate company five years ago and the work force fell to 400. The work force has since fallen to 180.

The factory's 54,000 ton silo contains 2,200 tons of domestically produced wheat and it mills 150 tons of wheat flour, 24 tons of corn starch and also rye, etc. every day.

The factory started pasta manufacturing 110 years ago and it possesses a production capacity of 4,500 tons. The current production is 3,000 tons and all sorts of pasta products are made.

(2) Scale

Number of employees	: 180
Products	:Flour, Pasta
Annual production(t)	:26,399 3,565
Working conditions	: 8 hr/day (paying 8 hr), 249 days/year

3.7.2 Water Conservation

(1) Features of water usage

① The city water is the only water source, and the volume of water use is measured. The volume of water use by area is also indicated to some extent.

② Looking at the volume of water by purpose of use, 80% is used on raw materials (24%), for the boiler (22%) and for domestic use (34%), and the remainder is used to wash mold forms and cool the compressor.

(2) Current condition of water conservation

① As was mentioned above, the volume of water use is measured and control of water usage is implemented to a certain degree.

② Compressor cooling water is discharged after being used only once.

③ Because a high percentage of water is used for domestic purposes, there is little point in calculating the unit consumption of water.

(3) Technical comment

① It is possible to recycle compressor cooling water by means of a cooling tower. Consideration should, however, be given to the maximum water temperature required for cooling and the minimum water temperature that can be obtained in a cooling tower during the summer.

② Because the water used for raw materials and the boiler is essential, it is near impossible to make any savings in this area.

③ It is extremely difficult to save on water used for other purposes (washing water, domestic water) too.

(4) Economic comment

In the event where the recycled use of cooling water is carried out by means of a cooling tower, the cost per unit of recycled water would not exceed 100 SIT/m^3 (roughly 30-40 SIT/m^3) and is cheaper than the existing cost relating to water and waste water of approximately 213 SIT/m^3. Thus, it is considered that this proposition would be economically feasible.

3.7.3 Pretreatment and Waste Water Treatment

The factory is mainly a milling establishment. The volume of waste water generation is 126 m^3/d, of which 50 m^3/d comes from the manufacturing processes, 55 m^3/d comes from domestic waste water and 21 m^3/d comes from compressor cooling water. The factory is divided into a bread making plant and a pasta making plant, and the volume of waste water generation over each factory is extremely small. Moreover, as this is a foodstuffs manufacturing factory, the waste water contains no substances that may have a detrimental effect on the WWTP and biodegradability is good. As a result, the pretreatment system shall be limited to one for reducing the pollution load of organic substances (COD, BOD). However, because the scale of an individually installed pretreatment system would be so small in this case, the economic efficiency would be poor and this would not be advantageous for either the factory itself or the WWTP.

In consideration of the above, a pretreatment system is considered to be unnecessary at this factory and the idea shall be abandoned.

As it was not possible to carry out a follow-up survey of water quality and water volume, pollution loads obtained from water quality data provided by NIGRAD are shown in Table 3.7.1.

Table 3.7.1 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Quantity m³/d	pH	COD_{cr} mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Total Waste Water	126	8.2	212 (26.7)	82 (10.3)	67 (8.4)	– (–)	– (–)

4. Tertiary Factories

4.1 A-1 TVT-Tovarna Vozil in toplotne tehnike - Boris Kidric - TIRNA VOZILA

4.1.1 Factory Outline

(1) Outline

TVT was established in 1863 as a factory for manufacturing and repairing railway rolling stock (steam engines and passenger cars). The company has now split up into 30 establishments and the survey target factory of Druzba za proizcodnjo in remont tirnih vozil d.o.o. mainly carries out the manufacture and repair of rolling stock, although its manufacturing activities have almost come to a halt.

Main work at the factory consists of dismantling and repainting rolling stock cars and repairing or renewing their component parts. Waste water is generated in the car washing and painting pre-washing processes, however, the car washing water is re-use for repeated use and no water is used in the painting process itself. As a result, there is no generation of waste water.

(2) Scale

Capital	:	448,000,000 SIT
Total factory area	:	37,000 m^2
Number of employees	:	533
Working conditions	:	8 hr/day (paying 8 hr), 254 days/year

4.1.2 Water Conservation

(1) Technical comment

① Grasping of water usage conditions at the small-scale plants

It is extremely difficult to accurately gauge the volumes of water used by plant and purpose of use at the 30 or so small-scale plants. However, because the water consumed by these plants does account for such a large proportion of the total water usage, it is vital to have an understanding of this water usage from the viewpoint of water conservation.

It is assumed that water in these small-scale plants is mainly put to use in large water tank (100 m^3) leakage tests and the washing of parts. Recycling for repeated use would be easy to achieve in the former case.

② Reduction of public water supply loss

The water loss accounts for as much as 15% of the overall public water supply. As the factory complex is broad and piping deteriorated, there is a strong possibility that the loss originates from the piping.

There is no accurate way to prevent leakage in technical terms, but a lot of patience is required. It is necessary to reduce the loss over the long term by partially closing pipes and searching for leaks when plants are not operating, or transferring underground piping to above ground as much as possible when piping renewal times come around, and so on.

③ Potential water saving

Through carrying out the above measures, it would be easy to save around 100 m^3/d of the current small-scale plant water usage of 237 m^3/d and water loss of 80 m^3/d.

(2) Economic comment

The above-mentioned conservation methods require man hours in the survey and examination stages, however, because equipment and running costs would be low, such methods would be economically feasible if implemented over time.

(3) Problem points

TVT controls water supply and waste water discharge over the whole factory complex, including the small-scale plants. However, because the water supply and waste water discharge costs are borne by each of the plants, there would be little profit for TVT even if water saving measures were to be implemented. Thus, in order to promote the conservation of water usage, it would be necessary for TVT to take the lead in forming a joint project team composed of members from all related plants and for the project team to survey, examine and promote the conservation.

4.1.3 Pretreatment

Looking at the main manufacturing facilities that discharge waste water in the TVT group, as it can be seen that the plating facilities are fitted with a waste water treatment plant and no waste water is generated from washing facilities due to water recycling, there is no need to install pretreatment or waste water treatment plants.

water treatment plant and no waste water is generated from washing facilities due to water recycling, there is no need to install pretreatment or waste water treatment plants.

The current quality, quality and pollution loads of discharged water from the TVT group are shown in Table 4.1.1.

Table 4.1.1 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	Quantity m³/d	pH	CODcr mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Effluent RJ I	Raw Water	103	8.4	74 (7.62)	31 (3.19)	29 (2.99)	( )	( )
Effluent RJ II	Raw Water	517	8.4	16 (8.27)	6 (3.10)	34 (17.6)	6.5 (3.36)	2.4 (1.24)
Total Waste Water (Discharge to Rever)		620	8.4	25.6 (15.9)	10.1 (6.29)	33.2 (20.6)	( )	( )

4.2 A-2 ELEKTROKOVINA-SVETILA

4.2.1 Factory Outline

The forerunner of this company, ELEKTROKOVINA, was established in 1948 and at its peak possessed a work force of 3,500. With the onset of organizational division and privatization following independence of the country, the company was split up into three medium-size factories and approximately 300 small enterprises. The total work force now numbers approximately 300.

This company forms one of three group factories, the other two being ELKO ELEKTROKOVINA MARIBORR (A-4) and ELEKTROKOVINA TEHNIKA, which provides maintenance services to group factories. The current owner of the company is the German firm SIEMENS.

The factory's main products are indoor, outdoor and industrial lighting fixtures and its annual production is 2,700,000 units, approximately 70% of which are exported mainly to neighboring countries. The factory now has approximately 260 employees; it once possessed 1,000 employees prior to independence but this figure dropped as a result of the restructuring typified by closure of the parts plant following establishment of the maintenance group.

Capital	: 1,000,000,000 SIT
Employees	: 266
Operating hours	: 8 hours/day
Products	: lighting fixtures
Annual production	: 764,913 units

4.2.2 Water Conservation

1) Features of water usage

Most of the water supply is used in pretreatment for coating and alumite processing, and minor quantities are used as cooling tower make-up water and spot welder cooling water. The overall usage is approximately 93 m^3/day.

All of the water used by the factory comes from the public water supply, and the supply system that was used from the time of the former ELEKTROKOVINA is currently used by approximately 30 companies in the group. Water is taken from the public water supply in three points each installed with water meters, and ELEKTROKOVINA TEHNIKA is currently in charge of these intake points.

Because the individual factories receiving the water supply do not have water meters, the water usage of each factory is estimated each month by taking the total of the readings of the above-mentioned three water meters and multiplying by the share ratios of each factory that are determined according to factory scale. The share ratio of the target factory is set at 36.33%, and the above-mentioned water usage quantity of 93 m^3/day is estimated based on this.

2) Current condition of water conservation

① Water conservation is already practiced through the recycling of cooling water for hydraulic molding machines by means of a water tower. The recycled water volume is 120 m^3/day and 12 m^3/d of make-up water is also used.

② Cooling water for spot welders is only used once, however, the operating rate of the welders is low and water usage minor so this does not pose a problem.

3) Technical comment

The installation of a water meter for the factory is a fundamental condition for water saving. In fact, it is preferable to control water usage by installing flow meters for each area of water use (manufacturing process washing water, cooling tower make-up water, domestic water, miscellaneous water, etc.). It is considered that room does exist for further water saving, for example, the cooling tower make-up water, etc.

4.2.3 Pretreatment and Waste Water Treatment

1) Current conditions

The factory possesses a waste water treatment system for treating washing water from the manufacturing processes, etc. that was constructed around 20 years ago, and this is still in good working order today. The basic processes of the waste water treatment system are oil separation, neutralization, and chemical precipitation.

In addition to the statutory measurements carried out twice annually, the quality of treated water is tested for pH, Fe, Cu, Ni and Zn twice per week by the factory.

2) Pretreatment and waste water treatment

As the factory is already treating its waste water to within existing discharge standards, there is no need to install additional facilities.

4.3 A-3 PRIMAT-Tovarna kovinske opreme

4.3.1 Factory Outline

(1) Outline

TKO PRIMAT MARIBOR uses steel plate as a raw material to manufacture various types of safe boxes and steel furniture. The company has three plants in Slovenia, and the one located in Maribor is the OBRAT MELJE Factory.

The main processes consist of the machine processing of steel plate, painting and assembly, and the main source of waste water is the painting process.

(2) Scale

Capital	:	884,567,000 SIT
Total factory area	:	17,366 m^2
Number of employees	:	220
Products	:	safe boxes, steel furniture
Annual production(t)	:	1,220 727
Working conditions	:	8 hr/day (paying 8 hr), 249 days/year

4.3.2 Water Conservation

(1) Technical comment

① Recycling of cooling water for spot welding machines

In view of the fact that the 14 welding machines are concentrated into one area and the cooling water does not have to be very cold, it would be relatively simply to carry out water recycling.

A cooling tower would be used to recycle the water, however, because the tips of spot welding machines are very narrow, there is a risk that airborne dust might infiltrate the recycled water and block the tips if a normal open-type cooling tower were used.

In order to avoid this problem, it is desirable to use a closed-type cooling tower. In this type of cooling tower, the recycled water is indirectly cooled in pipes without coming into direct contact with the air. As a result, the cooling water is not contaminated, however, the cooling effect is slightly inferior compared with that obtained in an open cooling tower. Having said that, such a drawback would not prove too much of a problem in this case.

② Potential water saving

It is normally the case to expect a water saving of more than 90% when introducing a cooling tower, however, in consideration of the fact that the cooling capacity of the closed-type cooling tower may be insufficient in the summer, it is considered that approximately 70% of the existing cooling water can be saved. Thus, a water saving of approximately 60 m^3/day is considered possible.

(2) Economic comment

As a closed-type cooling tower would be used, the equipment and running costs would be higher than compared to the case of an open-type cooling tower. However, comparing this with the existing cost of approximately 200 SIT/m^3 incurred by the water supply and waste water, this proposal is still thought to be amply feasible in economic terms.

4.3.3 Pretreatment and Waste Water Treatment

(1) Pretreatment for WWTP discharge

a. Case 1

In this case, heavy metals, organic substances and phosphorous are partially removed from painting pretreatment waste water and painting booth washing waste water.

b. Case 2

In consideration of the future use of powder paint, this case deals only with the treatment of waste water from the painting pretreatment process (the treatment of painting booth washing waste water is omitted). The actual system of waste water treatment, however, is the same as that described in Case 1.

(2) Volumes, quality and pollution loads of waste water and treated water

Table 4.3.1 Volumes, Quality and Pollution Loads of Waste Water and Treated Water

Kind of Waste Water	Case	Quantity m³/d	pH	COD_{cr} mg/ℓ (kg/d)	BOD mg/ℓ (kg/d)	SS mg/ℓ (kg/d)	T-N mg/ℓ (kg/d)	T-P mg/ℓ (kg/d)
Pre-Treatment of Varnishing	Raw Waste Water	4.74	5.8	245 (1.16)	225 (1.07)	190 (0.9)	18 (0.09)	1,800 (8.53)
	Case-1	4.74	7	1,880 (8.91)	404 (1.91)	30 (0.14)	25 (0.12)	2 (0.09)
	Case-2	4.74	7	196 (0.93)	180 (0.85)	30 (0.14)	18 (0.09)	2 (0.01)
Varnishing	Raw Waste Water	0.86	9	14,000 (12.0)	2,050 (1.76)	450 (0.39)	55 (0.05)	120 (0.10)
	Case-1	0.86	7	1,880 (1.62)	404 (0.35)	30 (0.03)	25 (0.02)	2 (0.02)
Domestic	Raw Water	11		400 (4.4)	200 (2.2)	50 (0.55)	40 (0.44)	7 (0.08)
Total Waste Water	Raw Waste Water	109	7.7	161 (17.6)	46 (5.03)	17 (1.84)	5.3 (0.58)	80 (8.71)
	Case-1	109	7	137 (14.9)	41 (4.46)	7 (0.72)	5.3 (0.58)	2 (0.19)
	Case-2	108	7	49 (5.33)	28 (3.05)	6 (0.69)	4.9 (0.53)	1 (0.09)

(3) Equipment cost and treatment cost

The equipment and treatment costs in Case 1 are shown in Table 4.3.2.

Table 4.3.2 Equipment and Running Costs of the Treatment System

	Equipment Cost SIT	Depreciation & Interest SIT/m³ ①	Running Cost SIT/m³ ②	Total Treatment Cost SIT/m³ ①+②
Case-1, Case-2	10,000,000	53	11	64

2) Pretreatment for reduction of the pollution load

Adoption of a powder painting process will lead to a reduction in the pollution load. Consequently, there is no need to install a pretreatment system for reducing the pollution load.

3) Conclusion

Under the present painting system, as there is a danger that the quality of total waste water may go over BTX standards, it is necessary to adopt a system of coagulating sedimentation.

In the case where the painting system is changed to one using powder paint in the future, measures for dealing with pH and P in the painting pretreatment waste water are sufficient.