(2) The average unit cost of improvement is 4.7 ฿/m^3
(i.e. the saving rate is 20%)

Groundwater Critical Area
63,488 x 2,285/934 = 155,321 (m^3/d)
Bangkok Groundwater Area
63,488 x 7,923/934 = 538,560 (m^3/d)

Considering the fact that 400,000 to 600,000 m^3/d of groundwater should be saved in order to reduce the present quantity of pumping up in the Bangkok Metropolitan area down to the safe yield level (Refer to 8.1), the above potential quantity seems to be the minimum which can be achieved.

Needless to say, being based on various assumptions, the above estimates are not entirely reliable. In addition, the demand for water in the Bangkok Metropolitan area is expected to increase as economic/industrial activities grow. Consequently, the important thing is to implement variety of improvement measures as listed in the technical guidelines.

However, if the average cost of improvement is set at 1.4 ฿/m^3 (i.e. if the saving rate is set at 10%), water saving method alone will not be enough to reduce the pumping up quantity down to the safe yield level. In case the cost of improvement is set low, other measures listed in Fig. 8.1 should be positively considered.

8.3 Problems in Implementing Water Saving Measures

As explained above, the reduction of water consumption alone may not be enough to prevent the subsidence of land. Other countermeasures against land subsidence should be taken together with water saving measures.

Table 8.1 sums up the various countermeasures against land subsidence to be taken in the public and private sectors. For each program listed in Table 8.1, specific problems are discussed in the followings.

8.3.1 Water Act--Laws and Regulations Concerning Water Sources Utilization

In order to prevent land subsidence in the Bangkok Metropolitan area, it is essential to reduce the present quantity of pumping up (in particular, in the private sector) down to the the safe yield level.

As MWA is now intending, conversion of water source from wells to rivers is one effective way to achieve this purpose (Refer to Fig. 8.1). The surface water of the Chao Phraya River, however, is used not only by manufacturing factories but also by farms and households.

Therefore, it is important to maintain the flow rate of the river, making it available to diversified demands while distributing its surface water in a well-balanced way.

This may be achieved by constructing dam(s) in the upper reaches, building a giant reservoir in the plain area, diverting surface water from the Mekong River (Refer to 8.1).

All the above measures require much time and money. Implementing these measures, therefore, presupposes the establishment of a basic Water Act covering the entire nation.

In contrast, water saving measures in individual factories are relatively easy to implement. Nonetheless, to bring meaningful results in this respect, certain legal measures should be taken together with voluntary efforts by factories.

At present, the Groundwater Act controls pumping up rights by imposing a groundwater rate, while the MWA Act aims at providing river water through pipelines. The coordination of these two Acts is yet to be realized.

As water is not an exclusive industrial commodity, a comprehensive point of view is required in establishing effective laws and regulations to reduce groundwater consumption.

Also important are regional differences. As the safe yield of groundwater is different from region to region, the target quantity of water saving may not be uniform. Needless to say, priority should be given to those regions where the subsidence of land is grave.

8.3.2 Relocation of Factories

Adequate infrastructure is an essential condition for the operation of factories. Besides good harbors and roads, the supply of water constitutes a basic element of infrastructure.

If too many factories are concentrated in one area, the result is likely to be the excessive pumping up of groundwater and hence the subsidence of land. In such a case, alternative water sources (e.g. river or public industrial/city waterworks) should be available.

In the Bangkok Metropolitan area (including Samut Prakarn area), the concentration of factories clearly exceeds the supply capacity of groundwater.

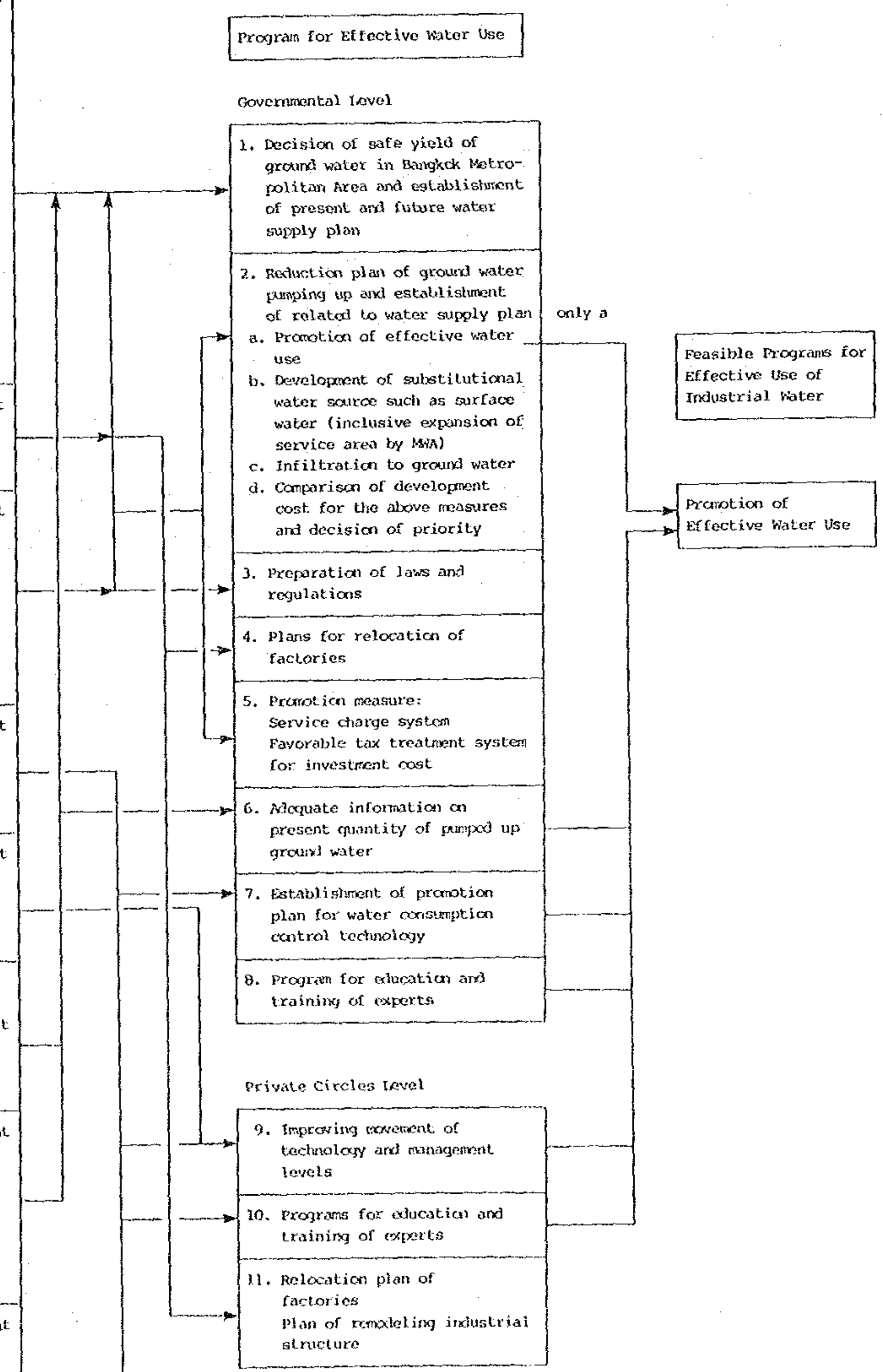
Consequently, despite the strenuous efforts by governmental agencies to change the water source from wells to rivers, the subsidence of land seems to be unstoppable.

To cope with this problem, the relocation of factories can be an effective solution. This policy is exemplified by the Eastern Seaboard Development Program.

Table 8.1: Problems and Measures related to Effective Use of Industrial Water

Present Situation/Problems	Measures	Promoter
A. System and Policy		
1. Water act, especially adjustment of plan for water utilization, preparation of laws and regulations, and intensification of enforcement regulations are necessary.	Quantity of pumped up groundwater in Bangkok Metropolitan Area is over 1,200,000 m³/day, and allowable quantity for prevention of land subsidence is said to be 600,000 to 800,000 m³/d. Therefore, pumping up of 400,000 to 600,000 m³/d groundwater must be reduced. In order to promote this reduction program in each industrial area, safe yield in each area must be estimated and reduction plan must be prepared to attain the object. MWA is reducing quantity of pumped up groundwater, but quantity of pumped up groundwater by industries is rather increasing. Thus, quantity of pumped up groundwater is not reduced as a whole. Reducible quantity of industrial water by adoption of water saving and effective water use is not sufficient, and developments of substitutional water source (surface water and others) are necessary. Use of surface water requires quantity adjustment with agricultural water and public water works. Plan for independent public industrial water works would necessitate adjustment with MWA Act and consideration of service charge. (Some factories would not like to pay high service charge.)	Government
2. Revieew of plans for factory location and factory relocation	By relocation of factories in industrial zone for modernization and expansion of factories, effective water use and waste water treatment shall be promoted. In this modernization plan of factory, change to new production process that does not use much water shall be included.	Government Private Sector
3. Measure for effective use of industrial water is not fully established.	As an incentive of effective water use, introduction of service charge system, especially gradual increase system by which user of much quantity of water has to pay higher service charge, is most effective. But, for those factories which depend on groundwater, service charge of public industrial water works would be operating burden. To solve the problems, laws and regulations should be enacted to enforce the promotion of effective use of industrial water, and public industrial water works should be constructed to supply substituted water of reasonable price by developing river water and other water sources.	Government
4. Personnel engaged in industrial water supply and discharge is shorthanded and system for authorizing process is not established.	Education and training system shall be expanded. At the same time, authorizing system such as "water control engineer" and "environmental preservation engineer" shall be newly established, so that control capabilities shall be intensified.	Government
5. Test and inspection institutions, evaluation body of test process and services related to industrial water supply and discharge are not established.	Confirmation of water quantity and quality data by establishment of flow meter repair center and authorizing system for material standardizing, for example. Establishment and operation of technology development center for promotion of water treatment technology.	Government
B. Technology		
6. Designation of safe yield of pumped up groundwater in area of land subsidence is not clear.	This figure is basis for restriction of pumping up quantity of groundwater. It is necessary to clarify target quantity of reduction of pumping up groundwater. The data are also used for future plans of factory relocation in various areas.	Government
7. Factory staff does not grasp exact quantity and quality of consumed water.	These data must be fundamentally grasped for effective use of industrial water. Quantity of process water and water for living including leakage must be clearly grasped. Recycled quantity from cooling tower for recycling use of water, quantity of flow, quantity of discharged water and quality of discharge water must be firmly grasped. Overall situation must be grasped by further investigation of those on these items.	Government Private Sector
8. Intermediate managing staff and engineers specializing in water treatment are shorthanded, and training institute of engineers is lacked.	Promotion for establishing guidance organization initiated by central government. Promotion of improvement activities of managing and technological levels by private circles. Establishment of engineering firms capable of acting as coordinator of these matters.	Government Private Sector

Table 8.1, Part 2



To make the public aware of the importance of water saving, instruction and guidance have to be provided.

For example, when a factory is newly built or renovated, advice should be given to employ water/energy saving type production lines.

8.3.3 Encouragement for Effective Use of Industrial Water

As mentioned, the reduction of water consumption in individual factories is an effective way to reduce the pumping up of groundwater in the Bangkok Metropolitan area. To achieve a significant level of water saving, however, factory operators must be motivated to do so.

In addition to legal measures, the cost of water will play an important role in motivating factories to consume less water. When any quantity of water is available without charge, no factory is induced to economize on it. Thus, cost-consciousness should be evoked to realize water savings.

In this context, it may be effective to install public industrial water works system that supply water at a much lower price than MWA. Such measures should be further studied. .

8.3.4 Training/Education of Personnel and Technical Qualification System

Accurate knowledge of the quantities and qualities of water used in factories is a prerequisite for the control of water consumption. The Factory Act and the Groundwater Act make it compulsory to furnish a flow meter at each well.

However, mere installation of flow meters is not enough. More important is the existence of specialists who are capable of making use of flow meters to control water consumption. As the use of water depends on various factors ranging from regional characteristics to production lines, such experts should possess the appropriate know-how and experience.

Considering the present situation of the surveyed factories, it appears unavoidable to create experts in water control through OJT (On-the-Job Training). The skills of these specialist should cover not only the control of water consumption but the proper treatment of waste water as well.

To encourage the training of experts, some kind of public qualification system may be helpful. For example, steps may be taken to make it compulsory for each factory using a certain quantity of groundwater to employ qualified engineers.

8.3.5 Establishment of Service Centers for Flow Meter Repairs, Water Quality Tests, Data Analysis and Technical Development

Accurate data concerning the use of industrial water cannot be obtained without proper working of flow meters. And yet, in some of the surveyed factories, defective flow meters were left without repair.

Since in some cases these factories cannot do repairs by themselves, certain governmental support may be necessary.

Furthermore, as the recovery of water goes on, certain adverse effects on equipment (corrosion, clogging through scale formation and the like) may result from the use of reclaimed water.

The development of techniques based on the analysis of water qualities is indispensable for surmounting such troubles. Governmental support may be helpful in this respect, also.

As mentioned previously, the effective use of water depends on regional factors, so water-related techniques have to be developed on a regional basis.

8.3.6 Determination of Safe Yield

To control the pumping up quantity of groundwater, some criteria should be established. That is why a safe yield of groundwater should be determined for each region concerned.

According to a survey conducted by the Thai Government, the average safe yield ranges from 600,000 to 800,000 m^3. (the study suggests that 600,000 m^3/d may be closer to the average).

Of course, the safe yield differs from area to area. For example, in Samut Prakarn Province, the safe yield in the area along the Chao Phraya River is likely to be higher than that in the east of the Province.

If the safe yield is determined for each area on the basis of detailed analysis of local conditions, a precise plan for the effective use of industrial water can be established. In some cases, it may be convenient to set up the safe yield per square kilometer ($m^3/d/km^2$).

8.3.7 Acquirement of Accurate Data on the Water Used in Factories

In some of the surveyed factories, it was difficult for the study team to estimate the quantity of domestic water or to derive the leakage rate from the total water balance. The accurate data, however, is essential for the effective use of water.

For example, the discovery of a large leakage quantity may lead to the early adoption of some preventive measures, while accurate measurement of the blow water quantity and the degree of concentration from cooling towers is useful in reducing the quantity of make-up water.

Not only quantities of water but also its qualities are important. The clear understanding of the qualities of supply/waste water makes it easy to apply effective water treatment, or to re-use water for production line. Thus the comprehensive data of water is required for the effective use of industrial water.

8.3.8 Education/Training of Managers and Engineers

This is already mentioned in 8.3.4. Managers or engineers equipped with specialized knowledge will be of great help for the effective use of industrial water. For the time being, OJT should be carried out on every occasion.

Chapter 9

Suggestions for Effective Use of Industrial Water

Chapter 9 Suggestions for Effective Use of Industrial Water

9.1 Programs for Effective Use of Industrial Water

In Table 8.1, various measures explained in 8.3 are summarized as the programs for the effective use of industrial water. The programs are divided into some for the public sector and others for the private sector.

Among the programs, 2-a, 3, 5, 6, 8 (in the public sector) and 9 (in the private sector) are closely related to the study. In the following, these program items are explained one by one.

9.1.1 Promotion of Effective Water Use (Item 2-a)

The water saving measures suggested in this study should be applied not only in Samut Prakarn but also in the whole Bangkok Metropolitan area (including its surrounding areas). The following projects may be useful for this purpose.

a. To promote the technical guidelines for effective use of industrial water to all persons concerned (by holding seminars, for example)

b. To conduct the survey on an enlarged number of factories

c. To operate a model plant to demonstrate effective use of industrial water

d. To visit industrial factories in order to help them implement the technical guidelines for effective use of industrial water

e. To send experts to industrial factories in order to implement the technical guidelines for effective use of industrial water

These projects are relatively easy to implement, and hence are explained in detail later in this section (9.2).

9.1.2 Preparation of Laws and Regulations (Item 3)

In carrying out the water saving programs, certain legal measures which confirm the land subsidence as a public hazard and control the pumping up of groundwater will be required to make factories invest in water saving equipment or employ expert personnel.

Such legal measures may be taken at both the central and local government levels. (In case of local governments, the training of supervising staff may be necessary.)

9.1.3 Promotion Measures for Effective Use of Industrial Water (Item 5)

The voluntary cooperation on the part of factories is indispensable for the implementation of the water saving programs. Financing help or favorable tax treatment systems (e.g. low interest financing and reduced tax for investment of effective use) are effective incentives to bring out such cooperation.

In addition the shift of the water source from well to river (e.g. MWA water) may be encouraged by the raising of the groundwater rate from the present level (1 ฿/m³) and/or the installation of new public industrial waterworks that will supply water at reasonable prices.

The final goal is to reduce the pumping up quantity of groundwater. To achieve this goal, any and every creative measures should be employed.

9.1.4 Adequate Information on Present Quantity of Pumped Up Groundwater (Item 6)

The accurate data on the quantity of groundwater consumption is a prerequisite for any the water saving programs. As mentioned in 8.3, although the Groundwater Act makes it compulsory to furnish a flow meter for each well, the study revealed that some flow meters were out of order. Such irregularities should be promptly corrected.

9.1.5 Programs for Education and Training of Experts (Item 8)

It is vital for a national economy to secure stable water supply. In Thailand, if things are left untouched, some areas are likely to face the storage of water. So, some long-term program should be established to train experts on the control of water.

9.1.6 Improving Movement of Technology and Management Levels (Item 9)

Although some of the surveyed factories have already achieved remarkable levels of effective use of water, none have flow waters installed at inlet/outlet sides of the cooling towers. Also, the data on water qualities are often inadequate. Further efforts seem necessary to improve water control techniques on more accurate data.

For the technical improvement, the exchange of experience and know-how between factories concerned will be of great help. Needless to say, governmental backups (e.g. section of model factories or the invention of some incentive systems) may be required for this purpose.

Among the above programs, "9.1.1 Promotion of Effective Water Use" is the easiest to implement. The other programs, though important, cannot take immediate effects for the following reasons:

(1) As Japanese experience indicates, it takes a long time to establish or revise the water-related laws and regulations, though it should be done some day.

(2) At present, Thailand has no financing or favorable tax treatment systems for effective use of industrial water, and

the like. Establishing such systems from scratch may not be easy.

(3) Although it is highly advisable to raise the groundwater rate, various vested interests make it difficult to implement.

(4) The enlargement of MWA's supply area or the construction of public industrial waterworks takes a lot of time and money.

(5) The gathering of accurate data should be included in the program 9.1.1, Promotion of Effective Water Use.

(6) The training of experts is the most difficult of all, the programs.

Among the above, (1), (2) and (3) need not huge amount of money. Implementation of improving movement by the Thai government in near future is highly expected.

9.2 Feasible Programs

9.2.1 Promotion of the Technical Guidelines by Holding Seminars

In order to promote technical guideline for effective use of industrial water, two seminars (one on November 11, 1987 and the other on December 12, 1988) have been held.

The first one was attended by people from public organizations and universities, while the second was held for factory engineers.

The important point in holding such seminars is to set a clear target and define the participants. The lecturers may be found not only in governmental organizations or universities but also in private companies.

9.2.2 Survey on the Enlarged Number of Factories

As mentioned in 8.2, the survey covered only 2.2% of the whole factories in Samut Prakarn (or 17.6% in term of pumping up quantity). To generalize the result of the survey may be misleading.

In Japan, the Ministry of International Trade and Industry (MITI) has been conducting the similar kind of survey for over ten years, covering altogether more than 1,000 factories.

As has been practiced in Japan, the plan for the effective use of groundwater should be established on the basis of the survey of the area in question. The result of the survey in one area cannot be simply extended to another area. That is why the survey should be conducted on the enlarged number of factories.

The following are some practical hints for effective surveys.

(1) Selection of factories to be surveyed

Selection should be made among the leading factories that represent the area concerned (in the case of Samut Prakarn, approximately 200 factories belong to this category). The pumping up quantity of the selected factory should reach over 80% (preferably 90%) of the total pumping up quantity in the area.

However, with a limited staff and time, it may be difficult to survey a large number of factories. For Samut Prakarn, a practical way is to survey 40 to 50 (preferably in the same industry or in the same area) each year, thus completing the whole survey in 4 or 5 years.

(2) Procedure of the survey

As is the case in the study, the survey generally proceeds as follows:

Selection of factories ----> Questionnairing --->
Visiting survey ----> Analysis of results ----->
Preparation of technical guidelines

(3) Period and staff for the survey

The survey should be conducted in concentrated schedule. In addition to the staff members of IWD, the survey team may include the member(s) of regional bureau of MOI and expert(s) recruited from the outside. For example, the survey team may be organized as follows.

Item \ Period & Members	Period (Month)	Leader	Outside Expert	Survey Member	Assist-ant	Member from Regional Bureau
(1) Preparation (Selection and Questionnairing)	2	1	1	1		
(2) Visiting Survey	2	1	1	2	1	1
(3) Data Analysis	4	1	1	2		
(4) Preparation of Guidelines	2	1	1	2		
Total	10					

Each member of the survey team takes the following responsibility.

a. Leader :	To plan and control the whole process of the survey
b. Outside expert :	To give advice and help on the basis of expert knowledge
c. Survey member :	To conduct the survey
d. Survey assistant :	To take measurements in the field survey
e. Member from the regional bureau of MOI :	To assist the survey and to act as an intermediary for technical transfer

(4) Cost of the survey

Besides personnel expenses, the survey needs the costs for questionnairing (i.e. the printing and sending of questionnaires), technical seminars, reports and the like, which may not amount to a large sum.

As for expert(s) from the outside, it would require considerable cost.

(5) Qualifications required for the outside expert

Expert(s) provided from the outside should meet the following requirements.

(a) To have highly specialized experience and knowledge about the use and discharge of industrial water

(b) To have sufficient experience and knowledge about the treatment of supply/waste water.

(c) To have general knowledge about the use of water for various production lines

(d) To have general knowledge about various production lines

(e) To be able to attend the field survey and give appropriate advice

Although it is of great help if expert(s) from the outside have detailed knowledge about, say, the food or textile industry, such expert(s) are hard to find. So, for the purpose of the survey, general knowledge of production lines should be regarded as satisfactory.

9.2.3 Operation of a Model Plant to Demonstrate the Effective Use of Industrial Water

To encourage the effective use of industrial water, one of the surveyed factories may be selected as a model plant.

With appropriate water saving equipment (for example, cooling towers) installed, this model plant will demonstrate actual process and result of the effective use of industrial water.

To put the technical guidelines into practice in this way will greatly encourage other factories to do the same. However, the establishment of a model plant is expected to face the following problems.

(1) Difficulty of selecting a model plant

In a model plant, water saving equipment must be installed in the production line, the maximum cooperation of the selected factory is required.

(2) Installation cost

The factory selected as a model plant is not expected to bear the installation cost of water saving equipment. It is, however, difficult for IWD to put public money to install the equipment for a private enterprise.

(3) Operation and control

It is doubtful whether the selected factory pays due attention to the operation/control of water saving equipment which does not bring in visible profit. Insufficient operation/control of equipment in a model plant may turn out to be counterproductive.

Taking the above problems into account, the operation of a model plant, though very effective if realized, seems to be difficult to implement.

9.2.4 Visit to Factories to Help Them Implement the Technical Guidelines

As is practiced in Japan (refer to Fig. 2.18), the guidance through visiting each factory may be effective to implement the measures specified in the technical guidelines. Fig. 9.1 shows the simplified procedure of such guidance adjusted to the conditions in Thailand. The outline of the visiting guidance is as follows.

(1) Organizations in charge

IWD and regional bureaus of MOI take charge of the visiting guidance. The staff of the other central/local government organizations may join whenever necessary.

(2) Cooperation from private sector

To obtain cooperation from the private sector, an advisory committee for the effective use of industrial water is to be organized. This committee will consist of members of private companies and experts from universities and research centers.

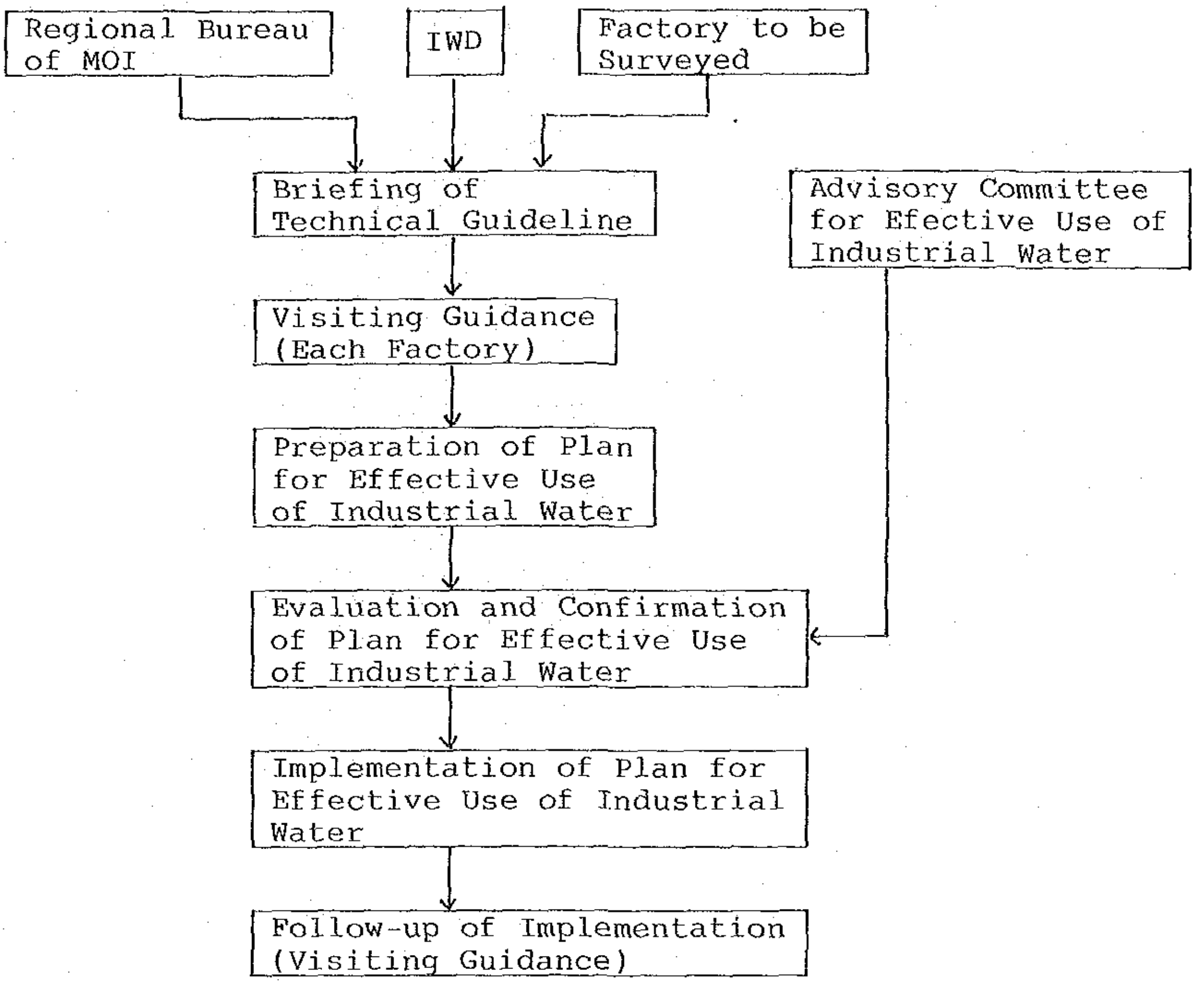


Fig. 9.1: Example of Implementation of Visiting Guidance

(3) Plan for visiting guidance

A team consisting of three or four members (two or three members from IWD and one expert from the outside) visits one or two factories per day. The team should visit the same factory at least twice.

The first visit is to set up the plan for effective use of industrial water of the factory, and the second is to check the implementation of the plan. Besides these two visits, the team may call on the factory from time to time to follow up the guidance.

(4) Plans for the effective use of industrial Water of individual factories

The technical guidelines prepared by the study team do not reflect the particular conditions of each individual factory.

Therefore, the best way to implement the guidelines is not to impose them on factories but to encourage each factory to establish its own plan, which is the main aim of visiting guidance.

(5) Review of factories' plan for the effective use

The plan for the effective use set up by each factory is reviewed by IWD members and outside experts. The approved plan is reported to the above-mentioned committee in order to obtain its cooperation. The plan for the effective use of factory is a kind of informal agreement between the factory and the organization. Such voluntary cooperation on the factory's side is indispensable.

(6) Follow-up of factories' plan for the effective use

As mentioned above, at least one follow-up visit is necessary for each factory. The follow-up visit may be repeated whenever necessary. If the plan for the effective use is not implemented properly, the guidance team should investigate the reason and give appropriate advice.

In some areas in Japan, such guidance by visiting has been proved very effective. According to the experience in Japan, the following conditions are helpful in bringing out factories' efforts to reduce groundwater consumption.

(1) By virtue of the Public Pollution Control Law, the central and local governments assume responsibility to take the measures for the prevention of land subsidences and private companies are obliged to be cooperative.

(2) Some local governments have established their own regulations to control the pumping up of groundwater.

(3) Factory managers and engineers in general know the importance of the saving of groundwater

(4) Knowledge level of inhabitants for land subsidence is fairly high, so behavior of factories which pump up groundwater are watched by these inhabitants.

(5) Financial and tax incentives are provided for the effective use of groundwater.

Thailand at present lacks such conditions. Also, the technical staff for visiting guidance appears to be in short supply. Hence it is too early to expect much effect from visiting guidance. The visits to factories, however, may, serve to make them more conscious of the use of water as well as to promote good relationships between IWD and each factory.

9.2.5 Sending Experts to Factories in Order to Implement the Technical Guidelines

Upon the establishment of the plan for the effective use of a factory, IWD may send technical experts on particular water usages (cooling water, washing water, etc.) or production processes (in the paper, textile or other industries) to the factory to help it implement the plan.

This project, however, presupposes the positive attitude on the factory's side, which for the time being cannot be expected. The sending of experts may be effective if it is carried out after the visiting guidance stated in 9.2.4.

9.2.6 Examination of Programs and Summary of Suggestions

The detailed examination in the above paragraphs has made it clear that each program has various practical problems. the underlying reason for these problems is the lack of basic conditions (laws, regulations, tax and financing systems, awareness, and the like) for the effective use of industrial water.

The following basic conditions are very important for the implementation of these programs in Thailand.

(1) Preparation of Laws and Regulations

  (a) Confirmation of land subsidence as a public hazard

  (b) Obligations of government and private companies for prevention of land subsidence

  (c) Preparation of laws and regulations to control pumping up of groundwater

(2) Encouragement of incentives for effective use of water

  (a) Raising of groundwater rate

  (b) Low interest financing and favorable tax on investment for effective water use

(3) Education and training of experts

(4) Level up of knowledge for land subsidence and groundwater saving

  (a) Staff and engineers of related governments and private companies

  (b) Inhabitants who live in land subsidence areas

Chapter 10

Conclusion

Chapter 10 Conclusion

The land subsidence in the Bangkok Metropolitan Area is serious. To curb further subsidence, a wide range of measures (refer to 8.1) should be urgently taken. Although the saving of water consumption alone cannot cope with the situation, the study on effective use of industrial water would contributes to the solution of the problem.

The study covered only around 2% of the factories in Samut Prakarn Area. As suggested in this report, the study should be extended to cover a wider area.

Taking measures for effective use of industrial water implies that certain conditions (refer to the programs in Table 8.1) should be satisfied. Moreover, those measures should be harmonized with other measures.

Appendix

APPENDIX PART 1

Manual for the Effective Use of Industrial Water

1. Introduction

The diagram below shows the steps that should be taken to proceed with the effective use of industrial water at a factory. A brief explanation of each of the steps in the diagram is as follows:

2. STEP 1 : Recognition of Background and Objectives

Although the background and the objective of effective use are dwelt on in Chapter 1, there are several useful factors besides those.

They are :

(1) Prevention of Land Subsidence

This is the main objective of the effective use described in Chapter 1.

(2) Preservation of Ground Water

Since ground water is not unlimited, if a large quantity of ground water is pumped up, the level of the ground water will gradually drop until it becomes difficult and eventually practically impossible to pump up. Effective use is imperative to preserve ground water resources.

(3) Saving of Water Resources

Even of MWA or public industrial water works - waterworks were to be used in place of ground water, there is a limit to the amount that can be supplied so that a sufficient quantity may not always be available. Therefore, it is inevitable that effective use of the water is required.

(4) Preservation of the Environment

As the more water is used means that there will be more waste water, it naturally leads to higher level of environmental pollution. Using the water effectively will reduce the waste water and thus lower environmental pollution.

STEP 1	Recognition of Background and Objectives
STEP 2	Clarification of the present condition of Industrial Water Usage
STEP 3	Selection of the Objects of Effective Use
STEP 4	Study of Methods of Effective Use
STEP 5	Preparation of Concrete Measures
STEP 6	Study of Economical Efficiency
STEP 7	Implementation

STEPS FOR PROCEEDING WITH THE
EFFECTIVE USE OF INDUSTRIAL WATER

(5) Economical Returns

Although the present cost of ground water is low (2 to 2.5 ฿/m^3 including ground water tax), there is a possibility that the price of ground water will rise in the near future. Also, although it is believe that the cost of MWA or industrial waterworks is 6 to 8 ฿/m^3, there is a very good likelihood that these will rise too. Effective use of water is possible even when the cost of the water is low as described in 4.8 of the main document, and, by carrying out these methods, economical returns can be expected.

3. STEP 2 : Clarification of the Present Situation of Industrial Water Usage

The methods of clarifying the present situation of industrial water usage are practically the same as the methods that were carried out in this study. The main points are as follows :

(1) Confirmation of the Accurate Amount of Water Consumption

The confirmation of the amount of water consumption is the most basic step in proceeding with the effective use of water. It will be necessary to obtain the amount of water consumption as accurately as possible not only by direct measurements but also by calculating from pump capacities, the specifications of the equipment using the water, the diameter of the piping, the capacity of the tanks and other factors. It will be very convenient if the results are then compiled into the form of the questionnaire used in this study (refer to 1.3 of this Appendix).

(2) Confirmation of the Quality of the Water Used

As the method of effectively using the water may change depending on its quality, the quality should be confirmed as possible.

Among the water quality items, water temperature, pH, turbidity, electrical conductivity, etc. are items which are comparatively easy to measure and even by obtaining just these values can be a great help in studying the effective use of water.

(3) Confirmation of Locations of Water Usage

When recycling used water, if the distance between effluent points of the waste water and use points of the recycled water are too long, the piping construction costs will become very high.

Therefore, it is very useful for the study of the effective use that the use points of water, the effluent points of the waste water, the piping of the supplied water and waste water are located on a layout drawing.

(4) Preparation of Flow Diagram of Water Supply and Waste Water Discharge

In order to confirm the present situation of industrial water usage, it will be very useful if a flow diagram of the water and waste water as described in the main document is prepared. Using such a flow diagram will simplify the selection of the objects of the effective use described in the next paragraph.

4. STEP 3 : Selection of the Objects of Effective Use

Based on the confirmation of the present situation of industrial water usage mentioned in Step 2, the objects (places and uses) for the implementation of effective use of water should be selected. The followings are the points that should be considered in making the selections :

(1) Place where a fairly large amount of water is used

compared to the total amount of water used in the factory.

(2) Place where water is used on a once-through basis or where the level of recovery is not high.

(3) When the waste water is practically clean (for example, cooling water) or when the waste water is not very dirty.

(4) When it is allowed that the cooling water temperature is quite high (over 35°C).

(5) When the quality of materials to be washed is not very acutely effected by the washing water quality and quantity.

(6) When the quantity of water used per unit production is extremely high compared to other process with similar conditions. For example, the amount of water required to wash one empty bottle at a beverage manufacturing factory, the amount of water required to process a ton of waste paper at a paper mill, the amount of water used for washing 1 m of cloth at a dyeing plant, the amount of washing water required to prepare one automobile for painting, etc.. However, comparisons must be limited to those processes where the industrial water usage is very similar.

(7) When the amount of domestic water used is excessively high compared to the number of person using it. With regard to the quantity of water used per person, please refer to 3.4 of the main document and this Appendix, 3.2.

5. STEP 4. Study of Methods of Effective Use

Study which of the following methods of effective use can be applied to the objects selected in the preceding paragraph. With regard to details of methods of effective use, please refer to 4.2, Chapter 5 and Chapter 6 of the main document.

(1) Thorough control of water use

Applicable to (6), (7), etc. of the foregoing paragraph.

(2) Water recycling

Applicable to (2), (3), (4), etc. of the foregoing paragraph.

(3) Multistage or cascade use

Applicable to (3), (5), (6), etc. of the foregoing paragraph.

(4) Reclamation of waste water

Applicable to (3), (5), etc. of the foregoing paragraph.

(5) Water saving apparatus

Applicable to (e), (6), (7), etc. of the foregoing paragraph.

(6) Improvement of operation control

Applicable to water treatment equipment (such as ion exchanging equipment, sand filter, etc.) and cooling tower (when recycling use is already being implemented).

6. STEP 5 : Preparation of Concrete Measures

After the method of effective use has been decided upon, concrete measures should next be prepared. Of these, the design of equipment should be requested to the respective manufacturers. In such case, at least the following points should be made clear.

(1) Objects of equipment.

(2) Required capacity and water balance.

(3) Outline of the flow of the equipment.
It is preferable that a rough flow sheet be attached.

(4) Water quality to be required.

When the water is to be treated, then the water quality before and after treatment will be required.

(5) Water temperature used.
For the cooling water, temperature is important.

7. STEP 6 : Study of Economical Efficiency

Following the preparation of the concrete measures, the construction costs, the operating costs, etc., should be estimated. It is convenient to study economical efficiency from the unit cost of improvement shown in 4.3 of the main document.

When the unit cost is higher than anticipated, it will be necessary to reconsider the concrete measures of the method of effective use.

8. STEP 7 : Implementation

When the program is complete, it should be implemented. In this case, it will be necessary to record the situation of water usage prior to implementation of the effective use for comparison with the situation after implementation. By doing so, it will be possible to define clearly the effects of the effective use of water.

9. Supplementary Note

This document gives only a brief description of the steps that should be taken by a factory for proceeding with the effective use of water. For details of the respective points, please refer to the main document and the appendix.

APPENDIX PART 2

1. Items related to Chapter 1

1.1 Questionnaire

1.1.1 Questionnaire for the Study on Effective Use of Industrial Water

1.1.2 Answer Example

1.1.3 Instruction to Answer

1.2 List of Equipment Supplied by JICA to IWD

1.3 Seminar Program of Effective Use of Industrial Water

2. Items related to Chapter 2

2.1 Quality of Industrial Water used by Pulp and Paper Industry in Japan

2.2 Required Standard Quality of Industrial Water in Japan (for Paper, Pulp and Paper Product Industry)

2.3 Standard of Water Quality Management in a Steel Mill in Japan

2.4 Factory Act, B.E. 2512 (1969), An Extract

2.5 Notification of Ministry of Industry No. 13 (B.E. 2525)

2.6 Notification of Ministry of Industry No. 15 (B.E. 2527)

2.7 Implementation of Ground Water Act (B.E. 2520)

2.8 Notification of Ministry of Industry No. 7 (B.E. 2528)

3. Items related to Chapter 3

3.1 Manual for Visiting Survey in the Study on Effective Use of Industrial Water

3.2 Unit Water Usage

3.3 Quantity of Consumed Water

3.4 Example of Well Water Quality in Japan

3.5 Waste Water Treatment

1.1.1

==============
CONFIDENTIAL
==============

C#: ________

F#: ________

QUESTIONNAIRE FOR THE STUDY ON THE EFFECTIVE USE OF INDUSTRIAL WATER IN THE KINGDOM OF THAILAND

(DRAFT)

AUGUST 1987

INDUSTRIAL WORKS DEPARTMENT
MINISTRY OF INDUSTRY

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

F#: ________

1. Outlines of Company and Factory

1.1 Company

A. Name: ________________________________

B. Capital: ______________ Thousand B

1.2 Factory

A. Name: ________________________________

B. Address: ________________________________

C. Telephone: ______________

D. Classification of Industry: ________________________________

E. Annual Amount of Shipment *1: __________ Million B

F. Total Area *2: __________ m^2

G. Total Number of Workers: __________

H. Average Daily Working Hour *3: _____ (_____) hours/day

I. Annual Working Day *4: ______ (______) days/year

J. Product Shipment

Name of Main Product				
Annual Quantity of Production in 1986 ( ) *5				
Annual Quantity of Shipment (mil B)				

K. Special Notes on Operation and Others in 1986:

____

____

____

____

F#: ______

1.3 Person to Contact related to this Study

A. Name: ______________________

B. Title: ____

____

- -

Notes:

*1: Please fill in actual quantity of shipment from January to December in 1986.

If difficult, please fill in quantity of shipment in recent one year.

*2: Please fill in total area including plant, dormitory and company house.

*3 and 4: Please fill in data in 1986.

If operation in 1986 was different from normal year, please fill in data in normal year in ( ).

*5: Please fill in unit such as unit, ton, kg, m^2, m^3, and others.

F#: ________

2. Monthly quantity of make-up water in 1986

Please complete the table below of monthly quantity of make-up water in 1986.

Items / Month	Total Quantity of Make-up Water (m^3/day)	Well Water (m^3/day)	Potable Water (m^3/day)*	Other (m^3/day)	Monthly Operating Day (day)
Jan					
Feb					
Mar					
Apr					
May					
Jun					
Jul					
Aug					
Sept					
Oct					
Nov					
Dec					
Avr**					

Remarks: * Fresh water supplied by MWWA.
** Annual average

3. Quantity of consumed water classified to use

   Please fill in quantity of consumed water classified to usage in Table A of page 5, referring to page 5 of "Answer Example".

4. Process diagram of production line

   Please draw detailed process diagram of each production line of main product in your factory, indicating source of water, usage of water and place from where waste water is discharged, referring to page 10 of "Answer Example".

   If you have diagram, please fill in necessary information.

5. Flow diagram of water supply and waste discharge

   Please complete Figure A of page 6, referring to page 6 of "Answer Example".

6. Drawing of factory layout

   Please draw drawing of your factory layout that shows places where water is used, referring to page 11 of "Answer Example".

   If you have drawing, please indicate places where water is used.

   Please use same number as the above Item 3.

F#: ________

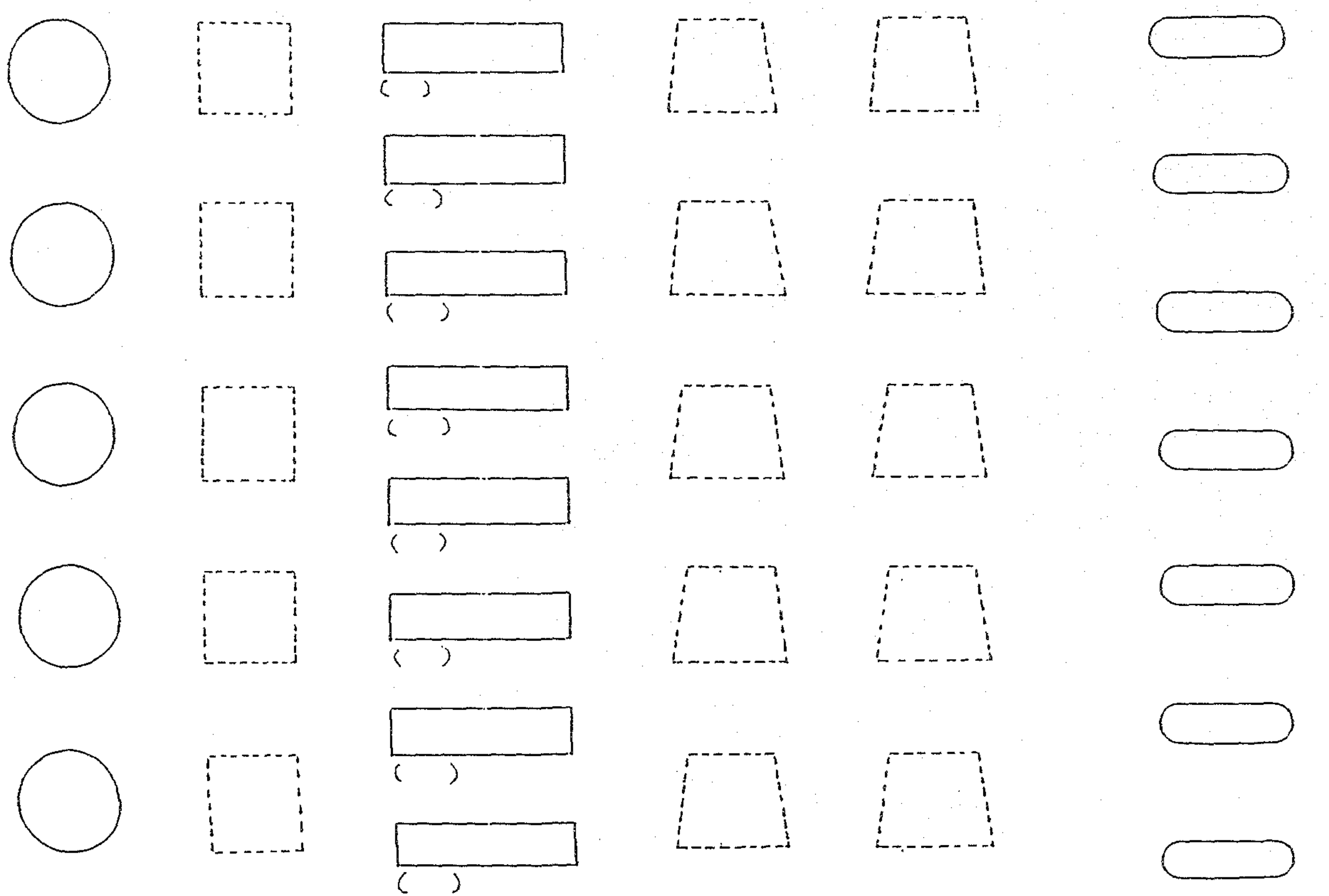
Table A: Quantity of Consumed Water Classified to Use (__/__)

Place	Use	No.	Process or Equipment	Water Quantity in Operating Day (m^3/d) cl. to Source 1)					Op Hr (h/d)	Op Dy (d/y)	CW Temp at Outlet 6) (°C)	Specification of Equipment and Operating Method	Remarks
				WW 2)	PW 3)	OW 4)	RW 5)	Total					
Total													

Note: 1) Please fill in annual average quantity of operating day.
Please fill in additionally peak quantity in ( ) if seasonal change is high.
2) WW = Well water; 3) PW = Potable Water; 4) OW = Riverbed and/or Surface Water; 5) RW = Recycling Water;
6) CW = Cooling Water

F#: ______

Figure A: Flow Diagram of Water Supply and Waste Discharge



F#: ________

7. Quality of well water

If you have analysis data of well water, please complete the table below:

Items	Unit	Raw Water	After Treatment
Temperature	°C		
Turbidity	°		
pH	-		
COD by Mn	ppm		
BOD	ppm		
Alkalinity	ppm		
Total Hardness	ppm		
Chroline Ion	ppm		
Total Iron	ppm		
Evaporation Residue	ppm		
Electric Conductivity	μS/cm		
Depth of Well	m		

F#: ________

8. Waste water treatment and recycling

   Please complete Table B of page 9, referring to page 9 of "Answer Example".

   If you do not have analysis data, please fill in design data in (   ).

   Please use separate sheet for each object of treatment.

9. Please describe outlines of water saving, if you have carried out in recent one year.

   ____

   ____

   ____

   ____

10. Please describe outlines of the existing or planned water saving system.

   ____

   ____

   ____

   ____

11. Please describe the possibility of adopting water saving system in your factory.

   ____

   ____

   ____

   ____

(Thank you for your cooperation)

F#: ________

Table B: Waste Water Treatment and Recycling (__/__)

Object of Treatment (Please circle 1 or 2.) (Please fill in 3, if otherwise)	1. Waste Discharge 2. Water Recycling 3.	
Treatment Process		
Maximum Capacity (m^3/d)		
Treatment Quantity (m^3/d)		
Date of Installation		
Water Quality	Influent	Effluent
SS (ppm)		
BOD (ppm)		
COD (ppm)		
Cl^- (ppm)		
pH		
Temperature (°C)		
Oil (ppm)		
Heavy Metals (ppm)		
Flow in from		
Flow out to		
Remarks		

1.1.2

ANSWER EXAMPLE

OF

QUESTIONNAIRE

FOR

THE STUDY

ON

THE EFFECTIVE USE OF INDUSTRIAL WATER

IN

THE KINGDOM OF THAILAND

AUGUST 1987

INDUSTRIAL WORKS DEPARTMENT
MINISTRY OF INDUSTRY

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

1. Outlines of Company and Factory

1.1 Company

A. Name: A Co., Ltd

B. Capital: 2,500 Thousand B

1.2 Factory

A. Name: B Factory

B. Address: C Road, Samrongtai, Prapradaeng Samut Prakan

C. Telephone: 250-1010

D. Classification of Industry: Textile Deying & Finishing

E. Annual Amount of Shipment *1: 35 Million B

F. Total Area *2: 3,702 m^2

G. Total Number of Workers: 35

H. Average Daily Working Hour *3: ( ) 9 hours/day

I. Annual Working Day *4: 291 days/year

J. Product Shipment

Name of Main Product	Towel			
Annual Quantity of Production in 1986 (kg) *5	250,000			
Annual Quantity of Shipment (mil B)	35			

K. Special Notes on Operation and Others in 1986:

1.3 Person to Contact related to this Study

A. Name: ______________________________

B. Title: ____

____

- -

Notes:

*1: Please fill in actual quantity of shipment from January to December in 1986.

If difficult, please fill in quantity of shipment in recent one year.

*2: Please fill in total area including plant, dormitory and company house.

*3 and 4: Please fill in data in 1986.

If operation in 1986 was different from normal year, please fill in data in normal year in (   ).

*5: Please fill in unit such as ton, kg, m^2, m^3, psc. and others.

2. Monthly quantity of make-up water in 1986.

Please complete the table below of monthly quantity of make-up water in 1986.

Items / Month	Total Quantity of Make-up Water (m^3/day)	Well Water (m^3/day)	Potable Water (m^3/day)*	Other (m^3/day)	Monthly Operating Day (day)
Jan	312	311	1		19
Feb	293	292	1		25
Mar	357	356	1		24
Apr	302	301	1		26
May	358	357	1		22
Jun	326	325	1		27
Jul	301	300	1		26
Aug	377	376	1		21
Sept	301	300	1		27
Oct	421	420	1		23
Nov	325	324	1		26
Dec	306	305	1		25
Avr**	330	329	1		291

Remarks: * Fresh water supplied by MWWA.
** Annual average

3. Quantity of consumed water classified to use

   Please fill in quantity of consumed water classified to usage in Table A of page 5, referring to page 5 of "Answer Example".

4. Process diagram of production line

   Please draw detailed process diagram of each production line of main product in your factory, indicating source of water, usage of water and place from where waste water is discharged, referring to page 10 of "Answer Example".

   If you have diagram, please fill in necessary information.

5. Flow diagram of water supply and waste discharge

   Please complete Figure A of page 6, referring to page 6 of "Answer Example".

6. Factory layout drawing

   Please draw layout drawing of your factory that shows places where water is used, referring to page 11 of "Answer Example".

   If you have drawing, please indicate places where water is used.

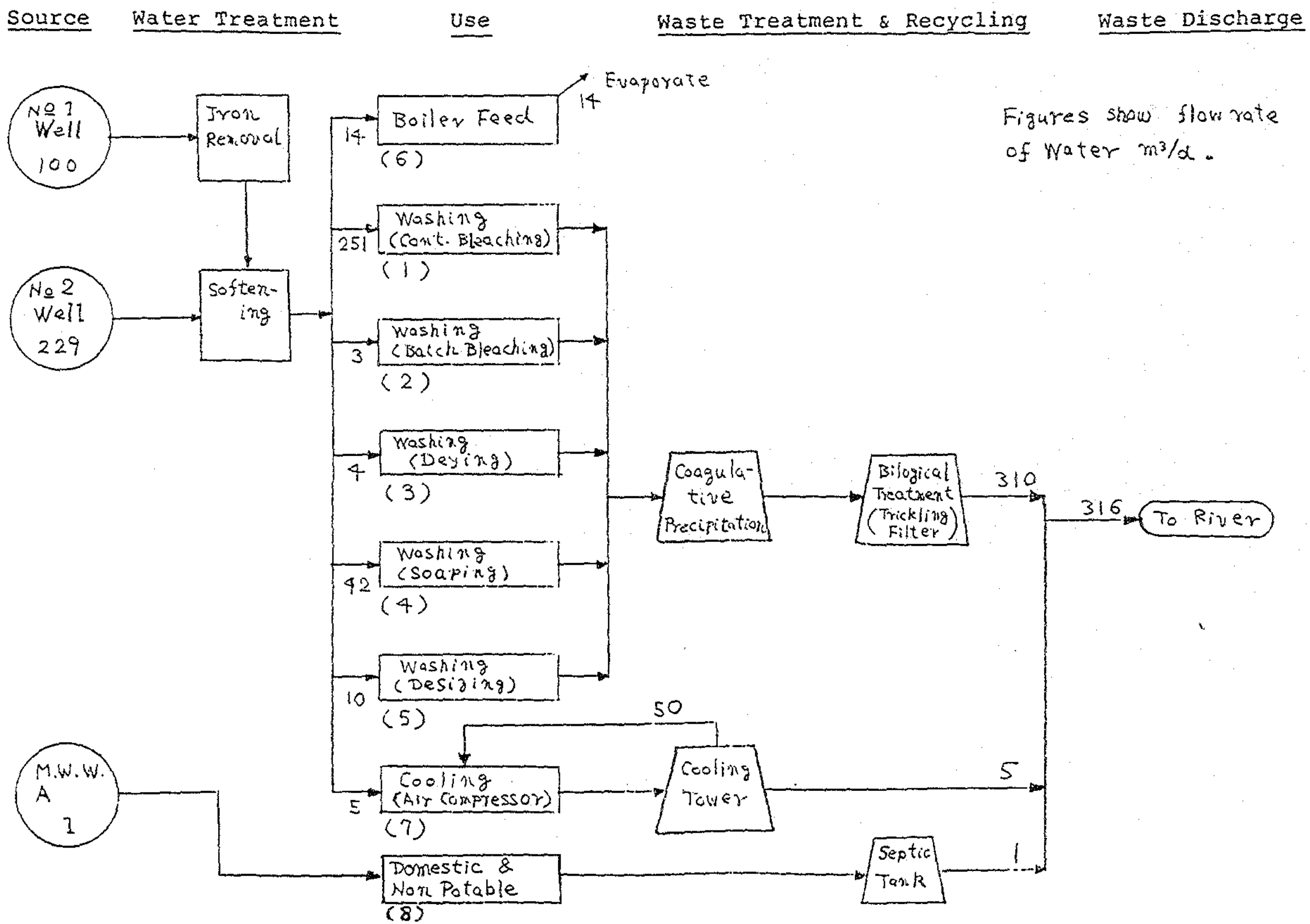
   Please use same number as the above Item 3.

Table A: Quantity of Consumed Water Classified to Use (1/1)

Place	Use	No.	Process or Equipment	Water Quantity in Operating Day cl. to Source (m^3/d) 1)					Op Hr (h/d)	Op Dy (d/y)	CW Temp at Outlet 6) (°C)	Specification of Equipment and Operating Method	Remarks
				WW 2)	PW 3)	OW 4)	RW 5)	Total					
Plant	Washing	1	Continuous bleaching	251				251	7	291			1 unit
	"	2	Batch bleaching	3				3	4	"			Wins type, 1 unit
	"	3	Deying	4				4	7	"			Overmyer type, 4 units
	"	4	Soaping	42				42	"	"			2 units
	"	5	Desizing	10				10	6	"			Wins type, 1 unit
Boiler House	Boiler Feed	6	Boiler	14				14	9	"			Max. Capacity 4 tons/hr
	Cooling	7	Air Compressor	5			50	55	9	"	35	Motor 5.0 kW Cooling Tower	Recycling use 42°C to 35°C
Office	Domestic & Non-pot.	8	Drinking, Toilet, etc.		1			1	9	"			
Total				329	1		50	380					

Note: 1) Please fill in annual average quantity of operating day.
Please fill in additionally peak quantity in ( ) if seasonal change high.
2) WW = Well water; 3) PW = Potable Water; 4) OW = Riverbed and/or Surface Water 5) RW = Recycling Water;
6) CW = Cooling Water

Figure A; Flow Diagram of Water Supply and Waste Discharge



7. Quality of well water

If you have analysis data of well water, please fill in the table below:

Items	Unit	Raw Water	After Treatment
Temperature	°C	18	
Turbidity	°	1	1
pH	-	7.0	7.1
COD by Mn	ppm	3.4	4.0
BOD	ppm		
Alkalinity	ppm	188	154
Total Hardness	ppm	57	28
Chroline Ion	ppm	40	36
Total Iron	ppm	1.7	0.2
Evaporation Residue	ppm	452	375
Electric Conductivity	μS/cm	770	700
Depth of Well	m	50	-

8. Waste water treatment and recycling

Please complete Table B of page 11, referring to page 9 of "Answer Example".

If you do not have analysis data, please fill in design data in (   ).

Please use separate sheet for each object of treatment.

9. Please describe outlines of water saving, if you have carried out in recent one year.

____

____

____

____

10. Please describe outlines of the existing or planned water saving system.

____

____

____

____

11. Please describe the possibility of adopting water saving system in your factory.

____

____

____

____

(Thank you for your cooperation)

Table B: Waste Water Treatment and Recycling (__/__)

Object of Treatment (Please circle 1 or 2.) (Please fill in 3, if otherwise)	1. Waste Discharge 2. Water Recycling 3.	
Treatment Process	Coagulative Sedimentation and Biological Treatment	
Maximum Capacity (m^3/d)	500	
Treatment Quantity (m^3/d)	311	
Date of Installation	July 1975	
Water Quality	Influent	Effluent
SS (ppm)	68	15
BOD (ppm)	110	30
COD (ppm)	60	35
Cl^- (ppm)		
pH	6.9	7.2
Temperature (°C)		
Oil (ppm)	8.7	2.0
Heavy Metals (ppm)		
Flow in from	Bleaching Process	and Deying
Flow out to	River	
Remarks		

Figure B: Process Diagram of Production Line

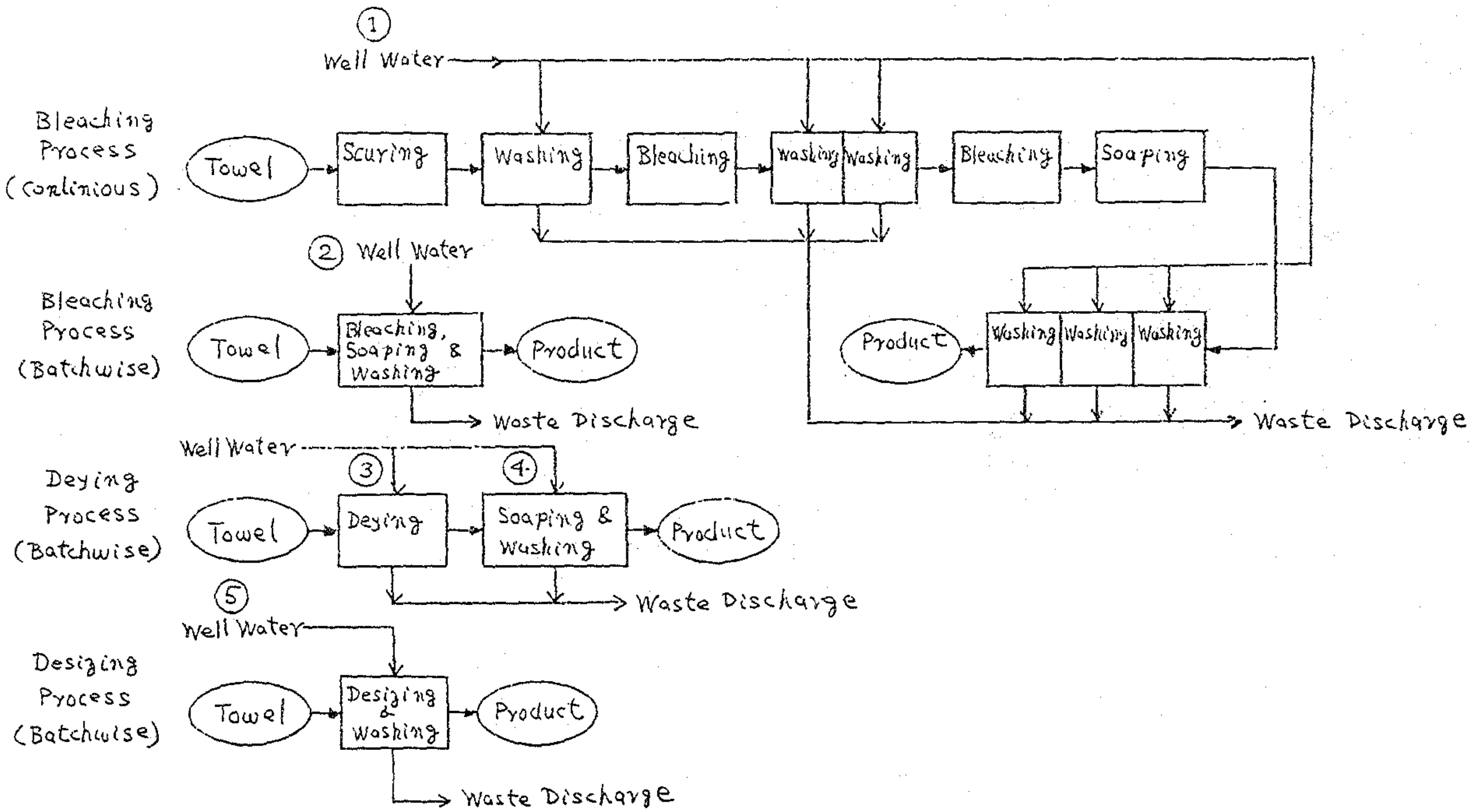
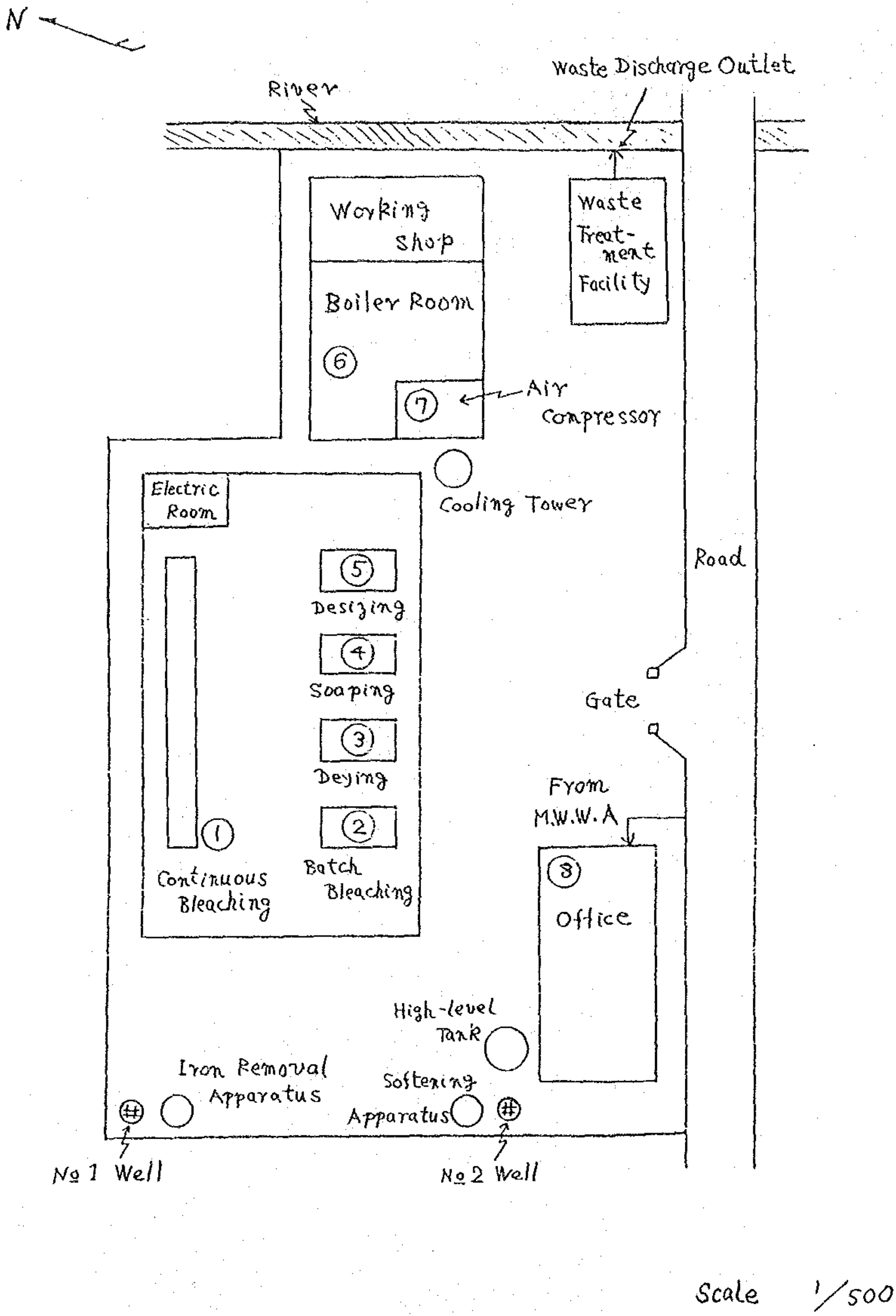


Figure C: Drawing of Factory Layout



1.1.3 INSTRUCTION TO ANSWER

INSTRUCTION TO ANSWER QUESTIONNAIRE FOR THE STUDY ON THE EFFECTIVE USE OF INDUSTRIAL WATER IN THE KINGDOM OF THAILAND

AUGUST 1987

INDUSTRIAL WORKS DEPARTMENT

MINISTRY OF INDUSTRY

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

When you answer to the "Qustionnaire" for "The Study on the Effective Use of Industrial Water in the Kingdom of Thailand", please read carefully the following instructions.

1. Table A: Quantity of Consumed Water Classified to Use
(Cl. 3 of Questionnaire & p-5 of Answer Example)

1.1 Terms for use of water

Please use the following terms for use of water:

A. "Boiler Feed": water that is used for generating steam in a boiler.

B. "Material": water that is used as a part of final product or is added as a part of product material.

C. "Process": water that is used for dipping and resolution of material and/or semi-product.

D. "Washing": water that is used for washing equipment, material, semi-product and final product.

When it is difficult to distinguish "C" and "D", please use a term "Process/Washing water".

E. "Cooling": water that is used for cooling equipment and/or product.

F. "Air Conditioning": water that is used for adjusting temperature and moisture inside the building.

Water used by air washer for air cleaning and temperature conditioning is included in this category.

G. "Domestic": water that is used for drinking, cooking, washing, bathing and others.

H. "Non-potable": water that is used for toilet flushing, sprinkling, pond and washing, other than "G".

When it is difficult to distinguish "G" and "H", please use a term "Other".

1.2 Source and Quantity of consumed water

1.2.1 Source

Terms for "Water Source" in this study are as follows:

A. "Well": water that is supplied by well.

B. "Potable": water that is supplied by WMMA.

C. "Other": water that is supplied from riverbed underflow and/or surface.

D. "Recycling": water that is used again after it is used in one process.

It does not matter whether water is treated after the first use and it is used in the same process as the first.

In case that "Air Conditioning Water" is used again after it is cooled by a cooling tower, please classify it as "Recycling water".

1.2.2 Quantity of consumed water

Please fill in annual average quantity of operating day.

In case quantity of consumed water changes much in accordance with season, please fill in quantity of peak season (average quantity in summer, for example) in ( ).

1.3 Temperature of cooling water outlet

Please fill in if you have data.

1.4 Specification of equipment and operating method

Please fill in such informations as capacity of refrigerator, driving power of compressor, capacity of cooling tower and operating method of equipment.

Especially, please fill in season and period when peak quantity is filled in.

2. Figure B: Process Diagram of Production Line

(Cl. 4 of Questionnaire & p-10 of Answer Example)

2.1 General

The diagram is used to understand how water is used in your factory. Therefore, please clearly point out places where water is used.

2.2 Production line

Please write name of process and/or equipment, starting from material to final product.

Please also fill in the same number of process and/or equipment as is used in the Table A.

2.3 Equipment and/or process where water is used

Please connect process and/or equipment where water is used with arrow line (→) to show flow direction of supply and/or waste water.

3. Figure A: Flow Diagram of Water Supply and Waste Discharge

(Cl. 5 of Questionnaire & p-6 of Answer Example)

3.1 Water source

Please use the terms in the above Clause 1.2.1.

In case your factory has more than two wells, please draw flow diagram for each well.

3.2 Water treatment

Water treatment is a process (such as filtration, softening, ion exchange, iron removal, disinfection and so forth) conducted before water is used.

3.3 Use of water

Please use the terms specified in the above Clause 1.1 and list up in the same order as Clause 1.1.

In the case of same use, please sum up in accordance with place of use or process.

3.4 Place

Please write "No." in ( ) using the same "No." in Table A.

3.5 Waste treatment and recycling

Please be sure to fill in not only waste water treatment but also cooling tower, heater, cooler and others.

3.5 Waste discharge

If there are more than two outlets, please give name and number to each outlet.

3.6 Flow quantity of each point

Please fill in flow quantity (m^3/d) of each point. The value should be same as that in Table A.

4. Figure C: Drawing of factory layout

(Cl. 6 of Questionnaire & p-11 of Answer Example)

4.1 Naming

Please use same name as that in Table A.

4.2 Facilities where water is used

Please point out clearly facilities where water is used, using the same name as that in Table A.

4.3 River water inlet point and others

Please show clearly locations of river water inlet point, wells, water works service pipe, discharge gate of waste water and others.

5. Other General Items

5.1 Flow quantity

If flow quantity is not known because of lack of flow meter, please assume flow quantity from the followings:

A. Diameter of pipe

B. Capacity of installed pump

C. Distribute quantity at water source to each process

D. Quantity of recycling water of cooling tower is figured out from the capacity of circulating pump.

Quantity of make-up water for cooling tower is generally two to three per cent of total reclycling water.

E. Quantity of cooling water for refrigerator and compressor is figured out from specification of each equipment.

5.2 Quantity of domestic water

Quantity of domestic water consumed in factory is generally 100 to 300 liters per day per head.

1.2 Equipment Supplied by JICA to IWD

Equipment supplied by JICA to IWD is listed below:

No.	Items	Qt.	Remarks
1	Portable Type Ultrasonic Flow Meter (Fuji Electric Co., Ltd.: FLB-2002)	2 units	
	1) Main Unit	2 sets	
	2) Small Sensor	2 sets	Mounting barker and 5 m cable
	3) Soft Case	2 sets	Strap
	4) Power Cords	2 sets	Cable for AC & DC 2 m
	5) Test Piece	2 sets	
	6) Extension cable for sensor	80 m	
	7) Others	1 set	Compound for mounting sensor, roll paper & printer ink cartridge etc.
2	Portable Digital Temperature Meter (Sato Co., Ltd.: MC-20R)	2 units	
	1) Main Unit	2 sets	
	2) Sensor	2 sets	
	3) Soft Case	2 sets	
	4) Others	1 set	Battery
3	Portable Digital pH/ORP Meter (Central Kagaku Co., Ltd.: UC-23)	2 units	
	1) Meter Unit	2 sets	
	2) Sensor		
	a) Standard Type (UC-502E)	2 sets	
	b) Throw-in Type pH Control (UC-303E)	2 sets	
	3) UC Meter Carrying Case	2 sets	
	4) Exclusive Battery Charger (220V)	2 sets	
	5) Others	1 set	Internal Fluid, 4M-KCl,Thermometer
4	Portable Digital Conductivity Meter (Central Kagaku Co., Ltd.: UC-33)	2 units	
	1) Meter Unit	2 sets	
	2) Sensor	2 sets	
	3) UC Meter Carrying Case	2 sets	
	4) Exclusive Battery Charger (220 V)	2 sets	
5	Portable Digital Turbidity/Temp. Meter (Central Kagaku Co., Ltd.: UC-61)	2 units	
	1) Meter Unit	2 sets	
	2) Sensor Unit	2 sets	10m Cable, Light Shield Tube & Standard Plate
	3) Meter Unit Storage & Carrying Case	2 sets	
	4) Exclusive Battery Charger (220V)	2 sets	

1.2 Equipment Supplied by JICA to IWD (continued, 2/2)

No.	Items	Qt.	Remarks
6	COD Meter	2 units	
	(Central Kagaku Co., Ltd.: HC-407)		
	1) Main Unit	2 sets	Transformer
	2) Elelctrolytic Electrode	2 sets	(-) PT-207, (+) PV-207
	3) Indicator Electrode	2 sets	
	4) Stirrer	2 sets	
	5) Support Rod	2 sets	
	6) Exclusive Heater	2 sets	
	7) Tall Beaker	10 sets	
	8) Others	1 set	Reagent, Pilette, etc.
7	Sample Bottle	1 set	
8	Personal Computer	1 set	
	1) Computer (NEC: PC-9801 VM 21)	1 unit	
	2) Display (NEC: N-5913-L)	1 unit	
	3) Printer		
	a) PC-PR201-F2 (NEC)	1 unit	
	b) HR-25 (BROTHER)	1 unit	
	4) CVT Sheet Feeder		
	a) PC-PR201-24 (NEC)	1 unit	
	b) CF-100 (NEC)	1 unit	
	5) Rack (NEC: RS-253)	1 unit	
	6) Software		
	a) TwinStar (NEC)	1 unit	
	b) Lotus 1,2,3 (NEC)	1 unit	
	7) Converter for Printer (NEC, KSW-P2)	1 unit	
	8) Tractor Feeder (NEC: PR-201-23)	1 unit	
	9) Automatic Voltage Regulator (MATSUNAGA: SVC-1010-A)	1 unit	
	10) Others		
	a) Connector Leads	1 unit	
	b) Floppy Disc	1 set	
	c) Printer Ribbon	1 set	
9	Video Camera (National: NV-M5EN)	1 unit	
	Accessories		
	1) Battery Pack	2 unit	
	2) Carrying Case	1 unit	
	3) Video Tape	10 units	
	4) Others	1 unit	Connector Leads
10	Video Television System		
	1) Video Cassette Recorder (Panasonic: NV-G15PX)	1 unit	
	2) Color Television (National: TC-AL2100NT)	1 unit	
	3) Others	1 unit	Connector Leads

1.3 Seminar Program of Effective Use of Industrial Water

1.3.1 Seminar in 1987

Date: Wednesday, November 11, 1987

Place: Bangkok Palace Hotel

	Time
1. Opening Address by Mr. Pisal Khongsamran Director-General, IWD	09:30-09:50
" by Mr. Ben Saito, Resident Representative, JICA Bangkok Office	
2. "Use of Water, Especially Industrial Water in Japan" by Shun-ichiro Uchida	09:50-11:00
Coffee Break	11:00-11:15
3. "Problems caused by Pumping Up of Ground Water" by Shun-ichiro Uchida	11:15-12:20
Luncheon	12:20-13:20
4. Projection of a Film entitled "Re-Use of Water"	13:20-13:50
5. "Guidance of Effective Use of Industrial Water in Japan" by Naoto Hashimoto	13:50-15:00
Coffee Break	15:00-15:15
6. Question and Discussion	15:15-17:00

# # #

Note: Interpreted by Mrs. Nongnuch J. of IWD

List of Participants' Organization in Seminar

Organization	Person
Ministry of Industry	
Department of Industrial Works	2
Department of Mineral Resources	6
Provincial Industrial Office	
Samut Prakan Provincial Industrial Office	1
Nakorn Pathom Provincial Industrial Office	1
Chantaburi Provincial Industrial Office	5
Songkhla Provincial Industry Office	1
Bang Poo Industrial Estate	1
Sura Maharas Public Co., Ltd.	3
Sugar Factories Inc.	2
Ministry of University Affairs	
Faculty of Engineering, Kasetsart University	2
Faculty of Engineering, Khon Kean University	2
Faculty of Engineering, Chieng Mai University	1
King Mongkut's Institute of Technology, North Bangkok Campus	5
King Mongkut's Institute of Technology, Latkrabang Campus	4
Institute of Environmental Research, Chulalongkorn University	4
Ministry of Defence	
The Glass Organization	3
The Textile Organization	2
The Tanning Organization	2
The Preserved Food Organization	1
Ministry of Science, Technology and Energy	
Office of National Environment Board	2
Thailand Institute of Scientific and Technological Research	3
Ministry of Finance	
The Excise Department	2
Ministry of Public Health	
The Government Pharmaceutical Organization	1
Department of Health	2
Asian Institute of Technology	1
Total	59

1.3.2 Seminar in 1988

Date: Monday, Deccember 12, 1988

Place: Imperial Hotel

	Time
1. Opening Address by Mr. Ben Saito, Resident Representative, JICA Bangkok Office	09:30-09:35
" by Mr. Yingyong Srithong, Director-General, IWD	09:35-09:45
2. Session I, chaired by Mr. Shun-ichiro Uchida	
(1) "Background and Objectives of the Study" by Mr. Adisorn Naphavaranonth Chief Industrial Water Supply Service Sub-Division	09:45-10:15
Coffee Break	10:15-10:30
(2) "Present Situation of the Water Usage and Effective Use of Industrial Water for the Studies Area" by Mr. Naoto Hashimoto	10:30-11:40
Luncheon	11:40-13:00
3. Session II, chaired by Mr. Naoto Hashimoto	
(1) "Practical Methods of the Effective Use of Industrial Water for Cooling" by Mr. Hozumi Eto	13:00-14:10
(2) "Practical Methods of the Effective Use of Industrial Water for Washing" by Mr. Shun-ichiro Uchida	14:10-15:05
Coffee Break	15:05-15:25
4. Question and Discussion chaired by Mr. Hozumi Eto	15:25-16:45

List of Participants' Organization in Seminar

Organization	Person
Private Company	
Chemical Factory	14
Food Factory	15
Metal Factyory	15
Paper Factory	5
Textile Factory	6
Consultant	3
Industrial Works Department	
Industrial Environment Division	9
Total	67

2.1: Quality of Industrial Water used by Pulp and Paper Industry in Japan

Item \ Source / Factory Number	Industrial Water	Public Waterworks	River Water	Infiltrated Water	Ground Water	Sea Water
Factory Number	5	2	11	15	27	6
Turbidity (ppm)	0 - 7.0	0 - 0.9	0 - 35	0 - 7.6	0 - 13.8	3.7
pH	7.1 - 7.7	6.4 - 6.5	6.5 - 8.2	6.5 - 8.2	6.5 - 7.8	6.9 - 8.9
Total Hardness (ppm)	1 - 55	1.3	1.7 - 42	4.2 - 47	2.5 - 161	699 - 5,760
Total Residue (ppm)	55 - 113	79	37 - 167	42 - 158	2 - 476	3,600 - 38,000
Permanganate Consumption (ppm)			0 - 8.7	0 - 2.3	1.6 - 4.8	
Disolved Oxygen (ppm)	8.0		2.6 - 10	0 - 8.8	0 - 130	5.2
Fe (ppm)	0 - 0.3	0.2 - 0.8	0 - 0.5	0 - 0.7	0 - 2.8	0 - 0.9
Chloride as Cl^- (ppm)	0 - 7.7	1.3	0 - 14.4	0 - 16.4	6.4 - 12,500	17,200 - 18,600
Sulphate as SO_4^{2-} (ppm)			4 - 19.2	0 - 6.0	2.4 - 6.1	2,350 - 6,000

2.2: Required Standard Quality of Industrial Water in Japan
(for Paper, Pulp and Paper Product Industry)

Unit: mg/lit
except Turbidity and pH

Item / Use	Turbidity (Degree)	pH	Alkalinity ($CaCO_3$)	Hardness ($CaCO_3$)	Total Residue	Chloride as Cl^-	Fe (Fe)	Mn (Mn)
Cooling	10	7.5	50	100	150	30	0.05	0.02
Washing	5	7.5	30	30	100	10	0.05	0.02
Material Water	5	7	50	80	80	30	0.05	0.02
Air Conditioning	2	7	50	50	100	10	0.05	0.02
Product Processing	5	7.5	40	50	100	50	0.05	0.02

2.3: Standard of Water Quality Management in a Steel Mill in Japan

Item / Water	pH	Turbidity (ppm)	SS (ppm)	Total Hardness (ppm)	Ca Hardness (ppm)	Total Fe (ppm)	Chloride as Cl^- (ppm)	Phosphate as PO_4^{3-} (ppm)	Silica (ppm)	Elect. Cond. (μS/cm)	Oil & Grease (ppm)	Remarks
PIWW	6.0-8.6	16>	18>	100>		2>	50>					Target Value of
PIWW	6.5-8.6	10>	10>	90>			30>		25>			City Managing
BF (IC)	7.0-8.6	20>	10>	100>	70>	2>	30>			300>		
BF (DUC)	8.0-8.6		50>									
Chemical Plant	7.5-8.5	20>	10>	120>	80>	2>	20>		100>	600>		
Sintering Plant	7.0-8.4	20>	10>	150>	100>	2>	30>			400>		
Converter (DC)	8.0-9.0	10>	5>	35>	25>	1>	50>	1>	150>	900>		
Converter (IC)	7.0-8.4	20>	10>	100>	70>	2>	30>			300>		
Converter (DUC)	9.0-12		30>									
EAF	7.0-8.4	20>	10>	120>	80>	2>	30>			400>		
CC (IC)	7.0-8.4	20>	10>	100>	70>	2>	30>			300>	1>	
CC (DC)	7.0-8.6	5>	3>	150>	100>	1>	100>			600>		
Roll. Mill (IC)	7.0-8.4	20>	10>	150>	100>	2>	100>			600>		Blooming Mill, Plating Mill & Hot Strip Mill
Roll. Mill (DC)	7.0-8.4		30>							1,000>	5>	"
Power Plant	7.0-8.4	20>	10>	150>	100>	2>	30>			400>		
Boiler Feed	7.0-8.0	5>	1>	Tr		Tr						

Remarks: Elect. Cond. = Electrical Conductivity
PIWW = Public Industrial Water Works
Roll. Mill = Rolling Mill
(IC) = (Indirect Cooling)
(DUC) = (Duct Catch)
(DC) = (Direct Cooling)

2.4 Factory Act, B.E. 2512 (1969), An Extract

Section 4. This Act shall not apply to factories owned by the State or governmental organisations and operated by the State or governmental organisations.

Section 5. In this Act:

"Factory" means a building, place or vehicle using machines, the output of which is more than 2 H.P. or is equivalent thereto, or employing seven or more workers whether or not using machines for making, producing, assembling, canning, repairing, maintaining, testing, modifying transforming or destroying any matters. However, it is in accordance with the category and kind of factories specified in the Ministerial Regulations.

"Machine" means an object, of several components, used for creating energy, changing or converting energy, or transmitting power, whether by means of water pressure, steam, fuel, air, gas, electricity or other forms of energy, either separately or collectively, and to include accessories, fly-wheel, pully, fan belt, axle, gear or other conjunctive parts.

"Worker" means a person working in a factory but does not include a person who does an administrative work.

"Official" means a person appointed by the Minister for carrying out this Act.

2.5 Notification of Ministry of Industry No. 13 (B.E. 2525) issued in accordance with the Factory Act B.E. 2512

Subject: Duty of Licensees to operate industrial plants

GOVERNMENT GAZETTE Volume 99 Part 89 dated June 29, 1982: — By virtue of Section 39 (16) of the Factory Act B.E. 2512, the Minister of Industry hereby announces the principles and procedures to be followed by the licensees to operate industrial plants:

1. The following industrial plants must have the supervisors and machine operators to take responsibility of the system of prevention of polution, whose qualifications are specified in 2.

 1.1 An industrial plant discharging waste water at higher than 60 cubic meters/hour (with the exception of cooled water), or having the BOD load of influent at higher than 100 kilogram /day.

 1.2 An industrial plant using heavy metals in the production process discharging waste water at higher than 50 cubic meters/ day, and having the content of heavy metals in the discharged waste water at the following values:

  1.2.1 Zinc at higher than 250,000 milligrams/day
  1.2.2 Chromium at higher than 25,000 milligrams/day
  1.2.3 Arsenic at higher than 12,500 milligrams/day
  1.2.4 Copper at higher than 50,000 milligrams/day
  1.2.5 Mercury at higher than 250 milligrams/day
  1.2.6 Cadmium at higher than 1,500 milligrams/day
  1.2.7 Barium at higher than 50,000 milligrams/day
  1.2.8 Selenium at higher than 1,000 milligrams/day
  1.2.9 Lead at higher than 10,000 milligrams/day
  1.2.10 Nickel at higher than 10,000 milligrams/day
  1.2.11 Manganese at higher than 250,000 milligrams/day

 1.3 An industrial plant dealing with iron and steel:

  1.3.1 Using drying furnace or acids or other substances which may be poluting the environment in the production process, with production capacity of higher than 100 tons/day;

1.3.2 Using steel smelters with the total capacity of 5 tons/batch.

1.4 An industrial plant producing petrochemicals from the raw materials obtained as by-products of the oil refinery in the production process at higher than 100 tons/day.

1.5 An industrial plant of any size separating or processing the natural gas.

1.6 An industrial plant producing chlor-alkali, using sodium chloride (NaCl) as raw material in the production of soda ash (Na_2CO_3), caustic soda (NaOH), hydrochloric acid (HCl), chlorine (Cl_2) and bleaching (NaOCl) each or several combined at higher than 100 tons/day.

1.7 An industrial plant of any size producing cement.

1.8 An industrial plant engaged in ore smelting or production of metals at higher than 50 tons/day.

1.9 An industrial plant producing paper pulp at higher than 50 tons/day.

1.10 An industrial plant of any size engaged in crude oil refinery.

2. The supervisors, machine operators responsible for the system of prevention of pollution, shall meet the following qualifications:

2.1 The supervisors are holders of bachelor degree in engineering, or science with experiences in the field of environment, who are approved by the Industrial Works Department. For an engineering consultant firm, it must have the service of qualified persons as indicated earlier.

2.2 The machine operators must be graduates of the secondary education, lower level, with the certification from the persons as mentioned in 2.1.

2.3 The persons stated in 2.1 and 2.2 must register themselves with the Industrial Works Department, and complying with the regulations and procedures as prescribed by the Industrial Work Department.

2.6 Notification of Ministry of Industry No. 15 (B.E. 2527) issue in accordance with the Factory Act B.E. 2512

Subject : Duty of Licensees to operate industrial plants

By virtue of Section 39(16) of the Factory Act B.E. 2512, the Minister of Industry hereby announces the principles and procedures to be followed by the licensees to operate industrial plants

1. The licensees to operate the following industrial plants must take response to do as specified in 2.

   1.1 An industrial plant producing pulp at higher than 50 tons/day

   1.2 An industrial plant producing chemical except fertilizer as follows :

      1.2.1 Chlor-alkali plant, using Sodium Chloride ($NaCl$) as raw material for the production of Soda Ash (Na_2CO_3), Caustic Soda ($NaOH$), Hydrochloric Acid (HCl), Chlorine (Cl_2), Sodium Hydrochlorite ($NaOCl$) and Bleaching Powder each or several combined at higher than 100 tons/day.

      1.2.2 An industrial plant producing petrochemicals from the raw materials obtained as by products of the Oil Refinery in the production process at higher than 100 tons/day.

   1.3 An industrial plant of any size engaged in crude oil refinery.

   1.4 An industrial plant of any size producing cement.

   1.5 An industrial plant producing iron and steel, using iron ores or scrap iron as raw material with production capacity higher than 100 tons/day or using melting furnace with the total capacity of 5 tons/batch.

   1.6 An industrial plant engaged in are smelting or production of metals at higher than 50 tons/day.

2.7 Implementation of Ground Water Act (B.E.2520)

Groundwater Act

The original Groundwater Act was named the Groundwater Act B.E. 2520* which has been enforcing since 1977 until now. The principle of the Groundwater Act is government control of groundwater activities. This includes drilling for groundwater and its use as well as disposal of wastewater through wells. Under the provisions of the Act, no one may utilize groundwater from designated "groundwater areas" without an official permit.

The Act is comprised of 8 sections which deal with the definition of terms and general informations, the constitution of groundwater committee, the application for and cancellation of permits, the duties of permit holders, the authority of officials, the amendment and revoke of permits, the penalties for violations and the temporary enforcement.

The Minister of Industry has responsibility for the Act. He may issue directives on drilling, cancellation of drilling, conservation of groundwater, disposal of liquids into the aquifers through wells, and protection of public health and environment.

The Act will not be immediately enforced in all region of the country, it will be implemented in specific areas where groundwater resources are indicated critical with respect to water quality or overexploitation. In doing so, the Minister may issue a directive designating the region of concern as a "Groundwater Area". Groundwater in this area is defined as one occurring in layers of earth or rocks at depths indicated in the ministerial regulations. Under provisions of the Act, it will still possible to utilize groundwater outside the Groundwater Area or even within the area if permission is obtained.

The chief executive administering the Act is the Director-General of the Department of Mineral Resources, Ministry of Industry. The Director-General has a mandate to issue, amend or revoke all permits. He shall appoint Groundwater Area Officials to process applications for permits, permit renewal, appeals, and registration of wells which existed prior to the Act. Personnel shall also be appointed for on-site inspection. They will have power to give written instruction to a permit holder to refrain from or correct activities which may cause damages to the groundwater resources. Although the permit holder has the right to appeal, he must abide by the order until a decision is made by the Minister on the matter.

The Act also requires that there be a Groundwater Committee to advise the Minister in establishing regulations and in making recommendations to the Director-General. The Committee is to be chaired by the Director-General of the Department of Mineral Resources. Other members include administrative personnel from the Public Works Department, the Royal Irrigation Department, the Public Health Department, the Metropolitan Water Works Authority and three experts appointed by the Minister.

Three kinds of permits are designated, they may be issued for one year for drilling purpose, for five years to facilitate disposal of liquids into the aquifers through wells, and for ten years for groundwater use. All may be renewed. Permits for drilling and groundwater use are not required for government organizations which have responsibility to provide water for agricultural or non-industrial purposes. However, these government organizations are not exempt from ministerial regulations concerned with drilling, well development or abandonment, controlled extraction of groundwater, public health or environmental protection.

Implementation of the Act

The Minister issued directives on technical principles involving groundwater use as follows:

1. Bangkok and five adjoining provinces were designated as the Bangkok Groundwater Area Groundwater occurring at depths exceeding 15 meters below ground surface in this area is subject to administration under the Act.

2. Specifications for drilling and construction of wells provided under the Act. Standard forms for daily drilling reports, well records and other informations were prescribed.

3. Methods of groundwater extraction and conservation were outlined.

4. Technical measures to protect groundwater from pollution were described and drinking water standards issued.

5. Technical principles were given for disposal or injection of water or liquids into the aquifers through wells.

6. Pricing of water use rate by any methods not more than one Baht per cubic meter of water, and discount rate or exemption for particular holders of permit for use of groundwater in particular groundwater areas are under consideration.

Violations of the Act or of the ministerial directives are to be punished by a fine which may range from 500 to 20,000 Baht (US $1.00 is approximately equivalent to 22.50 Baht) depending on the nature of violation. Severe punisment is reserved for those engaged in groundwater activities without a permit. The penalty is imprisonment not exceeding six months or a fine not exceeding 20,000 Baht, or both. Equipment, tools or machinery used in carrying out the violation may also be confiscated.

Under the ministerial regulations, orders and rules were made by the Director-General of the Department of Mineral Resources to certify private drillers or contractors and to direct the authorized personnel. Critiria for issuing permits are also created by the Groundwater Committee. The most significant criterion for issuing the groundwater drilling permit is the site where groundwater to be drilled should be situated beyond a certain distance from the nearest public water distributing pipeline and no any other source of suitable surface water available, e.g., 200 meters for a household and 300 meters for a factory. Moreover, the well is specified with size and depth in order to control the pump capacity and to allocate water from each aquifer respectively.

2.8 NOTIFICATION OF MINISTRY OF INDUSTRY
No. 7 (B.E. 2528)

Issued under the Deep Well Act, B.E. 2520
Re: Prescribing principles and technical measures for conservative use of deep well water

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By virtue of Section 6 (1) of the Deep Well Act, B.E. 2520, the Minister of Industry on advice of the Deep Well Commission, hereby issues a Notification prescribing principles and technical measures for conservative use of deep well water as follows:

Clause 1. The provision of Clause 2 of the Notification of Ministry of Industry No. 3 (B.E. 2521), issued under the Deep Well Act, B.E. 2520; Re: Prescribing principles and technical measures for conservative use of deep well water, shall be cancelled and replaced by the followings:

"Clause 2. Pumping of deep well water.

(1) All deep wells shall have water meter, except that the Commission shall specify to the contrary.

(2) In case the meter is installed, fill in the particular as prescribed by the authority for the use of deep well according to the form specified by the Mineral Resources Department, and submit it to the Local Deep Well Official within the 7th of the following month.

(3) The deep well having diameter from 200 mm. upwards shall have the diameter of the top of the well no less than 25 mm., complete with cover so that the water level in the well could be inspected.

Government Gazette Vol.102,Part 95,Special Issue Page 28,dated 25:7:85

(4) The level of water in the deep well must be measured and the result found shall be reported together with sample water collected from the well according to the method prescribed by the Mineral Resource Department, which shall be submitted to the Local Deep Well Official within 15 days from the date having been notified in writing by the Local Deep Well Official.

Clause 2. Add the following as Clause 3, Clause 4, Clause 5 and Clause 6 of the Notification of Ministry of Industry No. 3 (B.E. 2521), issued under the Deep Well Act, B.E. 2520; Re: Prescribing principles and technical measures for conservative use of deep well.

"Clause 3. Water meter

(1) The water meter installed at the deep well shall be magnetic type meter, which has been certified by the Ministry of Commerce and has been tested for accuracy by the institute approved by the Mineral Resources Department, and shall have the following features:

A. The accrued water consumed shall be in cubic meter.

B. The figure for measuring the volume of water at the dial can record no less than five figures discounting the decimal points and shall be in the same line.

C. There is no other button or mechanism for which the figure can be adjusted from outside.

Clause 4. Installation of water meter for the deep well.

3.1 Manual for Visiting Survey in the Study on Effective Use of Industrial Water in the Kingdom of Thailand

1. Main Point of the Study

This Study is conducted to collect information on actual status of water usage in factory in order to examine effective use of industrial water, and main point is to clarify how industrial water (including domestic water and non-potable water) is used.

For this purpose, it is necessary to understand production process first and to grasp completely status of water usage in connection with production process.

Items related to environment such as waste water treatment and waste water quality are closely connected with effective use of industrial water, but those items are not included in the main point of the Study. Therefore, it is advised not to make mistake in understanding the main point.

2. Preparation

2.1 Study on Answered Questionnaire

The following items in the answered questionnaire shall be studied:

(1) Production process, especially process where water is used;

(2) Quantity of water usage classified by source of water and purpose of water usage, and variation of water usage;

(3) Usage of recovered water (Does the recirculating process of water clearly described?);

(4) Is the water balance complete?;

(5) Layout of equipment that uses water;

(6) Location and diameter of water source (well, intake gate, service pipe of public water works and others).

2.2 Outlines and Problems related to Measures for Effective Use of Industrial Water

On the basis of the above study described in Clause 2.1, outlines of measures for effective use of industrial water, as well as problems related to measures shall be grasped.

(1) Possibility of adopting measures for effective use of product processing and washing water (adoption of multi-stage counter current washing process, recycling of waste water and other measures);

(2) Water quantity of one through process in indirect cooling system;

(3) Water quantity of one through process in air conditioning system;

(4) Relations between quantities of domestic water and non-potable water, and numbers of workers.

3. Visiting Survey

3.1 Hearing and Question

Survey team shall hear explanation of contents of answered questionnaire by factory staff.

Question by survey team shall aim to clarify unclear points in answered questionnaire, paying attention to the following items in addition to the items described in 2.1.

(1) In case water quantity is unknown, survey team shall collect such data as diameter of pipeline, specification of pump, capacity of cooling tower, capacity of refrigerator, capacity of compressor and others by which water quantity could be estimated.

(2) In the case of boiler feed water, recovery of drain shall be checked.

(3) Quality of material water, and influence of water quality to product quality.

(4) In case product processing and washing water, the followings shall be checked:

(a) Influence of water quality to product quality;

(b) Influence of decrease of water quantity to product quality;

(c) Waste flow of water (in such a case that water is supplied in spite of the process is not in operation.);

(5) As for indirect cooling water, the followings shall be checked;

(a) Shape of cooling equipment (heat exchanger, jacket, coil and others);

(b) Condition of cooled substance (air, liquid, solid and others) and its temperature;

(c) Temperatures of inlet and outlet, or raise of temperature;

(d) Necessity of using well water (requirements for temperature, quality and others).

(6) As for direct cooling water, pollution of discharged waste water shall be checked in addition to the above (5).

(7) As for air conditioning water, installed condition and capacity of cooling tower shall be checked.

(8) As for domestic and non-potable water, details of usage (water is supplied to neighboring houses as domestic water, for example) shall be checked.

3.2 Site Observation

In order to grasp the whole production process, it is preferable to check from the first process to the final process. It is also advised that survey team endeavors to understand production process as much as possible, not adhering to water usage.

Survey team shall pay special attention to the followings:

(1) It is preferable to confirm, at the site, route of water flow, diameter of pipeline, specifications of pump and other equipment, and so forth, even if informations on these items are answered.

(2) As for material water, survey team shall confirm that it is used only as material and that it does not include water for other use (washing and others).

(3) Product processing and washing water shall be checked carefully. Special attention shall be paid because unnecessary flow and/or meaningless overflow is applied in some cases.

Survey team must be careful because explanation by factory staff and actual condition related to water usage of batch wise type, semi-continuous type and continuous type are occationally different.

(4) As for cooling water, the followings shall be checked:

(a) Temperatures at inlet and outlet, and temperature of cooled substance.

(b) Route of recycling water shall be confirmed in case recycling water (recovered water) is used.

(c) In case well water is used in one through process, problems to be occurred by recycled use of water.

(5) Operating condition of air washer, in air conditioning process.

(6) As for domestic water and non-potable water, it is all right to omit observation except water that is consumed for special uses.

(7) As for waste water treatment facility, use of non-potable water for treatment (defoaming water, deluting water, chemical dissolving water and other) shall be confirmed.

Waste water treatment itself and discharge condition of waste water shall be observed from standpoint of water re-use.

Site observation shall be conducted taking time as long as possible. If time is limited, however, the following items shall be observed:

(1) Facilities that consumes large quantity of water;

(2) Product processing and washing water;

(3) Direct cooling water.

3.3 Water Flow Measurement

Point of water flow measurement shall be carefully decided after completing observation of the whole factory.

The following points shall be studied as those of flow measurement:

(1) Point where total quantity of make-up water can be measured;

(2) Point where large quantity of water is used;

(3) Point where estimation of quantity of water use is completely impossible;

Measurement point and obtained data shall be carefully evaluated, and they shall be adopted only in case that their rationality in the total water balance is confirmed.

3.4 Water Quality Measurement

Sampling point and measurement items shall be carefully decided after completing observation of the whole factory. Main sampling points and measurement items are as follows:

(1) Well water -- temperature, pH and electric conductivity

(2) Make-up water other than well water -- temperature, pH and electric conductivity;

(3) Waste water from product processing and washing (for re-use) -- pH, turbidity, electric conductivity and COD;

(4) Recycling water for cooling and air-conditioning -- temperature and electric conductivity;

(5) Recycling water and re-used water other than above -- measurement items shall be decided in accordance with condition.

Quality measurement of waste water (before treatment and after treatment) shall be conducted only when it is necessary for measures for effective use of industrial water such as water re-use, and shall be conducted after obtaining complete concent of the factory side.

4. Others

(1) Items and figures filled in the answered questionnaire shall be reconfirmed as much as possible. Especially, special attention shall be paid to the usage of recovered water and the recycling route because wrong data on these items are often filled in.

(2) As for the factory which owns independent water source other than well and public water works (for example, the rights to river water and others), details of its water source and possibility of stable water intake in the future shall be confirmed.

(3) Layout drawing of the factory is very useful, even if it is uncomplete. In case survey team cannot receive drawing itself, be sure to make a sketch of drawing.

(4) As brochure, catalog of product and other publications of the factory are useful to understand production process, be sure collect as many as possible.

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3.2 Unit Water Usage

Although description of the unit uage of industrial water (for example water usage/production outout) and the unit usage of domestic water (for example the per capita per day consumption) as well as the water charges, which were the subject of many questions during the studying period, could not be given in this Report, they are now given herewith.

(1) Unit Water Usage (In this case, Water Usage/Production Output Ratio of Industrial Water)

Generally, Unit Usage to be used to estimate future demands for industrial water are to be (i) per production output of that factory (industry), (ii) per one worker of that factory (industry) or (iii) per the land area of that factory (industry). Generally, however, (i) is the most applied.

The figure derived by the amount of water used annually to produced a given production output at a certain factory divided by the annual production output of that factory is called the water usage/production output ratio of industrial water (hereafter shows as W/P). The average of figures obtained from similar factories, for example, textile industries is the W/P of the country's textile industry. Naturally, this figure varies with each factory's production process, the specifications of the production facilities, the working hours, the water resources situation of the area and other factors. It is never the same but by collecting a large quantity of data it is possible to give the figure some significance. While the figure is usually used to estimate future water demands, it should be noted that the basis for this W/P ratio is not volume of output (quantity of merchandise) but value of production (monetary amount). For example, even if the quantity of water required to produce 1 ton of paper is approximately the same for any grade of paper, the higher the grade of paper produced the more the production output, hence the W/P ratio will go down. Thus in the same industry,if the W/P ratio of usage becomes low, it can be said that, as a general trend the product measure is becoming a higher grade and has a higher added value.

As mentioned before, since a W/P ratio based on production output (monetary amount) is greatly affected by economic activity, etc., to apply it for the short term work of effective use of water makes judgement very difficult without the factory's W/P ratio variations over a long period, Therefore, it is mostly used for future estimations and the like. For instance, it could be used as a check list for the application for approval issue of a business establishment. In each industry, besides this W/P ratio data in many cases are collected on the output of a representative product of the industry, for instance, the tons produced of crude steel in the integrated iron and steel manufacturing industry. Each industry collects data which is easiest for it to use such as the amount of water needed to process one barrel of oil in the oil refining industry. But to collect this data for all industries required a common denominator. Hence, the production output had to be used. However, it will be necessary also to collect the unit rate per representative product of each industry and use it to make modifications.

Also, although in Japan water usage per day (m^3/day) divided by the annual shipment value (x 10^8 yen/year) is applied as the W/P ratio, there are countries that indicate W/P ratios by dividing the annual water usage by the annual production output. So care must be taken when handling units used in W/P ratios.

For your information, the water demand estimation calculation formula used in the Thai Eastern Seaboard Development Program is as shown in Table 1. Industrial water demand is based on a per worker W/P ratio whereas for harbor water both a per laborer W/P ratio and a per ton of shipping cargo handled W/P ratio are used. Moreover, in this case, industrial water is regarded as water supplied from outside the factory, that is, make-up water, so an item called "recovery ratio" is included.

Also, the rate of water leakage is an important factor in water resources development. In Japan, the rate of water leakage in industrial water system is less than 7% due perhaps to the areas supplied being comparatively small. Care must be taken when this figure becomes large because the amount of water to be developed from water resources is the quantity of water leakage added to the total water actually needed by each factory.

Table 1. Water Demand Estimates of Eastern Seaboard Development Program

- o Estimation of Industrial Water Demand :

$$D_I = E_n \times Ucn \times (1 - Rn) \times 365/(1 - Uw)$$

Where, D_I : Demand for industrial water (m^3/year)

E_n : No. of employees (persons)

Ucn: Water used per employee per day (m^3/day/head)

Rn : Ratio of recovered water

Uw : Rate of water leakage

- o Harbor Operation Water Demand :

$$Dp = ((W \times Ucw) \times 365 + (Cv \times Ucc))/(1 - Uw)$$

Where, Dp : Demand for harbor operational water (m^3/year)

W : No. of harbor laborers (persons)

Ucw: Water used per laborer per day (m^3/day/head)

Cv : Shipping cargo handled (10^6ton/year)

Ucc: Water used per ton of shipping cargo (m^3/ton/year)

Uw : Rate of water leakage

(2) W/P Ratios of Factories Surveyed

We will now take up the W/P ratios of the 59 factories in the Samut Prakarn Province that were surveyed by us. Tables 2 and 3 show, respectively, the ratios based on make-up water and on total water usage. As information, we show Japanese records in Tables 4 and 5. In Japan, however, there are many factories that use seawater partially as cooling water.These are shown in parentheses ( ) in the 1985 column as excluded figures. The actual W/P ratio in Japanese industries is the fresh water and seawater added together. While there are considerable differences in production scale, products, etc., as well as in the temperature of the water used between the factories surveyed in the Samut Prakarn Province and Japanese factories so it cannot be said that a W/P ratio is large or small, nevertheless we believe the tables can be used as reference. In Table 6, we show examples of W/P ratios based on land area and per employee.

Table 2: Water Units of Surveyed Factories (Make-Up Water Base)

Code No.	Fact. No.	Make-up (Raw) Water (m^3/d)	Production Output (M฿)	Total Area (m^2)	No. of Employees (Person)	Water Unit (A) (m^3/Y 10^4 ฿)	Water Unit (B) ($m^3/d/$ $100m^2$)	Water Unit (C) ($m^3/d/$ person)
F-01	170	1,200	400	12,100	700	10.95	0.99	1.71
F-02	103	1,065	-	48,000	450	-	2.22	2.37
F-03	135	178	200	5,500	100	3.25	3.24	1.78
F-04	130	100	-	56,000	214	-	0.18	0.47
F-05	127	654	-	27,200	465	-	2.40	1.41
F-06	114	1,098	670	33,600	400	5.98	3.27	2.75
F-07	110	163	48	13,000	130	12.39	1.25	1.25
F-08	109	665	-	16,400	1,000	-	4.05	0.67
F-09	91	300	-	24,000	150	-	1.25	2.00
F-10	78	54	-	-	45	-	-	1.20
F-11	65	37	0.6	3,600	75	225.08	1.03	0.49
F-12	48	323	350	64,000	214	3.37	0.50	1.51
F-13	43	1,120	459	44,800	880	8.91	2.50	1.27
F-14	21	68	3.5	2,000	15	70.91	3.40	4.53
P-01	145	1,245	60	10,000	65	75.74	12.45	19.15
P-02	124	1,230	-	30,000	330	-	4.10	3.73
P-03	107	2,958	-	4,800	249	-	61.63	11.88
P-04	84	13,260	1,100	80,000	900	44.00	16.58	14.73
P-05	39	152	-	81,600	323	-	0.19	0.47
T-01	146	10,384	-	144,000	4,530	-	7.21	2.29
T-02	197	166	-	19,200	100	-	0.86	1.66
T-03	203	1,885	-	6,400	180	-	29.45	10.47
T-04	193	26	3	3,200	50	31.63	0.81	0.52
T-05	200	180	-	12,800	76	-	1.41	2.37
T-06	198	442	-	6,400	76	-	6.91	5.82
T-07	189	549	120	4,800	300	16.70	11.44	1.83

Table 2: Continued

Code No.	Fact. No.	Make-up (Raw) Water (m³/d)	Production Output (M฿)	Total Area (m²)	No. of Employ-ees (Person)	Water Unit (A) (m³/Y 10^4 ฿)	Water Unit (B) (m³/d/ 100m²)	Water Unit (C) (m³/d/ person)
M-01	61	504	544.5	45,108	507	3.38	1.12	0.99
M-02	96	1,192	1,200	9,600	684	3.63	12.42	1.74
M-03	89	162	15	24,000	250	39.42	0.68	0.65
M-04	206	8	8	4,000	40	3.65	0.20	0.20
M-05	73	620	143.9	70,400	350	15.73	0.88	1.77
M-06	53	70	50	8,807	390	5.11	0.79	0.18
M-07	34	58	-	2,400	87	-	2.42	0.67
M-08	42	40	72	15,600	201	2.03	0.26	0.20
M-09	69	496	-	21,000	200	-	2.36	2.48
M-10	207	17	15	6,400	60	4.14	0.27	0.28
M-11	116	212	530	24,300	345	1.46	0.87	0.61
M-12	97	107	-	7,200	31	-	1.49	3.45
M-13	208	20	-	9,600	90	-	0.21	0.22
M-14	115	269	73.2	83,315	310	13.41	0.32	0.87
M-15	101	3,162	2,139	41,600	469	5.40	7.60	6.74
M-16	100	529	140	12,634	127	13.79	4.19	4.17
M-17	56	140	-	24,213	413	-	0.58	0.34
M-18	64	617	5,476	124,800	583	0.41	0.49	1.06
M-19	57	350	2,710	17,600	341	0.47	1.99	1.03
M-20	49	23	70	19,200	105	1.20	0.12	0.22
C-01	155	75	100	20,800	67	2.74	0.36	1.12
C-02	168	330	450	81,600	102	2.68	0.40	3.24
C-03	209	36	15	275	120	8.76	13.09	0.30
C-04	210	40	-	32,000	110	-	0.13	0.36
C-05	149	1,560	-	64,000	325	-	2.44	4.80
C-06	147	27	180	32,000	67	0.55	0.08	0.40
C-07	106	138	100	12,000	96	5.04	1.15	1.44
C-08	94	752	533	20,336	531	5.15	3.70	1.42
C-09	82	226	720	22,400	276	1.15	1.01	0.82
C-10	51	300	-	17,000	100	-	1.76	3.00
C-11	25	1,020	180	80,000	240	20.68	1.28	4.25
C-12	7	250	-	20,000	109	-	1.25	2.29
C-13	29	45	18.8	25,600	94	8.74	0.18	0.48

Table 3: Water Units of Surveyed Facotires (Total Water Base)

Code No.	Fact. No.	Total Water Used (m^3/d)	Production Output (M฿)	Total Area (m^2)	No. of Employees (Person)	Water Unit (A) (m^3/Y 10^4 ฿)	Water Unit (B) (m^3/d/ 100m^2)	Water Unit (C) (m^3/d/ person)
F-01	170	1,740	400	12,100	700	15.88	14.38	2.49
F-02	103	5,065	-	48,000	450	-	10.55	11.26
F-03	135	850	200	5,500	100	15.51	15.45	8.50
F-04	130	100	-	56,000	214	-	0.18	0.47
F-05	127	5,451	-	27,200	465	-	20.04	11.72
F-06	114	5,618	670	33,600	400	30.61	16.72	14.05
F-07	110	5,923	48	13,000	130	450.39	45.56	45.56
F-08	109	14,825	-	16,400	1,000	-	90.40	14.83
F-09	91	3,865	-	24,000	150	-	16.10	25.77
F-10	78	714	-	-	45	-	-	15.87
F-11	65	41	0.6	3,600	75	249.42	1.14	0.55
F-12	48	346	350	64,000	214	3.61	0.54	1.62
F-13	43	1,720	459	44,800	880	13.68	3.84	1.95
F-14	21	68	3.5	2,000	15	70.91	3.40	4.53
P-01	145	1,845	60	10,000	65	112.24	18.45	28.38
P-02	124	3,430	-	30,000	330	-	11.43	10.39
P-03	107	6,307	-	4,800	249	-	131.40	25.33
P-04	84	18,060	1,100	80,000	900	59.93	22.58	20.07
P-05	39	212	-	81,600	323	-	0.26	0.66
T-01	146	63,873	-	144,000	4,530	-	44.36	14.10
T-02	197	166	-	19,200	100	-	0.86	1.66
T-03	203	1,925	-	6,400	180	-	30.08	10.69
T-04	193	26	3	3,200	50	31.63	0.81	0.52
T-05	200	u/k	-	12,800	76	-	-	-
T-06	198	442	-	6,400	76	-	6.91	5.82
T-07	189	555	120	4,800	300	16.88	11.56	1.85

Table 3: Continued

Code No.	Fact. No.	Total Water Used (m³/d)	Production Output (M฿)	Total Area (m²)	No. of Employ-ees (Person)	Water Unit (A) (m³/Y 10⁴ ฿)	Water Unit (B) (m³/d/ 100m²)	Water Unit (C) (m³/d/ person)
M-01	61	731	544.5	45,108	507	4.90	1.62	1.44
M-02	96	1,562	1,200	9,600	684	4.75	16.27	2.28
M-03	89	2,604	15	24,000	250	633.64	10.85	10.42
M-04	206	968	8	4,000	40	441.65	24.20	24.20
M-05	73	1,432	143.9	70,400	350	36.32	2.03	4.09
M-06	53	70	50	8,807	390	5.11	0.79	0.18
M-07	34	153	-	2,400	87	-	6.38	1.76
M-08	42	50	72	15,600	201	2.53	0.32	0.25
M-09	69	8,866	-	21,000	200	-	42.22	44.33
M-10	207	145	15	6,400	60	35.28	2.27	2.42
M-11	116	350	530	24,300	345	2.41	1.44	1.01
M-12	97	2,282	-	7,200	31	-	31.69	73.61
M-13	208	164	-	9,600	90	-	1.71	1.82
M-14	115	1,369	73.2	83,315	310	68.26	1.64	4.42
M-15	101	7,962	2,139	41,600	469	13.59	19.14	16.98
M-16	100	1,601	140	12,634	127	41.74	12.67	12.61
M-17	56	1,396	-	24,213	413	-	5.77	3.38
M-18	64	2,077	5,476	124,800	583	1.38	1.66	3.56
M-19	57	950	2,710	17,600	341	1.28	5.40	2.79
M-20	49	427	70	19,200	105	22.27	2.22	4.07
C-01	155	355	100	20,800	67	12.96	1.71	5.30
C-02	168	6,030	450	81,600	102	48.91	7.39	59.12
C-03	209	90	15	275	120	21.90	32.73	0.75
C-04	210	40	-	32,000	110	-	0.13	0.36
C-05	149	15,960	-	64,000	325	-	24.94	49.11
C-06	147	27	180	32,000	67	0.55	0.08	0.40
C-07	106	178	100	12,000	96	262.00	1.48	1.85
C-08	94	4,522	533	20,336	531	30.97	22.24	8.52
C-09	82	1,016	720	22,400	276	5.15	4.54	3.68
C-10	51	2,300	-	17,000	100	-	13.53	23.00
C-11	25	15,420	180	80,000	240	312.68	19.28	64.25
C-12	7	2,477	-	20,000	109	-	12.39	22.72
C-13	29	77	18.8	25,600	94	14.95	0.30	0.32

Table 4: Water/Production Ratio of Industry in Japan (Make-Up Water Base)

Unit; m³/Y/10⁴ ¥

Sector \ Year	1973	1978	1985	
Food	15.09	4.13	3.23	(1.66)
Textiles	14.42	12.06	9.20	
Cloth & Other Textile Products	1.64	0.93	0.54	
Wood & Wood Products	1.04	0.88	0.80	(0.02)
Furniture & Ornament	1.16	0.66	0.50	
Pulp, Paper & Paper Products	33.68	32.08	27.29	(0.26)
Publishing, Printing & Related Industry	0.62	0.56	0.32	
Chemicals	13.65	9.98	7.87	(11.98)
Petroleum & Coal Products	1.33	1.13	1.19	(37.20)
Rubber Products	4.00	2.82	1.97	
Leather Products	2.08	1.52	1.25	
Ceramics, Stone & Clay Products	4.84	3.65	2.95	(5.87)
Iron & Steel	5.84	5.06	4.37	(16.50)
Non-Ferrous Metals	4.02	3.08	3.23	(5.31)
Fabricated Metals	2.22	1.69	1.21	(0.002)
Machinery & Equipment	1.33	1.01	0.56	(0.15)
Electrical Machinery	1.64	1.08	0.63	
Transportation Equipment (Automobile, etc.)	1.48	0.89	0.47	(0.06)
Precision Instruments	1.46	0.93	0.70	
Others	3.23	2.53	0.64	
Total	6.66	4.30	2.89	(3.16)

Note: Figure in ( ) shows sea water unit.

Source: Industrial Census (1985), MITI

Table 5: Water/Production Ratio of Industry in Japan (Total Water Base)

Unit; m³/Y/10⁴ ฿

Sector \ Year	1973	1978	1985	
Food	16.12	6.18	5.07	(1.66)
Textiles	15.45	15.09	11.61	
Cloth & Other Textile Products	1.76	0.94	0.56	
Wood & Wood Products	1.08	0.95	0.94	(0.02)
Furniture & Ornament	1.21	0.68	0.53	
Pulp, Paper & Paper Products	48.03	51.57	46.97	(0.26)
Publishing, Printing & Related Industry	1.02	1.07	0.58	
Chemicals	50.47	50.52	39.78	(11.98)
Petroleum & Coal Products	6.76	7.49	8.61	(37.20)
Rubber Products	7.98	9.00	7.41	
Leather Products	2.15	1.62	1.32	
Ceramics, Stone & Clay Products	9.54	9.69	10.34	(5.78)
Iron & Steel	34.51	43.66	42.83	(16.50)
Non-Ferrous Metals	12.93	11.66	10.89	(5.31)
Fabricated Metals	2.54	2.19	2.37	(0.002)
Machinery & Equipment	1.78	2.12	1.50	(0.15)
Electrical Machinery	2.40	2.78	1.97	
Transportation Equipment (Automobile, etc.)	6.66	7.08	5.47	(0.06)
Precision Instruments	1.76	1.17	1.12	
Others	4.56	4.94	1.49	
Total	15.86	15.24	11.33	(3.16)

Note: Figure in ( ) shows sea water unit.

Source: Industrial Census (1985), MITI

Table 6: Example of Unit Water Usage for Area and Works of Industrial Water in Japan (1985)

Water Source	Fresh Water		Sea Water	
Item / Sector	Factory Area ($m^3/d/100m^2$)	Regular Workers ($m^3/d/$Person)	Factory Area ($m^3/d/100m^3$)	Regular Workers ($m^3/d/$Person)
All Manufacturing	10.40	19.16	2.90	5.34
Food	5.80	6.92	1.90	2.27
Textiles	5.78	10.16	-	-
Cloth & Other Textile Products	0.47	0.22	-	-
Wood & Wood Products	0.33	1.08	0.01	0.02
Furniture & Ornament	0.30	0.52	-	-
Pulp, Paper & Paper Products	28.48	90.14	0.16	0.50
Publishing, Printing & Related Industry	2.46	0.75	-	-
Chemicals	27.25	118.73	8.20	35.76
Petroleum & Coal Products	9.96	202.43	10.03	203.85
Rubber Products	6.90	8.82	-	-
Leather Products	1.58	1.11	-	-
Ceramics, Stone & Clay Products	3.11	12.37	1.74	6.91
Iron & Steel	20.74	114.87	7.99	44.24
Non-Ferrous Metals	6.88	26.67	3.35	13.00
Fabricated Metals	1.72	2.91	-	-
Machinery & Equipment	1.45	2.15	0.15	0.22
Electrical Machinery	3.88	2.71	-	-
Transportation Equipment (Automobile, etc.)	7.74	12.54	0.08	0.13
Precision Instruments	1.76	1.18	-	-
Weapon	0.06	1.02	-	-
Others	1.79	1.85	-	-

Source: Industrial Census (1985), MITI

When looking at these data, consideration must also be given to the point that the general tendency is for the Japanese industrial structure to be heavy industry while that of Thailand and the majority of the factories surveyed is light industry.

As a result of searching whether other countries had such data concerning W/P ratios, we found them for Beijing and Tianjin of mainland China and attach them herewith as Tables 7 and 8 respectively.

However, as stated before, as W/P ratios depend on national and regional climatic conditions, industrial structure, etc. and cannot be expressed unconditionally, it will be necessary to search for measures to reduce the amount of make-up water from data collected over a long period from the factories in Samut Prakarn Province.

Table 7: Water Use in Various Industrial Sector in Beijing (1984)

Item / Sector	Make-Up (Raw) Water (10^6 m³/Y)	Production Output (10^9 ฿/Y)	Unit Water Use Rate (m³/10^4 ฿)
Metallurgy	100.56	19.75	50.9
Coking Plant	22.08	2.88	76.8
Chemical Industry	195.83	38.61	50.7
Construction Material	45.47	6.62	68.9
Pulp & Paper	25.10	1.52	165.1
Mechanical Industry	106.04	59.12	17.9
Timber Industry	63.53	3.24	196.1
Food Industry	44.39	13.95	31.8
Textile	55.11	19.66	28.0
Sewing Factory	3.89	7.90	4.9
Leather Industry	3.71	2.77	13.4
Educational Products	16.33	9.93	16.4
Others	15.15	5.82	26.0
Total	697.19	191.74	36.4
Power Plant	296.49	5.25	564.5
Sum	993.68	196.99	50.4

Note: Currency Conversion: Yuan ≑ 35 Yen, Baht ≑ 5 Yen

Source: Report on Water Resources Policy and Management for the Beijin-Tianjin Region of China

Table 8: Industrial Water Use in Various Industrial Sectors in Tianjin (1984)

Item / Sector	Number of Entp.	Make-Up Water (10^6 m³/y) River Water	Tap Water	Ground Water	Make-Up (Raw) Water (S/Ttl)	Water Re-Used (10^6 m³/Y)	Water Used (10^6 m³/Y)	Rate of Water Re-Use (%)	Industrial Output (10^9 ฿/Y)	Water Used per Output (m³/10^4 ฿)	Raw Water per Output (m³/10^4 ฿)
Total	4,289	63.0	116.0	243.0	422.0	1,120.0	1,540.0	72.7	175.700	87.6	24.0
Metallurgy	61	2.8	7.4	17.1	27.3	123.7	151.0	81.9	14.728	102.5	18.5
Power	4	5.8	0.2	2.6	8.6	397.2	405.8	97.9	3.542	1,145.7	24.3
Petroleum	12	1.5	0.1	58.0	59.6	68.7	128.2	53.5	7.343	174.6	81.2
Chemical	413	18.4	20.2	80.6	119.1	267.9	387.1	69.2	26.579	145.6	44.8
Machinery	1,454	0.9	40.1	22.5	63.6	34.9	98.5	35.5	51.772	19.0	12.3
Building Material	270	0.6	2.7	5.1	8.5	2.8	11.2	24.6	3.248	34.5	26.2
Forestry	100	-	1.1	0.8	1.9	0.6	2.5	22.7	1.428	17.5	13.3
Food	270	8.8	8.8	14.4	32.0	11.2	43.1	25.9	12.803	33.7	25.0
Textile	319	2.4	17.4	29.2	49.1	182.2	231.3	78.8	33.159	69.8	14.8
Garment	458	-	1.0	0.05	1.0	0.02	1.1	1.6	5.530	2.0	1.8
Leather	130	0	0.6	1.2	1.8	0.1	1.9	5.3	2.030	9.4	8.9
Pulp & Paper	36	21.5	6.7	7.5	35.6	25.0	60.7	41.3	2.506	242.2	142.1
Culture & Education	286	-	3.7	1.2	4.9	0.3	5.1	5.4	5.019	10.2	9.8
Others	476	0.2	5.5	2.9	8.6	5.7	14.3	39.9	6.356	22.5	13.5

Source: "Report on Water Resources Policy and Management for the Beijing, Tianjin Region of China"

Note: Currency Conversion: Yuan ≑ 35 Yen, Baht ≑ 5 Yen

Remarks: Entp. = Enterprise; S/Ttl = Sub Total

(3) Study of Domestic Water Usage

Although a study of the domestic water usage of the 59 factories investigated by us is already given in Fig.3.7, if we were to show it again it would be as shown in Fig.1. As shown in this diagram, if the W/P ratio based on the daily per worker consumption was plotted it will be seen that there is a wide difference between factories. Although the majority of the factories register ratios of 300 l/cap.day or less, some 20% of the investigated factories have ratios over that with some exceeding 500 l/cap.day. Let us look into this question of water usage ratios (unit ratio).

The results of a questionnaire sent out by the Japanese Water Works Association to various countries are shown in Table 9. According to this study, the ratio in Bangkok Metropolitan Area was 443 liters/cap.day, with the maximum daily usage being 526 liters/cap.day. However, in 1981 MWA's water supply was from surface water, with the Sam Sen and Thonburi plants in addition to Stage I, Phase 1 of the Bang Khen plant which had just started up, still using a large quantity of groundwater.

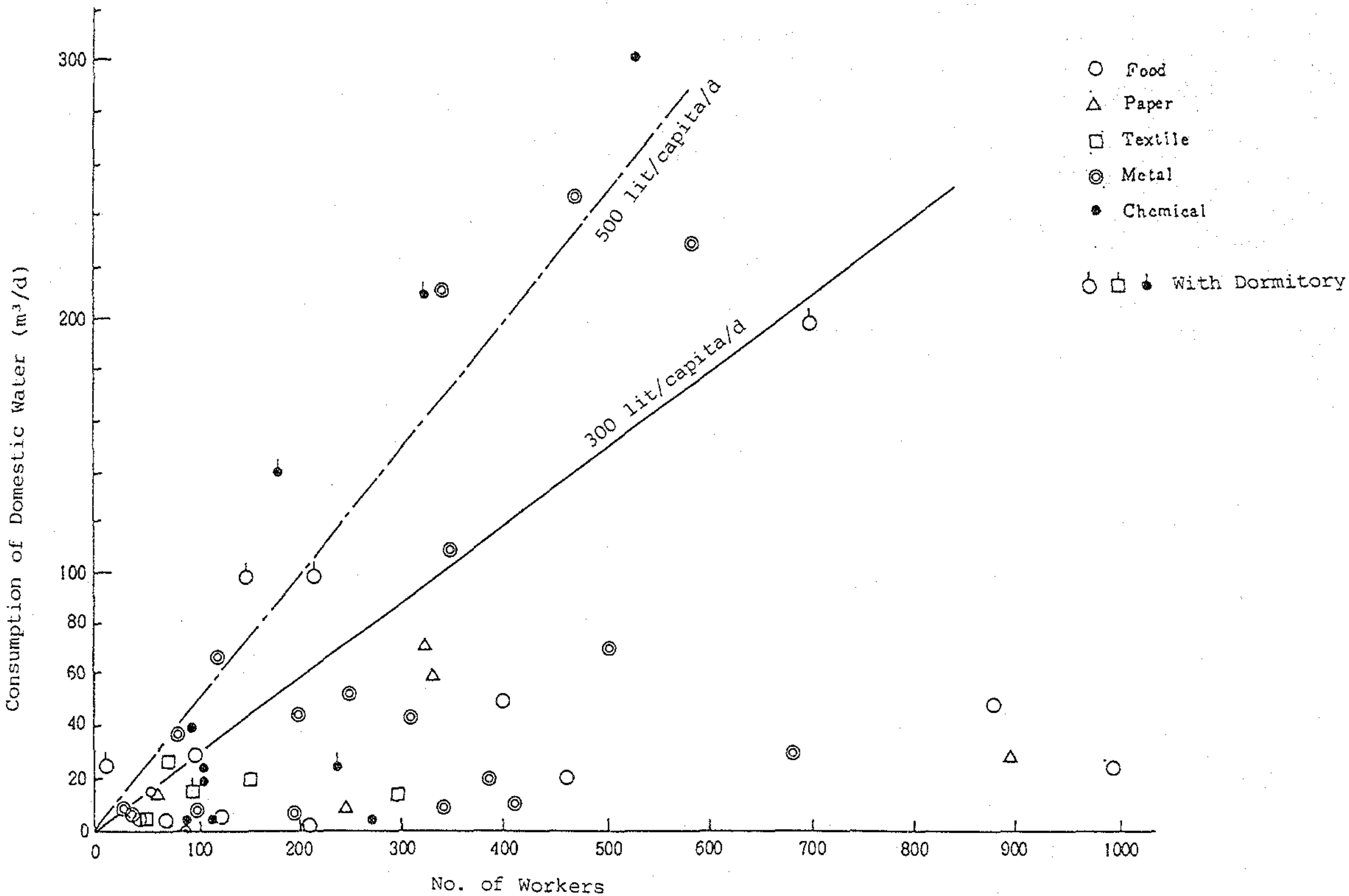

Fig. 1: Consumption of Domestic Water in Studied Factories

Table 9: Water Unit of Public Water Works in Major Cities of World

Country	City	Water Consumption (lit/capica/d)		Year
		Average	Maximum	
United Kingdom	Thames W.A.	257	-	1976
"	Sevan Trent W.A.	-	289	1981
Cyprus	Nicosia	117	158	1977
Framce	Lyon	311	400	1977
"	Paris	315	-	1976
Switzerland	Zurich	303	399	1981
"	Geneve	523	765	1980
Austria	Wien	301	406	1977
Netherlands	Amsterdam	205	269	1978
Federal Republic of Germany	Dusseldorf	321	480	1977
"	Frankfurt	262	324	1980
"	Hamburg	221	303	1980
Portugal	Lisbon	196	256	1979
Spain	Barcelona	246	294	1980
Italy	Tolino	376	420	1980
Denmark	Copenhagen	265	360	1980
Finland	Helsinki	401	504	1981
Norway	Oslo	655	818	1977
Repblic of South Africa	Johannesburg	365	462	1981
Tunisia	Tunis	82	-	1977
Australia	Melbourne	490	1,161	1980
Thailand	Bangkok	443	526	1981
Singapore	Singapore	302	-	1981
Hong Kong	Hongkong	278	-	1981
U.S.A.	Los Angeles	693	1,166	1980
"	San Fransisco	1,491	2,718	1979
"	Denver	956	2,025	1980
"	Boston	1,036	1,560	1978
"	Chicago	888	1,602	1980
"	Honolulu	697	929	1980
Canada	Montreal	925	1,105	1981
Venezuela	Caracas	476	494	1978
Japan	Tokyo	447	556	1981
"	Osaka	566	753	1981

Note: 1) Water consumption is water supply base.
2) Figures are from answers to questionnaire issued by Japan Water Works Association in 1982.

Although we do not know what MWA's tariff system was in those days, if assuming it is unchanged at present, a water usage of 500 liters/cap.day, as mentioned later on, means that the proportion of consumption expenses taken up by water fees of a family is very large to the extent that it is probably too much for an individual to bear. Also, when one remembers that the majority of the drinking water currently comes from bottled mineral water, the figures for Bangkok Metropolitan Area in Table 9 are conjectured to be examples of the use of groundwater by the private sector.

On the other hand, if these figures represent MWA's water supply, for which a leakage rate of 40% must be considered, then the actual per capita water usage averages

$$443 \times (1-0.4) = 226 \text{ liters/cap.day}$$

and it is a maximum of

$$526 \times (1-0.4) = 316 \text{ liters/cap.day}$$

or roughly 300 liters/cap.day. Nevertheless, the fees for such a rate of water usage would still be too much for a family to bear.

In the case of Japan, although Tokyo and Osaka figures are shown in Table 9, on a country-wide basis and, moreover, on an accounted usage base, the water used by the actual consumers is as shown in Table 10.

Table 10: Average Water Unit per Capita per Day from Public Water Works in Japan (Accounted Usage Base)

(Unit: lit/capita/d)

Population to be Served (10^4 Person) \ Year	1975	1980	1982	1983	1984	1985
over 100	355	345	349	353	356	354
50 - less 100	314	325	344	348	349	347
25 - less 50	311	309	318	327	332	332
10 - less 25	292	289	296	306	317	318
5 - less 10	289	288	297	309	316	316
3 - less 5	264	278	284	294	301	302
2 - less 3	248	254	263	273	283	282
1 - less 2	231	244	254	266	275	280
0.5 - less 1	212	235	247	255	266	266

Source: Public Water Works Census, Ministry of Health and Welfare

Although care must be taken in comparing the figures for Japan and Bangkok Metropolitan Area as they are, because of differnces in climatic conditions (for instance, there are factors which point to Bangkok's use of water for laundering and bathing being bigger than Japan's), Bangkok's unit water usage ratio, from even the point of view of the water rates, should decline in keeping with the extension of the water service system.

In Thailand's Easter Seaboard Development Program, the water demand as of the year 2001, when the population is estimated to be 1,384,000, is said to be 91.5 x 10^6 m^3/year which works out to daily per capita usage of 181 l/cap.day, a more or less appropriate figure. However, in fact, as it is believed that well water will be used for bathing and for laundering instead of water from the waterworks system which is chargeable, the actual ratio of water usage will probably be a larger figure.

Therefore, besides the industrial water of the factories studied in the Samut Prakarn Province, there is this kind of domestic water included, so for those factories with unit water usage ratios exceeding 500 l/cap.day especially, we will have to look for for future follow-up surveys.

The probable causes and countermeasures for the anticipated unit water usage ratios, are as follows :

a. Although it will be difficult to prevail a water-saving consciousness in inhabitants which has been brought up in an environment blessed with plenty of water resources, especially in the workers and families, leadership must be strengthened for the sake of preventing land subsidence of the whole area.

b. Is it possible that, as a labor relations measure, the factories are supplying groundwater for improving private use at no charge ? If so, it will be difficult to raise the level of water-saving consciousness of the people.

c. The amount of water supply of the factories is base on only flow meters attached to wells, and figures estimated from the pipe diameters, etc.. Therefore, it is difficult to grasp the loss of water due to leakage, etc. in the factories and, from the standpoint of water balance, it is possible that the reason for such large figures is because water for domestic use has been saddled with these loss quantities.

d. Water supplied other than to dormitories must be clarified. Also the quantities used for sprinkling, industrial water in the adjacent areas, etc. must be grasped.

(4) Service Water Rates

Although waterworks rates are dwelt on in 2.8 of Chapter 2, we would like to mention a little more about domestic service water rates and industrial water costs.

Table 11 shows what proportion of the consumption expenses of a Japanese family is taken up by water fees. It can be seen that the cost of water is about 1% of the total consumption expenses. In order to make similar calculations for Thailand, we searched for data which resulted in Tables 12 and 13. However, as these data are somewhat old some analogical inference had to be added to make the study.

Table 11: Water Service Charge in Monthly Average Expenditure of Family in Japan

Item \ Year	1975	1979	1980	1981	1982	1983	1984
Total Expenditure (฿)	32,095	43,816	46,989	48,901	51,532	52,775	54,196
Water Service Charge (฿)	150	307	330	378	448	475	539
Percentage (%)	0.5	0.7	0.7	0.8	0.9	0.9	1.0

Source: Annual Survey Report of Household Expenditure,
Statisc Bureau of Prime Minister's Office
(Family living in a city with population more than 50,000)

Currency Conversion: 5 Yen = 1 Baht

Table 12: Details of Monthly Household Income in Thailand

(Unit: Ƀ/Family)

Region	Nationwide			Metropolitan			North-East			East			Central			South		
Item \ Year	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76
Total Income	685	1,183	1,928	1,557	2,063	3,442	493	790	1,496	499	854	1,536	811	1,302	2,251	785	908	1,828
Cash Income	553	997	1,426	1,519	1,965	3,012	316	528	902	372	695	1,066	702	1,137	1,753	661	775	1,384
Salary	174	376	545	785	994	1,608	92	166	287	95	231	345	172	298	548	193	250	531
Add. Income	338	560	762	564	857	1,169	157	327	532	252	434	624	474	781	1,074	444	480	736
Misc. Income	41	61	119	170	114	235	67	35	83	25	30	97	56	58	131	24	45	117
Income other than Cash	132	186	502	38	98	430	177	262	594	127	159	470	109	165	498	124	133	444
Person per Family	5.5	5.7	5.5	5.5	6.2	5.6	5.9	6.0	5.9	5.3	5.6	5.0	5.6	5.6	5.2	5.3	5.3	5.2

Source: Report, Household Expenditures Survey 1962/63
Report, Socio-Economics Survey 1968/69 and 1975/76
through National Statistical Office

Remarks: Add. = Additional; Misc. = Miscellaneous

Table 13: Details of Monthly Household Expenditure in Thailand

(Unit: ฿/Family)

Region	Nationwide			Metropolitan			North-East			East			Central			South		
Item / Year	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76	1962/63	1968/69	1975/76
Total	723	916	2,004	1,476	1,664	3,323	549	540	1,612	551	688	1,592	834	998	2,375	835	765	1,913
Food	308	441	923	658	855	1,345	241	254	813	223	330	773	347	498	1,032	356	373	901
Fancy Good	30	49	96	66	88	128	25	30	60	25	42	68	31	53	75	32	39	74
Clothes	108	96	203	131	128	249	89	69	188	92	94	158	132	98	261	118	85	190
House	109	96	338	251	185	741	71	62	238	94	58	263	117	87	378	144	69	278
Medical	48	61	128	98	88	209	29	42	94	34	46	109	66	70	165	56	58	117
Transportation	29	56	151	95	118	296	19	25	100	20	40	101	31	60	179	34	43	190
Society, Culture & Education	27	43	79	79	99	182	22	17	50	18	25	58	27	40	85	26	28	80
Miscellaneous	64	74	107	98	103	173	53	41	69	45	53	62	83	92	200	69	70	83
Person per Family	5.5	5.7	5.5	5.5	6.2	5.6	5.9	6.0	5.9	5.3	5.6	5.0	5.6	5.6	5.2	5.3	5.3	5.2

Source: Report, Household Expenditures Survey 1962/63
Report, Socio-Economics Survey 1968/69 and 1975/76
through National Statistical Office

we used Table 13 to compare with Table 11 and we took the figures for the Bangkok Metropolitan Area as reference. We then assumed by analogical inference that the total outlay of 3,323 B/month for 1975/76 would have now doubled to 6,646 B/month. If the quantity of water used per person per day was 200 liters the amount consumed in one month by a family of 5.6 persons would be

200 liters/cap.day x 5.6 x 30days = 33.6 m^3/month.

Based on this amount, if we look up MWA's water tariffs in Table 2.26 we see that the rate is 4.30 B/m^3. Therefore, the monthly charge would be

4.30 B/m^3 x 33.6 m^3/month = 144.48 B/month.

If we see what proportion this is of the family's monthly consumption expenses we get

144.48/3,646 x 100 = 2.2%,

that is, a much bigger share than in Japan.

While these calculations are based on assumptions so there is probably some fluctuation in such proportions, if the share to be borne by a family is great, it will naturally cause that family to reduce the amount of water that it uses. If the per capita consumption reduced from 200 liters to half or 100 liters, the proportion taken up of the overall consumption expenses would come to about 1%.

To see what effect water tariffs have on a family's consumption expenses is extremely important as it is a matter which is deeply connected with the future development of water resources and especially with ground water pumping control measures.

As mentioned in (3) above, among the factories studied there were some which consumed 300 to 500 liters/cap.day of domestic water. This is because in areas which are outside the range of MWA's water supply ground water obtainable at comparatively low cost is used which is probably the reason for the low level of cost-consciousness prevailing. If this was so, then ground water requires the fostering of cost-consciousness.

According to Table 9, Bangkok's maximum unit water usage ratio is 526 liters/cap.day and the average ratio is 449 liters/cap.day. However if these were MWA's actual water supply figures, they are too high. If we took 500 liters/cap.day and calculated the share of consumption expenses as before, the expenses for water usage would come to 7.8% of the total, a figure which is far too much for a family to bear.

3.3 Quantity of Consumed Water

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
F-01	170	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	24	-	24	-	24	
		Material	-	2	-	2	-	2	
		Washing	635	-	231	866	-	866	
		Cooling	-	-	54	54	540	594	
		Air Cond.	-	-	-	-	-	-	
		Others	235	4	15	254	-	254	
		Total	870	30	300	1,200	540	1,740	31.0
F-02	103	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	65	-	-	65	-	65	
		Material	-	-	-	-	-	-	
		Washing	470	-	-	470	-	470	
		Cooling	180	-	-	180	4,000	4,180	
		Air Cond.	-	-	-	-	-	-	
		Others	350	-	-	350	-	350	
		Total	1,065	-	-	1,065	4,000	5,065	78.9
F-03	135	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	24	-	-	24	-	24	
		Material	5	-	-	5	-	5	
		Washing	78	-	-	78	-	78	
		Cooling	36	-	-	36	672	708	
		Air Cond.	-	-	-	-	-	-	
		Others	35	-	-	35	-	35	
		Total	178	-	-	178	672	850	79.1
F-04	130	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	5	-	-	5	-	5	
		Washing	93	-	-	93	-	93	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	2	-	-	2	-	2	
		Total	100	-	-	100	-	100	0.0

3.3 Quantity of Consumed Water (Continued, 2/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
F-05	127	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	38	-	-	38	-	38	
		Material	20	-	-	20	-	20	
		Washing	492	-	-	492	-	492	
		Cooling	44	-	40	84	4,797	4,881	
		Air Cond.	-	-	-	-	-	-	
		Others	20	-	-	20	-	20	
		Total	614	-	40	654	4,797	5,451	88.9
F-06	114	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	100	-	-	100	-	100	
		Material	52	-	-	52	-	52	
		Washing	206	-	-	206	40	246	
		Cooling	589	-	-	589	4,480	5,069	
		Air Cond.	-	-	-	-	-	-	
		Others	71	-	-	71	-	71	
		Outside	80	-	-	80	-	80	
		Total	1,098	-	-	1,098	4,520	5,618	81.6
F-07	110	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	100	-	-	100	-	100	
		Cooling	53	-	-	53	5,760	5,813	
		Air Cond.	-	-	-	-	-	-	
		Others	10	-	-	10	-	10	
		Total	163	-	-	163	5,760	5,923	97.2
F-08	109	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	1	-	-	1	-	1	
		Material	9	-	-	9	-	9	
		Washing	420	-	-	420	-	420	
		Cooling	179	-	-	179	14,160	14,339	
		Air Cond.	-	-	-	-	-	-	
		Others	56	-	-	56	-	56	
		Total	665	-	-	665	14,160	14,825	95.5

3.3 Quantity of Consumed Water (Continued, 3/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
F-09	91	Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	55	-	-	55	65	120	
		Material	-	-	-	-	-	-	
		Washing	20	-	-	20	-	20	
		Cooling	100	-	-	100	3,500	3,600	
		Air Cond.	-	-	-	-	-	-	
		Others	115	-	-	115	-	115	
		Outside	10	-	-	10	-	10	
		Total	300	-	-	300	3,565	3,865	92.5
F-10	78	Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	10	-	10	-	10	
		Material	-	-	-	-	-	-	
		Washing	-	30	-	30	-	30	
		Cooling	-	9	-	9	660	669	
		Air Cond.	-	-	-	-	-	-	
		Others	-	5	-	5	-	5	
		Total	-	54	-	54	660	714	92.4
F-11	65	Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	2	-	-	2	4	6	
		Material	6	-	-	6	-	6	
		Washing	5	-	-	5	-	5	
		Cooling	19	-	-	19	-	19	
		Air Cond.	-	-	-	-	-	-	
		Others	5	-	-	5	-	5	
		Total	37	-	-	37	4	41	9.8
F-12	48	Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	123	-	-	123	8	131	
		Material	10	-	-	10	-	10	
		Washing	18	-	-	18	-	18	
		Cooling	15	-	-	15	15	30	
		Air Cond.	-	-	-	-	-	-	
		Others	157	-	-	157	-	157	
		Total	323	-	-	323	23	346	11.7

3.3 Quantity of Consumed Water (Continued, 4/18)

Code No.	Fact. No.	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
			Water Quantity Classified by Use and Source (m^3/d)						
F-13	43	Boiler	20	-	-	20	-	20	
		Material	-	-	-	-	-	-	
		Washing	940	-	-	940	-	940	
		Cooling	30	-	80	110	600	710	
		Air Cond.	-	-	-	-	-	-	
		Others	50	-	-	50	-	50	
		Total	1,040	-	80	1,120	600	1,720	34.9
F-14	21	Boiler	8	-	-	8	-	8	
		Material	4	-	-	4	-	4	
		Washing	31	-	-	31	-	31	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	25	-	-	25	-	25	
		Total	68	-	-	68	-	68	0.0
Food Total		Boiler	436	34	-	470	77	547	14.1
		Material	111	2	-	113	-	113	0.0
		Washing	3,508	30	231	3,769	40	3,809	1.1
		Cooling	1,245	9	174	1,428	39,184	40,612	96.5
		Air Cond.	-	-	-	-	-	-	0.0
		Others	1,131	9	15	1,155	-	1,155	0.0
		Outside	90	-	-	90	-	90	0.0
		Total	6,521	84	420	7,025	39,301	46,326	84.8

3.3 Quantity of Consumed Water (Continued, 5/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m³/d)							
P-01	145	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	180	-	-	180	-	180	
		Material	-	-	-	-	-	-	
		Washing	1,050	-	-	1,050	600	1,650	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	15	-	-	15	-	15	
		Total	1,245	-	-	1,245	600	1,845	32.5
P-02	124	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	70	-	-	70	-	70	
		Material	-	-	-	-	-	-	
		Washing	1,100	-	-	1,100	2,200	3,300	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	60	-	-	60	-	60	
		Total	1,230	-	-	1,230	2,200	3,430	64.1
P-03	107	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	115	-	-	115	77	192	
		Material	-	-	-	-	-	-	
		Washing	2,833	-	-	2,833	3,272	6,105	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	10	-	-	10	-	10	
		Total	2,958	-	-	2,958	3,349	6,307	53.1
P-04	84	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	330	-	-	330	300	630	
		Material	-	-	-	-	-	-	
		Washing	11,000	-	1,900	12,900	4,500	17,400	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	30	-	-	30	-	30	
		Total	11,360	-	1,900	13,260	4,800	18,060	26.6

3.3 Quantity of Consumed Water (Continued, 6/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
P-05	39	Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	26	-	-	26	-	26	
		Cooling	2	-	-	2	60	62	
		Air Cond.	-	-	-	-	-	-	
		Others	94	-	-	94	-	94	
		Outside	30	-	-	30	-	30	
		Total	152	-	-	152	60	212	33.0
Paper Total		Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	695	-	-	695	377	1,072	35.2
		Material	-	-	-	-	-	-	0.0
		Washing	16,009	-	1,900	17,909	10,572	28,481	37.1
		Cooling	2	-	-	2	60	62	96.8
		Air Cond.	-	-	-	-	-	-	0.0
		Others	209	-	-	209	-	209	0.0
		Outside	30	-	-	30	-	30	0.0
		Total	16,945	-	1,900	18,845	11,009	29,854	36.9

3.3 Quantity of Consumed Water (Continued, 7/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
T-01	146	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	720	-	-	720	-	720	
		Material	-	-	-	-	-	-	
		Washing	8,128	-	-	8,128	-	8,128	
		Cooling	-	-	-	-	-	-	
		Air Cond.	830	-	-	830	53,489	54,319	
		Others	706	-	-	706	-	706	
		Total	10,384	-	-	10,384	53,489	63,873	83.7
T-02	197	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	32	-	32	-	32	
		Material	-	-	-	-	-	-	
		Washing	99	6	-	105	-	105	
		Cooling	14	-	-	14	-	14	
		Air Cond.	-	-	-	-	-	-	
		Others	-	15	-	15	-	15	
		Total	113	53	-	166	-	166	0.0
T-03	203	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	50	-	-	50	40	90	
		Material	-	-	-	-	-	-	
		Washing	1,460	-	-	1,460	-	1,460	
		Cooling	150	-	-	150	-	150	
		Air Cond.	-	-	-	-	-	-	
		Others	205	-	-	205	-	205	
		Outside	20	-	-	20	-	20	
		Total	1,885	-	-	1,885	40	1,925	2.1
T-04	193	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	5	-	-	5	-	5	
		Material	-	-	-	-	-	-	
		Washing	15	-	-	15	-	15	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	5	1	-	6	-	6	
		Total	25	1	-	26	-	26	0.0

3.3 Quantity of Consumed Water (Continued, 8/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m³/d)							
T-05	200	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	This factory does not operate normally and is now						
		Material	being under test run only.						
		Washing	(155)						
		Cooling	assumed						
		Air Cond.							
		Others	(25)						
		Total	Plan180			180		Unknown	Unknown
T-06	198	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	62	-	-	62	-	62	
		Material	-	-	-	-	-	-	
		Washing	353	-	-	353	-	353	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	27	-	-	27	-	27	
		Total	442	-	-	442	-	442	0.0
T-07	189	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	21	-	-	21	-	21	
		Material	-	-	-	-	-	-	
		Washing	513	-	-	513	6	519	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	15	-	-	15	-	15	
		Total	549	-	-	549	6	555	1.1
Textile Total		Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	858	32	-	890	40	930	43.0
		Material	-	-	-	-	-	-	0.0
		Washing	10,723	6	-	10,729	6	10,735	0.1
		Cooling	164	-	-	164	-	164	0.0
		Air Cond.	830	-	-	830	53,489	54,319	98.5
		Others	983	16	-	999	-	999	0.0
		Outside	20	-	-	20	-	20	0.0
		Total	13,578	54	-	13,632	53,535	67,167	79.7

3.3 Quantity of Consumed Water (Continued, 9/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
M-01	61	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	245	-	-	245	-	245	
		Cooling	189	-	-	189	227	416	
		Air Cond.	-	-	-	-	-	-	
		Others	69	-	-	69	-	69	
		Total	503	-	-	503	227	730	31.1
M-02	96	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	51	-	-	51	50	101	
		Material	-	-	-	-	-	-	
		Washing	70	-	-	70	-	70	
		Cooling	290	-	-	290	320	610	
		Air Cond.	-	-	-	-	-	-	
		Others	30	-	-	30	-	30	
		Outside	750	-	-	750	-	750	
		Total	1,191	-	-	1,191	370	1,561	45.6
M-03	89	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	5	-	-	5	-	5	
		Material	-	-	-	-	-	-	
		Washing	18	-	-	18	1,417	1,435	
		Cooling	46	-	-	46	1,025	1,071	
		Air Cond.	-	-	-	-	-	-	
		Others	93	-	-	93	-	93	
		Total	162	-	-	162	2,442	2,604	93.8
M-04	206	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	-	-	-	-	-	-	
		Cooling	1	-	-	1	960	961	
		Air Cond.	-	-	-	-	-	-	
		Others	5	2	-	7	-	7	
		Total	6	2	-	8	960	968	99.2

3.3 Quantity of Consumed Water (Continued, 10/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
M-05	73	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	38	-	-	38	-	38	
		Material	-	-	-	-	-	-	
		Washing	314	-	-	314	-	314	
		Cooling	76	-	-	76	812	888	
		Air Cond.	-	-	-	-	-	-	
		Others	110	-	-	110	-	110	
		Outside	82	-	-	82	-	82	
		Total	620	-	-	620	812	1,432	56.7
M-06	53	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	5	-	-	5	-	5	
		Material	-	-	-	-	-	-	
		Washing	25	-	-	25	-	25	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	20	-	-	20	-	20	
		Outside	20	-	-	20	-	20	
		Total	70	-	-	70	-	70	0.0
M-07	34	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	-	-	-	-	-	-	
		Cooling	20	-	-	20	95	115	
		Air Cond.	-	-	-	-	-	-	
		Others	38	-	-	38	-	38	
		Total	58	-	-	58	95	153	62.1
M-08	42	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	29	-	-	29	-	29	
		Cooling	5	-	-	5	10	15	
		Air Cond.	-	-	-	-	-	-	
		Others	6	-	-	6	-	6	
		Total	40	-	-	40	10	50	20.0

3.3 Quantity of Consumed Water (Continued, 11/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
M-09	69	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	94.3
		Material	-	-	-	-	-	-	
		Washing	122	-	-	122	2,251	2,373	
		Cooling	329	-	-	329	6,119	6,448	
		Air Cond.	-	-	-	-	-	-	
		Others	-	45	-	45	-	45	
		Total	451	45	-	496	8,370	8,866	94.4
M-10	207	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	-	-	-	-	-	-	
		Cooling	2	-	-	2	128	130	
		Air Cond.	-	-	-	-	-	-	
		Others	15	-	-	15	-	15	
		Total	17	-	-	17	128	145	88.3
M-11	116	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	5	-	-	5	-	5	
		Material	-	-	-	-	-	-	
		Washing	130	-	-	130	10	140	
		Cooling	67	-	-	67	128	195	
		Air Cond.	-	-	-	-	-	-	
		Others	10	-	-	10	-	10	
		Total	212	-	-	212	138	350	39.4
M-12	97	Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler							
		Material	assumed						
		Washing	(49)						
		Cooling	(48) 97			97	2,175	2,272	
		Air Cond.							
		Others	10			10	-	10	
		Total	107			107	2,175	2,282	95.3

3.3 Quantity of Consumed Water (Continued, 12/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
M-13	208	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	-	-	-	-	-	-	
		Cooling	18	-	-	18	144	162	
		Air Cond.	-	-	-	-	-	-	
		Others	2	-	-	2	-	2	
		Total	20	-	-	20	144	164	87.8
M-14	115	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	205	-	-	205	350	555	
		Cooling	2	-	-	2	750	752	
		Air Cond.	-	-	-	-	-	-	
		Others	62	-	-	62	-	62	
		Total	269	-	-	269	1,100	1,369	80.3
M-15	101	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	75	-	-	75	-	75	
		Material	-	-	-	-	-	-	
		Washing	1,768	-	-	1,768	-	1,768	
		Cooling	844	-	-	844	4,800	5,644	
		Air Cond.	-	-	-	-	-	-	
		Others	475	-	-	475	-	475	
		Total	3,162	-	-	3,162	4,800	7,962	60.3
M-16	100	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	440	-	-	440	-	440	
		Cooling	21	-	-	21	1,072	1,093	
		Air Cond.	-	-	-	-	-	-	
		Others	68	-	-	68	-	68	
		Total	529	-	-	529	1,072	1,601	67.0

3.3 Quantity of Consumed Water (Continued, 13/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
M-17	56	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	4	-	-	4	-	4	
		Material	-	-	-	-	-	-	
		Washing	37	-	-	37	-	37	
		Cooling	88	-	-	88	1,256	1,344	
		Air Cond.	-	-	-	-	-	-	
		Others	11	-	-	11	-	11	
		Total	140	-	-	140	1,256	1,396	90.0
M-18	64	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	1	-	-	1	-	1	
		Material	-	-	-	-	-	-	
		Washing	301	-	-	301	-	301	
		Cooling	15	-	-	15	1,420	1,435	
		Air Cond.	2	-	-	2	40	42	
		Others	298	-	-	298	-	298	
		Total	617	-	-	617	1,460	2,077	70.3
M-19	57	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	8	-	-	8	-	8	
		Material	-	-	-	-	-	-	
		Washing	40	-	-	40	-	40	
		Cooling	90	-	-	90	600	690	
		Air Cond.	-	-	-	-	-	-	
		Others	212	-	-	212	-	212	
		Total	350	-	-	350	600	950	63.2
M-20	49	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	10	-	-	10	-	10	
		Cooling	5	-	-	5	404	409	
		Air Cond.	-	-	-	-	-	-	
		Others	8	-	-	8	-	8	
		Total	23	-	-	23	404	427	94.6

3.3 Quantity of Consumed Water (Continued, 14/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
Metal Total		Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	192	-	-	192	50	242	20.7
		Material	-	-	-	-	-	-	0.0
		Washing	3,803	-	-	3,803	4,028	7,831	51.4
		Cooling	2,156	-	-	2,156	22,445	24,601	91.2
		Air Cond.	2	-	-	2	40	42	95.2
		Others	1,542	47	-	1,589	-	1,589	0.0
		Outside	852	-	-	852	-	852	0.0
		Total	8,547	47	-	8,594	26,563	35,157	75.5

3.3 Quantity of Consumed Water (Continued, 15/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m^3/d)							
C-01	155	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	5	-	-	5	-	5	
		Material	-	-	-	-	-	-	
		Washing	20	-	-	20	-	20	
		Cooling	1	-	-	1	280	281	
		Air Cond.	-	-	-	-	-	-	
		Others	49	-	-	49	-	49	
		Total	75	-	-	75	280	355	78.9
C-02	168	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	19	-	-	19	-	19	
		Material	10	-	-	10	-	10	
		Washing	80	-	-	80	500	580	
		Cooling	50	-	-	50	5,200	5,250	
		Air Cond.	-	-	-	-	-	-	
		Others	151	-	-	151	-	151	
		Outside	20	-	-	20	-	20	
		Total	330	-	-	330	5,700	6,030	94.8
C-03	209	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	1	-	-	1	-	1	
		Material	-	-	-	-	-	-	
		Washing	29	-	-	29	-	29	
		Cooling	2	-	-	2	54	56	
		Air Cond.	-	-	-	-	-	-	
		Others	4	-	-	4	-	4	
		Total	36	-	-	36	54	90	60.0
C-04	210	Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	-	-	5	5	-	5	
		Material	-	-	-	-	-	-	
		Washing	-	10	5	15	-	15	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	-	20	-	20	-	20	
		Total	-	30	10	40	-	40	0.0

3.3 Quantity of Consumed Water (Continued, 16/18)

Code No.	Fact. No.	Water Quantity Classified by Use and Source (m³/d)							
C-05	149	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	25	-	-	25	-	25	
		Material	400	-	-	400	-	400	
		Washing	285	-	-	285	-	285	
		Cooling	300	-	-	300	14,400	14,700	
		Air Cond.	-	-	-	-	-	-	
		Others	350	-	-	350	-	350	
		Outside	200	-	-	200	-	200	
		Total	1,560	-	-	1,560	14,400	15,960	90.2
C-06	147	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	2	-	-	2	-	2	
		Cooling	-	-	-	-	-	-	
		Air Cond.	-	-	-	-	-	-	
		Others	16	-	-	16	-	16	
		Outside	9	-	-	9	-	9	
		Total	27	-	-	27	-	27	0.0
C-07	106	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recovery Rate (%)
		Boiler	65	-	-	65	15	80	
		Material	-	-	-	-	-	-	
		Washing	10	-	-	10	-	10	
		Cooling	3	-	55	58	25	83	
		Air Cond.	-	-	-	-	-	-	
		Others	5	-	-	5	-	5	
		Total	83	-	55	138	40	178	22.5
C-08	94	Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total	Recory Rate (%)
		Boiler	102	-	-	102	20	122	
		Material	4	-	-	4	-	4	
		Washing	88	-	-	88	-	88	
		Cooling	200	-	-	200	3,750	3,950	
		Air Cond.	-	-	-	-	-	-	
		Others	328	-	-	328	-	328	
		Outside	30	-	-	30	-	30	
		Total	752	-	-	752	3,770	4,522	83.9

3.3 Quantity of Consumed Water (Continued, 17/18)

Water Quantity Classified by Use and Source (m^3/d)

Code No.	Fact. No.	Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
C-09	82	Boiler	-	-	-	-	-	-	
		Material	-	-	-	-	-	-	
		Washing	184	-	-	184	-	184	
		Cooling	30	-	-	30	790	820	
		Air Cond.	-	-	-	-	-	-	
		Others	4	-	-	4	-	4	
		Outside	8	-	-	8	-	8	
		Total	226	-	-	226	790	1,010	78.2
C-10	51	Boiler	26	-	-	26	-	26	
		Material	10	-	-	10	-	10	
		Washing	135	-	-	135	-	135	
		Cooling	60	-	-	60	2,000	2,060	
		Air Cond.	-	-	-	-	-	-	
		Others	69	-	-	69	-	69	
		Total	300	-	-	300	2,000	2,300	87.0
C-11	25	Boiler	100	-	-	100	-	100	
		Material	30	-	-	30	-	30	
		Washing	190	-	-	190	-	190	
		Cooling	450	-	-	450	14,400	14,850	
		Air Cond.	-	-	-	-	-	-	
		Others	50	-	-	50	-	50	
		Outside	200	-	-	200	-	200	
		Total	1,020	-	-	1,020	14,400	15,420	93.4
C-12	7	Boiler	-	-	-	-	67	67	9
		Material	-	-	-	-	-	-	
		Washing	130	-	-	130	-	130	
		Cooling	43	-	-	43	2,160	2,203	
		Air Cond.	-	-	-	-	-	-	
		Others	77	-	-	77	-	77	
		Total	250	-	-	250	2,227	2,477	89.9

3.3 Quantity of Consumed Water (Continued, 18/18)

Code No.	Fact. No.	Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
C-13	29	Boiler	1	-	-	1	2	3	6
		Material	-	-	-	-	-	-	
		Washing	34	-	-	34	-	34	
		Cooling	2	-	-	2	30	32	
		Air Cond.	-	-	-	-	-	-	
		Others	8	-	-	8	-	8	
		Total	45	-	-	45	32	77	41.6
Chemical Total		Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	344	-	5	349	104	453	23.0
		Material	454	-	-	454	-	454	0.0
		Washing	1,187	10	5	1,202	500	1,702	29.3
		Cooling	1,141	-	55	1,196	43,089	44,285	97.3
		Air Cond.	-	-	-	-	-	-	0.0
		Others	1,111	20	-	1,131	-	1,131	0.0
		Outside	467	-	-	467	-	467	0.0
		Total	4,704	30	65	4,799	43,693	48,492	90.1
Gross Total		Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total	Recovery Rate (%)
		Boiler	2,525	66	5	2,596	648	3,244	20.0
		Material	565	2	-	567	-	567	0.0
		Washing	35,230	46	2,136	37,412	15,146	52,558	28.7
		Cooling	4,709	9	229	4,947	104,778	109,725	95.5
		Air Cond.	832	-	-	832	53,529	54,361	98.5
		Others	4,975	92	15	5,082	-	5,082	0.0
		Outside	1,459	-	-	1,459	-	1,459	0.0
		Total	50,295	215	2,385	52,895	174,101	226,996	76.7

Water Quantity Classified by Use and Source (m^3/d)

3.4 Example of Well Water Quality in Japan

Items		Range	Average
Turbidity	(°)	0 - 35.0	4.4
pH		6.0 - 8.7	7.2
Total Hardness	(mg/lit)	1.0 - 250.0	62.4
Chloride Ion	(mg/lit)	1.5 - 1,000.0	38.2
Total Iron	(mg/lit)	0 - 5.0	0.59
Evaporation Residue	(mg/lit)	21.0 - 432.0	154.7

3.5 Waste Water Treatment

Note: Influent / Effluent

Code No.	Fact. No.	Main Treatment Process	SS (mg/l)	BOD (mg/l)	COD (mg/l)	pH	Oil (mg/l)	Heavy Metals (mg/l)	Flow out to	
									River	Sea
F-01	170	Coagulation/-Sedimentation & Trickling Filter	-	-	-	-	-	-	o	
			*1-3	-	-	11.9	-	-		
F-02	103	Activated Sludge	71-184	2,000	1,587-4,448	5.4-7.5	-	-	o	
			13-19	20	87-114	7.8	-	-		
F-03	135	Sedimentation, Oil Separater & Oxidation Ditch	100	550	1,200	8	-	-	o	
			20	20	60	8				
F-04	130	Activated Sludge	-	-	-	-	-	-		o
			-	-	-	-	-	-		
F-05	127	Anaerobic Digestion & Activated Sludge	507	1,821	2,740	6.6	214	-	o	
			*18	27	219	7.1	<5	-		
F-06	114	Activated Sludge	*190	*559	310	*7.70	-	-	o	
			*2	*12	<3	*8.20				
F-07	110	Activated Sludge & Activated Carbon	-	-	-	-	-	-	o	
			*8	-	-	*7.46	-	-		
F-08	109	Activated Sludge	-	-	-	-	-	-	o	
			*7	30	-	*6.95	-	-		
F-09	91	Oxidation Ditch (Biological Treatment)	1,140	4,180	2,011	5.9	7,303	-	o	
			10	280	103	7.5	6.7	-		
F-10	78	Activated Sludge	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
F-11	65	Septic Tank	-	-	-	-	-	-	o	
			-	-	-	-	-	-		

Note: Figure starting from * was measured by the Study Team.

Table 3.5: Waste Water Treatment (Continued, 2/6)

Note: Influent / Effluent

Code No.	Fact. No.	Main Treatment Process	SS (mg/l)	BOD (mg/l)	COD (mg/l)	pH	Oil (mg/l)	Heavy Metals (mg/l)	Flow out to River	Flow out to Sea
F-12	48	Septic Tank	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
F-13	43	Oil Separation & Activated Sludge	-	-	-	7-8	-	-	o	
			*68		*273	*7.1				
F-14	21	Sedimentation & Aeration	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
P-01	145	Not equipped	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
P-02	124	Sedimentation & Lagoon	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
P-03	107	Precipitation & Biological Treatment	2,653	589	-	*7.54	-	-	o	
			*83	50	-	*7.38	-	-		
P-04	84	Coagulation & Sedimentation	1,200-1,350	130-180	-	6.5-7.5	-	-	o	
			28	20-80	-	"	-	-		
P-05	39	Chemical Treatment	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
T-01	146	Activated Sludge	70	200	640	7.3	-	-		o
			14	10	80	7.6	-	-		
T-02	197	Sedimentation	-	-	-	-	-	-	o	
			*6	-	-	*7.7	-	-		
T-03	203	Aeration & Sedimentation	-	-	-	-	-	-	o	
			-	-	-	*7.61	-	-		

Note: Figure starting from * was measured by the Study Team.

Table 3.5: Waste Water Treatment (Continued, 3/6)

Note: Influent / Effluent

Code No.	Fact. No.	Main Treatment Process	SS (mg/l)	BOD (mg/l)	COD (mg/l)	pH	Oil (mg/l)	Heavy Metals (mg/l)	Flow out to River	Flow out to Sea
T-04	193	Coagulation & Sedimentation, Aeration & Sedimentation	- / -	- / -	- / -	- / -	- / -	- / -	o	
T-05	200	Surface Aeration (Biological Treatment)	220 / -	418 / -	- / -	8.5 / -	- / -	- / -	o	
T-06	198	Surface Aeration (Biological Treatment)	- / -	- / -	- / -	- / -	- / -	- / -	o	
T-07	189	Coagulation/- Sedimentation & Biological Treatment	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-01	61	Coagulation & Sedimentation	68 / *30	8 / 6	8 / 4	7.0 / *7.5	5 / 1	- / -	o	
M-02	96	Sedimentation & Filtration	- / 300-500	- / -	- / -	- / *7.7	- / -	- / -	o	
M-03	89	Sedimentation, Aeration & Activated Carbon	- / 4	- / -	- / -	- / 6.42	- / 3.6	- / -	o	
M-04	206	Not Equipped	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-05	73	Coagulatiuon & Sedimentation	*210 / *7	- / 0.2	- / -	*12.0 / *7.72	- / -	- / -	o	
M-06	53	Sedimentation Sand Filtration & Charcoal	- / -	- / -	- / -	- / -	- / -	- / -	o	

Note: Figure starting from * was measured by the Study Team.

Table 3.5: Waste Water Treatment (Continued, 4/6)

Note: Influent / Effluent

Code No.	Fact. No.	Main Treatment Process	SS (mg/l)	BOD (mg/l)	COD (mg/l)	pH	Oil (mg/l)	Heavy Metals (mg/l)	Flow out to River	Flow out to Sea
M-07	34	Not Equipped	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-08	42	Not Equipped	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-09	69	Sedimentation	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-10	207	Not Equipped	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-11	116	Coagulation & Sedimentation	139 / 20	- / -	- / -				o	
M-12	97	Chemical Reduction, Coagulation & Sedimentation	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-13	208	Pond	- / -	- / -	- / -	- / -	- / -	- / -	o	
M-14	115	Coagulation & Sedimentation	84 / 18	- / -	36 / 29	10.6 / 7.9	29 / 5	Cr0.52 / Cr0.40	o	
M-15	101	Chemical Reduction, Caugulation & Sedimentation	19 / 10.6	- / -	- / -	7.2 / 6.6	- / -	20 / 0	o	
M-16	100	Chemical Treatment	- / 5	- / 16.4	- / -	- / 5.97	- / -	- / 0	o	
M-17	56	Neutralization & Sedimentation	- / -	- / -	- / -	- / -	- / -	- / -	o	

Note: Figure starting from * was measured by the Study Team.

Table 3.5: Waste Water Treatment (Continued, 5/6)

Note: Influent / Effluent

Code No.	Fact. No.	Main Treatment Process	SS (mg/l)	BOD (mg/l)	COD (mg/l)	pH	Oil (mg/l)	Heavy Metals (mg/l)	Flow out to	
									River	Sea
M-18	64	Coagulaltion & Sedimentation	-	-	305	-	7.9	-	o	
			-	-	190	-	7.3	-		
M-19	57	Precipitation	136	-	6	7	7		o	
			25	-	3	7	4			
M-20	49	Precipitation & Sand Filtration	-	-	-	7	-	12	o	
			-	-	-	7	-	0.2		
C-01	155	Biodisc & Sedimentation	65	74	-	7.48	-		o	
			27	13	-	6.78	-			
C-02	168	Aerated Lagoon	25	720	147	7.2	-	-	o	
			8	15	34	7.5	-	-		
C-03	209	Coagulation & Sedimentation & Sand Filtration	-	-	-	5-6	-	-	o	
			-	-	-	7.2-7.8				
C-04	210	Pond	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
C-05	149	Sedimentation, Sand Filtration, Activated Carbon & Resin	-	-	-	-	-	-	o	
			*0	-	-	*6.89	-	-		
C-06	147	Activated Sludge, Sand Filtration & Carbon Filtration	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
C-07	106	Caugulation/-Sedimentation & Biological Treatment	-	-	-	-	-	-	o	
			-	15-20	-	6.5-7.5	-	-		

Note: Figure starting from * was measured by the Study Team.

Table 3.5: Waste Water Treatment (Continued, 6/6)

Note: Influent / Effluent

Code No.	Fact. No.	Main Treatment Process	SS (mg/l)	BOD (mg/l)	COD (mg/l)	pH	Oil (mg/l)	Heavy Metals (mg/l)	Flow out to	
									River	Sea
C-08	94	Activated Sludge	-	-	400-800	5-7	-	-	o	
			*6	-	10-40	7.5-8.0	-	-		
C-09	82	Coagulation & Sedimentation	-	600-1,100	500-1,000	6.5-7.5	5-10	-	o	
			-	15-45	20-40	6.5-7.5	3-5	-		
C-10	51	Coagulation/-Sedimentation & Aeration	-	-	-	-	-	-	o	
			*56	-	-	-	-	-		
C-11	25	Coagulation/-Sedimentation & Activated Sludge	300-500	1,000-1,500	2,000-3,000	7-8 9	- -	- -	o	
			29	9	88	9	-	-		
C-12	7	Aerated Lagoon	-	-	-	-	-	-	o	
			-	-	-	-	-	-		
C-13	29	Not Equipped	-	-	-	-	-	-	o	
			-	-	-	-	-	-		

Note: Figure starting from * was measured by the Study Team.

JICA