On-Site Wastewater Reclamation in Commercial Buildings and

□ *For as long as most people in the U.S. can remember, we have enjoyed an abundant supply of clean, safe, fresh tap water in this country, a situation which we have taken for granted. However, it is becoming apparent that we now face a water crisis. Plumbing engineers, who will be intimately involved in the efforts to meet that crisis, should find the following information helpful.*

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Despite the apparent abundance of annual average rainfall of 1,800 mm, Japan's freshwater availability on a per capita basis is approximately one-fifth of that of the United States and Sweden. There are many factors associated with the current and predicted water shortages in Japan. Seasonal and geographical variations in rainfall during the monsoon and typhoon seasons in the Pacific and Japan Sea Coasts have caused difficult water resources development and management problems in both flood and drought years.

In 1970, the domestic and industrial water demands were approximately 34 percent of the total water demand, reaching 48 percent in 1985. These figures reflect the increasing demand for household water uses, including flush toilets, washing machines, and hot-tub baths (rather than the traditional public bath houses), and for industrial water demands as reflected by the tremendous increase in the Gross National Product (GNP) in recent years. As a result, there have been serious water supply shortages in the major metropolitan centers of Japan: It is estimated that even the new local water resources developments will be unable to meet anticipated demands by the year 1990 in the three major population centers of Japan: Tokyo, Osaka, and Kita-Kushu.

To alleviate this potentially catastrophic condition, there have been several water conservation measures implemented in large metropolitan centers which included on-site wastewater reclamation and reuse. Focusing on the unique features of the on-site wastewater reclamation and reuse systems in commercial buildings and apartment complexes as practiced in Japan, the primary impetus arises when large volume water-demanding facilities are being planned. Then, potential building bans due to the limited capacities of water supply, sewer, and wastewater treatment facilities may be lifted if on-site water reclamation and recycling systems are adopted. The secondary impetus for including such systems come from the realization that the vul-

Table 1—Reclaimed Water Use and Recycling in Various Applications

Applications	Number of Installation	Percent	Toilet Flushing Water	Cooling Water	Ornamental Lake	Cleansing Water	Laboratory Water	Fire Hydrant
I. Individual On-Site Reuse and Recycling								
Office	29	55.8	29	5	3	3		1
Store	3	5.8	3	3	1			
School	6	11.6	6	1				1
Hospital	2	3.8	2					
Hotel	2	3.8	2					
Clubhouse	4	7.7	4		1			
Housing	1	1.9	1		1	1		
Sub-Total	47	90.4	47	9	6	4		2
II. Regional Reuse and Recycling								
Office	2	3.8	2	1				
Apartment	2	3.8	2		2	1		
Research Institute	1	2.0		1			1	
Sub-Total	5	9.6	4	2	2	1	1	
Total (I and II)	52	100.0	51	11	8	5	1	2

and Reuse Systems Apartment Complexes

nerability of the water supply systems under catastrophic incidences such as earthquakes may be reduced, and thereby the minimum environmental sanitation may be sustained in the metropolitan areas.

Since 1970, facilities planning for municipal wastewater reclamation and reuse and industrial water recycling has been initiated by local and national government agencies. In metropolitan Tokyo, for example, installations of dual water supply systems and on-site wastewater reclamation and reuse facilities in special planning districts have been promoted for toilet flushing water and for air-conditioning makeup water in large buildings and apartment complexes. Also, in Fukuoka City where water supply was restricted for more than 19 hours per day in 1978, due to the severe drought, water conservation programs must be submitted to the city if the water supply pipes to the buildings are greater than 50mm in diameter or if the floor space of the building is more than 5,000 m^2.

Because of these governmental directives, there has been a steady increase in the number of wastewater reclamation and reuse facilities installed or being planned. There were more than 100 projects as of 1980 in the water-short areas of Japan. To promote these projects, a financial assistance program for the installation of water reuse systems was established in 1979 by the national government to grant a low interest rate loan through the Japan Development Bank upon the recommendation of the prefectural governors.

Current Status of On-Site Wastewater Reclamation

Among several water supply alternatives, the on-site wastewater reclamation and reuse systems have been considered the most attractive and implementable due mainly to the following reasons:

- They may be able to provide a solution to the water supply and demand inbalances *in situ*, or on a regional basis where the concentration of population and industries has created water shortages.
- Implementation of on-site wastewater reclamation and reuse systems results in reduction of water intakes as well as reduction in pollutant loads in the receiving water.
- Although on-site wastewater reclamation and reuse systems are costly at present, they are nonetheless financially feasible on a long-term basis with the aid of government subsidies.
- In many instances advanced waste treatment is required for effluent discharges, and the technology associated with these systems has been well established. In these instances, the wastewater reclamation and reuse systems may be easily adopted.

In addition on-site wastewater reclamation and reuse systems become a necessity when the increased volume of wastewater cannot be adequately handled by the existing sewers due to the capacity limitations. Furthermore, the mass emission rate of pollutants must be reduced for the protection of the fishery resources and the other beneficial uses in receiving waters.

Classification of On-Site Wastewater Reclamation and Reuse Systems

Wastewater reclamation and re-

Table 2—Volume of Reclaimed Water in Various Applications

Applications	*Number of Installations*	*Flowrate, m^3/day* 0-10	11-50	51-100	101-500	501-1,000	1,001-5,000
I. Individual On-Site Reuse and Recycling							
Office	29	6	10	2	9	1	1
Store	3		1	1	1		
School	6	2	3		1		
Hospital	2			1			1
Hotel	2				2		
Clubhouse	4		1	1	2		
Housing	1		1				
Sub-Total	47	8	16	5	15	1	2
II. Regional Reuse and Recycling							
Office	2				2		
Apartment	2				2		
Research Institute	1			1			
Sub-Total	5			1	4		
Total (I and II)	52	8	16	6	19	1	2

Water Reuse

Continued from page 23

use systems may be classified according to size of the facility and area served. An individual system consists of reclamation of wastewater and reuse within buildings such as schools and commercial establishments. Since the recycling system is normally confined to one building, wastewater reclamation facilities and distribution systems may be smaller and may be designed on an individual basis. However, the required space must be provided for the treatment facilities within the building proper.

A regional reuse and recycling system is implemented on a collective basis such as in apartment complexes or in commercial and financial districts where wastewaters from these buildings are collectively reclaimed and re-supplied to the same buildings in the district. Since these buildings are located in relatively small confines, it is easier to define water use characteristics and wastewater quality.

The systems may be further expanded to the terminal wastewater treatment plant where municipal wastewater is treated and reclaimed by advanced waste treatment processes. There are several advantages for a large-scale operation in that the effect of water conservation could be considerable and the unit cost of reclaimed water would be less costly. However, due to the distances involved in the necessary distribution lines, the costs could be prohibitively high both in material and construction costs, particularly in well established and congested downtown areas. Thus, the large-scale wastewater reclamation and reuse systems may be implemented only in newly developed areas such as in a "new town" or in reclaimed lands near oceans.

Tables 1 and 2, pages 22, 23 summarize the current status of major reclaimed water use and recycling in various applications, and the volume of reclaimed water use. Almost all reclaimed water use is for toilet flushing water, with only a limited amount used for cooling water, ornamental lake, cleansing water, and fire hydrants. Because of the relative ease in implementation, 47 installations or 90.4 percent are individual on-site reuse and recycling systems, and reclaimed water use of 101 – 500m^3/day is the most common.

Water Quality Requirements and Treatment

There have been several water quality standards established for water supplies such as for drinking water, public bathing, and swimming pools, but there have not been any uniform standards for the on-site wastewater reclamation and reuse systems. However, based on experiences gained through the pilot and demonstration facilities, there are some common bases to be considered in formulating any such standards and criteria. These criteria should include: public health, aesthetics and public acceptance, maintenance (such as corrosion prevention) of piping and distribution systems, and reliable operation of treatment facilities.

Among the reuse and recycling systems reported in Table 2, influent biochemical oxygen demand (BOD_5) and suspended solids (SS) are reported to be in a range of 70-750 mg/l, and 60-600 mg/l, respectively. After treatment, reclaimed water quality is in a range of BOD_5 3-30 mg/l, chemical oxygen demand (COD) 5-40 mg/l, SS trace to 30 mg/l, normal-hexane extract 0-8 mg/l, and ABS 0-2 mg/l, respectively.

Several treatment processes and operations are used in accordance with wastewater characteristics and dependent on the intended reuse applications. Typically, wastewater will undergo treatment trains of screening, on-line flow equalization, biological oxidation, media filtration, and disinfection. Chemical coagulation-flocculation steps may be added before the filtration. In a case of physical-chemical treatment sequences, chemical coagulation-flocculation, membrane process, and activated carbon treatment are used. Figure 1 shows standard flow sheets for the treatment trains used in the on-site wastewater reuse systems. Table 3 shows a summary of treatment trains used in the on-site systems in commercial buildings and apartment complexes.

It is noted in Figure 1 that the activated sludge process and the direct media filtration of the effluent are the most common treatment trains for the on-site systems. Out of 17 installations using treatment train No. 1 (Table 3), four use ozonation and two use activated carbon treatment as an additional treatment step. Next to the treatment train No.

Table 3—Summary of Treatment Trains Used in the On-Site Wastewater Reclamation and Reuse Systems (For the treatment flow sheet, refer to Figure 1)

			Standard Flow Sheet				
Applications	*No. 1*	*No. 2*	*No. 3*	*No. 4*	*No. 5 & 6*	*No. 7 & 8*	*Others*
I. Individual On-Site Reuse and Recycling							
Office	12	4	4		6	1	2
Store	1		2				
School		1	3	1			1
Hospital	1		1				
Hotel				1		1	
Clubhouse	2	1					1
Housing							1
Sub-Total	16	6	10	2	6	2	5
II. Regional Reuse and Recycling							
Office	1		1				
Apartment		1		1			
Research Institute						1	
Sub-Total	1	1	1	1		1	
Total	17	7	11	3	6	3	5

1, 11 installations use treatment train No. 3 consisting of two step biological processes: normally activated sludge process plus attached growth biological systems such as submerged media biological contactor or rotating biological contactor. The effluent is filtered before being stored in a reclaimed water storage tank. Of 11 installations reported in Table 3 for the treatment train No. 3, three installations use ozonation and two use ion exchange as additional treatment steps.

Two case studies describe a detailed analysis of the on-site wastewater reclamation and reuse systems practiced in an apartment complex and commercial buildings.

On-Site Wastewater Reclamation, Reuse in an Apartment Complex

The S apartment complex is located approximately 30 Km east of the Tokyo metropolitan area, and consists of 2,250 apartments. An

Figure 1A—Standard Flow Sheets for On-Site Wastewater Reuse Systems

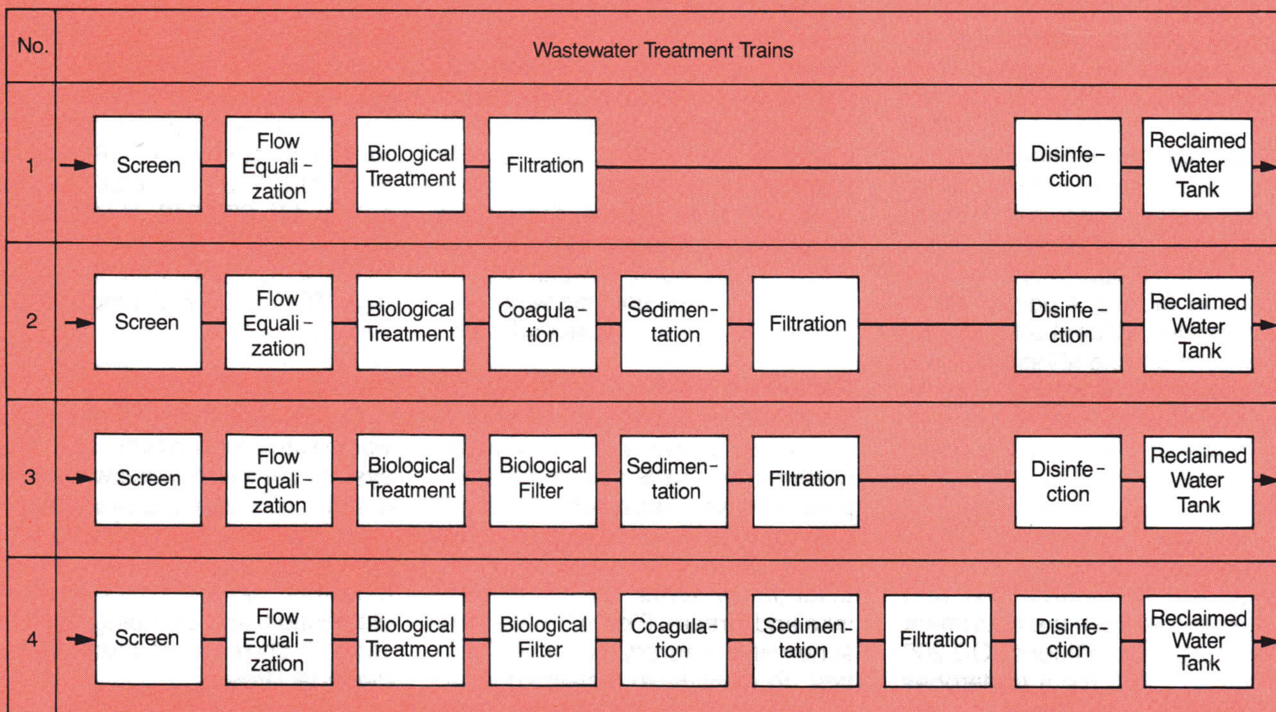
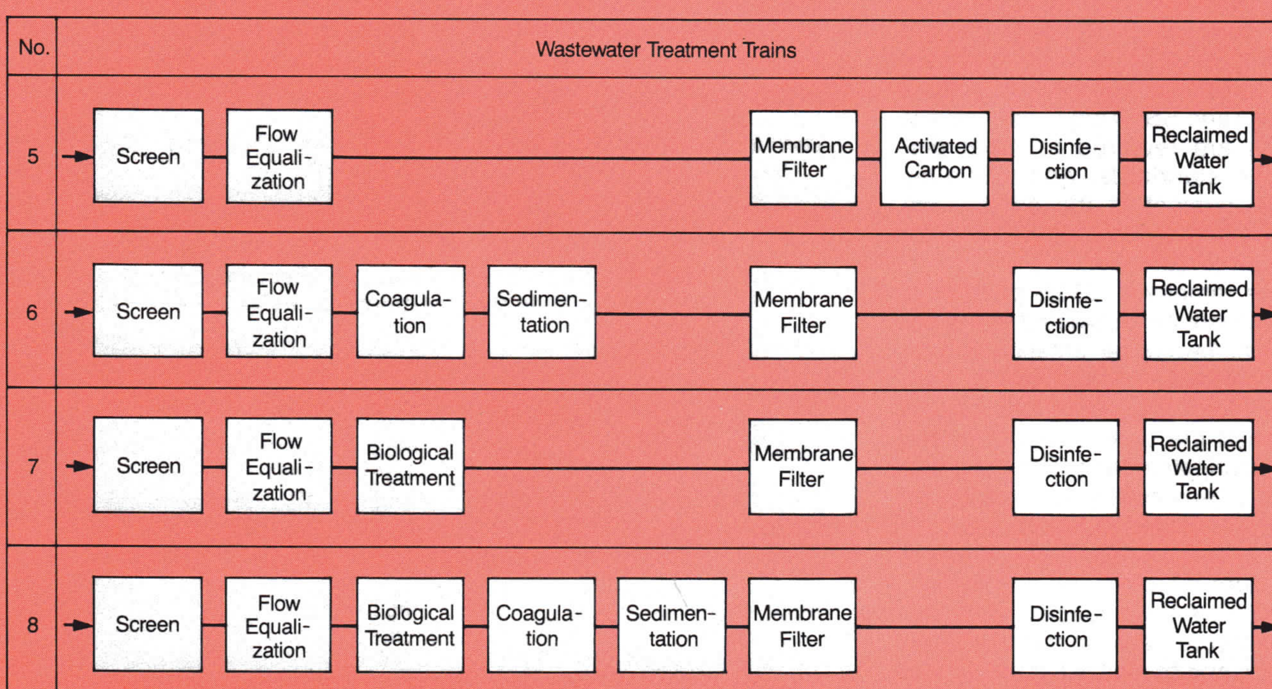


Figure 1B—Standard Flow Sheets for On-Site Wastewater Reuse Systems



on-site system was constructed in 1978 to supply reclaimed water to 888 rental units, totaling 3,220 residents, in eight to eleven story buildings in one section of the complex. The intended uses of reclaimed water were for toilet flushing, cleansing water for garbage collection areas, and an ornamental pond and stream. Based on the water use survey results shown in Table 4, reclaimed water uses for toilet flushing and cleansing purposes were estimated to be 50 l per capita per day. Thus a total flow rate of 160m³/day was used for facilities design.

The water quality criteria for reclaimed water are shown in Table 5. A summary of wastewater treatment facilities at the S apartment complex is shown in Table 6. A portion of the tertiary treated effluent after chemical coagulation and filtration serves as an influent to the on-site wastewater reclamation and reuse system. Figure 2 represents a schematic diagram of the wastewater reclamation and reuse system.

Treatment Facilities

As shown in Figures 2-A and 2-B, wastewater from the apartment complex (average effluent BOD 200 mg/l and SS 250 mg/l) undergoes the following treatment trains: screening, aerated grit chamber, comminutor, extended aeration activated sludge process, sedimentation, alum coagulation, sedimentation, dual media filtration. Effluent water qualities from these treatment processes are approximately BOD 10 mg/l and SS 10 mg/l, respectively, which are required to meet discharge standards. Approximately 75-80 percent of the effluent are discharged at this stage after chlorination (Figure 2-A).

The remaining 20-25 percent of the effluent are subjected to the on-site wastewater reclamation and reuse systems. Intake water is withdrawn from the splitter box located between the dual media filter and the chlorination tank. The main element of wastewater reclamation facilities as shown in Figure 2-B consists of an ozonation facility for color and odor removal, and disinfection. There have been special safety features incorporated in the ozonation facility, and the following safety features are derived from pilot-scale experiments: 1) automatic control of ozone generation to prevent excess ozone generation, 2) a stand-by ozone generator for shut-down and maintenance, 3) deozonation facility (adsorption tower) to prevent secondary pollution, and 4) special ventilation facility for the ozone generator room. With respect to reclaimed water quality assurance, continuous automatic monitoring of TOC and turbidity is conducted in the following schedule: 1) if TOC and turbidity values exceed 15 mg/l and 5 units, respectively, for 15 minutes, reclaimed water flow is automatically switched to additional treatment of activated carbon treatment with a sound of alarm, 2) if water quality values after activated carbon treatment still show excess, the on-site reclamation and reuse system shuts down. Then, potable water will be introduced to the finished water reservoir in lieu of the reclaimed water.

Reclaimed Water Distribution Systems

The reclaimed water distribution systems for the S apartment complex involve distribution pumps, pressure tanks, outside and inside pipings, toilet equipment, and recirculation systems for ornamental lake and stream. Figure 3 shows the schematic diagram of these facilities. To distinguish reclaimed water lines from the potable water lines, epoxy coated steel pipes were used and pipes were clearly marked with a marking tape.

Since flat-rate water pricing is used, flow meters are installed only to a group of apartment units for future evaluation. A yellowish-color toilet was used to mask potential coloring of the toilet facilities by the reclaimed water.

Reclaimed Water Quality

An intensive monitoring to characterize reclaimed water qualities at the point of reuse was conducted from February, 1978 to October, 1978. The results are reported in the following statistical parameters: arithmetic mean, 97.5% confidence limit, and 90% confidence limit. The results are reported in above order for the following water quality parameters: color 0.9, <6, <2; turbidity 0.3, <3, <1, total dissolved solids 445,600,540 mg/l; SS 1.3, 4.0, 2.7 mg/l; COD 3.5, 6.7, 5.4 mg/l; BOD_5, 2, 4, 3 mg/l; PO_4^{3-} 0.5, 1.8, 1.4 mg/l; TOC 4.1, 9.2, 7.2 mg/l, respectively.

Capital and O & M Costs

Capital cost items for the on-site wastewater reclamation and reuse system consist of wastewater reclamation facilities (ozonation, activated carbon treatment, and monitoring), indoor and outdoor pipings, reclaimed water reservoir tank, and distribution and pumping systems. Table 7 shows cost breakdown of these facilities.

Based on the construction costs shown in Table 7, per apartment unit construction costs are approximately $873 each, and, based on the prevailing interest rate and amortization, a monthly payment per an

Table 4—Average Daily Water Use in Various Applications (l/day/cap.)

Bath-tub	*Laundry*	*Bathroom*	*Kitchen*	*Toilet*	*Cleansing*	*Car-Washing*
50	60	30	50	40*	10*	10

*Reclaimed water uses for toilet flushing and cleansing; 50l/day/capita.

Table 5—Water Quality Criteria for Reclaimed Water Use in the Apartment Complex

Item	*Unit*	*Criteria*
Odor	—	non-existence
Color	Unit	<10
Turbidity	Unit	< 5
TDS	mg/l	<1,000
SS	mg/l	< 5
pH	Unit	5.8-8.6
COD	mg/l	<20
BOD_5	mg/l	<10
PO_4^{3-}	mg/l	<1.0
ABS	mg/l	<1.0
Coliform	count/ml	non-existence
General bacteria	count/ml	<100
Residual chlorine	mg/l	>0.2
TOC	mg/l	<15

apartment would amount to $6. At the S apartment complex, $2.20 are collected monthly per apartment to cover operation and maintenance costs (O & M) for the on-site wastewater reclamation and reuse system. Since reclaimed water use per apartment is estimated to be 6 m³/month (average 4 persons per dwelling unit), the reclaimed water costs including capital and O & M

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Figure 2A—Schematic Diagram of the On-Site Wastewater Treatment Systems and Reclamation Facilities at the S Apartment Complex

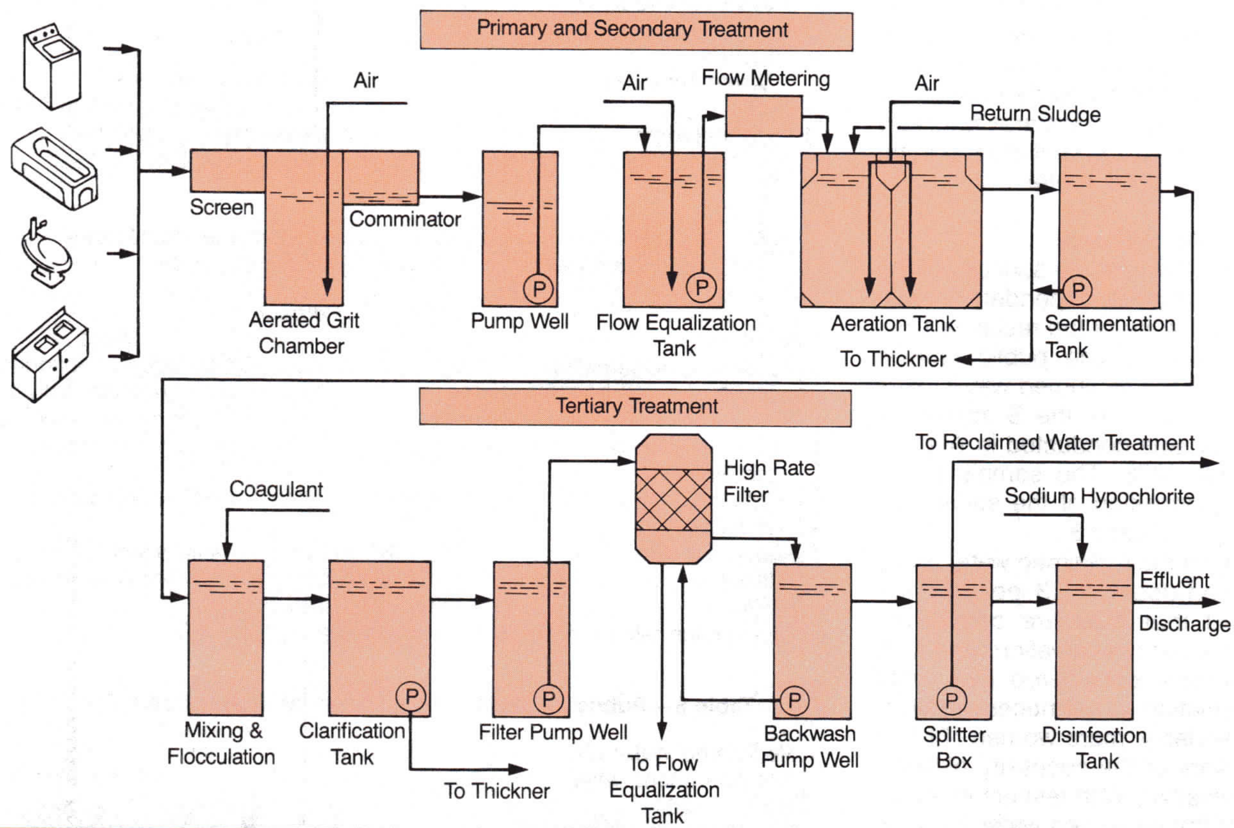
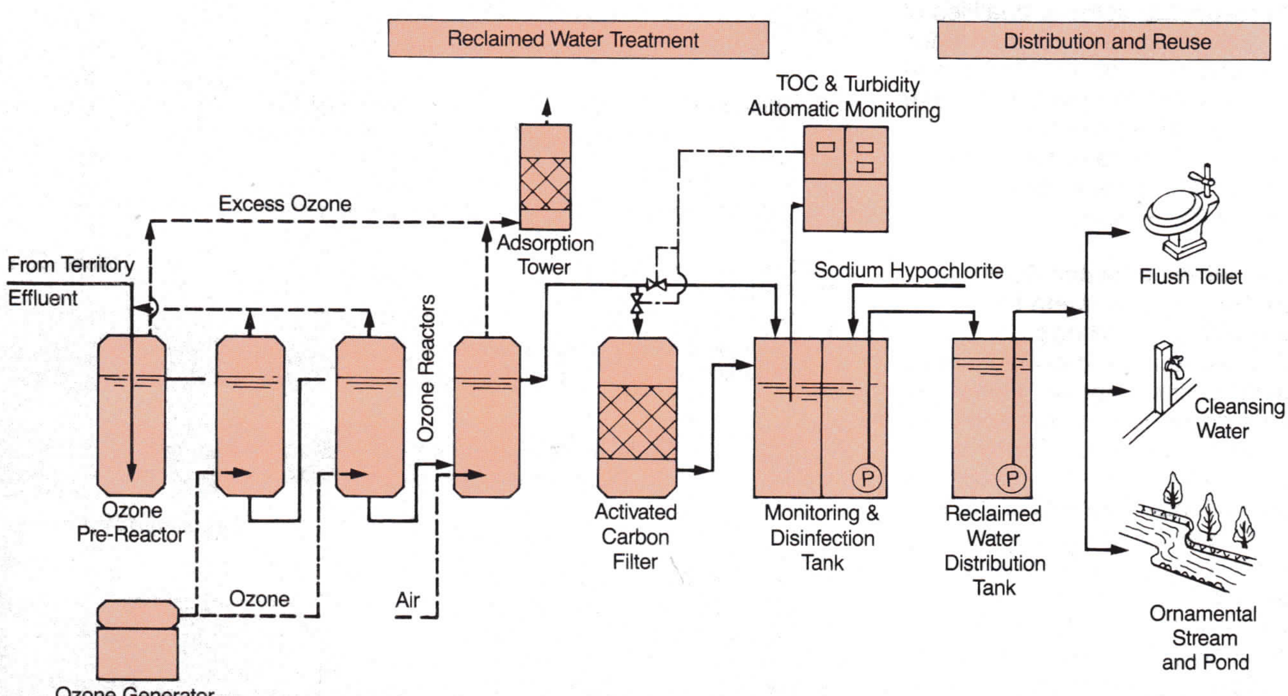


Figure 2B—Schematic Diagram of the On-Site Wastewater Treatment Systems and Reclamation Facilities at the S Apartment Complex.



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would become $1.36 per cubic meter.

At the S apartment complex, however, only the O & M costs in the amount of $2.20 are collected from the residents. Thus, the use of reclaimed water would amount to 38¢ per cubic meter, and the cost of the reclaimed water compares favorably with the prevailing cost of a tap water at 62¢ per cubic meter.

Table 6—Summary of Wastewater Treatment Facilities at the S Apartment Complex

Population served	4,700
Wastewater generation	260l/day/capita
Average wastewater flow rate	1,222 m^3 day
Secondary treatment	Extended Aeration
Tertiary treatment	Coagulation, flocculation, and filtration
Sludge treatment	Centrifugation
Treatment facility area	3,470 m^2
Structure	
Treatment tanks	Reinforced concrete semi-basement roofed; 754 m^2
Control room	Reinforced concrete, two storied; 413 m^2

Table 7—Construction Costs* for the On-Site Wastewater Reclamation and Reuse System (160 m^3/day)

Facilities	*Construction Costs*	*Percent*	*Items*
Wastewater reclamation facilities	$403,624	52.0	Ozonation, monitoring, chlorination, activated carbon, and electrical
Indoor piping and facilities	83,534	10.8	Dual system piping
Outdoor piping and facilities	174,038	22.4	Dual system piping
Reclaimed water tank and facilities	114,162	14.8	Tank, distribution systems, electrical
TOTAL	$775,358	100.0	

*Conversion rate of ¥210 = $1 was used for the calculation.

Table 8—Public Acceptance Survey at the S Apartment Complex

	Reclaimed Water Users		*Non-Users*		*Total*	
	224 Apartment Units		301 Apartment Units		525 Apartment Units	
Male	204	426	275	555	479	981
Female	222		280		502	

*Fifteen years old or older residents participated in the survey.

Public Acceptance

Since the ultimate success of the on-site system is dependent on public acceptance of the reclaimed water, a side-by-side public opinion survey of the reclaimed water users and non-users of the S apartment complex was conducted in August-October, 1978. The sampling size and composition of the survey are reported in Table 8.

Among the reclaimed water users and non-users, 61.3 percent answered that they are concerned about water conservation, and only 1.4 percent considered that water conservation is not necessary. Understandably, more women (71.1%) are aware of the necessity of water conservation. With respect to actual use of the reclaimed water for toilet flushing, 84.5 percent considered that they have not noticed any difference from tap water, and only 3.1 percent noticed some differences. With respect to esthetic qualities of the reclaimed water such as odor, foam, and color, overwhelming majorities felt that the reclaimed water made no differences (odor: 81.1% male, 77.3% female; foam: 85.8% male, 77.7% female; color: 81.3% male, 74.2% female).

Table 9—Description of the Buildings Where Reclaimed Water is Served

Building	*Description*	*Toilet Facilities (No.)*
T Office Building	14 stories above ground and 3 stories basement	Urinals: 61
Floor space	29,700 m^2	Toilets: 77
Population	1,400	
M Office Building	24 stories above ground and 3 stories basement	Urinals: 229
Floor space	125,800 m^2	Toilets: 394
Population	7,500	
O Service Building	4 stories basement	Urinals: 3
Floor space	5,000 m^2	Toilets: 3
Population	10	

Regional Wastewater Reuse And Recycling System for Commercial Buildings

The area from the Tokyo train station to the Imperial Palace includes major government and commercial districts where many headquarters of major corporations are located. Since September 1976, a district heating and air-conditioning corporation has been providing necessary building services to selected buildings in this area for heating, air-conditioning, and reclaimed water. The objectives of the collective utility corporation in the district are: (1)

Table 10—Volumes of Grey Water and Planned Reclaimed Water Use in the Buildings

Buildings		*Influent Flow m^3/day*	*Reclaimed Water Flow m^3 day*
T Office Building	Grey Water	65	95
M Office Building	Grey Water	185	375
O Office Building	Grey Water	44	6
	Cooling water blow-down	285	
TOTAL		579	476

Figure 3—Reclaimed Water Distribution Systems

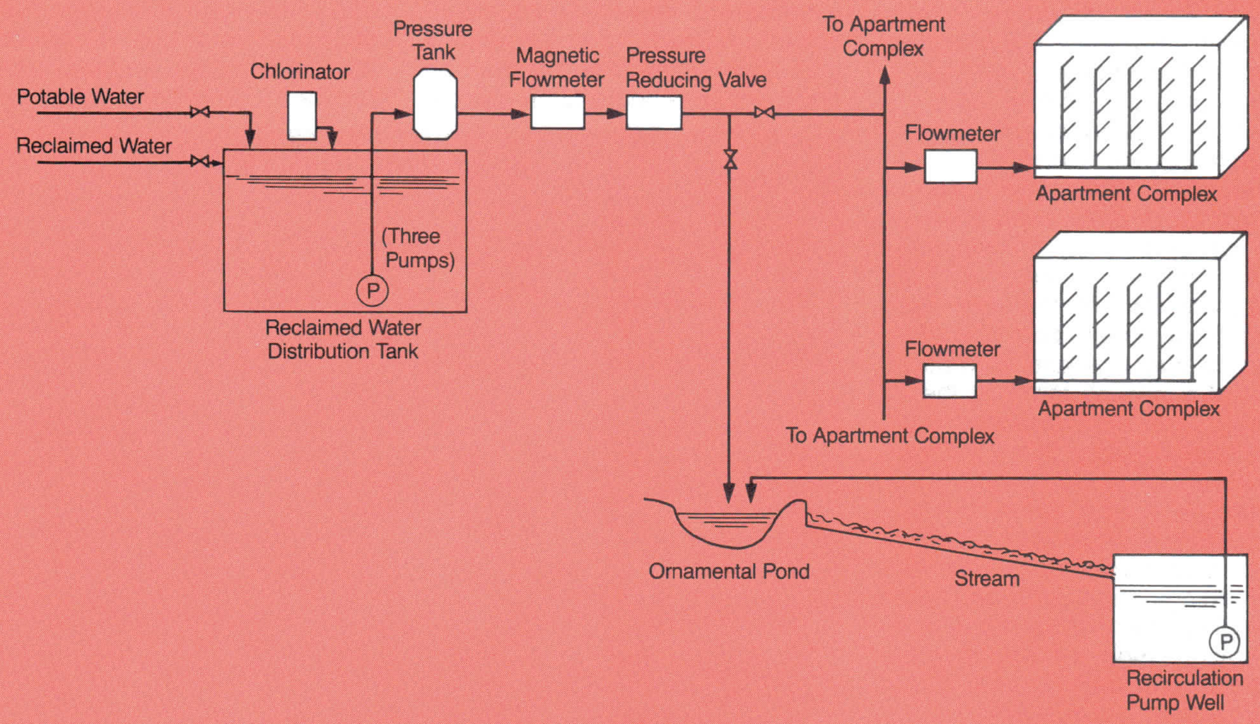
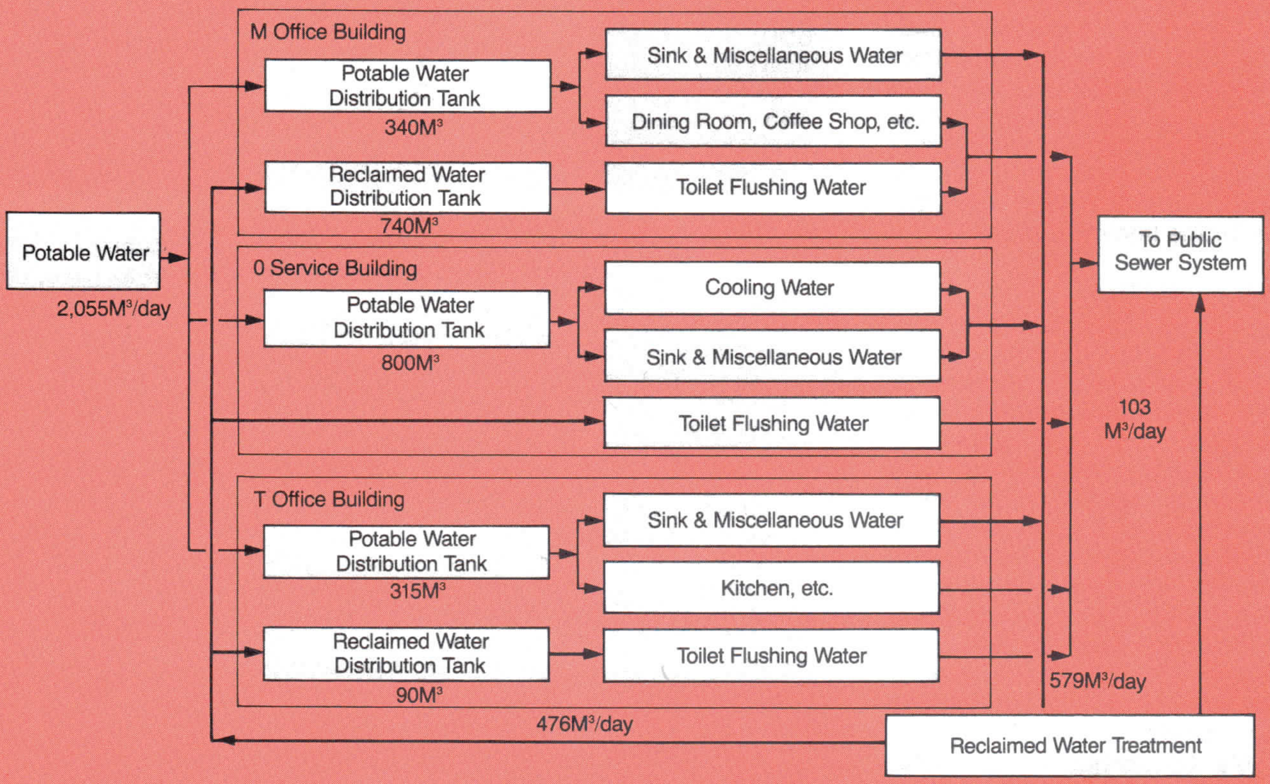


Figure 4—Schematic Diagram of the Water Supply and Reclaimed Water Systems for the Three Office Buildings



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efficient energy utilization, (2) reduction in utility space requirements in an individual building, (3) hazard prevention and esthetics, and (4) alleviation of operator and maintenance manpower shortages.

The district wastewater reclamation and reuse system was planned as a part of the utility services originating at the O building. The sources of water for the reuse system are grey waters from three surrounding buildings and blow-down water of a cooling tower at the O building. The use of reclaimed water is for toilet-flushing. Since the system is located in the basement of the O building, special safety precautions were incorporated. Table 9 shows a description of the commercial buildings where reclaimed water is supplied from the O building service station. Figure 4 on page 29 shows a schematic diagram of the water supply and reclaimed water systems for the three buildings.

Table 10 on page 28 shows grey water influents to the on-site wastewater reclamation system and the volume of planned reclaimed water use. The wastewater reclamation facilities consist of grey water treatment by the activated sludge process and the treatment of cooling water blowdown by chemical treatment. The two streams are then combined to undergo a media filtration. Figure 5 shows this regional wastewater reuse and recycling system for the commercial buildings. Table 11 shows design specifications for the treatment systems.

Operational Characteristics

As shown in Table 10, influent flows from three buildings consisted of grey waters and a cooling water blow-down. Daily grey water flow was in a range of 178 to 270 m^3, and the average was 212 m^3/day which was approximately 72 percent of the design flow. The summer month flows were approximately 1.6 times higher than the winter month flows. The reclaimed water use was, on an average, 385 m^3/day for working days, and 23 m^3/day for holidays and weekends.

Table 12 shows average water quality characteristics of the influent grey water and the reclaimed water after treatment shown in Figure 5.

Capital and O & M Costs

Since the on-site wastewater reclamation and reuse systems are installed underground in the second and third floors, the construction costs are considered to be approximately 30 percent higher than the equivalent facilities above ground. Table 13 summarizes capital and O & M costs for the production of 476 m^3/day reclaimed water. Annual reclaimed water use was based on 300 working days, and calculated to be 142.8×10^3 m^3/year. Based on the

Table 11—Design Specifications for the Regional Wastewater Reuse and Recycling System (Influent Flow: 579 m^3/day)

Equipment	*Unit*	*Specifications*
Ultrascreen	1 unit	110 m^3/hr. screen 0.5 mm
Flow Equalization Tank	200 m^3	16 hr. storage, 10 m^3 air/m^3 day
Aeration Tank	79 m^3	6.4 hr. aeration, 0.56 Kg BOD/m^3/day, 100 m^3 air/Kg BOD removed day
Sedimentation Tank	79 m^3	6.4 hr. sedimentation, 13 m^3/m^2 day
Storage Tank	207 m^3	17 hr. storage
Chemical Mixing Tank	6.5 m^3	30 min. contact
Flocculation Tank	10 m^3	50 min. contact
Clarification Tank	55 m^3	4.7 hr. sedimentation
Filter Pump Well	16 m^3	
High Rate Filter	2 units	Downflow pressurized, 120 m^3/m^2/day
Chlorine Contact Tank	6 m^3	12 min. contact
Reclaimed Water Distribution Tank	360 m^3	15 hr. storage
Drainage Tank	45 m^3	To sewer liner discharge in non-use hours

Table 12—Average Water Quality Characteristics

*Water Quality**	*Influent Grey Water*	*Reclaimed Water*
pH	6.9	7.6
SS	70	1
COD	49.5	5.2
BOD_5	66	2
Total - N	7	1
NH_3 - N	0.1	—
ABS	5.7	0.2
Total P	6.8	2.5

*mg/l as stated except pH unit.

Table 13—Capital and O & M Costs* for the Production of 476 m^3/day Reclaimed Water (In Thousand Dollars)

Capital Cost Items:	*In Thousand Dollars*
Machinery and Construction	$523.8
Piping and Construction	166.7
Electrical	176.2
Structural	466.7
Miscellaneous	95.2
TOTAL	$1,428.6
O & M Cost Items:	
Rent for the Building	49.0
Maintenance	23.2
Property Tax	16.9
Amortization (Building: 30 Years, Facilities: 7 Years)	141.4
Interest	100.0
Operator	25.2
Electricity (47,000 KwH/day)	29.3
Miscellaneous (water analysis)	24.0
TOTAL	$409.0

*¥210 = $1.00 was used for cost conversion.

Figure 5A—Regional Wastewater Reuse and Recycling System for the Commercial Buildings

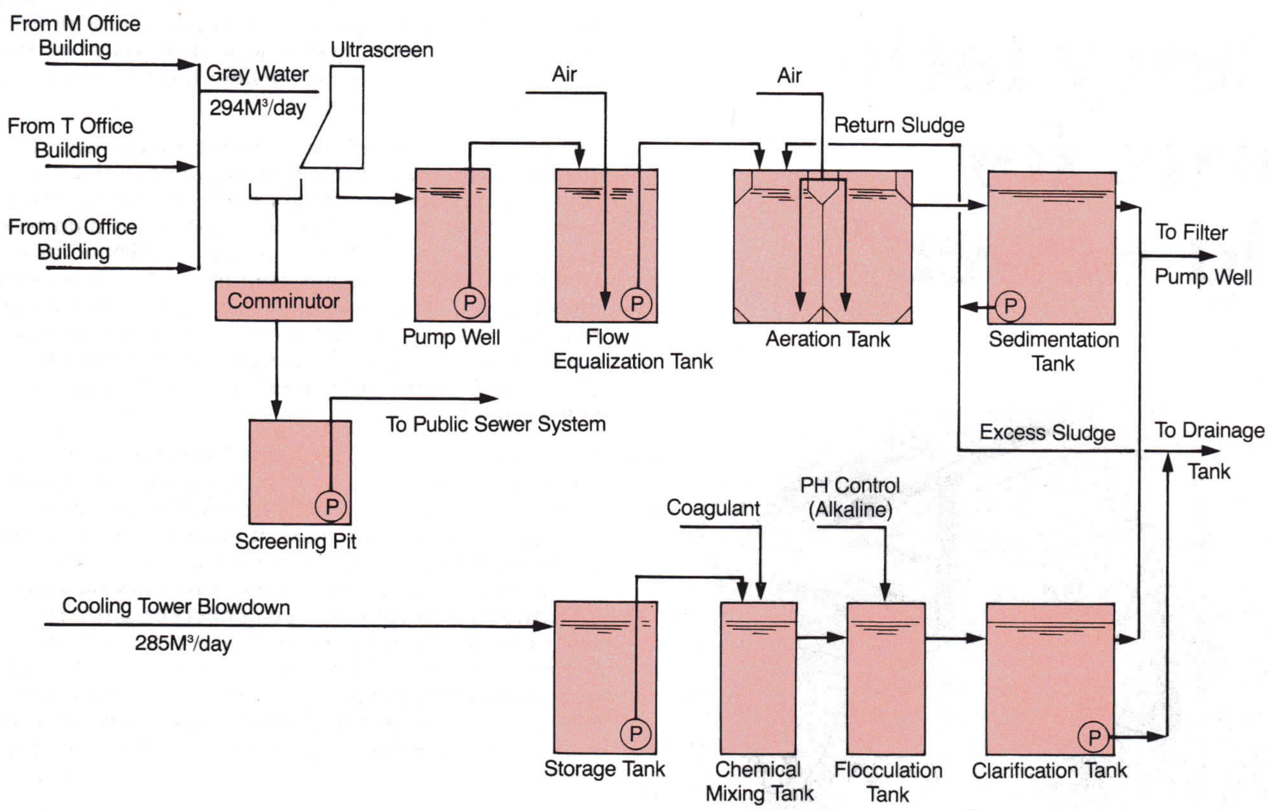
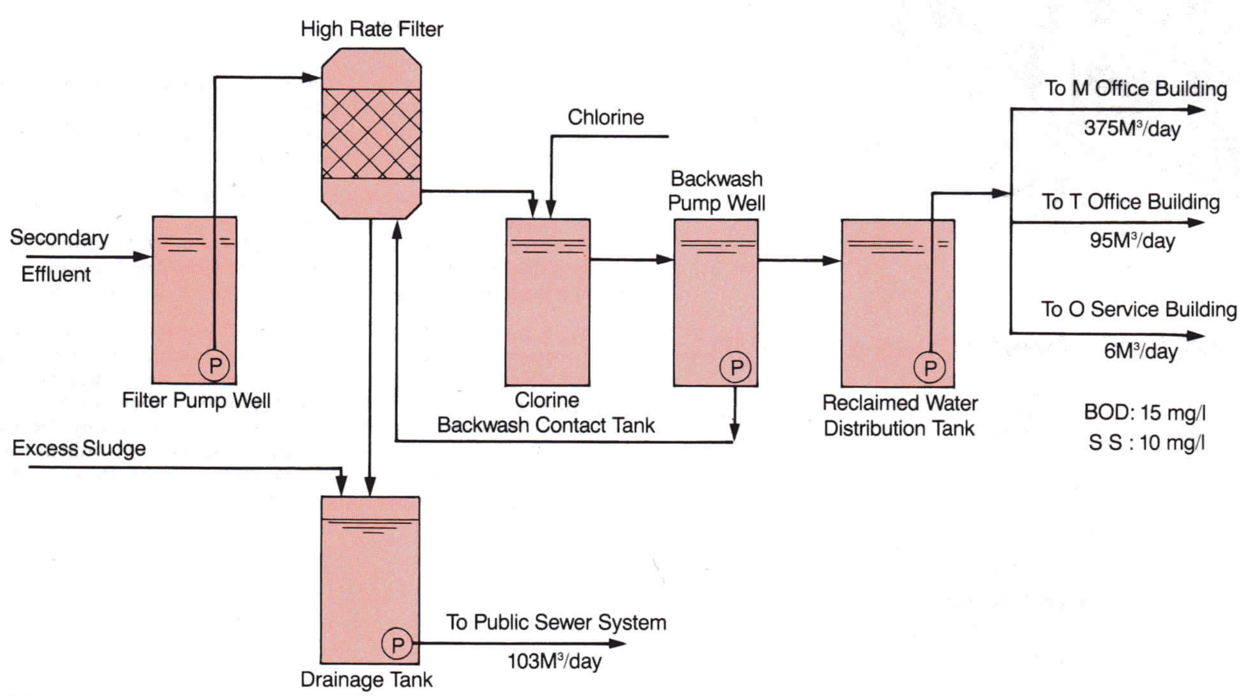


Figure 5B—Regional Wastewater Reuse and Recycling System for the Commercial Buildings (Reclamation Facilities)



Water Reuse

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total O & M cost items, direct cost attributable to the production is 55¢/m^3 which includes operator, electricity, and miscellaneous cost items.

The current water supply costs, on the other hand, are approximately \$1.20/m^3 for large users, and the sewer use charge is about 69¢/m^3 in Metropolitan Tokyo, totaling \$1.89/m^3. Thus, the reclaimed water is still considered to be less expensive than the existing municipal water supply.

Current Problems and Future Prospects

Through governmental directives, there has been a steady increase in the number of on-site wastewater reclamation and reuse facilities in Japan, totaling more than 100 projects as of February 1980. Laws and regulations governing the use of reclaimed water are complex, and confusing. There have been the established acts governing potable water supply, sewerage, and industrial water, respectively, enforced by the Ministries of Health, Construction, and Industry and Trade. By introducing reclaimed water into this complex picture, some procedures must be established to incorporate reclaimed water into the traditional water supply-wastewater receiving functions of a municipality.

Several potential problems:

- Establishment of uniform standards of safety with respect to reclaimed water quality, structures and facilities, and operation and maintenance.
- Rational methods of enforcing the use of lower quality water (reclaimed water by origin) to a selected water reclamation district.
- Pricing policy and methods of cost allocation, e.g., federal and local governments, and users.
- Accommodation of reclaimed water in the existing water supply and sewerage regulations, and needs for new legislation.

Uniform accounting methods for pricing reclaimed water have not been established. The cost of reclaimed water may be calculated on the basis of direct costs attributable to O & M; on the other hand, amortization of the capital cost items may be included in the pricing policy. In addition, general cost estimates for required land, construction, and O & M are difficult to establish and general cost trends regarding the treatment facilities, pipings, and distribution facilities have not been established.

Additional treatment steps which may be required for the production of reclaimed water will depend on the effluent discharge regulations of the area. Thus, whether to consider the on-site wastewater reclamation and reuse systems as wastewater treatment systems or unique water treatment facilities will affect cost of reclaimed water. It is a common practice to compare the price of reclaimed water with that of potable water supply, and it is often the case as a result that reclaimed water is found to be more costly. The reasons are often due to the stricter water quality requirements for reclaimed water than for wastewater discharge, O & M costs, necessities of additional treatment trains and dual water supply systems. When an amortization of the capital cost items are included in the pricing of reclaimed water, it is reported that the reclaimed water is 1.5 to 2 times more costly than the existing potable water supply at present for apartment complexes, and for an individual on-site wastewater reclamation and reuse system.

However, it is anticipated that the next large increment of freshwater supply will be much higher in cost than existing supplies due mainly to the remoteness of new water sources, escalating energy and delivery costs, and environmental considerations. With the introduction of a large scale wastewater reclamation and reuse along with stricter discharge regulations, it is probable that the reclaimed water will become more and more competitive in price in the future. In addition to the existing low-interest loan from the Japan Development Bank some forms of financial assistance may be introduced to the on-site wastewater reclamation and reuse systems similar to the existing subsidies for water supply and wastewater treatment facilities.

Public Health and Engineering

Currently, reclaimed water use is largely limited to toilet flushing and ornamental and landscape irrigation where human contacts are kept to a minimum. In the expanded use of reclaimed water, the major concerns are to minimize health risks associated with viruses and toxic substances. Because of these concerns, the on-site wastewater reclamation and reuse systems normally consist of biological secondary treatment, chemical coagulation and flocculation, media filtration, and possibly carbon adsorption. A combination of ozonation and chlorine disinfection is often used for the inactivation of viral agents. No virus detection is reported in Japan so far in a reclaimed water after media filtration followed by chlorination and ozonation in these systems.

Major water quality concerns related to the use of reclaimed water are: turbidity, odor, foaming, coloring to toilet facilities, slime and scaling, and corrosion control. Uniform standards for these concerns are expected to be established in the future when adequate experiences are gained from the existing and future reclamation and reuse projects.

From the engineering standpoints, the on-site wastewater reclamation and reuse systems require additional internal piping, storage tank, raised distribution tank, pumping, and other treatment facilities which require special considerations for space requirements, structural safety, and space and construction expenses. Special attention must be paid to construction methods and compact installations of the equipment. Due to the dual piping systems required for buildings, positive cross-connection prevention measures must be exercised and uniform identification of the reclaimed water piping must be developed and enforced. □□