OFFICE OF
WATER RECYCLING

INDUSTRIAL WATER RECYCLING

California State Water Resources Control Board, March, 1979

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FIGURES AND TABLES

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Industrial Water Recycling ...the planned use of wastewater by industry for applications that would not otherwise occur...can be accomplished by three methods. An industrial facility can reuse its own wastewater within the plant boundary. Also, it can market its effluent for other uses, such as irrigation. The third method, which is emphasized in this brochure, is wastewater reclamation, or the use of municipal wastewater by industry.

Some believe that wastewater reclamation is an idea whose time has come. But what is the basis for this opinion? Is it merely supposition, or are there sufficient data to show that reclamation is a viable water supply alternative? The discussions which follow address this issue as it relates to the State of California and its industries.

The Water Outlook

In California, the State Water Resources Control Board plays a major role in reclamation because of its responsibility for administering the Clean Water Grant Program. The Board is using its Clean Water Grant funding powers to encourage reclamation. In addition, the Office of Water Recycling was recently established within the State Board to promote reclamation and recycling of wastewater.

WATER SUPPLY AND DEMAND IN CALIFORNIA

In 1972, California's statewide water demand exceeded the reliable water supply by 800 billion gallons. By the year 2000, that deficit may climb to over 1 trillion gallons.

Furthermore, there is a logistics problem. About 70 percent of California's total streamflow is north of Sacramento—yet 80 percent of the demand for water is south of the state capital.

Over the past 12 years, industrial water use in California (see Fig. 1) has intensified in several areas:

- The pulp and paper manufacturing industry—water requirements have increased 233 percent.
- The primary metals industry—water requirements have increased 70 percent.
- The food industries—water requirements have increased 13 percent.

...statewide water demand exceeded the reliable water supply by 800 billion gallons.

About 70 percent of California's total streamflow is north of Sacramento—yet 80 percent of the demand for water is south of the state capital.

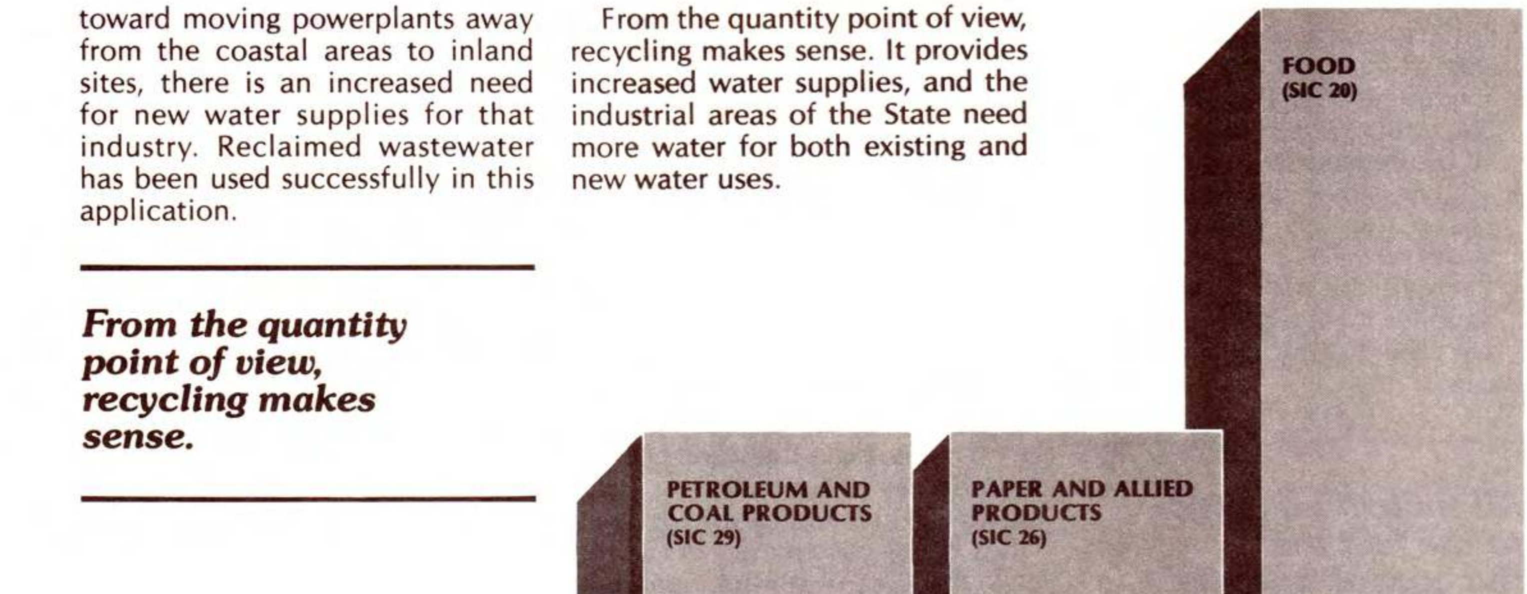
The largest industrial use of water is for cooling purposes. In addition, there are new demands for cooling water supplies for electric powerplants. With the recent trend

FIGURE 1
INDUSTRIAL WATER USE IN CALIFORNIA *by Standard Industrial Classification (SIC)*
(Based on 1972 usage—in billions of gallons)

toward moving powerplants away from the coastal areas to inland sites, there is an increased need for new water supplies for that industry. Reclaimed wastewater has been used successfully in this application.

From the quantity point of view, recycling makes sense. It provides increased water supplies, and the industrial areas of the State need more water for both existing and new water uses.

From the quantity point of view, recycling makes sense.



COST TRENDS FOR WATER SUPPLIES

All indicators point to the fact that the cost of water, like the cost of all other commodities, is on the rise. There are several specific reasons why the cost to use fresh water supplies will increase in the future. The major reasons are:

- Inflation, which increases the cost of construction.
- Higher drinking water quality standards, which raise the cost of future supplies.
- Higher sewer charges, which make the use of traditional water supplies more expensive.
- Energy costs, which make future supplies more expensive.

Let's briefly look at each of these items.

All indicators point to the fact that the cost of water is on the rise.

Inflation

After years of inflation of less than 2 percent annually, the 1970's have seen general price levels rising at rapid rates. Double-digit inflation has subsided, but current rates of 6-8 percent are still high. Inflation impacts all of our economic planning—it is only logical that it should also affect the cost of water.

Higher Drinking Water Quality Standards

Much has been written recently about proposals by EPA to raise drinking water quality standards, particularly with an eye on potentially toxic organic chemicals. Only time will tell if the standards will be raised, but it seems certain that the new interim drinking water standards will not be relaxed. In all probability, they will be tightened and the cost of traditional potable water from the water distribution agencies will rise accordingly.

...it seems certain that the new interim drinking water standards will not be relaxed.

Higher Sewer Charges

In many areas, the sewer charges are set as a function of water usage. With new treatment facilities being constructed in California, the cost of sewage treatment is expected to rise. In fact, many industries have already seen their sewer bills double and triple to pay for their share of the new facilities.

Energy Costs

Large areas of the State are involved in the pumping of ground water for water supplies. The central and southern parts of the State make use of large conveyance facilities that transport water hundreds of miles from Northern California through the Central Valley over the Tehachapi Mountains into the Los Angeles area. Colorado River water is also pumped into the southern part of the State. Pumping, either from ground water or surface water, is an energy-using proposition, and energy costs are rising more rapidly than almost any other cost of production. Therefore, when existing, low cost contracts for power to convey water expire, the price of the water will rise dramatically because of the higher cost of the energy used to pump it.

THE ROLE OF INDUSTRY

The industrial community has a significant role to play in recycling and reclaiming wastewater. The motivations for industry include the following:

- Changing water rights regulations.
- Tightening effluent guidelines.
- Fluctuating freshwater supplies.
- Emerging pretreatment guidelines.

Water Rights Regulations

The Board has changed its water rights regulations to assure that use of reclaimed water is fully examined as a water supply alternative in industrial applications for new water rights or for changes in existing rights.

...many industries have already seen their sewer bills double and triple.

Effluent Guidelines

New NPDES (National Pollutant Discharge Elimination System) permits are becoming more restrictive on the discharge of pollutants. Furthermore, renewed permits on existing industrial point source discharges are following the same trend. By in-plant recycling of waterflows that would otherwise be discharged, the net amount of water that needs to be treated to meet permit requirements is reduced. By "marketing" industrial effluents for other uses such as irrigation or byproduct recovery, the economic impact of meeting the permit requirements is reduced or eliminated.

By "marketing" industrial effluents, the economic impact is reduced or eliminated.

Freshwater Supplies

The future reliability and costs of freshwater supplies are of great concern to the industrial community. In drought periods, activities such as domestic use and agriculture will have priority over industry for the limited supply. To further complicate the situation, few new water supply projects are being developed because of construction costs and lack of suitable dam sites. Recycling and reclamation reduce industry's dependence on freshwater supplies.

Reclaimed wastewater may prove to be a lower cost water supply than traditional freshwater sources.

Pretreatment Guidelines

EPA is establishing guidelines for pretreatment of industrial wastes prior to discharge to municipal systems. These guidelines are designed to assure that potentially toxic materials do not enter and upset the municipal treatment facilities. Costly and complex pretreatment systems are required to remove toxics from wastewater streams. Recycling, in many instances, will be a more economically attractive alternative than pretreatment and discharge.

SUMMARY

The next 25 years are forecast to bring water shortages to most areas in the State. This makes reclaimed wastewater an attractive new supply to investigate carefully and begin developing now. In those areas where surplus water is forecast, the cost of water will rise dramatically. Reclaimed wastewater may prove to be a locally available, lower cost water supply than traditional freshwater sources. So, for both quantity and price reasons, reclamation is an idea whose time has come.

Reclaimed Water

as an Industrial Water Supply

Reclaimed wastewater has the potential to replace freshwater supplies in a variety of industrial uses. In addition, there are opportunities for industry to upgrade its effluents and market them as reclaimed water supplies. To convert the potential into actual uses, two factors must be evaluated:

- **Use of the reclaimed water, which determines water quality requirements.**
- **Treatment needed to achieve the required quality, which determines the cost of reclaimed water.**

Each factor is discussed below.

QUALITY REQUIREMENTS FOR VARIOUS INDUSTRIAL USES

Although industrial water uses cover quite a broad range, major uses can be grouped into the following general categories:

- Cooling tower makeup water.
- Once-through cooling; including such uses as pump, compressor, and bearing cooling; turbine exhaust condensing; and direct contact (or "quench") condensing.
- Process water.
- Boiler feedwater.
- Washdown water.
- Miscellaneous uses, including site irrigation, fire protection and dust control.

Three categories of industrial water use are of particular interest because they are high-volume uses with excellent prospects for using reclaimed wastewater: (1) cooling tower makeup; (2) once-through cooling; and (3) process water. The remaining categories have less potential for reuse in significant quantities, and will not be considered further.

Cooling Tower Makeup

Cooling tower makeup water represents a significant water use for many industries. For industries such as electric power generating stations, oil refining, and many types of chemical and metal plants, one-quarter to more than one-half of a facility's water use may be cooling tower makeup. Because a cooling tower normally operates as a closed-loop system isolated from the process, it can be viewed as a separate water system with its own specific set of quality requirements which are largely independent of the particular industry involved.

Reclaimed wastewater has the potential to replace freshwater supplies in a variety of industrial uses.

The quality requirements for water used as cooling tower makeup are set by the inevitable buildup of harmful makeup water constituents within the closed-loop system. This buildup occurs because pure water is lost by evaporation in the cooling tower to accomplish heat removal. Evaporation removes only pure water, leaving behind any impurities present in the makeup water.

...one-quarter to more than one-half of a facility's water use may be cooling tower makeup.

All water contains some impurities such as calcium, magnesium, sodium, and chloride. The buildup of these impurities in a cooling system is controlled by bleeding off a portion of the cooling water and replacing it with makeup water. The bleedoff discharge, called "blowdown," carries accumulated impurities out of the system.

If the impurities are allowed to build up to too high a level, the result will be scale deposits on heat exchanger surfaces. This lowers the heat transfer capacity of the equipment and eventually requires shutdown and cleaning.

Although scaling is the most prevalent problem in cooling systems, excessive impurity buildup may also cause accelerated corrosion, sliming, or plugging problems from accumulated suspended matter.

Various chemical additives are used in cooling water systems to control scale, slime, and corrosion. The chemical additives needed depend on the character of the makeup water. All additives have definite limitations and cannot eliminate the need for blowdown.

The rate at which scaling and corrosion conditions develop in a cooling system depends largely on the level of impurities in the makeup water. A high blowdown rate can lower the rate of impurity buildup, but this also causes a higher demand for makeup water and greatly increases the cost of chemical additives. In actual practice, a fairly common operating condition for cooling towers involves about a fivefold concentration increase between makeup and blowdown.

...scaling is the most prevalent problem in cooling systems...

Under these operating conditions, the general quality requirements for recirculating cooling tower makeup are given in Table 1. The applicability of some of these criteria to a particular case must be evaluated based on materials of construction, internal cooling water chemical treatments, and the actual impurity buildup factor.

TABLE 1

QUALITY REQUIREMENTS OF COOLING WATER MAKEUP FOR RECIRCULATION

Characteristic	Concentration (mg/l)
Silica (SiO_2)	50
Aluminum (Al)	0.1
Iron (Fe)	0.5
Manganese (Mn)	0.5
Calcium (Ca)	50
Bicarbonate (HCO_3)	24
Sulfate (SO_4)	200
Chloride (Cl)	500
Total dissolved solids	500
Hardness ($CaCO_3$)	650
Alkalinity ($CaCO_3$)	350
Methylene blue active substances	1
Chemical oxygen demand (COD)	75
Suspended solids	100
Phosphorus (P)	0.3

Source: EPA "Water Quality Criteria," 1972, except phosphorus.

Once-Through Cooling

Once-through cooling refers to cooling processes which do not involve recirculation of cooling water. Instead, the cooling water accepts process heat loads by sustaining a temperature increase and is then discharged. Except for the temperature increase, the once-through water quality is essentially unchanged.

Once-through cooling is used in a wide variety of applications...

Once-through cooling involves substantial water volumes but does not directly involve a consumptive use of the water. Some once-through cooling systems withdraw cool water from and discharge heated water to the same water body (i.e., river, lake, or ocean). However, some once-through systems use well water or municipal supplies. For these latter systems and some analogous situations, a strong incentive exists to substitute reclaimed water.

Quality requirements for once-through cooling are considerably less stringent than requirements for cooling tower makeup. The primary quality concerns are (1) biological activity producing slime growths in the cooling system and (2) potential deposits from suspended matter in the water. Except in unusual situations, the scaling and corrosion problems described earlier are not a consideration in once-through systems.

Once-through cooling involves substantial water volumes but does not directly involve a consumptive use of the water.

The temperature of the water is of particular concern in once-through cooling systems. Substitution of a higher temperature supply may not be technically feasible in some cases.

Once-through cooling is used in such a wide variety of applications that numerical quality limits cannot be standardized. Potential applications require analysis on a case-by-case basis.

Even within a single industry, process water quality requirements vary from plant to plant...

Process Water

As might be expected, quality requirements for water used in industrial processes are highly dependent on the particular industry involved. Even within a single industry, process water quality requirements vary from plant to plant depending on the particular products involved. For this reason, it is not possible to generalize on the quality requirements for

TABLE 2

INDUSTRIAL PROCESS WATER QUALITY REQUIREMENTS

	PULP & PAPER[1]					TEXTILE PRODUCTS[4]		
PARAMETER	Mech. Pulping	Chemical Unbleached	Pulp & paper Bleached	CHEMICAL[2]	PETROCHEMICAL & COAL[3]	Sizing Susp.	Scour'g Bleach'g Dye'g	CEMENT[5]
Al								
Cu						0.05	0.01	
Fe	0.3	1.0	0.1	0.1	1.0	0.3	0.1	2.5
Mn	0.1	0.5	0.05	0.1		0.05	0.01	0.5
Zn								
Ca		20	20	68	75			
Mg		12	12	19	30			
Cl	1,000	200	200	500	300			250
NH_4								
HCO_3				128				
NO_3				5				
SO_4				100				250
SiO_2		50	50	50				35
Hardness		100	100	250	350	25	25	
Alk.				125				400
TDS				1,000	1,000	100	100	600
TSS		10	10	5	10	5	5	500
COD								
Color	30	30	10	20		5	5	
pH	6-10	6-10	6-10	6.2-8.3	6-9			6.5-8.5
CCE[6]								1

[1]Water quality requirements for paper and allied products are quite variable, depending on the process involved and the desired quality of the finished product. Generally, it is desirable to minimize the suspended solids in the water since they will adversely affect both the color and brightness of the product. Water turbidity and color are also potential sources of trouble in the production of finer-grade products. Other constituents that must be controlled, or kept as low as possible, include: silica, aluminum, and hardness (to prevent corrosion or scaling of process equipment) and microorganisms (to avoid slime growths, paper staining, and odor).

[2]Due to the diverse nature of the chemical industry, water quality requirements vary widely. The criteria presented above represent the most stringent criteria for the industry as a whole. In general, water which is moderately soft and relatively low in silica, suspended solids, and color is required. The dissolved solids and chloride content of the water is not too critical. Neutral waters preferred, with a pH range of 6.2 – 8.3 optimum.

[3]Water quality requirements for petroleum and coal products are moderate. The process water should be in the pH range of 6-9 and be fairly low in suspended solids (10 mg/l). But many constituents, such as SiO_2, Na, K, and bicarbonates, are acceptable as received and will not cause processing difficulties.

[4]Nonstaining water is mandatory in most textile mill operations. Hence, the water should be as free of turbidity, color, iron, and manganese as possible. Also, hardness can adversely affect the soaps used in the various operations; hardness may also increase the breakage of silk during reeling and throwing operations as well as cause the deposit of curds on the textiles. Nitrites and nitrates may cause problems in wool and silk dyeing.

[5]Over half the cement produced in the U.S. is manufactured by the 'set' processes. Water quality requirements are not severe, except that the water have no acidity.

[6]Carbon chloroform extract.

Source: Industrial Water Engineering, July/August 1973, pp. 27-29.
Note: All values are in mg/l except color and pH.

industrial process water. Table 2, which contains a cross section of process water quality requirements, illustrates the variety in quality needs for several industries.

TREATMENT TECHNOLOGY FOR RECLAMATION

Although the specific quality requirements for the various industrial water uses are highly variable, several general requirements can be identified. As a starting point, consider municipal wastewater which has received biological secondary treatment and disinfection. This water may be of suitable quality for some industrial uses. Where quality upgrading for reuse is necessary some or all of the following steps are required:

- Residual organics should be well oxidized to reduce bacterial growth and sliming/scaling.
- Ammonia levels should be reduced from levels normally present in municipal secondary effluent to prevent nutrient stimulation of bacterial growths, to eliminate ammonia interference with chlorination for bacterial control, and to reduce ammonia corrosion of copper-based alloys.
- Phosphorus levels should be reduced to prevent nutrient stimulation of bacterial action and to reduce phosphate scaling potential.
- Suspended solids levels should be reduced to remove the "seed" bacterial source and eliminate material which might form sludge deposits.
- Ions such as calcium, magnesium, iron, and silica should be removed to reduce scale formation.

The necessary quality upgrading can be accomplished by the technology depicted in Figure 2. However, this complete treatment train will not be necessary for every industrial reuse application.

...necessary quality upgrading of wastewater can be accomplished...

These treatment technologies are identified for wastewater quality upgrading in industrial reuse because they effect the following changes:

- Nitrification—produces a high degree of oxidation of organics and concurrently removes ammonia.
- Chemical Precipitation—removes phosphorus and residual suspended solids and lowers the concentration of scale-forming compounds such as calcium, magnesium, iron and silica.
- Filtration—removes suspended solids and, when used following lime treatment, removes precipitate carryover.

Table 3 is a generalized matrix of treatment technology requirements for the various industrial uses considered here.

COST OF TREATMENT FOR WASTEWATER RECLAMATION

The capital, operating, and total reclaimed water costs for the three principal reclamation processes that provide incremental treatment beyond biological secondary treatment are presented in Figures 3, 4, and 5. The costs are based on the ENR (Engineering News Record) Construction Cost Index for August 1978. These cost data are averages taken from the published sources noted and do not reflect unusual site conditions which may exist at a specific plant. The estimates are order-of-magnitude costs, which are generally accurate within a +50 percent to −30 percent range.

The costs in Figures 3 through 5 include neither the costs for transporting (piping and pumping) the reclaimed wastewater to the industrial user nor the internal industrial costs associated with reclaimed water usage.

...one or more large usage points will be more cost-effective than a series of small, widely separated uses.

The cost for transporting the reclaimed wastewater will vary with the distance between the reclaimed wastewater source and the user, the magnitude of the reclaimed water usage involved, and the nature of the terrain over which the reclaimed water is to be transported. The ideal situation would be one in which several fairly large industrial water users were close to the reclaimed water supply. This would permit economy-of-scale in the reclaimed water transport system.

The internal costs which indus-

TABLE 3

TREATMENT TECHNOLOGY FOR WASTEWATER RECLAMATION AS AN INDUSTRIAL WATER SUPPLY

Industrial Water Use	Nitrification	Chemical Precipitation	Filtration
Cooling Tower Makeup	Normally	Yes	Yes
Once-Through Cooling			
—Turbine Exhaust Condensing	Sometimes	Seldom	Sometimes
—Direct Contact Cooling	Seldom	No	Sometimes
—Equipment and Bearing Cooling	Yes	Yes	Yes
Process Water	Yes	Yes	Yes
Boiler Feedwater	Requires more extensive treatment; use of reclaimed wastewater generally not recommended.		
Washdown Water	Sometimes	Seldom	Yes
Site Irrigation	No	No	Normally

trial users of reclaimed wastewater may incur include modifications or additions to in-plant piping and distribution systems and possibly some changes in in-plant chemical usage for corrosion and/or scale control. The existence on the industrial site of one or more large usage points for the reclaimed wastewater will be more cost-effective than a series of small, widely separated uses.

The reclaimed water production cost (exclusive of transport and internal industrial costs) will, of course, vary with the size of the reclamation facility and the extent of reclamation treatment required for the particular use. As an example, consider a 5-mgd reclaimed water supply including all three of the reclamation treatment processes (i.e., nitrification, chemical precipitation, and filtration). Reclaimed water would cost about 70¢ per 1,000 gallons, depending on the cost of capital. If only filtration were required in this example, the reclaimed water would cost 18¢ per 1,000 gallons. This is competitive with purchased water in many areas of the State.

The ideal situation... several fairly large industrial water users close to the reclaimed water supply.

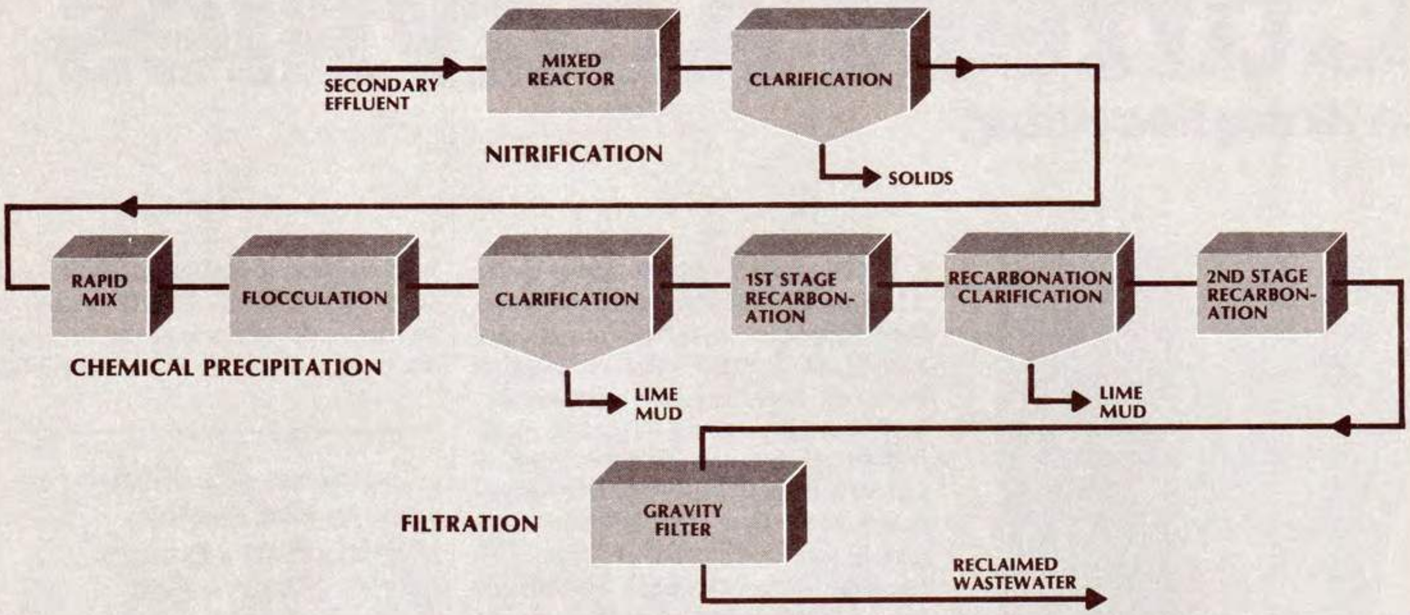


FIGURE 2
FULL TREATMENT SCHEMATIC
(Not required for every industrial reuse application)

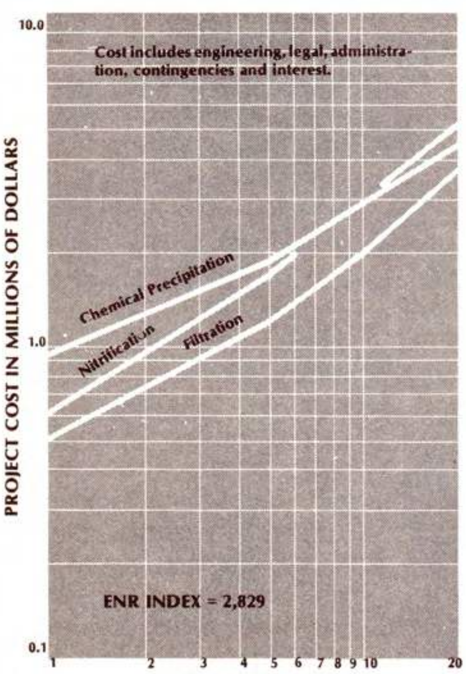


FIGURE 3. **CAPITAL COST CURVES**

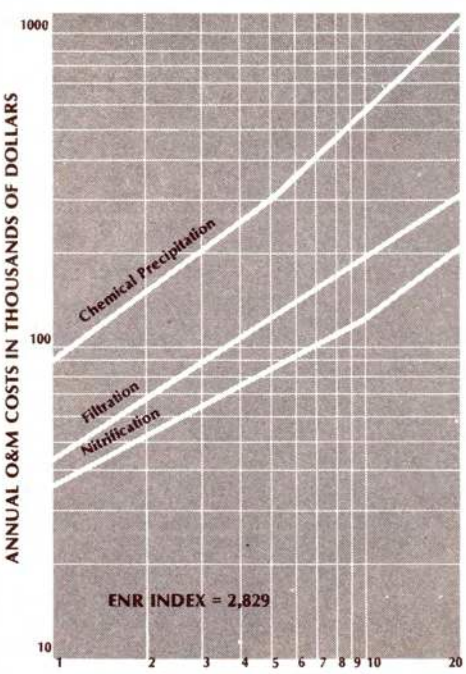


FIGURE 4. **ANNUAL OPERATION AND MAINTENANCE COST CURVES**

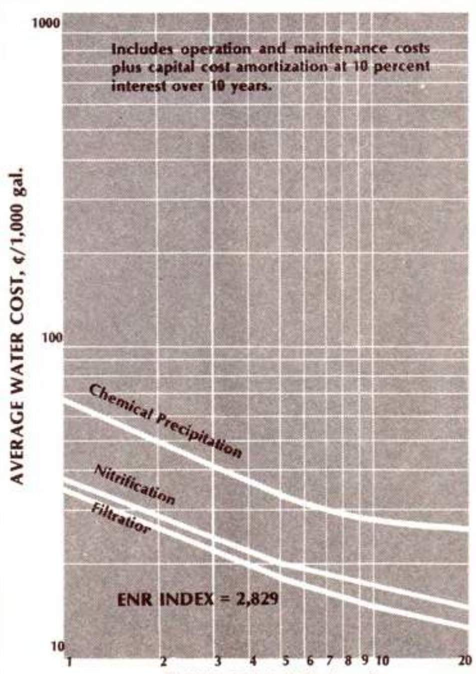
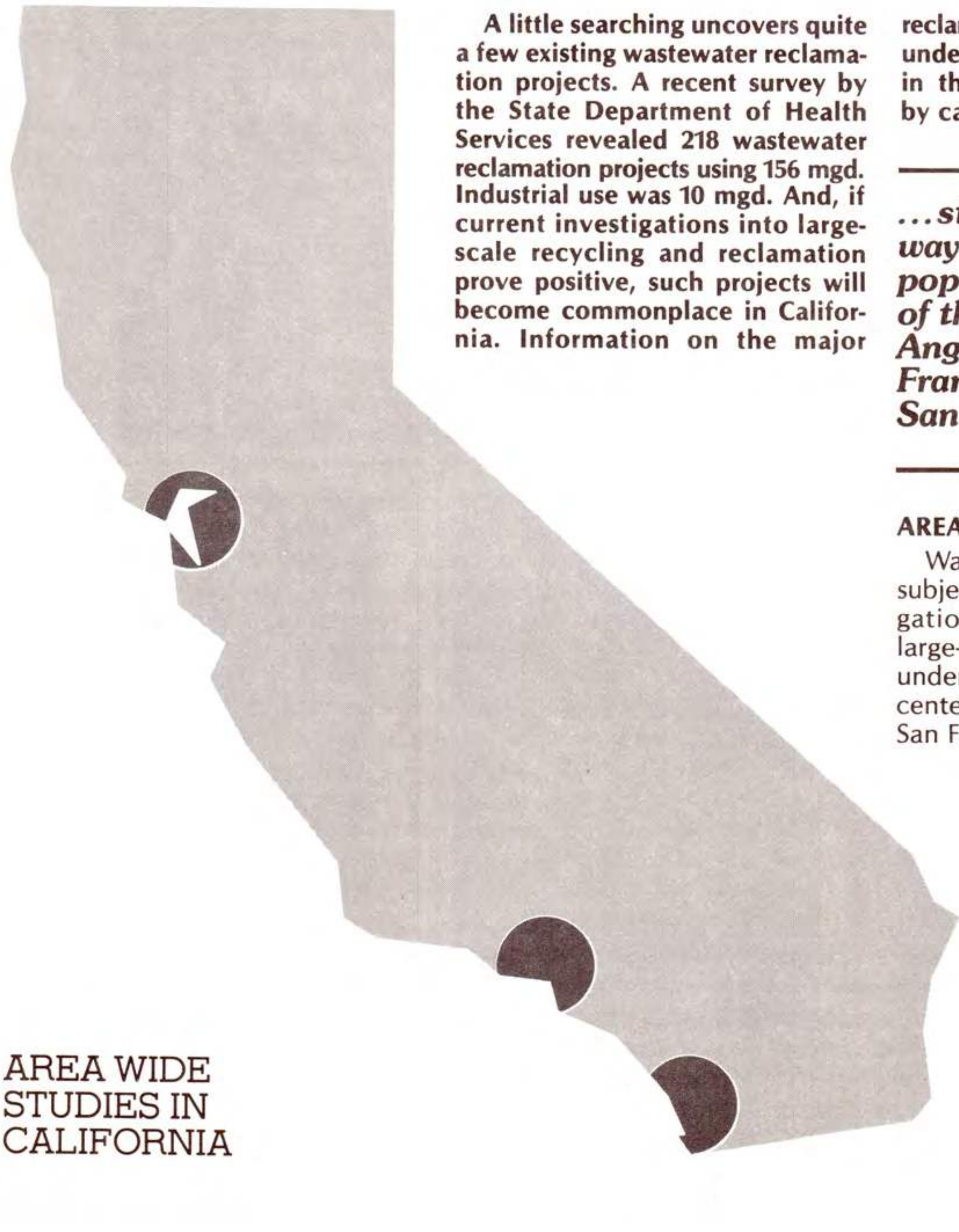


FIGURE 5. **AVERAGE WATER COSTS**

Current Activities
in Water Recycling



AREA WIDE STUDIES IN CALIFORNIA

A little searching uncovers quite a few existing wastewater reclamation projects. A recent survey by the State Department of Health Services revealed 218 wastewater reclamation projects using 156 mgd. Industrial use was 10 mgd. And, if current investigations into large-scale recycling and reclamation prove positive, such projects will become commonplace in California. Information on the major reclamation investigations currently underway in California is contained in the following pages, followed by case studies of three projects.

...studies are underway in the major population centers of the State—Los Angeles, San Francisco, and San Diego.

AREAWIDE STUDIES

Water reclamation has been the subject of a wide variety of investigations and projects. Currently, large-scale reclamation studies are underway in the major population centers of the State—Los Angeles, San Francisco, and San Diego.

Orange and Los Angeles Counties Water Reuse Study

In the Los Angeles area, six local agencies have joined with State and Federal agencies to undertake an extensive water reclamation evaluation. One major goal of the Los Angeles-Orange County study is to implement water reclamation projects as rapidly as possible. Near-term projects are expected to provide 40-85 mgd of reclaimed wastewater. The study will also address the marketing, engineering, institutional, financial, and legal aspects of implementing large-scale water reclamation projects in Southern California.

One major goal... is to implement water reclamation projects as rapidly as possible.

San Francisco Bay Area Regional Water Reuse Study

To study the potential for large-scale reuse of Bay Area wastewater, seven of the largest water and wastewater agencies from the area, plus State and Federal agencies, have joined forces. The study will be accomplished in two phases—Phase 1, which started in September 1978, and Phase 2, which will begin in the spring of 1979.

...seven of the largest water and wastewater agencies, plus State and Federal agencies, have joined forces.

Phase 1 will identify the major potential reuse markets for Bay Area wastewater. In Phase 2, markets will be evaluated for agricultural use (primarily on nonfood crops), powerplant cooling, and flow augmentation in the Sacramento/San Joaquin Delta. This flow augmentation would release high quality water for transportation through the California aqueduct to the central and southern parts of the State. Specific locations and quantities of demand for reclaimed wastewater will be identified. Sensitivity of demand to variation in water quality will also be examined.

San Diego Areawide Wastewater Reclamation Study

San Diego has begun a program to implement reclamation projects. The major issue is the possible degradation of ground waters. The study is expected to result in projects delivering 18-35 mgd for agriculture and landscape irrigation.

Pocatello Reuse Project

REUSE PROJECTS

Water reuse has been successfully accomplished in a wide variety of industries and geographical areas. Selected wastewater reclamation projects are described in the following pages. Note that in some cases industry is the supplier of wastewater for reuse; in others, it is the user of wastewater.

The Southeast Idaho Council of Governments (SICOG) instituted an areawide water quality management program in 1975. The planning area concentrated on six counties in the southeast portion of the State. Pocatello is the largest city and the Portneuf River the largest water source in the planning area. The focus of the water quality program was the Portneuf River and three point source discharges into it just northwest of Pocatello. The dischargers were the City of Pocatello, J. R. Simplot Company, and the FMC Corporation. In 1972, Pocatello, as a result of the more stringent effluent standards of the WPCA Amendments, had upgraded its wastewater treatment plant to include secondary treatment. In 1975, all three of these dischargers were exceeding the limits of their NPDES permits. SICOG, as the chief coordinating agency, funded a "Joint Wastewater Treatment Feasibility Study" with the City of Pocatello and the J.R. Simplot Company.

...using wastewater to irrigate and fertilize the fields was attractive to both the dischargers and the farmers.

The Portneuf River, which was classified for full body contact, did not meet the State's antidegradation guidelines for water quality. The City of Pocatello's Secondary Wastewater Treatment Plant (6 mgd) discharges into the river were high in BOD. The Simplot Company (14 mgd), a manufacturer of fertilizer, exceeded its NPDES permit for phosphorus, ammonia, organic nitrogen, and fluoride. The FMC Corporation (1.7 mgd), a manufacturer of elemental phosphorus, exceeded its temperature limits.

In its study of joint treatment systems, SICOG evaluated three possible alternatives:

- Joint treatment at the Pocatello Plant.
- Upgrading the plant to include physical/chemical treatment.
- Individual treatment at existing plants with joint disposal by land application.

The first choice was rejected because water quality standards would not be met. The second and third choices were looked at more closely. Both were viable solutions to the water quality problem. The land application was more attractive because it was both cost-effective and a potential resource for the agricultural area.

The planning area is predominantly an agricultural area which supports crops such as grains, alfalfa, potatoes, and sugar beets. With the average rainfall only 11 inches per year, irrigation is a necessity during the summer months. Droughts and heavy irrigation keep the Portneuf River low. The possibility of using wastewater to irrigate and fertilize the fields was attractive to both the dischargers and the farmers.

Simplot funded an agricultural study conducted by the University of Idaho. The University tested three agricultural plots during one growing season:

(1) normal irrigation water used,
(2) irrigation water and commercial fertilizer used, and
(3) wastewater effluent used.

TOP: The untreated control plots (shown at left) at Simplot Company's Pocatello irrigation site produced an average yield of 1.8 tons per acre, while the plots irrigated with effluent (shown at right) produced an average yield of 4.1 tons per acre. Over the past 3 years, the tonnage from the effluent plots has averaged almost double that of the untreated plots.

LEFT: Simplot's 15-million-gallon surge pond (shown during construction) serves as an interim storage and mixing area for the industrial effluent preceding irrigation.

The results showed the greatest crop yield in areas irrigated and fertilized by the wastewater effluent.

Seven thousand acres of privately owned agricultural land, of which approximately one-half was inaccessible to irrigation waters, was chosen as an experimental land application site by SICOG. This plan site was located 6 miles from the treatment plant, northeast of Pocatello. The cost for a full capacity, year-round system including pipelines, sprinkler irrigation systems, onsite storage lagoons, site preparation, and project design was estimated at $6 million.

The first step will cost $3 million. When completed, both Pocatello and Simplot will irrigate the area in the summer. Simplot effluent will be held in storage in the winter months and Pocatello alone will be discharging, within permit limits, into the Portneuf River. In the second step, there will be zero discharge into the river. Year-round storage and irrigation will be used by both Pocatello and Simplot.

...results showed the greatest crop yield in areas irrigated and fertilized by the wastewater effluent.

The funds for this project were shared by the City of Pocatello and the Simplot Company. Part of the funds will be recovered by assessing fees to the farmers for their share in the use of wastewater for irrigation and fertilizing. The price of water purchased from the Fort Hall Canal averaged only $13 per acre per year, while the price of nitrogen fertilizer averaged $50 per acre per year for the farmers in the area. With droughts limiting their water supply and with the price of fertilizers increasing each year, the advantages to land application of wastewater were numerous. Formerly unused acreage could now be used for growing crops. The City of Pocatello and the J. R. Simplot Company were able to bypass costly modifications to their treatment plants. When the plan is fully operational, there will be zero discharge into the Portneuf River.

Burbank Power and Light Reuse Project

The Burbank Power and Light Reuse Project is a situation where industry uses wastewater for cooling tower make-up water. About 10 years ago, the City of Burbank was exporting more sewage than it had contracted for with the City of Los Angeles. To cut down on the cost of exporting sewage and to conserve water, Burbank built a sewage treatment facility providing secondary treatment. The effluent goes to the Burbank Power and Light generating station located less than a mile from the treatment plant. The reclaimed water reaches the power facility by gravity flow. The power facility has 250 megawatts of generating capacity and uses approximately 1.3 gallons of cooling tower make-up per kilowatt hour generated. Since the sewage treatment plant has approximately 7 million gallons per day capacity, the total outflow from this secondary plant can supply the powerplant with all its cooling water requirements in normal operation.

The cost of city water varies greatly from reclaimed water. City water currently sells at 41.4¢ per 1,000 gallons; reclaimed wastewater is priced at 7.7¢ per 1,000 gallons. The cost of treatment of the reclaimed wastewater is estimated at 1.6 mils per kilowatt hour. The following table shows the cost savings from using reclaimed wastewater for the month of May 1978 when 29 million kilowatt hours were generated.

Operation and maintenance costs, with the exception of water treatment costs, have not varied greatly with the change in cooling water supply. There have been no major changes in cooling tower maintenance requirements. One reason why maintenance may not have changed at the powerplant is that the circulating water system has a high velocity which inhibits scaling.

TABLE 4
COMPARISON OF COST, Freshwater and Reclaimed Wastewater,
Cooling Water at Burbank Power and Light, May 1978

	Freshwater	Reclaimed Wastewater
Plant Output (kWh)	29×10^6	29×10^6
Water Use* (gallons)	29×10^6	37×10^6
Water Purchase Rate (per 1,000 gallons)	$0.414	$0.077
Treatment Rate (per kWh)	$0.0002	$0.0003
Water Purchase Cost	$12,000	$2,800
Treatment Cost	$5,800	$8,700
Total Water Cost	$17,800	$11,500

**Freshwater use is 80% of reclaimed water use, or one gallon per kilowatt-hour generated.*

City water sells at 41.4¢ per 1,000 gallons; reclaimed wastewater at 7.7¢...

This is not to say that problems do not occur when reclaimed wastewater is used. Major problems occur when the biological treatment unit of the sewage treatment plant is upset by toxic substances. Since the powerplant does not monitor the quality of its influent, it finds out too late that it has taken into the cooling system a slug of water high in dissolved solids or biological material. These occasional slugs have caused slime problems in cooling systems. However, the Burbank sewage agency has begun a program to eliminate the discharge of toxic substances to the sewer system.

The operation at Burbank Power and Light is a simple cooling process. The secondary effluent is discharged into the cooling tower, where it is chemically treated to control pH, scaling, hardness, and coliform. The wastewater is concentrated about 2½ cycles in the cooling system before discharge to the storm drain system in the area. Chemical treatment requirements are based upon both the quality of the influent water to the powerplant and the effluent discharge limitations.

Influent quality to the plant is not constant. Since the Burbank water system at times uses Colorado River water, at other times State Water Project water, and at other times local groundwater sources, dissolved solids vary greatly—from 300 to 900 mg/l. Thus, the chemical treatment at the powerplant must take into account the quality of the effluent from the treatment plant on any particular day or hour.

The use of reclaimed wastewater allows Burbank Power and Light great flexibility in its water purchasing agreements. For example, during its current operation, when it is operating at only 15 percent of capacity, the reclaimed wastewater can be diverted past the powerplant directly into the drainage system.

Simpson Paper Company

Simpson Paper Company's Shasta Mill, near Anderson, California, operates under some of the most stringent water quality regulations of any integrated pulp and paper mill in the United States. The regulations are tight because the mill discharges to the Sacramento River, a highly productive spawning ground for anadromous fish. In 1974, the plant was enlarged—the original paper machine was upgraded and a new paper machine was added. The discharge from the expanded mill could not be treated sufficiently to meet discharge standards—particularly total suspended solids (TSS) requirements. In anticipation, the Company investigated the use of secondary effluent for irrigating croplands.

In 1974, the plant was enlarged...

The Company owned suitable cropland which had about a 2.6-mile boundary along the Sacramento River. About 400 acres of this land had high permeability soil, which allowed rapid movement of the effluent percolate to the riverbed. Initial construction began in April 1975 with the moving of about 438,000 cubic yards of earth to produce the precise slopes and grades required for flood irrigation.

More than 19,500 feet of concrete cylinder pipe, ranging in diameter from 30 inches down to 12 inches was laid. About 470 automatic irrigation valves were installed, each capable of delivering up to 1,200 gallons per minute (gpm). These valves are of polyolefin construction, with the opening and closing action being controlled by admission of low-pressure air to a rubber bladder inside the valve dome. Sixteen valve timers are used on three irrigation mains. The timers have 11 ports or vents, each port activating from one to four irrigation valves in a programmed sequence. After each timer has cycled through its 11 ports, an electrical signal is sent to the next timer, which may be 1,000 feet or so down the main. In actual practice, the flow from each irrigation valve is limited to about 500 gpm. This occasionally requires two or more timers to be energized simultaneously.

From 15 to 40 percent of the effluent discharged from the pneumatically operated irrigation valves eventually reaches the lower end of the fields, where it is conveyed in earthen ditches to a common "Return Flow Sump." A pump, with automatic level control, recycles all surface runoff of effluent and natural rainfall back to the croplands via a "Return Flow Main," also equipped with automatic valves.

The project also included more than 50 test wells to monitor ground-water composition and movement.

Passage of the effluent through the soil removes the BOD_5 (5-day Biochemical Oxygen Demand) and essentially all of the COD (Chemical Oxygen Demand), including the color bodies. Since some of the sodium ions in the effluent are exchanged with calcium and magnesium in the soil, the chloride ion is used as the effluent tracer in the test wells.

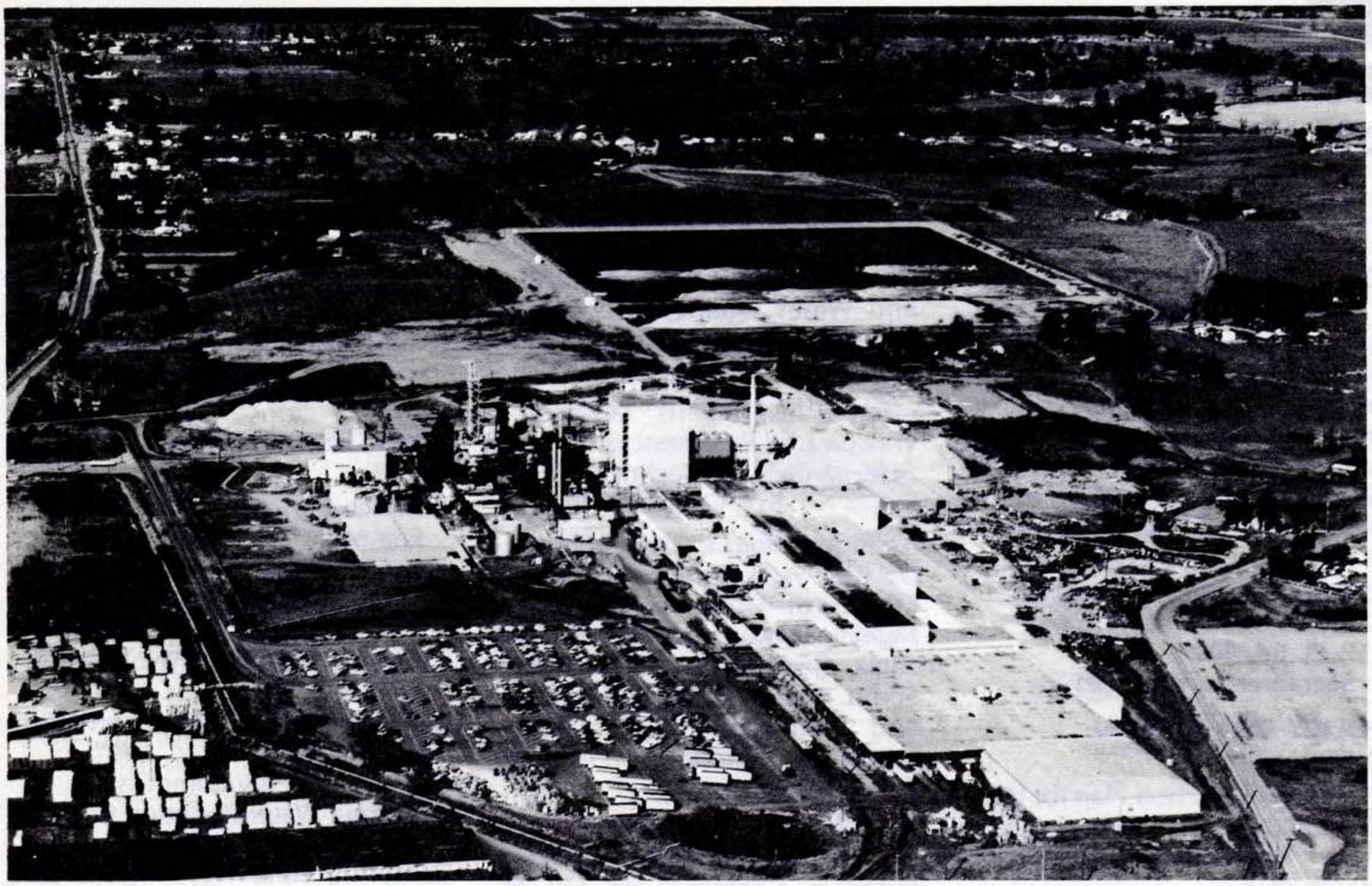
To allow flexibility in the irrigation schedule, one stabilization basin was oversized to provide up to 40 million gallons of effluent storage.

The first effluent irrigation was in January 1976...

In November 1975, about 260 acres were seeded to hybrid wheat and about 140 acres to red oats. The first effluent irrigation was in January 1976, and continued regularly throughout an abnormally dry winter and spring. Field corn and a few experimental rows of sweet corn were seeded to the harvested wheat fields. The crop yields were:

Crop	Yield Per Acre (pounds)
Oats (as hay)	7,800
Wheat (as grain)	3,900
Field corn (as grain)	6,700

In Northern California, 1976 was an uncommonly dry year, with the manmade reservoirs dropping to all-time low levels. As a result, the Sacramento River flows during most of the last quarter were below 5,000 cubic feet per second, requiring the Shasta Mill discharge to meet the most stringent condition prescribed in its discharge permit. During this 90-day period, about 383 million gallons of effluent were applied to the 400 acres that had been prepared for this purpose. This is the equivalent of 35 inches of rainfall and occurred during a period when evapotranspiration



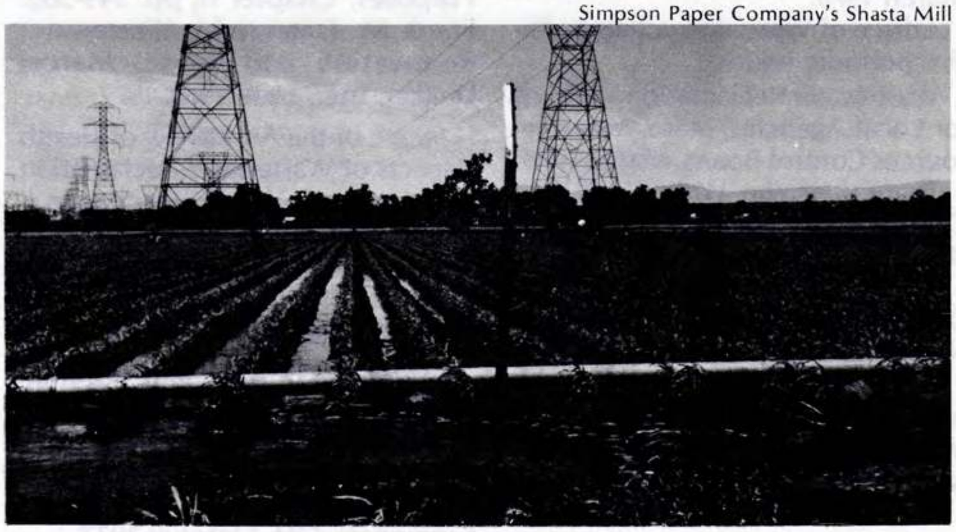
Photos Courtesy Simpson Paper Co.

Simpson Paper Company's Shasta Mill

totaled less than 4.5 inches.

In the first 13 months of operation, the fields received a total of 1.03 billion gallons of effluent. Some soils now show a slight deficiency of calcium and magnesium due to a displacement by sodium from the effluent. This will be corrected by the addition of gypsum or dolomitic limestone.

Simpson Paper Company, Shasta Mill, considers its effluent irrigation project to be a complete success. It is believed that, under proper management, any crop normally grown in the area with freshwater irrigation can also be grown with the treated effluent.



The Simpson Paper Company mill at Anderson, California produces reclaimed water for irrigation of 650 acres of cropland. The fully automated flood irrigation system is used to apply the wastewater to crops.

Sources
of Information

OFFICE OF WATER RECYCLING

The Office of Water Recycling is available to assist the industrial community in developing water reclamation projects. Any company interested in further information or help on technology, financing, health effects, or other related areas of water reclamation should contact:

Office of Water Recycling
Information Transfer Unit
P. O. Box 100
Sacramento, CA 95801

POLICY AND GENERAL INFORMATION

Policy and Action Plan for Water Reclamation in California, State Water Resources Control Board, March 1978.

Office of Water Recycling Bulletin; periodic issues.

Wastewater Reclamation: A Guide for Local Agencies, State Water Resources Control Board, March 1978.

Journal of the Water Pollution Control Federation, June 1978 issue: "Literature Review."

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Environmental Pollution Control Alternatives; No. 5012, USEPA, Cincinnati, OH, September 1976.

Physical-Chemical Wastewater Treatment Plant Design; No. 4002, USEPA, Cincinnati, OH.

AGENCIES INVOLVED IN WATER REUSE

American Institute of Chemical Engineers
American Water Works Association
California Association of Reclamation Entities of Water
California Department of Health Services
California Department of Water Resources
California Energy Commission
California Water Pollution Control Association
California State Water Resources Control Board
Office of Water Research and Technology
U. S. Bureau of Reclamation
U. S. Department of Energy
U. S. Environmental Protection Agency
Water Pollution Control Federation
Regional Water Quality Control Boards
—North Coast Region (1)
—San Francisco Bay Region (2)
—Central Coast Region (3)
—Los Angeles Region (4)
—Central Valley Region (5)
—Lahontan Region (6)
—Colorado River Basin Region (7)
—Santa Ana Region (8)
—San Diego Region (9)