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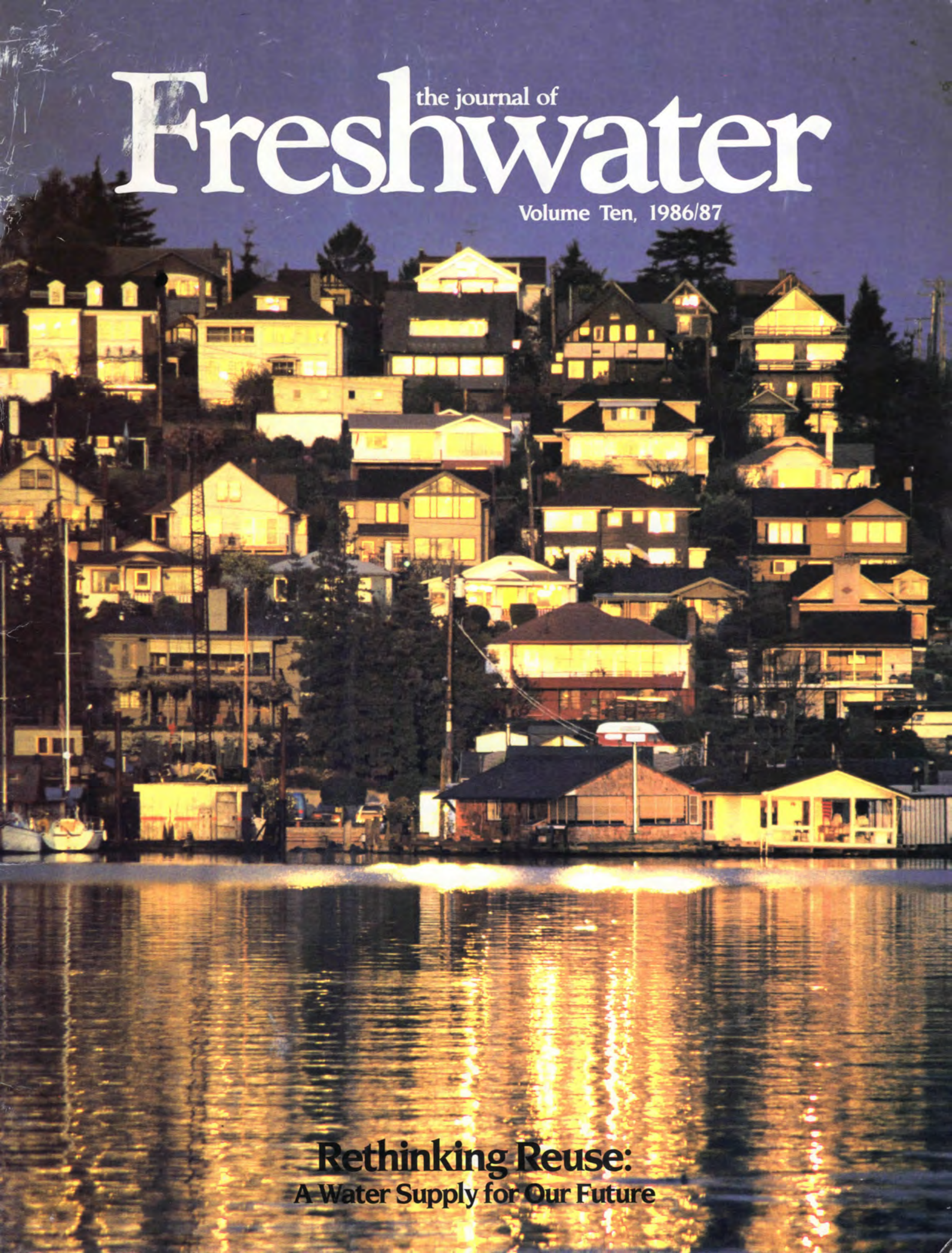

Rethinking Reuse:
A Water Supply for Our Future

the journal of
Freshwater

Published by the Freshwater Foundation for members of the Freshwater Society

Comment by the Editor

As we face the challenge of meeting growing water demands with less water, this year's *Journal* focuses on reuse as a viable "new" source of water supply.

A five-part overview of water reuse begins by looking at our growing water needs and suggests ways to extend limited supplies. Part II defines water reuse and provides a brief look at the history of this age-old concept. Part III focuses on reuse issues: public health, public attitudes and economics. Part IV highlights a number of reuse initiatives being undertaken by agriculture, industry, municipalities, the federal government and the private sector. Part V looks ahead to assess the future of water reuse.

Through this overview, the *Journal* seeks to assist in the process of "rethinking" reuse as a water supply for our future.

Linda Schroeder

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The Freshwater Foundation is a nonprofit corporation which built and equipped the Gray Freshwater Biological Institute, an international research center devoted to the multi-disciplinary study of the complex problems of freshwater. In 1976, the Institute was donated to the University of Minnesota. The Foundation continues to fund and support research as well as national and international information/education programs.

The Freshwater Foundation translates and interprets freshwater issues and their implications for the public through conferences, publications, and television and radio programs on all aspects of freshwater issues.

The Freshwater Society, formed in 1977, is an international membership organization which supports both freshwater research and public information programs of the Freshwater Foundation.

Journal of Freshwater Volume Ten, 1986/87

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Gray Freshwater Biological Institute

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The *Journal of Freshwater* is published by the Freshwater Foundation for members of the Freshwater Society. All editorial materials should be sent to the *Journal* Editor, 2500 Shadywood Road, Box 90, Navarre, Minnesota U.S.A. 55392. We cannot accept responsibility for unsolicited manuscripts, photos or artwork. All editorial submissions must be accompanied by a stamped, self-addressed envelope.

Perspective

Water resources have long determined the pattern of industrial, agricultural and municipal development in the United States. One-fifth of all U.S. industry is located in the Great Lakes region, in an area of the country long valued for its natural abundance of surface water and groundwater. On the other hand, it took massive, federally funded dams and water delivery systems to encourage development in the Western and Southwestern regions of the United States.

Now, the flow of many rivers is already allocated, competition for surface water supplies has intensified, and the increased use of groundwater has led to the overdrafting of 25 percent of the nation's available supplies. No new sources of water exist that haven't been claimed or aren't currently needed by someone, somewhere. By the year 2000, the Water Resources Council has estimated severe shortages of surface water and groundwater.

Complicating the issue of the quantity of available water supplies is the ever-increasing contamination of surface water and groundwater. As private and community wells are closed due to groundwater contamination, cities and individuals are forced to look for alternative sources, further intensifying competition for remaining supplies.

Current water policies, laws, management and engineering practices are all geared to supplying more water to meet the growing demand. But the challenge of the future will be learning to live with less, managing demand and stretching water supplies through conservation, recycling and reuse.

Change is needed in the way we perceive and use our water resources.

Water conservation, recycling and reuse provide two increasingly critical functions: pollution control and a stable water supply. For example:

- Internal recycling of water dramatically lessens the discharge of pollutants to the environment.
- Water reuse provides the adequate treatment necessary to allow continuous use of the same water supply.
- A 10 percent reduction in water for irrigation could yield a 5 percent increase in total available water supplies.
- Using wastewater for irrigation can lessen the competition for water between cities and farms, especially in the West where farmland is currently being retired to ensure adequate groundwater supplies for growing Sunbelt cities.

Decreasing supplies of surface water and groundwater, as well as increasing regional competition, require a new perspective in water management. New challenges call for new attitudes, policies and procedures.

Change is needed in the way we perceive and use our water resources. As an educational foundation dedicated to preparing people for change, the Freshwater Foundation has chosen to highlight current industrial, agricultural and municipal responses to the challenge of meeting future water demand with less water. These case studies offer realistic examples of ways to ensure adequate water supplies — and the lifestyles they determine — well into the 21st century.

Christine Olsenius

Christine Olsenius
Vice President for Education
Freshwater Foundation

Photo by Annie Griffiths


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America's Water Needs: How To Stretch a Limited Supply

by Franklin D. Dryden

Ever-increasing demands for water throughout the country are stressing limited available supplies. To avoid future shortages, we can look to more efficient use — and reuse — of our water resources.

We all drink it, and wash our clothes, take a shower and maybe water the lawn or wash the car occasionally. That couldn't take very much water, could it? In fact, such domestic uses for water took about 110 gallons per person per day in the United States in 1975 — an astonishing total of more than 23 billion gallons per day used in this country for direct domestic purposes.

Now let's consider the water that supplies our other needs, like food, power and material goods. It takes 1.5 million gallons of water, for example, to produce a year's supply of food for just **one** person. And it takes 100,000 gallons of water to produce the steel for **one** car.

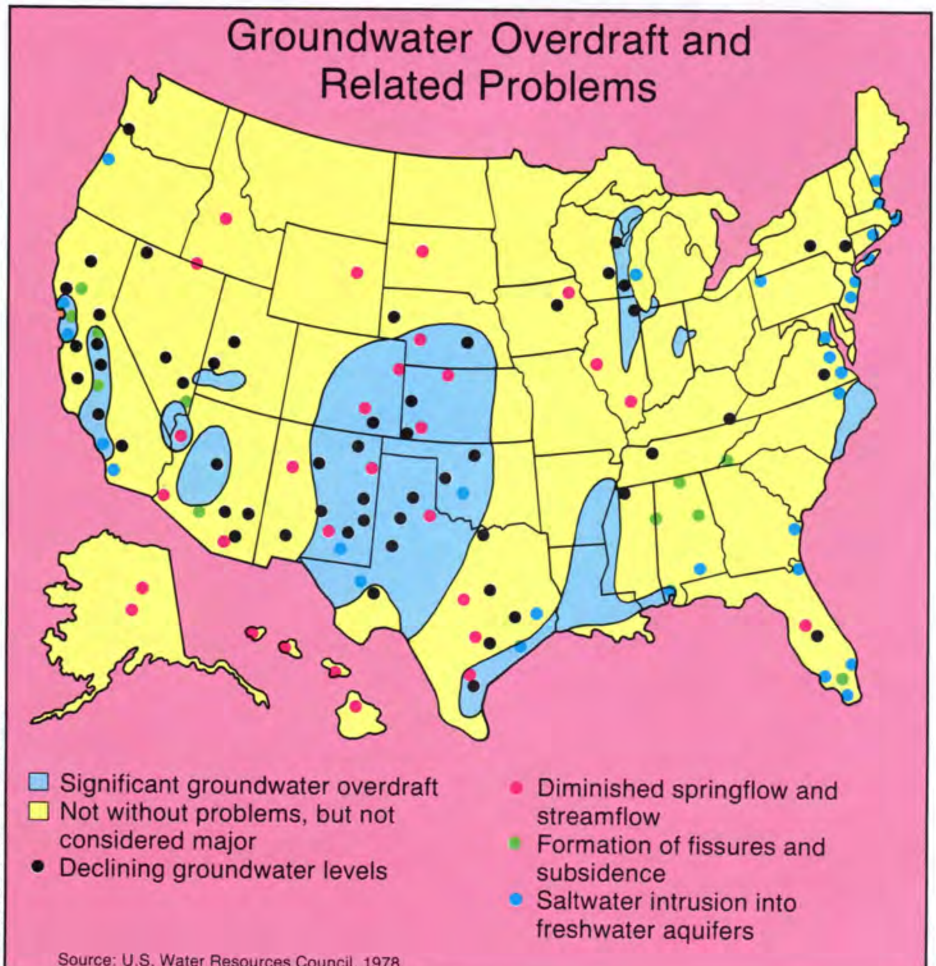
Domestic supplies — whose uses we can actually see and regulate in our homes — only accounted for about 6 percent of the freshwater withdrawn from lakes, streams and groundwater basins in 1975 to supply our total water needs of 335 billion gallons per day. As we continue to grow in numbers — from 213 million people in 1975 to an estimated 275 million in 2000 — our need for water grows proportionately.

Where Do We Get Our Water?

According to the most recent survey of the nation's water resources, the Second National Water Assessment prepared by the Water Resources Council (WRC) in 1978, about 75 percent of the withdrawals come from surface water and 25 percent from groundwater. The 675 billion gallons per day (bgd) considered to be available from rainfall in most years (95 out of 100) to fill lakes, reservoirs, streams and groundwater basins is about twice our total current usage and six times the rate of current consumption — but it doesn't always occur where we need it.

It takes 1.5 million gallons of water to produce a year's supply of food for just one person.

(Only about one-third of the water withdrawn is actually consumed. The rest flows back into rivers and streams from the discharges of power plants and municipal and industrial wastewater treatment plants.)



Freshwater Foundation/Joleen Ross

Is There Enough Water for Our Needs?

In many places, surface water is insufficient to meet demands and groundwater is being used at a faster rate than it is being replenished (overdraft). The National Water Assessment predicted a 10 percent decline in water withdrawals between 1975 and 2000, and a 30 percent increase in consumption during the same period. Data for 1980, however, indicate a 10 percent increase in withdrawals, with consumption staying steady at slightly more than 100 bgd. Based on the WRC predictions, severe shortages of both surface water and groundwater will occur by the year 2000.

Surface Water Depletions of 70 Percent...

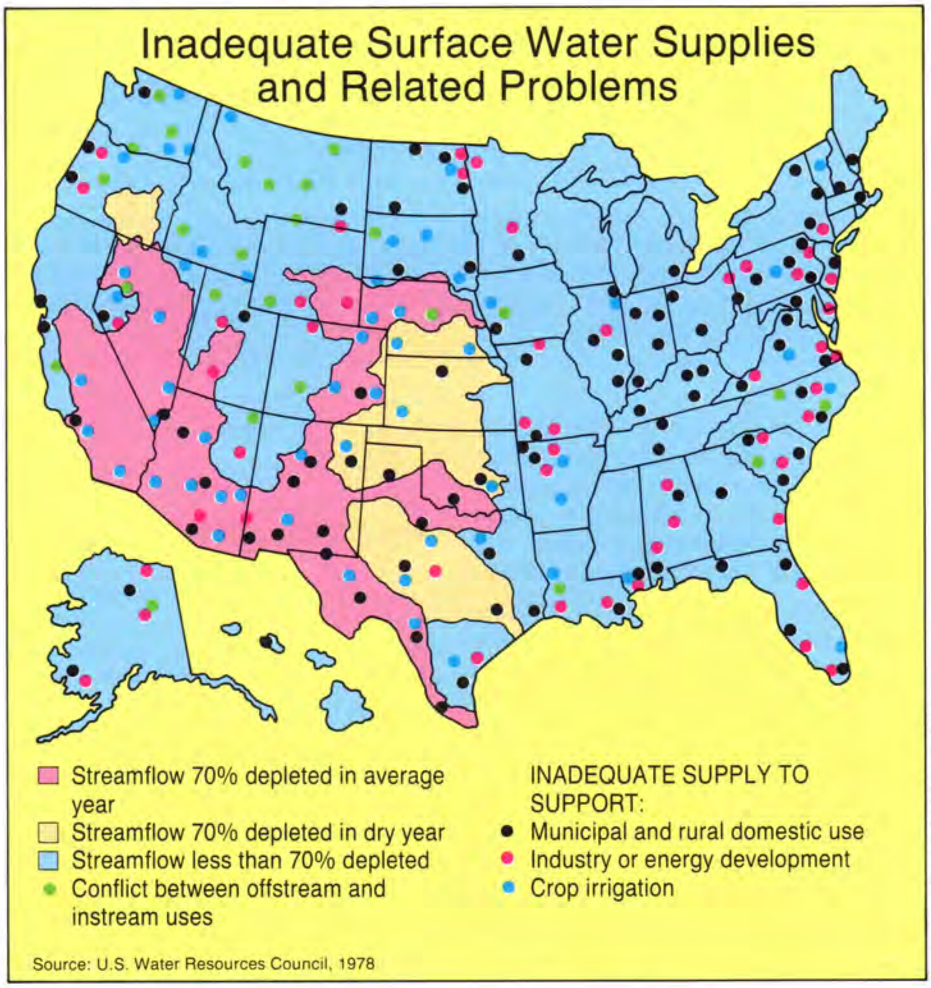
According to the WRC assessment, streamflows will be more than 70 percent depleted in parts of the country during normal and dry years. With 100 percent depletion meaning that a stream will be dry, a 70 percent depletion indicates severe impact on aquatic and wildlife habitats. In many specific locations throughout the country, water supplies are insufficient to satisfy offstream uses (municipal and rural domestic water supplies, industrial or energy development needs, and crop irrigation) or instream uses (fish and wildlife habitat, outdoor recreation, hydroelectric power generation and navigation).

...and Significant Groundwater Overdrafts

In 1975, 25 percent of all groundwater withdrawals were overdrafts, and reliance on groundwater continues to increase. Significant overdrafts are occurring in areas across the nation, and numerous localized problems include declining groundwater levels, diminished springflow and steamflow, subsidence, formation of fissures, and saltwater intrusion into freshwater supplies.

What Can We Do To Avoid Shortages?

The entire flow of many rivers has already been allocated to users. Opportunities for constructing new dams and water delivery systems are becoming economically and politically more difficult with time. It appears, then, that the most practical approaches to extending limited supplies include conservation, recycling and reuse.



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Conservation: A Cost-Effective Approach

Conservation is one of the least costly and most effective methods of meeting

A 10 percent reduction in irrigation demands (which represent more than 50 percent of total use) would be equivalent to increasing total supplies by 5 percent.

projected water demands. Techniques include such modern agricultural practices as drip irrigation, determining crop water requirements and controlling application rates. A 10 percent reduction in irrigation demands (which represent more than 50 percent of total use) would be equivalent to increasing total supplies by 5 percent.

A great deal of water can also be saved by controlling leaks and evaporative losses throughout municipal and irrigation water storage and conveyance systems. About 1 percent of total withdrawals can be saved by the relatively painless use of water-saving devices on toilets and showers. Even larger savings can be achieved by installing water meters in cities where water use is at present unmetered.

Recycling: "In-House Reuse"

Recycling refers to the industrial practice of using water several times over, with or without some internal treatment, prior to its discharge to a sewerage system or watercourse. In 1975, the average industry used its water twice before discharging it. Higher water costs and more stringent industrial wastewater treatment requirements could encourage industry to recycle a particular water supply as many as nine times by the year 2000.

Water Reuse: Reclaiming a Used Supply...

Water reuse is defined as the use, by someone other than the discharger, of previously used and contaminated water, after treatment to the degree necessary for its intended beneficial use. In 1975 there were 536 reuse projects reported in the United States.

Of this total, 470 involved either agricultural or landscape irrigation, 29 were industrial, 11 involved groundwater recharge and 26 included such miscellaneous activities as recreational lakes. Although reuse projects are broadly distributed across the country, the majority are in California, Texas and Arizona.

...To Meet Future Demands

By the year 2000, wastewater from municipal, industrial and steam electric power sources is expected to reach over 100 bgd, with about 25 percent from municipal sources.

With shortages in surface water and groundwater already severe in many areas, and with shortages growing more pervasive as population increases, such wastewater resources will indeed be perceived increasingly as **resources.** Conservation, recycling and reuse appear capable of stretching limited supplies to meet growing demands for water in the future.

Franklin Dryden has worked on numerous water reuse projects both as an independent consulting environmental engineer and during his 22 years with the Los Angeles County Sanitation Districts. He is a charter member and past chairman of the Water Reuse Committee of the Water Pollution Control Federation.

Rethinking Water Reuse

by Linda Schroeder

Reuse is not a new concept. Most of the water available to us has been "used" over and over again for centuries, without our being aware of it. What *is* new is the increasing awareness that planned reuse can help to assure sufficient water supplies for the future.

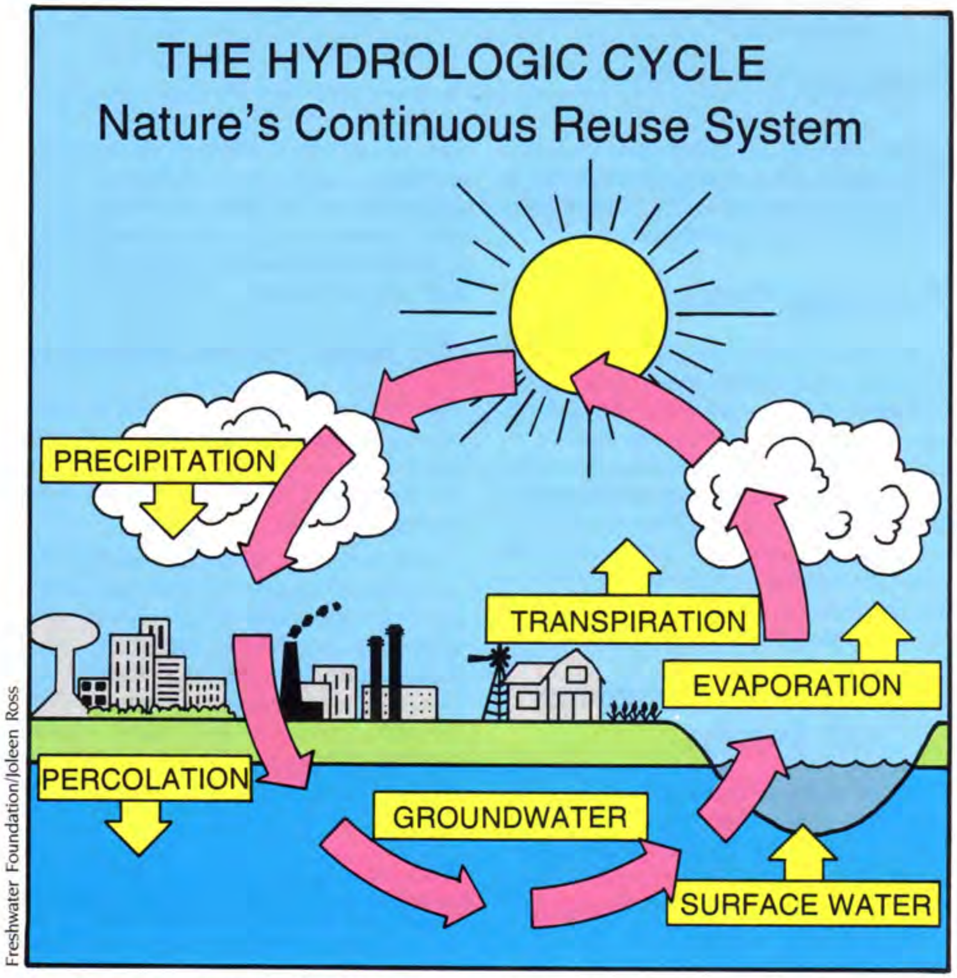
What is water reuse? It's what each of us does every time we drink a cup of coffee, take a shower, wash a car, fish in a lake or flush a toilet. It happens in power generation, manufacturing, irrigation, and transportation of people and commodities.

Whenever we use water in our daily activities, we're taking part in water reuse, because all of the water available to us today has been used and reused again and again thanks to the hydrologic cycle, nature's world-class — and world-size — reuse system. The water we drink, flush, or water our lawns with all re-enters the water system sooner or later, cleansed by nature or by human processes, to be used again.

"It's Nothing New"

So water reuse is nothing new to any of us. It's an essential part of our everyday lives. But this kind of reuse is pretty roundabout: It's indirect and unplanned — it just happens.

Increasingly, though, water reuse is purposefully planned and implemented. And it's often a direct reuse, one which avoids going back through the hydrologic cycle.



Reuse is not a new concept. All of the water available to us today has been used and reused again and again, thanks to nature's own reuse system — the hydrologic cycle.

To best understand what reuse is, we must first understand what it is we're reusing: wastewater. **Wastewater** is water that has been previously used and has usually suffered a loss of quality as a result of that use. And what happens to the wastewater? **Wastewater reclamation** is the treatment or processing of wastewater to make it usable again for some purpose.

Wastewater treatment consists of three basic processes:

- **Primary treatment** of sewage removes material that floats or settles.
- **Secondary treatment** introduces bacteria which consume the organic parts of the wastes.
- **Tertiary (or advanced) treatment** removes nutrients (such as phosphorus and nitrogen) as well as specific pollutants through various chemical, physical and biological processes.

This treatment process produces **reclaimed water**, which is sewage **effluent** (the liquid that comes out of a treatment plant) or other wastewater treated to meet the quality required for a particular reuse. And finally, **water reuse** is the use of this reclaimed water for a variety of purposes.

Unplanned or Planned?

As mentioned earlier, much water reuse is **unplanned** or inadvertent: Someone takes water from a particular water source (surface water or groundwater), uses it and returns it to the source without planning on it being used by someone else — although it is. We all practice this **indirect** reuse of water, when water is used, returned to the hydrologic cycle, naturally cleansed and then withdrawn for use — **reuse** — by someone else.

Of growing interest today, however, is the concept of **planned reuse**. Instead of discharging sewage effluent to a river or other water body, the treated wastewater is made available on purpose for some subsequent use. In this **direct reuse**, the wastewater goes directly from the treatment plant to the site of another specific intended use, without being returned to its original source for natural purification and dilution.

Recycling is a special kind of reuse, but the terms are not synonymous. **Recycling** usually involves running a supply of treated wastewater — or freshwater — through one user's closed system again and again. It's an example of planned, direct reuse that involves only one user, usually an industrial user. (A car radiator and cooling system is a good example of recycling water.)

To Drink or Not To Drink

Most direct reuse of water is for **nonpotable** or nondrinking purposes, which can include landscape watering, fire protection, industrial cooling, agricultural irrigation and power generation. **Potable** reuse, on the other hand, refers to using a reclaimed supply as drinking water.

Unplanned, indirect potable reuse is not uncommon: An upstream city empties its treated effluent into the river, where it later becomes the drinking water supply for a downstream city. And planned, indirect potable reuse is practiced in a number of areas, where reclaimed wastewater is injected into a groundwater source to supplement future drinking water supplies.

All of the water available to us today has been used and reused again and again.

The "new frontier" of water reuse is the study of planned, direct potable reuse, where wastewater is treated for direct discharge into a drinking water supply. Short-term instances of direct potable reuse have occurred in this country, and a major pilot project is in place to study the feasibility of large-scale direct potable reuse.

"Too Good To Waste"

Traditional perceptions of water supply (that there's plenty for everybody, and there always will be) have encouraged a use-it-once-and-get-rid-of-it attitude. Instead, as water supplies become increasingly limited, a wise approach will be to mimic nature and the hydrologic cycle, by viewing water as a "cyclical resource" to be used, cleansed and reused.

Wastewater is a potentially valuable resource, a resource "too good to waste." Like manure, sewage effluent is a nutrient-rich commodity — a waste product with inherent value to lawns, golf courses and agricultural crops. Why spend the money and energy to remove all those nutrients to meet wastewater discharge standards when they represent a **value** to another user?

Freshwater Foundation photo

Sewage effluent and sludge are increasingly being recognized as nutrient-rich commodities —waste products with inherent value to lawns, golf courses and agricultural crops.

Benefits of Water Reuse

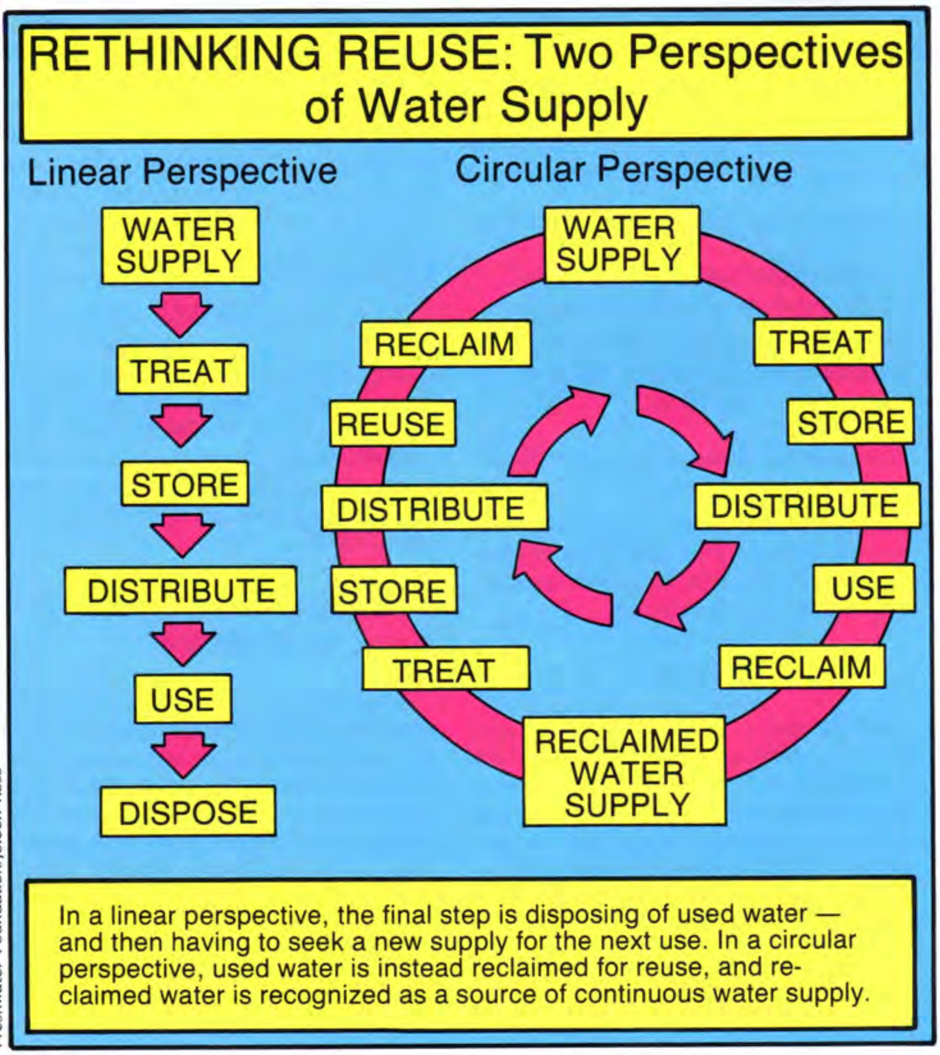
- Reclaiming water for nonpotable uses reduces the stress on potable freshwater supplies needed for drinking. Toilets, carwashes and industrial cooling plants need water — but they don't need potable water.
- Reclaiming water reduces the discharge of pollutants into the environment, reducing the stress on sensitive surface waters.
- Reclaiming water has economic benefits. Wastewater disposal costs are reduced, energy is saved, capital costs of expanded treatment plants can be deferred, and, in some cases, income is derived from the sale of effluent.

The Role of Reuse

Reuse is not a magic answer which will resolve all present and future water supply concerns. The viability of water reuse is site-specific: The proximity of the discharger and the potential user, the availability of other, more conventional supply sources, the economic benefits and liabilities, and the nature of regulatory guidelines and constraints all contribute to the feasibility of a potential reuse initiative. And the assurance of public health and assessment of public response are the most critical components of any reuse effort.

Reuse is not a new concept. It's a natural part of our daily interaction with the hydrologic cycle: It's just the way water works.

Increasingly, though, society is recognizing reuse as a concept of nature that human technology can learn from, as we seek to make the most intelligent use — and reuse — of our limited water supplies.



In a linear perspective, the final step is disposing of used water — and then having to seek a new supply for the next use. In a circular perspective, used water is instead reclaimed for reuse, and reclaimed water is recognized as a source of continuous water supply.

Freshwater Foundation/Joleen Ross

Linda Schroeder is editor of the *Journal.*

Water Reuse Past and Present: It's Been Common Sense for Centuries

by Sherwood C. Reed

Planned reuse of water likely dates back to prehistoric times. Awareness of this history makes clear that present reuse initiatives are no more than logical steps in our continuing understanding that wastewater is a usable resource.

It is likely that the first instance of water reuse was for agricultural purposes, and it may have happened soon after our ancestors left their caves and took up farming. These prehistoric reuse experiences developed into highly organized, managed systems. It is believed that ancient Greece and Rome used wastewater in their irrigation systems. The method has also persisted in a number of Asian countries where wastes are routinely collected for direct reuse in agriculture.

Early Municipal/ Agricultural Cooperatives

The first documented municipal wastewater reuse system in Europe was at Bunzlau, Germany. That community had a functional wastewater irrigation system in 1531 which continued in successful operation for at least 400 years. Another early example was the Crargentinny Meadows, near Edinburg, Scotland, where wastewater from the city was used for irrigation of vegetables starting in about 1650.

The convergence of a number of factors in the 1840s encouraged the agricultural reuse of water in England and other European countries. The cities were larger, and pressurized water distribution was becoming possible.

Making the Sewage/ Disease Connection

In 1841, Sir Edwin Chadwick recommended that all houses be connected to sewers and that the collected wastewater be pumped to the fields for agricultural reuse. The first system of this type was established at Rugby, England, in 1853. Although the existence of pathogenic bacteria was not yet known, opinion was growing that water contaminated with sewage was somehow responsible for diseases. The only apparent way to protect drinking water sources was to eliminate direct discharges by conveying the wastewater to sewage farms for reuse.

For the balance of the 19th century, consensus prevailed among engineers and public health officials that these sewage farms offered the most positive protection for water supplies and the greatest potential for beneficial reuse of the waste constituents. Large-scale, well-engineered systems were built in Berlin, Paris, Mexico City, and Melbourne, Australia, during the period from 1869 to 1900. The first such system in the United States was constructed in 1872 in Augusta, Maine.

The Theories of Disinfection...

This method of water reuse began to decrease, however, in the early 20th century. Cities grew even larger, development encroached on sewage farms, land costs increased, and, due to poor planning, it was not possible to further expand the systems. In addition, the germ theory was well defined and the advantages of filtration and disinfection for water supplies were becoming recognized.

One-third of all Americans depend on municipal water supplies containing one gallon of wastewater for every 30 gallons of flow.

...and Dilution

The capability to effectively treat and disinfect drinking water supplies and thereby protect public health soon led to the conclusion that it was probably all right to discharge untreated or partially treated wastewaters to streams, depending on the dilution available. By 1930, the prevailing "rule of thumb" in the United States was to allow discharge of raw sewage with a dilution ratio of 100 to 1.

By 1940, the only application systems still in use in the United States were found in warm, arid and semi-arid climates where the water itself had some real value and winter conditions did not interfere with year-round operations. That situation prevailed until passage of the 1972 amendments to the Federal Water Pollution Control Law. The goal of the law was to eliminate pollution of surface waters and to capitalize on reuse/recycling benefits by applying the wastewater to land. The use of this technology has increased dramatically since 1972, due in large part to federal encouragement and funding incentives.

The Economics of Industrial Reuse

The driving force for industrial and commercial reuse of water has probably always been economics. Possibly the first (and still the largest) such reuse was for cooling. Some early blacksmith must have discovered it was easier to keep a tub of water in the shop and use it over and over again, than to continually run out to the stream in back. Reuse of cooling water developed prior to federal involvement or regulation and will probably continue and expand on its own since in many cases it is the most economical option available.

The major incentives for water reuse in manufacturing are also economic, but to a large degree they have been imposed by regulation of water quality discharge limits. As these discharge limits have become more stringent, it has become more economical to conserve and reuse water, where possible, than to treat and discharge it.

Potable Water Reuse: An Age-Old Practice

Potable water reuse has in the broadest sense been a practice ever since there was an upstream discharge and a downstream water use on the same river. This indirect water reuse is much more prevalent in the United States than the public realizes or than many regulatory officials care to admit.

According to a 1971 National Technical Information Service estimate, one-third of all Americans depend on municipal water supplies containing one gallon of wastewater for every 30 gallons of flow.

In periods of low flow, the report suggests, previously used water may represent up to one-fifth of the total supply. More than 200,000 residents of Columbia, South Carolina, for example, get their municipal supplies from the Saluda River, whose flows are estimated to be 16 percent wastewater.

Unlike these instances of unplanned, indirect potable reuse, the history of direct planned potable reuse, where wastewater is treated to a suitable level and then returned to the water supply, is short, with only a few examples to date. The basic driving force is again economics. A community considers this option as a last resort only when other water sources are either economically or physically unfeasible.

One of the earliest recorded examples of direct reuse was at Chanute, Kansas, during a severe drought from 1952 to 1957. Windhoek, South Africa, has been reclaiming wastewater for potable reuse since 1968. A system in Occoquan, Virginia, begun in 1978, provides about 80 percent of the dry weather flow to the water supply reservoir during drought periods.

Breaking New Ground

Water Factory 21 in Orange County, California, has since 1976 provided very high levels of wastewater treatment prior to injection of reclaimed water into a drinking water aquifer. (That recharge is estimated to be less than 5 percent of the total recharge to the groundwater basin.) The city of Denver, Colorado, has embarked on a large-scale project to demonstrate the feasibility of direct potable reuse, and the city of El Paso, Texas, has recently started a groundwater recharge system similar in concept to that of Water Factory 21. All of these projects demonstrate the growing interest in direct potable reuse in arid climates.

The history of water reuse is centuries old. Realizing the future potential of all levels of water reuse will require the responsible balancing of rational, consistent water quality standards, the continued protection of human health, and the understanding that the concept of water reuse is here to stay.

Sherwood Reed is senior environmental engineer at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire. He has conducted research on water reuse and innovative waste treatment systems for more than 20 years.

Photo by Bob Firth

Potable water reuse has been a practice ever since there was an upstream discharge and a downstream water use on the same river. Minneapolis is one of the first of many cities that the Mississippi River passes through on its journey from the Headwaters State to the Gulf of Mexico.

Water Reuse and Public Health

An interview with Vincent P. Olivieri

Does the use of reclaimed water present special health concerns? Vincent Olivieri, associate professor of environmental health engineering, School of Hygiene and Public Health, The Johns Hopkins University, discusses public health concerns and the question of risk related to water reuse.

Q: As we begin to see increased interest in reclaiming wastewater, how concerned should the public be about the health implications of water reuse?

A: To begin with, water reuse is not exactly a new concept. It's been around for a long time — several thousand years at least.

It's happening all the time. Just look along a river that supplies water to a number of communities. In many cases, the amount of water used by these communities exceeds the total flow of the river. Obviously, someone is reusing part of that water supply. In fact, sometimes the effluent from one town is released into the river just a few miles upstream from the next one.

The idea that we're not already reusing wastewater is naive. What we're seeing is an increase in the **conscious** use of reclaimed water.

Q: What kinds of things concern the public about their water supplies?

A: If we have no water at all, our first concern is quantity. Only after we have enough water do we begin to concern ourselves with the "fine points" of quality and disease transmission. That's the attitude we have toward our water supplies. It's all basically a function of whether we have any or not.

"Mother Nature's a lot surer than we are. She's been at this for a very long time."

When we start to worry about quality, our first concerns are acute, or immediate, problems — like infectious diseases or metal contents. Then we get to the chronic, or long-term, problems, which act over a period of 20 to 60 years.

Photo by Runk/Schoenberger, Grant Heilman Photography

Any wastewater treatment system is attempting to mimic nature — to do what nature does, but to do it more efficiently. Regardless of the water source, public health depends on effective, failsafe treatment processes.

Q: What is the basic concern related to water reuse?

A: Whenever you send water through a pipe, you can distribute good water — or disease. The potential is always there, and that's a public health concern. There's always the potential for exposure on a massive scale. If a blunder is made, there'll definitely be a result.

Q: But can't the same be said of a conventional water supply? Won't a slip-up in the pre-treatment of any water supply carry a similar risk?

A: Not quite. Regardless of the water source, any water treatment system is attempting to mimic nature — to do what nature does, but to do it more efficiently. We're compressing a months-long process into just a few hours. If we start with a less-contaminated raw water supply, we're better off.

Q: But if incoming wastewater is treated to meet conventional drinking water standards, isn't that sufficient to protect public health?

"Whenever you send water through a pipe, you can distribute good water — or disease."

A: In terms of treatment, yes. With adequate money, time and staff, I can provide you with good water. But 100 percent of the time? That's another question.

Starting with a known contaminated supply, if any of it sneaks through, we have a problem. We have to be able to assure 100 percent safety 24 hours a day, 7 days a week, 52 weeks a year. Without a 100 percent system, we get caught.

Q: What about systems that treat conventional raw water supplies? Do they work all of the time?

A: Supposedly. Theoretically they do, but they don't. But the concern isn't the same when the incoming water is from a conventional source. A less-than-100 percent system is acceptable.

Q: But is that conventional water supply from the river — with the upstream town's effluent in it — really so much safer?

A: We like to depend on Mother Nature for at least a few minutes in there somewhere. It gives her a chance to allow for dilution, die-away and sedimentation. Mother Nature's a lot surer than we are. She's been at this for a very long time.

When we begin to depend entirely on human factors, we need to have a system with failsafes and backups. We begin to have to depend on that system entirely, and that presents opportunities for concern.

Photo by Christine Olsenius

Any water supply — reclaimed or not — can present a risk to public health.

Q: So how can we be assured of the safety of using reclaimed water?

A: This issue is one of having a failsafe system. We can accomplish this by installing as many barriers as possible between the contaminated water and someone's water tap.

The wastewater treatment plant contains several processes that represent barriers. The reservoir that removes microorganisms through sedimentation and die-away (over a period of months or even years) is another barrier. The water treatment plant provides other barriers. The more such barriers or backup systems we have, the better off we are.

Q: Should we be moving toward a goal of zero risk in water treatment?

A: No, that's simply not realistic. There's no such thing as zero risk. Water treatment simply minimizes risk — reduces the potential for exposure. We're making risk essentially undetectable. That's all we're doing.

We still have 10,000-20,000 cases of waterborne disease each year in the country — about 30-50 outbreaks. And those are the ones we catch. We have to keep in mind that, when the barriers break down, we'll have disease.

We're learning, and we're getting better at measuring, especially with organics. Underground storage tanks didn't just start leaking. Organics didn't all of a sudden "appear" in our water supplies. Instead, we've finally begun to be able to measure these things in the very small quantities in which they exist.

The initial response is to ban things and make a big fuss about organics in water at a rate of 2 parts per trillion. Then we give it to rats at a rate of 1.5 pounds per day for a year and find out that they get cancer. What have we really learned?

The perception of risk and the reality of risk are often not the same. And people who do the planning need to understand this. The people who plan sometimes respond to the public's perception, which may or may not be accurate.

Q: How do we know what's risk and what isn't?

A: When thousands of cases of cholera or typhoid broke out 100 years ago, there was no question as to the existence of a health issue. Now it's not so easy. But we don't necessarily have to have everything pinned down to make inroads to prevention. We do have to initiate some precautionary steps.

Until we get better epidemiological information — which will be difficult — it's going to be tough. In the meantime, if we can remove contaminants from the water, let's go ahead and do it. They're certainly not doing anybody any good.

"There's no such thing as zero risk."

The trick is to have the wisdom to recognize what is indeed a health issue and what is not. And that's not easy.

Q: What's the outlook for reuse in the near future?

A: Reuse has to play an increasing role. We should plan for it carefully. These things have to be implemented.

The trick is to consciously think about how reclaimed water is being used, and to continuously monitor what we do, so we can learn as we go. Yes, the public health concerns are there, and they need to be kept there. We just have to take what we consider to be appropriate precautions and do things with a bit of horse sense — nothing fancy.

We're going to be reclaiming and using more wastewater. We have to, and it's nothing new. That's really all there is to it.

Dr. Olivieri has been associated with The Johns Hopkins University since 1968. He holds a Doctor of Science degree in environmental health and has done extensive research in such areas as disinfection and the fate of microorganisms in the environment. Dr. Olivieri was interviewed by Linda Schroeder, *Journal* editor.

Awareness and Trust: Key to Public Acceptance of Water Reuse

by Loretta Lohman

Public response to the idea of water reuse is more favorable than not. With growing awareness of the need for innovative solutions to water problems, an increasingly informed public seems willing to accept and support the use of reclaimed water — even for drinking.

Photo by Mary Ann Evans

That sparkling glass of cold water is very inviting — and very old. The water we drink has been used and reused for centuries, moving endlessly through the hydrologic cycle.

People must not object to all forms of water reuse since water reuse is happening unremarked, all of the time. All the water we drink, or swim in, or wash cars with — all of the water we use — has been used before. That is a fact of the hydrologic cycle. As a river flows downstream, what is taken out upstream is virtually all returned directly to the river to be taken out again and again as it flows to the ocean. The same process applies to most of the groundwater we use, only recycling groundwater can take years rather than days or weeks.

"Who's Been Drinking My Water?"

Think for a moment about that glass of water you're drinking right now. You may have considered the possible contaminants in it or thought about how inexpensive it is. But have you ever thought that what is in your glass may be part of the water that was once used by your great-great-grandfather to water his horse? Under the hydrologic system it surely could be some of the same water.

If you think about water reuse in this way, you can start thinking about just what water reuse is — **nothing new.** Planned water reuse just removes some of the elements of chance.

Planned Reuse Is Nothing New

Deliberate planned water reuse has been occurring in this country for a long time without any spectacular public outcry. In 1926 the Park Service, in constructing a resort on the rim of the Grand Canyon, included a water reuse system for toilet flushing, landscape irrigation and dust control to make the available water (pumped from the Canyon floor at great expense) go further. In 60 years millions of visitors have suffered no ill effects.

Start thinking about just what water reuse is — nothing new. Planned water reuse just removes some of the elements of chance.

More recently, entire communities in California have been designed around the concept of using only treated wastewater for all outdoor uses — lawns, parks, car washing, even recreational lakes. Landscape irrigation and ornamental lakes, pools and ponds of reused water are accepted all over the country. On occasion, potable water reuse — water used for drinking and cooking — has been instituted in emergency situations in various communities around the country with no particular ill effect or public outcry.

"All in Favor, All Opposed..."

People don't object to water reuse. Universities, research organizations, water utilities, and even the Gallup organization have conducted numerous public attitude surveys concerning water reuse in every area of the country since 1965. The majority of people questioned have supported nonpotable water reuse. In almost every survey, close to 100 percent of the

Freshwater Foundation/Joleen Ross

respondents support the use of reclaimed water for landscape irrigation, industrial use, boating and recreational lakes. The majority accept irrigation of crops that aren't eaten raw, seawater intrusion barriers, toilet flushing and a whole variety of non-contact water reuses.

People don't object to water reuse.

Not all of the surveys asked about water reuse for drinking or cooking, but those that did found a remarkable degree of public acceptance. If potable water reuse were found to be the most readily achievable alternative to solving a water quantity or quality problem, 30 to 40 percent of respondents would be completely accepting of it, and another 30 to 40 percent would be reluctant to accept but not completely opposed to potable reuse. Only a small fraction of survey respondents would absolutely oppose potable reuse.

A Misperception of Public Perception

Who, then, is opposed to water reuse? Why is water reuse perceived as a problem of public acceptance? The most vocal opponents appear to be water professionals, engineers and those who make water policy.

Why? Ironically, many of the same studies that found general public support for water reuse found that the "experts" were opposed because they felt the **public** would never accept it. Only 1 to 2 percent were opposed on purely technical grounds. Most experts simply felt that water reuse was generally too controversial to succeed — but they are beginning to change their opinions as the results of various studies are more and more widely discussed.

Without benefit of a nationwide referendum on the topic of water reuse, the 21 years of public attitude surveys indicate a general willingness to accept most reuses. And people are willing to learn about water reuses that involve direct physical contact.

People Are Willing To Learn

For example, in Denver, where a potable reuse demonstration plant is in operation, two public attitude surveys three years apart not only conform to the findings of other studies but show how willing people are to learn about reuse. Controlled tests of ways to inform citizens about the reuse plant processes achieved almost unanimous support from those who learned how wastewater is treated for potable reuse.

Originally most of those tested only reluctantly accepted potable reuse in order to meet serious water shortages. When, however, they were shown the treatment process and how safety was continually monitored, most of the group not only accepted but wholeheartedly supported the concept of potable water reuse.

Making "Educated Judgments"

Our knowledge about the various constituents found in freshwater is part of a relatively young science. In effect our knowledge is still expanding with the development of more and more sophisticated techniques to identify and test for various potential contaminants. Perhaps we know a bit more about cleaning water than we know about what we are cleaning out of it. We do know, however, that we are able to make educated judgments on its safety after treatment.

Reclaimed water is often better treated and better analyzed than that which comes from our household taps.

A survey conducted last fall for the American Water Works Association shows that people generally trust their water utilities. Furthermore, comparing this survey to all of the surveys that address water reuse shows that the people who appear to most trust their utilities are those who have experienced water reuse projects — possibly because their utilities have kept them better informed about water in general and reuse in particular.

The water we reuse is the water we know the most about. We know what's in it before we treat it (we have to so that we can treat it), and we know what it should be like after treatment. Indeed, the public already affected by nonpotable reuse projects should know that reclaimed water is often better treated and better analyzed than that which comes from our household taps.

Trust: The Key to Public Acceptance

People generally trust their utilities — and that is a key to public acceptance of water reuse. The public understands the need for innovative solutions to water problems. People know that no place is safe from drought or pollution. They accept the fact that human intervention can clean water more quickly and often more effectively than the earth, the oceans and the clouds can cleanse the water over a long period of time.

When water users of this nation are asked to think about water reuse in sensible terms, and when they are shown the treatment and safety measures taken by specific water utilities, then they do accept and support water reuse — even for drinking.

Loretta Lohman is a social scientist currently conducting research on water economics and policy analysis in association with the Milliken Chapman Research Group, Inc., in Littleton, Colorado. Previously she spent 10 years as a research social scientist at the Denver Research Institute, University of Denver.

The Economic Benefits of Using Reclaimed Water

by Richard A. Mills and Takashi Asano

Reuse not only conserves, it often pays. Reclaimed water can, in many instances, provide significant savings to the user over conventional water supply sources.

One of the many merits of wastewater reclamation and reuse is that it can save money. This is not to say that reclaimed water is always cheap or always the lowest cost of water, but arid, water-short areas facing formidable costs for developing new freshwater supplies are increasingly turning to water reuse. Economics is an important factor.

The Traditional Perspective

Historically, water reuse has been largely viewed as a means of treatment and disposal of wastewater, primarily through land applications. The economics were approached by comparing water reclamation with other methods of wastewater treatment and disposal. The water supply benefits, such as a usable crop or replenishment of groundwater, were generally ignored.

Water supply managers, always seeking the highest quality water sources for their customers, have traditionally treated reclaimed water as a source of last resort. When they do add water reclamation and reuse systems to their sources of water supply, the potable and reclaimed water systems are managed as separate physical systems (which is necessary), but also as separate financial systems, which creates an unnecessary handicap for water reuse.

The Economic Analysis: Asking "*Should* It Be Done?"

The role of an **economic analysis** is to provide a basis for justifying a water reuse project in monetary terms. A project is considered justifiable if its total benefits exceed its total costs. If several alternatives can meet the same objective, then the alternative providing the maximum net benefit is the economically justifiable project.

An important aspect of the economic analysis is that it takes into consideration all costs and benefits associated with the alternatives under consideration, placing all alternatives on equal footing for comparison.

Another important aspect of an economic analysis is that it considers only the future flow of resources invested or derived from a project. Past resource investments are considered sunk costs irrelevant to future investment decisions. Thus, debt service on past investments is not included in an economic analysis.

Photo courtesy of City of Tucson Water Department

The use of effluent to irrigate golf courses is an economical — and accepted — practice in Tucson, Arizona. In fact, no new golf courses can be built in Tucson unless they irrigate with reclaimed water.

...and the Financial Analysis: Asking "*Can* It Be Done?"

The role of a **financial analysis** is to determine whether a water reuse project is financially feasible. For example, the project sponsor will need a source of capital. Sources of revenue must be available to pay for debt service and operational costs for both the proposed reuse project and any existing facilities. Sunk costs, while irrelevant in the economic analysis, must be considered in a financial analysis if they are a continuing financial obligation.

The water reclamation and reuse project sponsor is not the only important party in a financial analysis. Of particular importance for a water reclamation project is the participation of the user of reclaimed water.

For example, a reclaimed water customer may have to invest in piping modifications or a dual water system to accommodate the reclaimed water. Or, a farmer may be able to save on fertilizer costs by taking advantage of nitrogen and phosphorus remaining in treated wastewater. A prospective reclaimed water user will expect the difference in price between freshwater and reclaimed water to reflect any such added costs or savings.

A Hypothetical Example

To better understand the application of economic and financial analyses, consider the example of a community with a secondary wastewater treatment plant that discharges its effluent into an adjacent river. While satisfactorily meeting its pollution control requirements, this community is looking at the potential water supply benefits of water reclamation. The city determines that a golf course nearby can be irrigated with secondary effluent instead of potable water, which is obtained from wells.

Is It Economically Justified?

There are, however, added costs associated with using reclaimed water for irrigation:

1) A pumping station and pipeline distribution system would be needed to deliver the reclaimed water from the municipal wastewater treatment plant to the golf course.
2) Plumbing in the golf course would have to be modified to separate drinking fountains from the water system for irrigation.
3) Golf course staff would have to cover the drinking fountains during irrigation to prevent contact with reclaimed water spray.

The total costs for implementing and operating this water reclamation system for golf course irrigation would be $116 per acre-foot.

In looking at the benefits, the city would save on pumping well water, and the golf course would be able to reduce fertilizer applications, for a total savings of $160 per acre-foot. Because the total benefits exceed total costs by $44 per acre-foot, this project is economically justified.

Is It Financially Feasible?

To determine financial feasibility, the prices charged for potable water and reclaimed water need to be known. The city charges $220 per acre-foot for potable water.

For the city to break even financially, it must be able to recover the costs of constructing and operating the reclaimed water system as well as the fixed costs of the present potable system and administrative overhead. This break-even figure would amount to $180 per acre-foot.

One of the many merits of wastewater reclamation and reuse is that it can save money.

For the golf course to break even, the reclaimed water price must be sufficiently lower than the potable price to cover any increase in golf course expenses. The golf course is paying $220 per acre-foot for water now. Converting to reclaimed water would incur extra costs of $6 per acre-foot and save $10 per acre-foot in fertilizer costs, resulting in a break-even price of $224 per acre-foot. The range of acceptable price, then, that will benefit both the golf course and the city is between $180 and $224 per acre-foot.

Needed: A New Supply for a Growing City

As time passes and the city grows, it is faced with the need for additional water supply. The most economical source of freshwater available is a proposed reservoir at a cost of $340 per acre-foot. To recover this cost, the city calculated that everyone's water rate would have to increase.

As an alternative, it is determined that a market exists to use reclaimed water to irrigate city parks and schoolyards. Consideration of costs and benefits results in a net economic benefit ot $44 per acre-foot, making it an economically justifiable project.

The method of recovering the reclamation system costs, however, crucially affects the financial feasibility of this project. If all costs are borne only by the reclaimed water users, that is, the parks and schoolyards, the price would be $370 per acre-foot, while continuing with potable water would cost only $250 per acre-foot. These figures would do little to encourage the use of reclaimed water.

Photo courtesy of City of Tucson Water Department

In Tucson, Arizona, reclaimed water is used to irrigate seven golf courses and most of the city's parks. Reclaimed water costs 20 percent less than freshwater — and the savings rises as much as 40 percent during peak summer use.

A Solution Reflecting Benefits to All

From a broader perspective, though, all of the city's customers would benefit by the construction of a reclaimed water system. The city could obtain a new source of water for $340 per acre-foot. The potable water that would have been used by the parks would instead be available for new growth.

With this broader-based perspective in mind, the city could integrate the costs of both the freshwater and reclaimed systems. By doing this, the city could raise potable rates to $245 per acre-foot instead of $250 per acre-foot, and charge a discount rate of $220 per acre-foot for reclaimed water, to provide an incentive to use reclaimed water.

The important thing to remember is that water reclamation and reuse serve two functions: pollution control and water supply. In addition, it should be remembered that everyone can benefit from wastewater reclamation and reuse, not just the users of reclaimed water. With this understanding, cost recovery can be analyzed more flexibly and justifiable projects can be more financially feasible.

Richard Mills, associate water resource control engineer, and Dr. Takashi Asano, water reclamation specialist, are with the Office of Water Recycling, California State Water Resources Control Board. Dr. Asano is also professor of civil engineering at the University of California, Davis.

Water is beauty...

Photo by Grant Heilman

...pleasure...

...laughter...

Photo by David Edwards

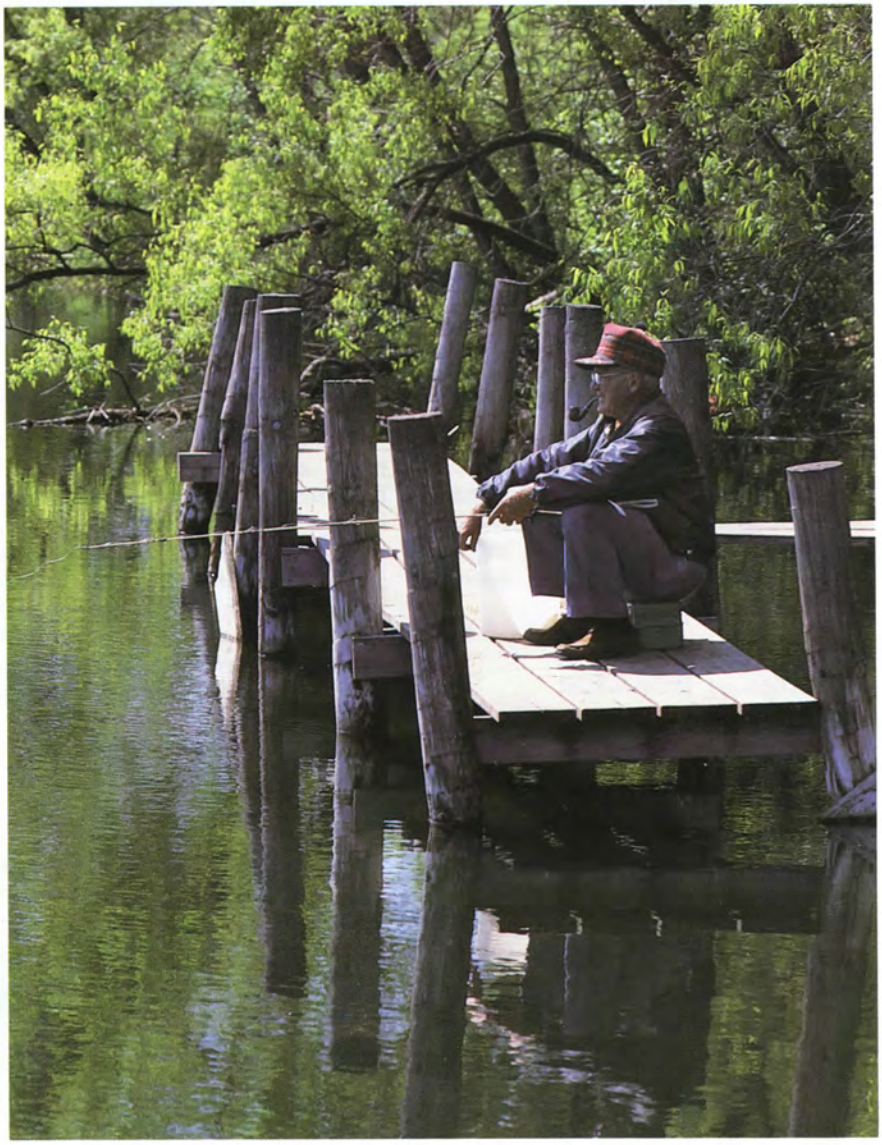


Photo by Michael Magnuson

Photo by Bob Firth

...and life.

Irrigating with Wastewater: A Benefit to Cities and Agriculture

by Eric H. Schroeder

To cities, it's wastewater. To farmers, it can be a valued resource — a nutrient-rich, less costly, readily available supply of irrigation water. Reclaiming municipal wastewater to irrigate crops results in benefits to everyone.

Wastewater treatment plants don't know what to do with excess effluent. Farmers don't have a constant supply of irrigation water. Reclaiming wastewater from sewage treatment plants and using it on agricultural lands seems to be a marriage made in heaven.

A Logical Solution to Two Problems

One of the oldest and most common reuses of water is for irrigation of agricultural crops. It has been going on in this country for more than one hundred years.

As water becomes more scarce and more expensive, and as wastewater becomes more abundant and more costly to treat, a logical solution to both problems is the reuse of wastewater for agricultural needs. Because agriculture is the largest user of freshwater in the United States (accounting for 50 percent of total use), it provides the greatest potential for savings in a comprehensive water conservation program.

Saving Now for Future Shortages

The use of reclaimed wastewater has been steadily increasing in California. California's agriculture depends on irrigation, which represents 85 percent of the state's total water use. Any saving of water now can represent a reduction in future water shortages.

The annual water demand in California is predicted to be 39.1 million acre-feet by the year 2000. If things continue as they are now, that projected need will outstrip the supply by 4.3 million acre-feet.

Reuse of water won't by itself solve the predicted water shortage, but it could have a significant impact.

There is, however, some hope. Municipal and industrial water treatment plants will, by the year 2000, produce 4.7 million acre-feet of effluent, a percentage of which could be reclaimed. Reuse of water won't by itself solve the predicted water shortage, but it could have a significant impact.

Benefits of Water Reclamation

Water shortage reduction is not the only benefit of reclaiming water. Other benefits include:

- reduced discharge of effluent into environmentally sensitive surface waters
- readily available nutrients through crop irrigation
- less expensive processing of wastewater, an economic boost to treatment plant owners and operators
- a more secure water source for areas subject to drought

Using reclaimed water on agricultural land can be the result of a number of incentives:

1) Often there is a shortage of readily available freshwater, or the available supply may be expensive.
2) The reclaimed water contains a high level of desirable nutrients.
3) The source of the effluent is close by.
4) The use of reclaimed water for irrigation is an integral part of a comprehensive water management and conservation program.

With Water Reuse, Everybody's Smelling Like a Rose in Texas

On a farm east of Lubbock, Texas, effluent from the City of Lubbock's Southeast Water Reclamation Plant has been used for irrigation since 1938. As population in the Lubbock area increased, the farm was expanded to deal with the greater output of effluent from the city's wastewater treatment plant.

Because of the increased flow from the treatment facility, the land available was eventually unable to handle the volume of reclaimed water and the groundwater level rose. Not only did the water table rise, but the water quality beneath the farm deteriorated.

In November 1980, a pumping, storage and distribution system was begun that would divert 50 percent of the flow from the first farm to another farm with little groundwater irrigation.

During 1982, this second farm was irrigated with secondary effluent. As the water emitted from the spray nozzles, the odor caused a public nuisance, so all of the effluent was pumped first to reservoirs to oxidize and eliminate most of the odor compounds. Unfortunately, much of the nutrient benefit of the effluent was lost through the reservoirs.

In 1984, by adding chlorine to the effluent, odors and biological activity were reduced and effluent from the Lubbock treatment plant was combined with water from the reservoirs to provide maximum nutrient levels and water flow while maintaining low levels of odor. The farmers receive the reclaimed water free of charge in exchange for disposing of all of the effluent on their land and allowing none to enter surface waters.

Lubbock's municipal treatment system also provides reclaimed water for industrial use. One-fifth of the 14 million gallons per day reclaimed by the total system is sold to Southwestern Public Service Company for cooling water and boiler feed water. This industrial application results in reduced water costs to the power company and increased revenues to the city.

Mutual benefits occur when reclaimed water is put to use. In Lubbock, Texas, agriculture, industry and wastewater treatment all come out smelling like a rose.

The use of reclaimed water for agricultural irrigation provides many benefits for both agriculture and the cities which provide the reclaimed water supply.

5) The economics of using reclaimed water are more attractive than the building of expensive tertiary treatment facilities.

Agricultural Use of Reclaimed Water — A Case Study

The City of Bakersfield, California, has reclaimed primary treated municipal wastewater for irrigation since 1912. The treatment plant effluent is used to irrigate nearly 5,100 acres that the City of Bakersfield owns and leases for agricultural use. Much of this land was acquired from the railroad and was poor agricultural land before the city reconditioned it.

Over a period of time, inherent problems of increased salinity and toxic buildup may cause the lease farmer to provide increased soil conditioning, but the added costs of not using freshwater for irrigation are more than offset by the savings due to lowered water costs. The lease requires the farmer to accept all of the effluent from the treatment plant. By 1996, 54 inches of reclaimed wastewater will be applied to the leased land each year.

During 1972 the wastewater reuse program irrigated 2,400 acres of corn, barley, alfalfa, cotton and permanent pasture. The corn, pasture and small grains grew well. The cotton, however, suffered a 25 percent lower-than-normal yield because the high nitrogen content of the wastewater directed growth to the plant rather than to the cotton bolls. The principal purpose of the farm at that time was wastewater treatment, not farming.

When the size of the farm was recently doubled, the primary focus shifted to crop production. The application of wastewater has improved the fertility of the soil and, with the exception of cotton (which tends to foliate too greatly because of the increased nitrogen), the crop yields have increased. To solve the cotton-growing problem, the farmer irrigates the crop with wastewater only early in the growing season and then switches to well or canal water during the setting of the bolls.

In the many years of successful irrigation with reclaimed water in Bakersfield, there have been no documented health problems nor any negative environmental impacts in conjunction with the irrigation practices. Bakersfield has shown long-term reuse to be successful, not only for wastewater treatment, but also for the economics of agriculture.

Eric Schroeder is a staff writer for the Freshwater Foundation.

Baltimore and Bethlehem Steel: A 45-Year Partnership in Resource Reuse

by Linda Schroeder

Municipal/industrial cooperation to reuse wastewater resources results in a "three-winner" partnership: the municipality, the industry and our valuable water resources. The long-standing agreement between the Bethlehem Steel Corporation and the City of Baltimore is a model of growing awareness of the need for more judicious use — and reuse — of our water resources.

Photo courtesy of Bethlehem Steel Corporation

At Bethlehem Steel Corporation's Sparrows Point Plant in Baltimore County, Maryland, a basic oxygen furnace is "charged" with molten iron to be refined into steel. The Sparrows Point Plant uses up to 100 million gallons per day of treated secondary effluent for its cooling and processing needs, making it the largest industrial reuse operation in the United States.

It takes 33,000 gallons of water to produce one ton of steel.

The steel industry requires enormous volumes of water for cooling and processing. So it was with Bethlehem Steel Corporation's Sparrows Point Plant in Baltimore County, Maryland. By agreeing to use 100 million gallons per day (mgd) of secondary effluent for its cooling and processing needs, the Sparrows Point Plant became the single largest industrial reuse operation in the United States — and perhaps in the world.

"The agreement was indeed a mutually beneficial one, and furthermore, it placed a value on effluent, which before then had had little such value."

Needed: A New Water Supply Source

Prior to 1940, groundwater and saltwater from Chesapeake Bay had provided a sufficient source of water supply for the Sparrows Point Plant. In 1941, however, the plant needed more water for plant expansion. Also, because of increased stress on its groundwater supplies, depletions were occurring and additional future yields seemed unlikely — especially at a reasonable cost. A new source of supply was needed for Bethlehem Steel.

The ensuing search led to Baltimore's Back River Wastewater Treatment Plant. Over all other alternatives, the Back River Plant's treated effluent offered the only continuous supply of reasonable-quality water at an economical price and within a reasonable distance. Agreement was reached in June 1941 between Bethlehem Steel and the City of Baltimore.

The Arrangement — and Initial Response

Under the arrangement, Bethlehem Steel agreed to receive 50 mgd of Baltimore's treated sewage effluent (that figure was later raise to 100 mgd). Two nine-mile-long gravity pipelines delivered the water from the treatment plant to Bethlehem Steel.

Dr. Abel Wolman, professor emeritus at The Johns Hopkins University, served as consulting engineer for Bethlehem Steel and conducted the 1941 search for a new water supply. He explains the initial response to the selection of treated effluent as the new water supply: "Everyone knew why it wouldn't work. There was extreme resistance to the concept at the time — remember this was 1941, not 1986."

"The state health department," Dr. Wolman continues, "considered such a proposal to be out of this world," and the labor unions said that sewage — it wasn't called wastewater yet — was not going to be a part of their operations. They'd strike instead." In both instances, however, once the dissenters came to understand the realities of the proposal and the precautions taken, their concerns were alleviated.

"The agreement was indeed a mutually beneficial one," Dr. Wolman explains, "and furthermore, it placed a value on effluent, which before then had had little such value."

45 Years Later

The Bethlehem/Baltimore agreement was unique in 1941, and it continues to be so today. Robert Mohr, manager of Baltimore's Back River Wastewater Treatment Plant, describes the notable features of the partnership: "First, it's an early example of cooperation between a municipality and the industry. Its second unique feature is its size. To accommodate the transport of 100 mgd, a 96-inch pipe and a 60-inch pipe both run a full nine miles from Back River to Bethlehem Steel. That's a lot of water."

What was a liability to be disposed of becomes instead a saleable commodity.

A third important aspect of the agreement, Mohr points out, is the spirit of cooperation that continues today. "It's been a very stable partnership," Mohr suggests. "Both parties are living up to it to the best of their abilities." Even the regulatory agencies, he notes, recognize the net economic and environmental benefits of the agreement and have worked to preserve it.

Benefits for Bethlehem...

Bethlehem Steel has a continuous supply of water at a reasonable cost. For a payment of $4,000-$5,000 per month, the steel plant receives 100 mgd of treated secondary effluent from the Back River Treatment Plant.

Besides being low-cost, the effluent is relatively chloride-free, which Bethlehem needs. (The corrosive characteristics of chlorides interfere with some steel-making processes.)

..and for Baltimore

Back River has an outlet for 100 mgd of treated secondary effluent. What was a liability to be disposed of becomes instead a saleable commodity.

"It may be less expensive to develop and operate recycling/reclamation systems than to meet treatment and discharge regulations."

The wastewater sent to Bethlehem doesn't have to be disinfected by Back River, as it would were it discharged directly to a water source. The savings to the treatment plant in chlorination for disinfection charges alone approach $250,000 per year. (Bethlehem Steel assumes responsibility for chlorination.)

With Back River's treated effluent going to Bethlehem Steel, discharges to the environmentally sensitive Back River are decreased. Under the agreement, the river is exposed to much less nutrient-loading, thus maintaining its water quality levels to meet state-imposed standards. (After use at Bethlehem Steel, the water is discharged under permit to Chesapeake Bay and its tributaries.)

The Success of the Agreement

What has assured the continued success of the Bethlehem/Baltimore partnership? According to Dr. Wolman, "It has provided a mutual way out regarding a useless large quantity of effluent that no one knew how to handle."

Mohr agrees. "It's an equitable agreement for both sides — it has to be to have stood the test of time. The city has said, 'We'll mutually participate in the benefits and share the liabilities.' That's the spirit of cooperation we're talking about."

Much of the plan's success dates back to its beginnings in 1941. According to Mohr, "Substantial credit goes to the individuals involved in the initial planning. The agreement took innovation and

Waste Pickle Liquor: A Resource Out of Place

Waste pickle liquor is a weak acid solution with a relatively high iron concentration, produced as a result of steel-cleaning operations.

Bethlehem Steel's Sparrows Point Plant was faced with a disposal problem related to this waste pickle liquor (WPL). For many years it was discharged into Chesapeake Bay with the knowledge and consent of the state, when dilution was still considered the solution to pollution. When such practices were recognized as being environmentally unsound, Bethlehem Steel was stuck with what was considered an unusable byproduct.

But it wasn't. To Baltimore's Back River Wastewater Treatment Plant, waste pickle liquor was found to be a potential resource.

Phosphorus removal is one component of the Back River Plant's treatment processes, and the plant would have to have purchased ferric chloride, or alum, on the open market to remove the phosphorus — at a cost of about $500,000 per year.

Instead, along comes Bethlehem Steel's waste pickle liquor. It was demonstrated that, when added to the wastewater treatment plant flow, the iron in the waste pickle liquor precipitates out the phosphorus. The acidity of the WPL is neutralized by the alkalinity of the wastewater. In essence, waste pickle liquor "does the job."

Once more we learn that the term "waste" is sometimes more a perception than a reality.

The benefits? Bethlehem Steel no longer has a waste disposal problem. The Back River Treatment Plant saves $500,000 annually by not having to pay for a phosphorus-remover. And, perhaps best of all, once more we learn that the term "waste" is sometimes more a perception than a reality.

creativity. It really was a stroke of brilliance."

Dr. Wolman, who sought out and recommended the partnership, clarifies his role in the process: "I served as an advisor, an arbiter in search of a major water supply at a sufficiently low price. My function was simply an obstetrical one."

"It Can't Be Done Everywhere"

Why have such municipal/industrial partnerships not become commonplace? "It can't be done everywhere," explains Dr. Wolman. "It will work only when there's an economical site and distance relationship between the waste site and the potential user. This juxtaposition was a good one."

Mohr also cities engineering and economic constraints as the limiting factors in many cases. Another potential impediment, he contends, is attitude. "I call it a four-post mentality," he explains. "People say, 'I don't care what happens beyond my property line. I don't care about the rest of the world.' With this sort of thinking, these cooperative efforts just don't happen."

The Future of Industrial Reuse

It appears that, for a number of reasons, industrial reuse will expand in the future. Dr. Wolman points out the factors to consider: "Keeping in mind the limits of geography, money and perception, situations will exist for such opportunities, with specifics to be worked out for every case."

"The perception that we don't have the right to exploit the environment is becoming an accepted cost of doing business."

Mohr agrees. "The opportunity is there," he suggests. "If we can get diverse interests together to take a hard look and find the common ground, it can be done."

Mohr also cites greater pressure on industry to consider reuse, due to environmental impact guidelines and regulations. "It may be less expensive," he explains, "to develop and operate recycling/reclamation systems than to meet treatment and discharge regulations." Granted, industry then has to assume the role of managing a "sideline operation," but, according to Mohr, "that is simply becoming the cost of doing business and maintaining the environment."

A Change in Attitude

Mohr thinks it's more than just regulatory and economic pressures that are encouraging industrial reuse. It's also a change in attitude. "The perception that we don't have the right to exploit the environment is becoming an accepted cost of doing business," he maintains. "What we're seeing is an attitude that encourages more judicious use of product resources."

According to Dr. Wolman, "There is no universal panacea for the concerns we face today. No single approach will work by itself. Instead, we must recognize the worth of many valuable approaches."

What might come closest to being that "universal panacea," though, is an enlightened attitude about the value and appropriate use of environmental resources. The willingness of Bethlehem Steel and Baltimore to work together toward the "more judicious use of product resources" demonstrates how municipal/industrial cooperation can be a three-winner partnership: the municipality, the industry, and the protection of our valuable water resources.

Linda Schroeder is editor of the *Journal.*

Photo courtesy of Bethlehem Steel Corporation

This hot strip mill uses large amounts of water for spray-cleaning and cooling as it processes slabs into large coils of thin sheet steel. This is one of many steps in a process that requires 33,000 gallons of water to produce one ton of steel.

Doing the Laundry with Less Water

by Muriel Morrisette

Water for washing laundry needs to be clean, but we don't necessarily have to be able to drink it. An innovative water treatment system treats and recycles wastewater for continuous reuse in laundry facilities — saving money for users of the system and saving potable water supplies for drinking.

John Lycke owns the Montauk Lighthouse Laundromat on Long Island in New York. Even before he made the decision to go into the coin-operated laundry business two years ago, Lycke was faced with some tough problems. Long Island depends on a limited store of groundwater for its entire supply of freshwater, and the laundry business must have access to a continuing supply of clean water. Wastewater disposal also posed a problem. The Suffolk County Board of Health and the New York Department of Environmental Conservation enforce strict waste disposal regulations.

"I had no choice but to find some method of cleaning and reusing our water supply," Lycke explains. "It was either that or build a whole series of septic tanks, and with the price of Long Island real estate, that was out of the question."

SAVE

WATER

Up to 90% of dirty wastewater is recycled and returned to the laundry for future washes and rinses.

ENERGY

Cost of fuel to heat wastewater is cut dramatically. The water is recycled hot and requires relatively little fuel to bring it back up to washing temperature.

SEWAGE CHARGES

Sewer volume charges are reduced proportionally with water savings.

MONEY

In the future, even more money is saved as the cost of water, energy and sewage charges continue to rise.

Courtesy of the Redux Corporation

A "Terrific" Solution

What Lycke found was a water treatment system marketed by the Redux Corporation of St. Louis, Missouri. The Redux system "works terrific," according to Lycke. "We use 1,000 gallons of water where we would have used 10,000 gallons without the system, and we have no sewage fees."

The Redux wastewater recycling and pollution control system makes it possible for businesses which use large quantities of freshwater to cut total water consumption by up to 90 percent. The system can also cut fuel costs dramatically and save on sewer volume charges and surcharges. A 500-gallon-per-minute Redux system, for example, may save an industry more than $5,000 per month in sewer charges.

A "Relatively Simple" Process

The Redux water treatment system is relatively simple, according to Jeffrey Davis, Redux marketing manager. "We have taken a lot of fairly well-established technology and packaged it in an easy-to-use form," he explains.

The system employs chemicals to coagulate oil, grease, suspended solids and other contaminants, including some heavy metals, and then uses dissolved air flotation to remove the waste. Wastewater is purified and recycled on a continuous basis at the rate it is produced, which is anywhere from 35 to 700 gallons per minute, depending on the installation.

The cost of energy for heating water is cut dramatically, because the water is recycled hot. Only 5 to 10 degrees of heat are lost in moving the water from the wastewater pit to the cleaned water collection tank.

A Diversity of Uses

Though most of the company's units are used for cleaning and recycling laundry water in hospitals, hotels, coin-operated laundries and commercial laundries, the system is also used by other industries. Metal finishers and platers, for example, use the Redux system to remove zinc and chromium from their wastewater.

In most Redux installations, treated water is reused again and again for the same purpose, but Davis explained that the treated water could be used for such diverse purposes as watering lawns, flushing toilets and washing trucks.

Businesses can cut total water consumption by up to 90 percent.

Pete Sclavounos is the owner of Modern Linen Supply, a large commercial linen supply operation in Hyattsville, Maryland. Modern Linen Supply currently uses only 1.2 gallons of water for every pound of clean linen, a 60 percent decrease over a few years ago when he used three gallons of water to clean every pound of linen (the average for the linen supply business).

"About five years ago we had a drought, and water prices kept rising," Sclavounos explains. "We had to find a way to use less water. So when we heard about the Redux water system, we decided to give it a try, and it's been doing a good job for us ever since."

The Redux water system seems to be an idea whose time has come. Any reuse technology that promises a 90 percent reduction in freshwater use, decreased fuel costs and sewer charges, and a clean wash as well deserves to be put to the test. According to happy customers, Redux seems to be passing the test with flying colors.

Muriel Morrisette is a staff writer for the Freshwater Foundation.

Tank Baths and Toll Booths: The U.S. Army Saves Water

by Eric H. Schroeder

Bring together a dirty Army tank and a lot of clean water, and what do you get? A clean tank and a lot of polluted water. Efforts by the Army to solve this water pollution problem have resulted in an innovative example of water reuse that saves not only water, but also time, energy, manpower and money.

Photo courtesy of USA-CERL

New Army tank-wash facilities recycle washwater and reduce freshwater use by 90 percent. They also save millions of dollars' worth of time, energy and manpower.

How much freshwater do you use when you wash your car? Can you imagine how much water the Army uses when it washes a 60-ton tank? And where does this dirty washwater go?

The problem is just that — it takes lots of water to wash a tank. And tanks can get very dirty, especially during training exercises at U.S. Army installations such as Fort Polk, Louisiana, and Fort Lewis, Washington. After field exercises in the clay soils of Fort Polk, it typically takes 4-8 manhours to clean several hundred pounds of dirt from an M60 tank using conventional washing methods. Manual scrubbing of the vehicles takes time and an excess of water, clogs storm drains and sanitary sewer systems, and pollutes nearby streams.

To solve the problems of pollution and excess use of water, the Army turned to its Corps of Engineers Construction Engineering Research Laboratory (CERL) at Champaign, Illinois, for help. In 1975, CERL began studying vehicle washing and maintenance at Army installations. As a result of these studies, CERL designed new, centralized tankwashing facilities at the Fort Polk and Fort Lewis training sites.

A 10-Minute Tank Bath...

Because the soiling conditions and predominant vehicle types vary greatly between Fort Polk and Fort Lewis, CERL developed different facilities for each location. At Fort Polk, where the heavy clay soil requires pre-washing, the tanks enter a tank bath where partially embedded pipes flex the tank treads and loosen the encrusted soil. At the same time, the tanks are blasted with four high-pressure water cannons. The average tank emerges from the bath within 10 minutes, leaving most of the soil behind. Fine-cleaning is then done at manned hose stations.

The new washing facilities have provided benefits worth more than $7.6 million at Fort Lewis and $10.4 million at Fort Polk.

The water treatment facility at Fort Polk consists of a large silt-settling pond and a settled water basin from which water is pumped back to the bath. Some freshwater is added to supplement the recycled water, but the overall reduction in the use of freshwater is 90 percent.

...and the "Toll-Booth" Approach

At Fort Lewis, Washington, tanks and wheeled vehicles do not need to be prewashed because of the soil conditions in the area. They are instead sent through a "toll-booth" washing operation. The "toll booths" have hose towers which are lighted for nighttime use, and the "toll-booth" design allows vehicles to move smoothly through the washing operation. Average cleaning times for tracked vehicles at the central cleaning facility are 10 to 20 minutes, and wheeled vehicles are cleaned in only 10 minutes.

The water treatment and recycling at Fort Lewis is a relatively simple operation because the wastewater does not have to be potable. Effluents from the washing facility flow by gravity to a sedimentation basin, during which time oil and grease are removed. Flowing through a sand filter, the water moves to a second holding basin where it is tested for water quality and, when necessary, supplemented with freshwater.

If not up to standard, the water is diverted back through the filter system. Once the water from the system meets quality standards, it is pumped back to the washing operations. Again, the overall savings in freshwater used is 90 percent.

Recycling Saves — and Pays

These tank-wash facilities typically pay for themselves in two years. A Fort Hood, Texas, facility has been approved at a cost of $5.9 million. For the first year alone, installation personnel predict savings of $4.6 million in manpower costs.

Following the successes of the Fort Polk and Fort Lewis facilities, vehicle-cleaning operations are being designed for most installations. CERL predicts that at least 20 new facilities will be in operation within the next five years.

What began as an attempt to find a solution to water pollution problems has resulted in the savings of not only water, but also time, energy and manpower. According to the U.S. Army Corps of Engineers, the new washing facilities have provided benefits worth more than $7.6 million at Fort Lewis and $10.4 million at Fort Polk. Recycling washwater not only saves water — it pays.

Eric Schroeder is a staff writer for the Freshwater Foundation.

Water Reuse in St. Petersburg: A 10-Year Success Story

by Muriel Morrisette

Watering lawns, parks and golf courses is a common — and growing — use of reclaimed water. In St. Petersburg, Florida, a 10-year-old dual-distribution system is recognized as a trendsetter in the management and reuse of wastewater resources.

Does the reuse of reclaimed wastewater work? The folks in St. Petersburg, Florida, know that it does, and they have a 10-year success story to prove it.

The Problem of Too Much Wastewater

Rapid growth during the mid-1960s presented St. Petersburg (and other local communities) with a new dilemma: how to safely dispose of ever-increasing quantities of wastewater. Compounding this problem, an Environmental Protection Agency report released in the late 1960s described Tampa Bay as the most polluted body of water in the nation.

Realizing the potential social and economic impacts of the virtual loss of the Bay, the Florida State Legislature acted to apply advanced wastewater treatment standards to wastewater effluent discharges into Tampa Bay. St. Petersburg was now faced with either an expensive upgrade of its wastewater treatment facilities or the development of new strategies to meet the more stringent "zero-discharge" requirements.

The city evaluated several wastewater management alternatives and concluded that, both technically and economically, the best plan was to use treated wastewater to irrigate large open-space areas like parks and golf courses, as well as residences. Implementation of the plan was begun in 1976.

Present Capacity and Future Potential

Today, St. Petersburg operates the largest wastewater reclamation operation and dual-distribution effluent spray-irrigation system in the United States. The system carries 21 million gallons of reclaimed wastewater a day through 250 miles of pipes, which range in size from 4 to 48 inches in diameter.

This water is used by 4,660 customers to irrigate 4,000 acres of parks, schools and golf courses, as well as industrial, commercial and residential neighborhoods that have been identified as Critical Water Quality Areas.

It is estimated that, when completely developed, the system will have the potential to serve more than 14,000 customers and will satisfy a demand for as much as

Photo courtesy of the City of St. Petersburg Marketing/Public Information Office

The Gizella Kopsick Palm Arboretum in St. Petersburg, Florida, is one of 55 park areas using reclaimed water for landscape irrigation.

42.2 million gallons of irrigation water per day by the year 2008.

How the System Works

Three of the city's four wastewater treatment plants currently supply water to the treated effluent distribution system. The fourth plant will be added to the system in 1987. These plants use an advanced, four-step wastewater treatment process which is monitored around the clock by city personnel. The effluent system is also monitored and tested for viral content by the Florida Epidemiology Research Center.

Reclaimed water is distributed to customers through a system of underground piping that is completely separate from the pipes which carry potable water. Reclaimed water pipes are brown in color so that service crews instantly know that they contain reclaimed water. Valve boxes are differentiated by shape and color-coding.

Photo courtesy of City of St. Petersburg Public Utilities/Reclaimed Water Section

Nearly two-thirds of the 780 homes in St. Petersburg's Yacht Club Estates, a designated Critical Water Quality Area, have access to reclaimed water for landscape irrigation needs.

Costs, Charges and Savings

The cost of the entire project, including construction, engineering, administration, legal, fiscal and contingency costs, as well as the $40 million distribution system, will eventually total about $120 million. Most of the funds for capital investment came from federal grants through the U.S. Environmental Protection Agency (EPA).

Projected demand for potable water has been reduced 30 percent — in spite of continued population growth.

St. Petersburg's dual-distribution system makes treated sanitary wastewater available for non-drinking purposes at a very attractive price. Customers are charged a monthly flat rate of $6 as opposed to the $10-$75 per month paid by customers using potable water for irrigation purposes. Some customers report additional savings, because the nutrients that remain in the reclaimed effluent help to fertilize lawns and gardens.

Benefits: Economic...

All St. Petersburg taxpayers benefit financially from the water reuse system for several reasons. First, it is less expensive to reclaim wastewater than to pump water from miles away. Second, the city receives a state fire marshall's discount, because reclaimed water is used for fighting fires in the area serviced by the system. Finally, and best of all, the water conservation and reuse program has postponed capital investment in new water plants for at least 25 years.

...and Otherwise

It is perhaps in the area of conservation that St. Petersburg's reclaimed water program has had its greatest success. Projected demand for potable water has been reduced 30 percent — in spite of continued population growth. Even during periods of drought, reclaimed water users' lawns were kept green without undue demands on the groundwater supply.

The improvement in Tampa Bay has been monumental. Thanks to zero-discharge of wastewater, the bay that the EPA called the most polluted body of water in the nation in the late 1960s is once again a source of beauty and recreation.

The Importance of Education

After only 10 years, St. Petersburg's system of wastewater reclamation and reuse is recognized as an outstanding trendsetter in water management, an accomplished conservator of freshwater and the environment, and a proven economic success. Joseph Towry, reclaimed water coordinator for the St. Petersburg Public Utilities Department, credits much of that success to public acceptance — due in great part to extensive public information/education programs.

These programs stress 1) conservation of potable water through wise use, and 2) environmental protection through wise disposal. The resulting public awareness of water supply and wastewater disposal issues creates interest in the benefits of using the reclaimed water system.

The continuing information and education effort stresses conservation, but it also includes information about how to use — and how not to use — reclaimed wastewater. Towry explains, "It is important that the user not lose sight of the origin of the reclaimed water."

Practicing "Conservival"

The city recently launched a "Conservival" water awareness program which stresses water conservation through the use of sound water management practices. The distribution of 100,000 brochures, coloring books, bumper stickers and water gauges helped spread the "Conservival message" throughout the city.

According to Towry, "We want the public to participate in getting the most use we can out of the limited water resources available." He adds that, by completely explaining the nature of the reclaimed water program to the public and by developing a well-defined set of policies, procedures and regulations to avoid legal entanglements and policy disputes, St. Petersburg has all but eliminated public misunderstanding and opposition. The city and its citizens are partners in the effort to attain the common goal of water conservation: "We will only survive tomorrow by being water-conscious today."

Muriel Morrisette is a staff writer for the Freshwater Foundation.

Project APRICOT: A Florida Community Plans Ahead

by Raymond C. Murphy

Recognizing future water needs can help communities to prepare today for tomorrow's needs. The community of Altamonte Springs, Florida, has adopted Project APRICOT, a plan to use reclaimed water to help alleviate future water shortages in Florida.

Could Florida be running low on freshwater? That seems impossible for a state with 53 inches of average annual rainfall, over 7,000 freshwater lakes, and one of the world's largest and most productive aquifers.

Florida's population, however, is expected to reach approximately 16 million by the turn of the century, with most of the people choosing to reside along water-poor coastal areas, which will substantially increase the withdrawal from the Floridan Aquifer.

One Community Plans Ahead

Altamonte Springs, an inland city with a service area population of 45,000, is located 10 miles north of Orlando. Altamonte Springs has decided to begin today to meet the challenges of the area's future water problems. They call their program "Project APRICOT" or "**A P**rototype **R**ealistically **I**nnovative **C**ommunity **O**f **T**oday." Under its auspices the city's Department of Public Works retained Howard Needles Tammen & Bergendoff-Florida (HNTB), an engineering firm, to help them find and implement practical approaches to water conservation.

HNTB found that, within the Altamonte Springs Water Service District, average single-family residential daily per capita water use is 125 gallons. Of that total daily consumption, 55 gallons (44 percent) is consumed within the home, and 70 gallons (56 percent) is used for irrigation of lawns, gardens, golf courses, cemeteries and other such areas.

A practical water conservation program would be to use an alternative water supply for irrigation rather than rely on severe rationing of drinking water supplies. HNTB's study further determined that the most readily available alternative is reclaimed water from wastewater treatment plant effluent.

Reclaiming Wastewater...

Altamonte Springs operates a regional wastewater treatment facility with a capacity of 7.5 million gallons per day (mgd). The effluent from the plant is discharged into the Little Wekiva River, a part of the Wekiva River System. Major portions of this river system have been designated as "Outstanding Florida's Waters," which strictly prohibits any further degradation of water quality in the stream.

At the present, the plant's effluent meets the wasteload allocation for the river. But the plant's capacity needs to be increased to 12.5 mgd to meet the demands of the city and its wholesale customers.

To upgrade the Altamonte Springs plant to 12.5 mgd and still meet the effluent quality standards, the city decided to pursue a dual water system concept for the parallel distribution of potable and non-potable water.

...for a Variety of Purposes

By means of this system, highly treated effluent will be delivered throughout the city to be used for the irrigation of residential, public and commercial properties, citrus groves, tree farms, crops, golf courses and other recreational facilities. The reclaimed water will also be used for several other purposes: fire protection, lake level control and ornamental uses, such as fountains and waterfalls.

It is the intent of the city as a future part of the program to install dual water systems in homes, commercial buildings and factories to be used for toilet flushing, sprinkler system supply, once-through cooling and process water, and general outside uses, such as auto washing. Commercial car washes could also be served by the reclaimed water system.

When the project is fully operational, around 1993, Altamonte Springs will have solved the water resource problems that many other communities will still be grappling with. Altamonte Springs with its progressive outlook and HNTB-Florida with its expertise have combined to anticipate future shortages and begin solving tomorrow's problems today.

Raymond Murphy is chief environmental engineer of Howard Needles Tammen & Bergendoff-Florida. He has 36 years' experience in the field of environmental engineering.

Photo courtesy of HNTB-Florida

In dual distribution systems, color coding (blue for freshwater, brown for reclaimed water) identifies the nature of the water supply being sent through the pipe.

Water Factory 21: Putting Reclaimed Water to the Test

by David G. Argo

Wastewater can be safely reclaimed, even for drinking. Extensive research at Water Factory 21 in Orange County, California, is providing information that will help future water supply planners consider reclaimed wastewater as a reasonable — and safe — source of "new" potable water supply.

California's Orange County Water District (OCWD) has successfully managed one of the area's most valuable resources for over 50 years — its groundwater basin. Orange County, which lies between San Diego and Los Angeles counties, receives less than 15 inches of rainfall each year and has no major rivers or local surface water supplies. Yet, in spite of these limitations, this basin supplies over 60 percent of the water used by the more than two million people who inhabit the county.

Widespread potable reuse of wastewater will evolve from necessity.

OCWD has artificially recharged its groundwater basin since 1933 by diverting Santa Ana River flow before it empties into the Pacific Ocean. In addition, the District has purchased surplus water, through the Metropolitan Water District of Southern California, from both the Colorado River and State Water Project aqueducts.

In the early 1950s, however, unprecedented demands were placed on the groundwater supplies by the postwar population boom, and Orange County was transformed from an agricultural community to a major metropolitan area, with a population presently exceeding two million.

The Threat of Seawater Contamination

During this period, a groundwater overdraft of more than 500,000 acre-feet took place, and water levels dropped to more than 100 feet below sea level. As a result, seawater pushed inland as far as 3½ miles and threatened to contaminate the county's groundwater basin.

To prevent the loss of this underground supply, OCWD initiated a series of studies to determine what could be done. Their findings indicated that recharge of the groundwater along the coastal region could form a freshwater mound that would push the threatening seawater back toward the ocean. The next step was to find a source of replenishment water.

In Search of an Available Supply

Major water shortages occur regionally, not just in one local area. Import supplies become scarce, and the underground reservoirs are subjected to severe overdraft. But one supply was found to be immune to drought or interruption: the more than 225 million gallons per day (mgd) of treated wastewater being discharged to the ocean. After several years of pilot plant studies to determine the feasibility of reclaiming wastewater, OCWD decided to construct a wastewater reclamation plant to provide a source of recharge water for the injection barrier.

Water Factory 21

In October 1976, Water Factory 21 (WF21) began operating in Fountain Valley, California, and since that time has produced a continuous supply of high quality water for the injection barrier.

The reclaimed water produced at WF21 is injected into the groundwater basin through a series of 23 injection wells. These wells extend 2½ miles across the historic floodplain of the Santa Ana River, an area subject to seawater intrusion.

Unchlorinated, municipally treated, activated sludge effluent obtained from the Orange County Sanitation District's Plant No. 1 in Fountain Valley provides the raw material for WF21. The extensive treatment processes at WF21 ensure that the reclaimed water is suitable for injection into — and eventual withdrawal from — the domestic supply.

Going Beyond Drinking Water Standards

Because the injected water eventually becomes drinking water for the county's two million residents, the reclaimed water produced by WF21 must meet the most stringent water quality criteria. To assure the water community that the water is safe for all domestic uses, the District carried out several years of monitoring and research to demonstrate the reliability of the treatment processes and the purity of the water produced.

The culmination of these efforts was a three-year study conducted by OCWD and Stanford University, sponsored by the U.S. Environmental Protection Agency (EPA), to specifically evaluate WF21's ability to produce reclaimed water suitable for drinking.

The results showed that reclaimed water from WF21 met EPA interim primary drinking water regulations more than 95 percent of the time. Reclaimed water without reverse osmosis treatment met most EPA

A need for reclaimed wastewater exists, and adequate technology is in place to meet that need.

secondary drinking water criteria parameters such as total dissolved solids, chlorides and sulfates. With reverse osmosis treatment, all secondary criteria were met.

Recognizing that many people feel today's drinking water standards are inadequate, WF21's effluent water quality was also compared to the one-in-a-million lifetime cancer risk levels developed for those priority pollutants not currently covered by EPA primary or secondary drinking regulations. Again the water met these criteria, even without including reverse osmosis treatment. The study produced no evidence that this reclaimed wastewater would pose a significant health risk if used as a municipal water supply.

A need for reclaimed wastewater exists, and adequate technology is in place to meet that need. Another important consideration, however, is cost.

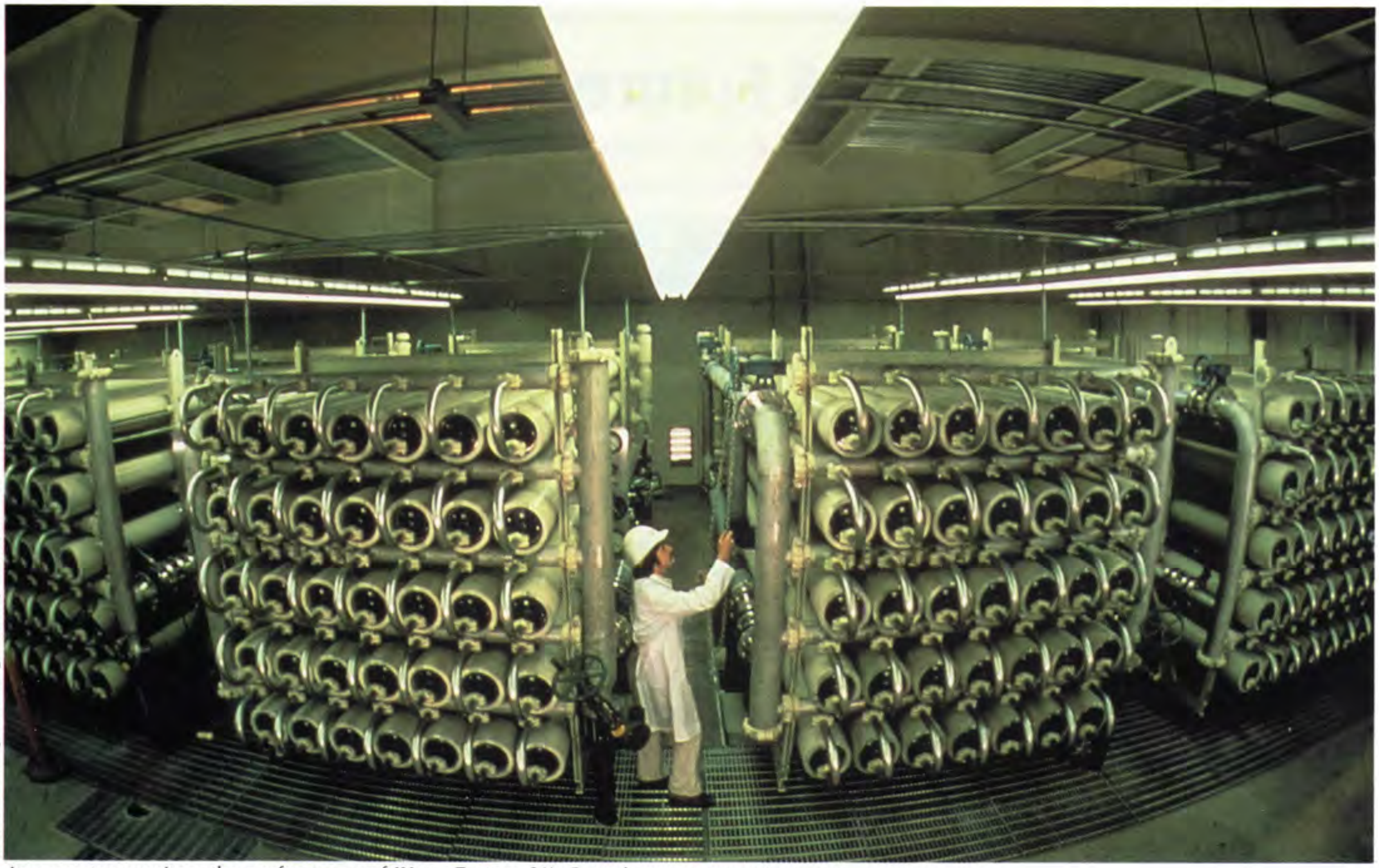


Photo courtesy of Orange County Water District

An operator monitors the performance of Water Factory 21's 5 mgd reverse osmosis system.

The Economics of Reclamation

If water reuse applications are to increase, the cost of reclamation must be comparable to, or less than, the cost of developing new water supplies. The Orange and Los Angeles Counties Water Reuse Study and OCWD recently compared the cost of developing new water supplies for Southern California with the cost of reuse.

They concluded that reclamation is less expensive. Because it takes a great deal of energy to import water from either the Colorado River or the State Water Project, local reclamation projects are more energy efficient. To deliver water from Northern California through the State Water Project to Southern California takes approximately 3,000 kwh per acre-foot, while energy consumption for reclaimed water can be as low as 2,500 kwh per acre-foot.

Public Acceptance of Potable Reuse

Since WF21 was in its conceptual stage, OCWD has been very sensitive to public reaction toward the concept of reusing water within the county. The project was endorsed as environmentally sound and supported by environmental groups, including the Sierra Club.

There is a high level of awareness among the professional water community that reclaimed water commingles with groundwater supplies, while providing a barrier to protect the basin from seawater intrusion. The District has also promoted public education and provided tours of WF21 for school groups from elementary level through college.

Wastewater can be safely reclaimed.

Widespread potable reuse of wastewater will evolve from necessity. Resistance will diminish with awareness that even conventional supplies contain an increment of wastewater. Public acceptance will increase as technological capability is repeatedly demonstrated, and as conventional supplies prove less and less adequate to meet the demand.

Reuse and Future Water Needs

Southern California is headed toward a water shortage that can only be offset by a combination of actions. Political, economic and environmental decisions have stalled improvements to state water aqueducts. Judicial decisions have reduced the area's water entitlement to Colorado River water.

During the past nine years, however, WF21 has demonstrated the effectiveness and reliability of advanced wastewater treatment technology for producing potable water from municipal secondary effluent. The sound scientific data base provided by WF21 will enable future water supply planners to consider reclamation as a viable alternative to more conventional supplementary supplies.

Now there are other water reclamation projects in various stages of implementation in parts of Texas, Colorado and Florida which contemplate some form of potable reuse. They too will advance the state of the art and demonstrate that wastewater can be safely reclaimed. WF21 has served as a forerunner to a series of facilities that will manufacture high quality potable water for reuse in the years to come.

David Argo, associated with the Orange County Water District in California for 15 years, was the District's assistant manager and chief engineer from 1977 to 1986. He is currently associated with Black & Veatch, a private consulting firm. He has also served as a consultant to the Denver Water Board, the Florida Department of Environmental Regulation, and private industry.

Reclaimed Water: A Future Supply for Denver?

by Eric H. Schroeder

Can sewage effluent be safely treated for direct, immediate use as drinking water? The Denver Potable Water Reuse Demonstration Plant is working on that question, and water planners (and water drinkers) throughout the world have a vested interest in the answer.

Denver, Colorado, is located in a semi-arid part of the United States. Despite outsiders' visions of Denver as a snowy Rocky Mountain city, in reality Denver receives on the average only 15.2 inches of precipitation annually. Because Denver is on the edge of the Great Plains, water must be brought in from the mountains and stored in reservoirs. Although current water needs are being met in the Denver metropolitan area, anticipated population growth could require water beyond present capabilities as early as 1987.

Processing Sewage into Potable Water

The Denver Water Department has been developing plans to meet this increased demand. One major plan is the processing of sewage into potable water — water of a sufficient quality that it may be reused as drinking water directly after treatment.

The Denver Potable Water Reuse Demonstration Plant is part of a feasibility project begun in 1968 when a small treatment facility (5 gallons per minute) was constructed to determine whether processed wastewater effluent could be directly treated to potable quality. Funded by the Denver Water Department through a grant from the Denver Water Board, the pilot project and its ensuing 10-year study were operated by the University of Colorado's Environmental Engineering Department.

During the first five years, more than 200,000 samples of water will be tested for more than 500 possible contaminants.

An Interim Step to a Full-Scale Plant

Because of concerns with the quality of the reclaimed water and possible health effects, the Denver Water Department and the U.S. Environmental Protection Agency (EPA) agreed on an interim step in 1979. Their cooperative efforts built a 1 million gallon per day (mgd) treatment plant to serve as the test site for the water reuse demonstration project. The EPA, which contributed $7 million of the $30 million project cost, is helping to direct the research on health effects.

This 1 mgd treatment facility currently provides the potable reuse water for testing and analysis. If the current project is accepted by area residents and meets health and safety standards, a full-scale plant will treat water for reuse to be combined with potable water from conventional treatment plants.

Photo courtesy of Denver Water Department

Clarification and recarbonation of treated wastewater is the first phase of the 10-step reuse treatment process at the Denver Potable Water Reuse Demonstration Plant.

In October 1980, the design for the 1 mgd demonstration plant was completed. Construction began in 1981 and was completed in 1985, which marked the beginning of a minimum of five — and perhaps ten — years of testing, analysis and evaluation.

The Testing Process

William Lauer, reuse project manager for the Denver Water Department, explains the need for a flexible-length testing period: "We have an agreement with EPA to go through five years of testing. If there are questions yet to be answered at that time, the Denver Water Department may elect to operate for a longer period of time to answer such questions."

"So far, in every way we can measure, it's as good as or better than the traditional water supplies we consider safe to drink."

The first phase of testing was completed in March 1986. During the six-month period, the treatment plant operated 24 hours a day, seven days a week to simulate actual production conditions. Thousands of chemical, microbiological, radiological, physical and virological tests were conducted to examine the quality of its product — potable water.

During the first five years of the demonstration plant's operation, more than 200,000 samples of water will be tested for more than 500 possible contaminants. Federal, state and local health agencies will work with the Denver Water Department to monitor the testing and analysis projects.

The Goal: Direct Potable Reuse

The demonstration plant uses effluent from the Metropolitan Denver Sewage District's wastewater treatment plant and produces 1 million gallons per day of potable water. The goal of the demonstration plant is to produce cleaner water than Denver's existing supply, which now comes from clean, protected mountain watersheds.

"This project is unique," explains Lauer, "because of its goal: to produce drinking water from reclaimed wastewater for the purpose of blending directly with existing water supplies. While most others are looking at less-direct connections, we're contemplating a direct connection between treatment and our municipal drinking water system."

Photo courtesy of Denver Water Department

"Pure water...again." The end product of the Reuse Demonstration Plant is displayed in a stylized drinking fountain. Denver's goal is to produce water "of equal or better quality" than customers now receive.

The Ultimate Question

And will it be safe to drink? "We don't know yet," Lauer admits. "We have at least five years of work to do to answer that question. So far, in every way we can measure, it's as good as or better than the traditional water supplies we consider safe to drink."

Denver residents, the ultimate test for the demonstration plant, are evenly divided over accepting the idea. One-third of the residents agree with the concept, one-third are skeptical, and one-third have adopted a wait-and-see attitude. Educating the Denver populace as to the feasibility and safety of the project will be an important component of the overall effort.

Meeting Future Needs in Denver...

During the winter, Denver requires about 120 million gallons of water a day, and in the summer that need can rise to 400-500 million gallons per day. If expanded to 100 mgd, the experimental reuse plant will have the capability of providing approximately 15 percent of Denver's potable water supply.

Because of the 5 to 10 years of testing remaining at the demonstration plant, there is currently no commitment to a larger permanent plant. Scientists, engineers and health officials want to make certain that the methods used are sound.

...and Throughout the World

The reuse plant attracts many visitors from other parts of the United States and from foreign countries as well. "We're being looked to as a trailblazer in this area," Lauer admits, "but we don't expect direct potable reuse to become widespread. It's too site-specific to be a viable option everywhere. But the information we generate will have applicability to water treatment in general in terms of understanding more about the removal of a wide variety of contaminants from water. We're shedding light on a vast array of water quality issues that will apply to both non-traditional and traditional water supplies."

Denver is looking out for its future — and the future water needs of its residents. But more is happening than that. The research being conducted at the Denver plant is important not only for what scientists and engineers can learn about the reuse of potable water in the metropolitan Denver area. It may also make a significant contribution to the quality of water throughout the world.

Eric Schroeder is a staff writer for the Freshwater Foundation.

Assessing the Future of Water Reuse

An interview with Richard E. Thomas

Will reuse continue to fulfill its potential as a future water supply? Richard Thomas of the U.S. Environmental Protection Agency (EPA) discusses the effects of water availability, public attitudes and the economics of water on the positioning of reuse as a water supply alternative for the future.

Reclaimed wastewater accounted for 700 million gallons per day (mgd) of water used in 1975. In 1980, an Office of Water Research and Technology report predicted a sevenfold increase in wastewater reuse by the year 2000 — to 4800 mgd.

Will that level of reuse potential be realized? No one can say. Since the demise of the U.S. Water Resources Council, periodic national projections are no longer published. But, according to Richard Thomas, national coordinator of a program that encourages water reuse within the U.S. EPA's Office of Municipal Pollution Control, the long-term future of reuse looks relatively promising. "We may be approaching a period where it may not increase as rapidly for a while," he admits, "but, after that, it's definitely going to increase again."

A Slowdown — and a Resurgence

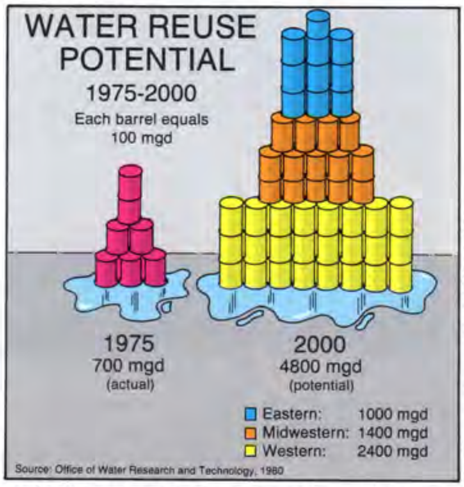
Thomas points to several reasons for a time of slowdown. "The overall environmental drive of the '60s has died out a bit," he explains, "and federal financial support is on the decline. Therefore, we may see several years of relatively slow progress, but then we'll see a renewed desire to keep our water supplies clean."

Coupled with this resurgence of concern for water quality will be a growing shortage of available water supplies. "A primary driving force with respect to water is availability," Thomas states. "As the availability of cheap subsidized water declines, there will be a resurgence of interest in reuse as a supply alternative."

Economics Will Favor Reuse

And the other primary driving force — economics — will also work in favor of water reclamation. "Interbasin transfer schemes won't be economically competitive," Thomas suggests, "even if additional supplies are found to be available for transfer."

"Water will become so valuable," he continues, "that people will no longer consider throwing away once-used water. As we all begin to really understand the cost of water, we'll be more concerned about it. Today, if we turned on the faucet at home and beer came out, I doubt we'd let the spigot run while we ran to find a glass. We have to develop the same attitude toward water."



A 1980 report on water reuse and recycling commissioned by the Office of Water Research and Technology predicted that reuse would increase by sevenfold in the 25-year period from 1975 to 2000. Although the potential for an increase of that magnitude still exists, it is not known whether such an expansion will be realized.

Freshwater Foundation/Joleen Ross

An Alternative to Severe Conservation

Thomas indicates that necessity will again be the mother of invention. "Reuse will increase as the need develops," he says. "We're using water wastefully, and our supplies are comparatively fixed. We're approaching the finite limits of our water supply to sustain our present lifestyles — but population continues to increase."

"One solution to such a dilemma," he continues, "would be extreme water conservation — to a level that would severely affect our lifestyles. But I think we'd all prefer to use water over and over again, if it means less of a change in how we live."

Another factor favoring water reuse is a prevailing change in public attitude. The general perception of wastewater as filth has, according to Thomas, changed dramatically. "There are large groups of people already conditioned to drinking river water that incorporates recycled wastewater. The old joke about the Missouri River is 'Flush — people downstream need the water.' "

Change Will Take Time

Water quality concerns, decreased availability, and an awareness of the true cost of water will all serve to encourage reuse — but Thomas believes that it will take time: "Most changes in human culture and practice are comparatively slow to take place," he says.

And is technology a problem? Thomas doesn't think so. "Of course there will always be problems and questions," he admits, "but we need to focus on the concept and the need. The technical know-how is available."

Thomas warns, however, that environmental policy depends on more than public attitude and technology. "Recognition of fact alone is not sufficient to ensure appropriate action," he explains. "The weighting of environmental decisions can be, I suggest, figured on a 10-point system: 1 point technical, 3 points institutional, and 6 points political. Therefore, it takes continuous public pressure on political and institutional decision-makers to keep something going."

Need Will Drive Reuse

"The reuse movement," states Thomas, "is at a transition point. Its future depends on researchers, instructional professors, practicing professionals — and the acceptance of the general public."

"Reuse will continue to increase," Thomas contends, "as the need continues to develop. Availability and economics, the primary driving forces for water, will help us to rethink reuse as a water supply for the future."

Richard Thomas has served for four years as national coordinator of the EPA Office of Municipal Pollution Control's innovative and alternative technology program, which has encouraged reuse by providing federal funds to construct hundreds of municipal treatment facilities which incorporate reuse. In addition, he has 20 years' experience in research related to wastewater treatment and reuse systems. Richard Thomas was interviewed by Linda Schroeder, *Journal* editor.

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