

# INDUSTRY, FRESH WATER **AND** SUSTAINABLE DEVELOPMENT



World Business Council  
for Sustainable Development



**Picture credits**

Nestlé

H. Anenden, World Health Organization

International Institute for Environment and Development

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## DISCLAIMER

This report is released as a joint publication by the World Business Council for Sustainable Development (WBCSD) and the United Nations Environment Programme (UNEP).

Although the report has been written by Mr. Albert Fry, case study information has been provided by members of WBCSD and UNEP. Neither WBCSD nor UNEP is responsible for the contents of the case studies. We provide a contact point within each company so that those wishing to explore the facts in more detail can do so directly with the company in question.

*April 1998*



The World Business Council for Sustainable Development (WBCSD) is a coalition of 125 international companies united by a shared commitment to the environment and to the principles of economic growth and sustainable development. Its members are drawn from 35 countries and more than 20 major industrial sectors. The WBCSD also benefits from a thriving regional network of business councils and partner organizations located mainly in developing countries and countries in transition.

The WBCSD provides a powerful and unified business voice on sustainable development issues and plays an important role in developing closer cooperation between business, governments and others, and in encouraging high standards of environmental management in business itself.

Its work program - comprising a number of working groups with company representatives - deals with policy development and environmental management issues. The WBCSD is also involved in a number of field projects in developing countries and countries in transition.



The United Nations Environment Programme (UNEP) was launched by the UN Conference on the Human Environment, held in Stockholm in 1972. It was established as the 'environmental conscience' of the UN system, and has created a basis for comprehensive consideration and coordinated action within the UN on environmental problems.

Its mandate is to catalyze and coordinate activities to increase scientific understanding of environmental change and develop environmental management tools. Among its milestones over the past two decades is the creation of Earthwatch to gather, analyze and convey information about the state of the global environment.

In the form of environmental management tools, UNEP's efforts have led to conventions to protect stratospheric ozone, to control the transboundary movement of hazardous wastes and to protect the planet's biological diversity, among others. UNEP continues to give Access to Fresh Water highest priority.

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# Letter from the Chairman

**F**resh water is key to sustainable development. Without adequate water supply food production declines, human health fails, the natural environment suffers and economic development is limited.

Water is an issue for all business sectors as well as the individual business. Not all sectors are equally dependent on water, but in areas with prolonged drought, all businesses are at risk. The goal must be to build a sustainable water future in an inclusive manner avoiding destructive competition or conflict between sectors and nations.

Increasing population and increasing standards of living drive demand ever higher for drinking water, for irrigation of crops, and for process water for industry. As these sectors take more water, less is available for the natural environment.

The challenges of meeting these growing needs are daunting, but I wish to stress that the situation is not hopeless. Despite regional shortages, the world is not running out of fresh water. The good news is that there is enough fresh water to meet needs in all but a few areas with most extreme water stress, if we cooperate and manage our finite resources wisely. The bad news is that most, individuals, businesses, and governments alike, still take water for granted.

This joint UNEP - WBCSD report is a wake-up call to business and to the other sectors of society. Business has technical and managerial skills which enable it to produce more goods and services using less water. Companies have the manpower and financial resources to invest in more 'eco-efficient' technology which protects water, uses water more efficiently, recycles water for reuse inside the plant and cleans water before it is returned for common usage. The case studies document how many companies are managing fresh water resources more sustainably.

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This report is a call for more businesses to adopt a new preventative strategy. Investment in water and sanitation ‘prevents’ shortages and health problems. Investing in programs to provide health care to those harmed by inadequate water supply and sanitation is an ‘end-of-pipe’ solution. A better solution is to fix the problem before it occurs. This report also calls for more partnerships within river basins and watersheds with all parties participating in the planning and management of fresh water for the benefit of all.

Climate change is affecting the reliability of fresh water supply. It is not just people, farmers and factories that need this water. Both UNEP and WBCSD are committed to ensuring that our natural environment receives its necessary supply of fresh water. Many have seen climate change as more significant than water. If we fail to maintain residual fresh water levels for our forests and other important natural ecosystems, we overlook one important way of preventing global warming. I end where I began, **fresh water is key to sustainable development.**



**Vic Cocker**  
*Group Chief Executive, Severn Trent Water  
Chairman, WBCSD Working Group on  
Access to Water*



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# Preface

This report is a joint publication by the United Nations Environment Programme (UNEP) and the World Business Council for Sustainable Development (WBCSD). It is meant to serve as an example of cooperation between an international governmental organization and a business group in disseminating information on fresh water, a subject of vital importance to human survival and socio-economic development. Seldom do individuals consider the many uses of this irreplaceable resource – drinking water, cooking, cleaning, growing food and livestock, fisheries and aquaculture, industry, recreation, power generation, transport of goods, and aesthetics. It is only through such unique partnerships that effective solutions can be found to critical issues such as access to, and sustainable supplies of, fresh water.

UNEP has a primary interest in guaranteeing adequate fresh water to protect the natural environment and aquatic life as well as to meet human needs. It is the natural environment that provides the basic commodity of freshwater. However, human activity has the potential to degrade the quality and restrict the quantity of water available to all users. The primary focus of business is on ensuring access to process water for its operations. However, in developing this document, it was quite remarkable to discover the commonality of interests. Both organizations are committed to the concept of sustainable development. WBCSD's emphasis on 'eco-efficiency' complements UNEP's 'cleaner production' program, and its emphasis on environmentally sound technology. Programs within each organization are moving towards pollution prevention and away from remedial action. Each recognizes industry's technical competence, managerial skills, and financial resources to improve water use efficiency. Each, also, is committed to protecting our natural environment.

The case studies in this report give examples of how progressive companies are protecting water, using less water, recycling and reusing water and preventing pollution. All of these actions limit pollution levels and serve to enhance water quality, thereby facilitating our ability to readily reuse this resource again and again. In developing this joint publication, UNEP and WBCSD agreed that both organizations need to get this message out to a broader cross section of industry and other important water users.

UNEP and WBCSD agree that agriculture not industry, in both developing and developed countries, is the largest user of fresh water, accounting for up to two-thirds or more of all use on a global scale. Thus, even modest efficiency improvements in the use of irrigation water could potentially generate enormous savings of fresh water, water that would be available for nature, for individuals and for industrialization, thereby fostering the goal of sustainable development.

*"In the end we will conserve only what we love, we will love only what we understand and we will understand only what we are taught."*

*Baba Dioum, Senegalese conservationist*

**A modest 15% efficiency gain in irrigation could free up double the amount of water currently used by humans to meet other essential needs.**

Both organizations reaffirm their commitment to the Dublin Principles and Agenda 21 and the self-evident common interest of all parties in giving water a true approximation of its economic value. To paraphrase Baba Dioum, we will only conserve what we value economically. There is ample evidence that, if water is free, subsidized or given away at artificially low prices, then society will continue to use it carelessly. Indeed, it is a cruel hoax to argue that the urban poor cannot be expected to pay for clean water supply. The truth is that they are already paying exorbitant prices for water off the back of a wagon or they are using dangerously contaminated water or else women are spending many hours each day fetching water from a distant tap. In many cases the evidence suggests that the urban poor in developing countries would be better off if there were social and economic framework conditions that encouraged private sector investment in water supply and sanitation.

This report could not have been completed without the leadership of Jim Oatridge, Severn Trent, who supervised the preparation of this document. Special thanks are due to all the companies and individuals who contributed case studies and reviewed the material, as well as the two principal authors, Walter Rast, Deputy Director of UNEP's Water Branch in Nairobi and Albert E. Fry, WBCSD in Geneva.

UNEP and WBCSD are glad to have had the opportunity to collaborate on this important document, and look forward to a continuing association.



**Klaus Töpfer**  
*Executive Director, UNEP*



**Björn Stigson**  
*President, WBCSD*

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# Executive Summary

1. **A number of regions are already suffering fresh water shortages. As populations increase and living standards rise in the first half of the 21<sup>st</sup> century, more regions will suffer increased water stress. The world is not running out of fresh water; but it is not distributed equally and, too often, it is not where it is needed. All users, individuals, farmers and industry should take action to protect and use water more efficiently and more sustainably.**
2. **Industry could be at risk when fresh water shortages occur.** Highest priority for scarce fresh water is given to domestic needs and then to farmers to grow food. Water for industry is often given relatively lower priority. Water for the natural environment, too, is often ignored. The fact that industry might be willing to pay more for water may be irrelevant and water for industry may not be available at any price. Water would then become a limiting factor for sustainable development and future industrialization in water scarce regions.
3. **Industry is not the major user of fresh water. Agriculture, in developing and many developed countries, is the largest user of fresh water.** Much of this water is subsidized, used inefficiently and is polluted by leaching out fertilizers and pesticides. Because of the huge amounts of water involved, even small efficiency gains in the agricultural sector could generate enormous water savings and water quality gains.
4. **Industry can and should take reasonable preventative action now.** This report has indicated examples of how many progressive companies are protecting, conserving, recycling, and reusing water, as well as improving the quality of their waste-water. Industry has access to technology, management skills and resources which enable companies to use less water, to use it more efficiently and to minimize risks to the natural environment.

5. **Companies can and should improve the efficiency with which they use, recycle and treat water.** Even though water represents a small fraction of total production costs for most companies, water should be protected and conserved since in many parts of the world it will become a limiting factor to sustainable development. Water should be considered valuable like energy or other resources used in production.
6. **Companies can and should become more active in water basin and water catchment planning and management.** When industry is seen as a partner in cooperative efforts to manage scarce fresh water resources, society is more likely to grant those companies higher priority during periods of shortages.
7. **Water prices, more in line with the real cost of providing that resource, encourage less wasteful consumption, encourage recycling and reuse and more adoption of 'best practice'.** Free or subsidized water sends the wrong message to users whether they be individuals, farmers or factory owners. Creative companies can use water conservation to improve their strategic and competitive position.
8. **Many urban governments are having difficulty finding the capital to modernize or expand drinking water supply and sanitation facilities.** Increasingly, governments are turning to the private sector for investment capital and management know-how. Charges or rates which reflect the full cost of supplying and treating fresh water would attract more private sector investment. Industry cannot be expected to invest heavily in water savings when fresh water is free or very inexpensive.

**Where do we go from here?** UNEP and WBCSD will continue to get the key messages out to businesses, large and small, everywhere. Both organizations recognize the need to involve all users, governments, both national and local, farmers, businesses, individuals and environmental groups, in water partnerships. Particularly at the river basin or catchment level, such cooperation, which may involve more than one country, will be crucial if society is to manage fresh water resources sustainably in water short regions.

However, this paper has made reference to a broader social issue of importance to the entire world, namely, **what to do about the 1 billion people currently without access to safe drinking water or the 2 billion without access to basic sanitation?** This question is even more dramatic since 90% of population growth is expected to

occur in the areas already lacking adequate water supply and basic sanitation.

The WBCSD believes this problem is worth addressing because the individuals at risk are the potential future employees and customers of our member companies. Further, sustainable industrial growth depends upon meeting their basic human needs. UNEP is concerned on humanitarian grounds and wants to ensure that ecosystem requirements for fresh water are met. UNEP intends to follow up on this report with a study to look at what is needed to see that ecosystems, biodiversity and the natural environment receive an adequate share of our finite fresh water resources.

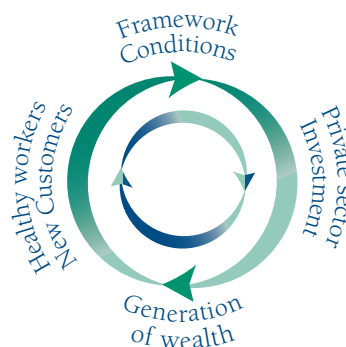
If society fails to address this fundamental issue, future economic development cannot be sustained and the natural environment will not be protected adequately.

WBCSD intends to follow up on this report with a study to look at what is needed to reach the following virtuous circle:

- ◆ **framework conditions** needed to encourage private sector investment in water supply and sanitation
- ◆ **private sector investment** to supplement lagging public sector investment in new water infrastructure and maintenance of that infrastructure
- ◆ **generation of national and local wealth** necessary to foster sustainable development, including basic water supply and sanitation for all
- ◆ **healthy new workers and customers** to foster sustainable economic growth and quality of life

UNEP and WBCSD agree that water is a necessary but not a sufficient condition for attaining the goal of sustainable development. Both organizations intend to work towards assuring that access to fresh water is an engine for poverty alleviation and social progress rather than an impediment to those desired ends.

Both organizations remain committed to improved management of the world's finite fresh water resources in support of sustainable development.



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# Introduction

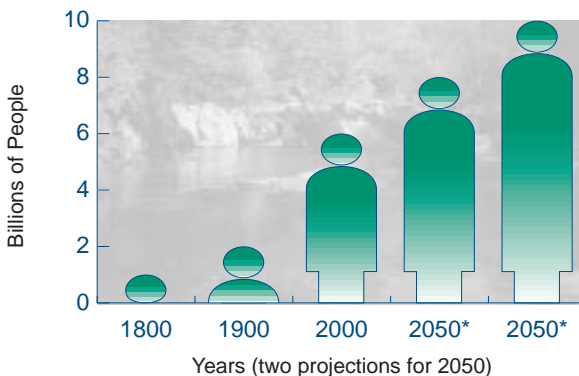
*“Water, water everywhere, and all the boards did shrink,  
Water, water everywhere, nor any drop to drink.”*

*The Rime of the Ancient Mariner - Samuel Taylor Coleridge*

From space, the Earth appears blue. It is the water planet. But, only a tiny fraction (less than 3%) of Earth’s water is fresh<sup>1</sup>. Mostly it is salty from the sea. A huge amount of Earth’s finite fresh water resource (97%) is locked up, most in the frozen Antarctica or deep underground beyond the easy reach of man. Worse, profligate actions by individuals have polluted much of the finite fresh water accessible to mankind. Thus like Coleridge’s *Ancient Mariner*, the Earth is awash in water with much of it unfit to drink.

Before the agricultural and industrial revolutions, less than one billion people competed for available fresh water. Despite occasional site-specific droughts, fresh water shortages were the exception rather than the rule. Today, as we approach the 21<sup>st</sup> century, there are six billion individuals competing for their share of the finite water resource. And projections are for at least eight or possibly more than ten billion by 2050. Yet the total quantity of water on Earth remains relatively constant.

## Population: the primary driver for increased water usage



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<sup>1</sup> As used in this report fresh is the opposite of sea water. Fresh water ranges from ultra-pure drinking quality to levels contaminated with a wide range of natural and man-made materials.

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More people means more fresh water demand. It may be useful to remind ourselves of some of the multiple uses of our fresh water resources. They include drinking, cooking, cleaning, industrial production, irrigation, fisheries, aquaculture, recreation, transportation, power generation, aesthetics and even putting out fires. Agriculture, which already accounts for over two-thirds of all human water use, will need more to grow food. Industry, currently accounting for only twenty percent of water consumed, is expected to expand its output four- or five-fold before 2050, thereby increasing its water requirements.

**“Is the world running out of fresh water?”, the answer is a resounding no.**

Industry uses water as a basic component of many products desired by humans. Water has traditionally been a convenient and cost-effective means of removing wastes and by-products from manufacturing processes. Water for most of industry is a relatively minor cost of conducting business. Now all this is changing. Those billions of additional people will need more water to drink, wash and cook. They will also need more food, goods and services, all of which require water. As a result, in certain locations, water for industrial expansion may not be available at any price.

But in addition there may not be adequate fresh water to meet the crucial needs of natural ecosystems, to maintain wetlands, for lakes and streams to provide recreation and fishing, and to replenish underground aquifers.

Against this background, it is becoming ever more apparent that few in society are using water in a sustainable manner. However, if one poses the question, “Is the world running out of fresh water?”, the answer is a resounding no.

The reason for this is that the world’s natural water cycle is constantly renewing itself. Large quantities of water are evaporated from the seas leaving the salt behind. This fresh water is then precipitated onto land surfaces as rain, snow or ice. The precipitation that falls on land supplies 45,000 cubic kilometers of new fresh water every year – e.g. enough to inundate all of Europe under 2.3 meters of water. Ice and snow melt from mountains to release fresh water to our rivers, streams, lakes, and to recharge underground streams and aquifers.

Further this water is constantly being reused by man or recycled by nature. When the farmer irrigates his crops, a good portion returns immediately to nearby water sources although it is often polluted and no longer useable without treatment. More is evaporated back into the air. The amount fixed in crops also is eventually recycled back to

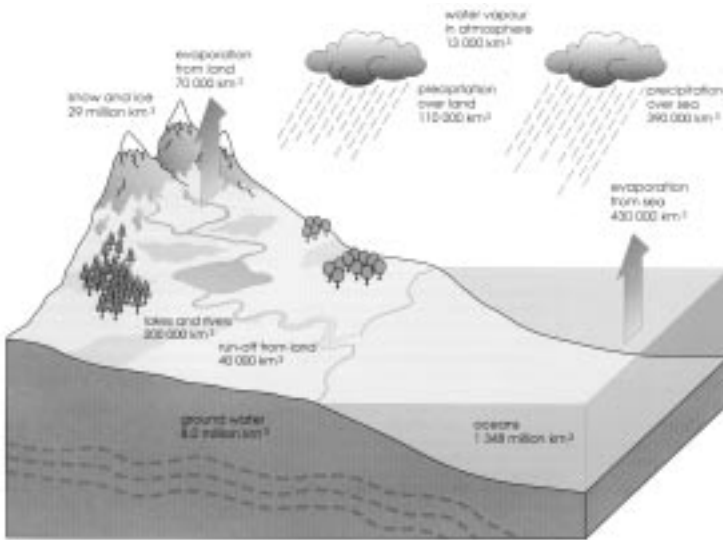


nature. When the factory uses water, or an individual takes a bath, most of the water eventually returns to nature. Increasingly the issue has become not whether water is recycled but rather how soon, where, and in what condition is the water available for other users? Not using so much water in the first place is a preferred alternative for all users.

Sanitation, cleaning our waste-water, makes our water healthier for the public and for aquatic life and easier to use, and it increases our ability to use the same drop of water again and again. In fact, water is used and reused multiple times along many rivers before it flows back to the sea.

Finally, technology is available to convert both saline and polluted water into fresh water, albeit still at high cost. Thus like most resources, water is not in danger of running out. Rather it is a case of needing to pay ever higher prices to deliver the desirable commodity – small comfort for the poor unable to pay more for water. Transport and cleaning water can be costly. Both actions require more energy and may exacerbate greenhouse gas emissions.

**“Are there likely to be increasing incidences of fresh water shortages?”, then the answer is an unequivocal yes.**



If, however, one poses a different question, “Are there likely to be increasing incidences of fresh water shortages?”, then the answer is an unequivocal yes.

Many arid areas are already suffering from continuous shortages; droughts affect other regions sporadically; aquifers are being drawn down more rapidly than nature replaces water; salt water intrusion

**“Seventy percent of electric energy in Columbia comes from hydro. If we run out of water, we run out of electricity. We must conserve our water and find alternate sources of energy in the longer term.”**

***Maria Emilia Correa,  
CECODES, Colombia***

makes much fresh water undrinkable; pollution from many sources reduces useable supplies; changing weather patterns like El Niño exacerbate drought in some regions and generate excess rain, storms and flooding in others. Even in countries where water has traditionally been abundant, such as England, changing weather patterns demand more careful management of water resources.

Thus there is evidence that water shortages are occurring more frequently, in more locations and with greater severity. Industry needs to prepare itself for an era of recurring fresh water shortages. Indeed, some observers believe that fresh water is already a limiting factor, both in terms of quantity and quality, in future development in specific regions. Sustainable development demands that we use our finite fresh water resources more intelligently and efficiently. All users must recognize this reality, begin planning together and then begin acting together. If not, individuals, farmers, business and the environment itself may pay very high penalties.

#### **The health connection to fresh water**

Various UN organizations have estimated that nearly one billion persons do not have adequate access to safe drinking water today. Nearly two billion, or over one in three of the Earth's population, do not have adequate sanitation facilities. There are more than three million deaths each year, some claim five million, from water related diseases.

President Jacques Chirac of France raised these stark facts with the General Assembly when he addressed the special UNGASS meeting in June 1997. He and other distinguished leaders have issued a call for action now to redress this unacceptable situation.

*“There is a liquid more precious than oil: water.”*

*UK Prime Minister Blair's  
address to the UN Special Session, New York, June 1997*

Others, including World Bank Vice President Serageldin, have warned that two out of every three persons in the world might not have adequate access to fresh water and sanitation by 2050, if leaders fail to respond. The UN Commission for Sustainable Development is giving fresh water highest priority in 1998.

Thus there is a humanitarian, health and environmental dimension to the fresh water issue. Clearly, there is a case for coordinated action on water supply and sanitation to prevent unacceptable social costs

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from overwhelming the capabilities of developing countries in the next century.

### Purposes of the UNEP-WBCSD report

The primary purpose of this paper is to attempt to explain what increasing incidences of fresh water shortages imply for industry and the business community. A related purpose is to demonstrate what creative and innovative companies have already done to protect water resources, to reduce water use, to use water more efficiently, and to improve the quality of water discharged by industry. The report presents a series of case studies which can serve as a benchmark for good practice by industry. It does not claim 'best practice', for that is an evolving target. But these 'smart' actions are technically and financially feasible. They have been done; they can be replicated; they are 'win-win' situations; and they contribute towards sustainable development.

Collectively, industry has considerable technology and management skills which can play an important role in facilitating how well society manages and uses its finite fresh water resources. But industry is only one player in this complex issue and alone can't do it all. However, in partnerships with governments, farmers, non-governmental groups and the public, industry can make major contributions to the task of identifying, assessing and solving water problems in the new century. Industry needs, first, to put its own house in order, and then help others by making contributions to improved access to fresh water and the wise management of the resource base. All stakeholders should prevent water pollution and water-wasting practices *now* – pollution prevention clearly pays off in the long run.

Then, if governments, especially local municipal governments, set the correct framework conditions, it is possible that the economic and technical power of the private sector could be unleashed to tackle some of the most pressing water issues.

What do we mean by that? In simple terms, it means that the price for water must be set at a level which turns it into a valued commodity, one worth conserving and using wisely and, most importantly, one in which industry would be willing to invest its time, talent and cash. Fresh water can no longer be regarded as a free good. The 1992 Dublin Principle was clear and correct when it said that: "*Water has an economic value in all its competing uses and should be recognized as an economic good.*"



**Industry can't  
do it all alone.**

**“Water has an economic value in all its competing uses and should be recognized as an economic good.”**

Or as the Comprehensive Assessment of the Fresh Water Resources of the World<sup>2</sup> puts it: “*Water is an economic good. Its economic values should be given due attention when appropriating scarce water resources among competing uses, without infringing on the basic rights to water services for all people at affordable prices.*”

Many municipal governments, especially in developing nations, lack the resources to build and operate essential water supply and sanitation facilities. The resources available from international lending institutions (e.g. the World Bank) and overseas development assistance are unlikely to be sufficient to meet these needs – some estimate that over US\$600 billion in new investment capital will be required in the next ten years alone. However, if national governments set appropriate water policies, industry could help fill this investment gap with ‘bankable’ projects. Bankable implies a cash flow which repays the investment and generates a profit. It also implies the commercial, political and legal stability necessary to cover the risk.

What risk are we referring to? If there is instability, legal and contractual uncertainty or rampant corruption, the risk premium will be very high. Stated more clearly, investors will require higher rates of return because of a high perceived risk, if they are prepared to invest at all. Banks, private companies and individuals do not invest unless there are reasonable framework conditions.

However, it is not just a matter of price and profit. In return, industry should be held accountable. Industry should be required to meet specific performance standards such as delivery of safe water to designated service areas; increase the time of day during which water service is available (in some areas water is delivered for only a few hours each day); eliminate water loss through leaking pipes by targeted amounts; and meet specified water quality parameters, or other goals. Water supply and treatment companies also should be accountable and provide monitoring and reporting to the public, meet service commitments, thereby delivering value for the charges they levy.

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<sup>2</sup> Lundquist, Jan and Gleick, Peter, *Comprehensive Assessment of the Fresh water Resources of the World Sustaining Our Waters into the 21st Century*.

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# Increased competition for water

I ncreasing demands for water are occurring from 3 key areas which, in aggregate, are exerting unsustainable pressures both in developed and developing countries. The areas are:

- ◆ **human needs** for safe drinking water and proper sanitation
- ◆ **agricultural needs** for expanded production to meet population growth
- ◆ **industrial needs** to provide more goods and services for a growing population

There is a fourth category of needs, **environmental needs**, which while not increasing, must be met to attain sustainable development. Society cannot afford to ignore water needs crucial to protect natural ecosystems, endangered species, biodiversity, watersheds and unique areas of special interest.

## Human needs

The major factors influencing the demand for fresh water are the world's rapidly growing population and its continuing urbanization. World population is expected to increase from approximately 6 billion in 2000, to 8-10 billion people in 2050, with 90% of future population growth occurring in developing countries. This growth will drive the move towards an increasing number of megacities, each in excess of 10 million individuals. This shift from rural to urban, and from low to high density, has major implications for water supply and water sanitation systems. Rapid urban growth combined with poor economic development can create enormous environmental and health problems.

UNEP and WBCSD have identified a number of areas where industry could play an active role. There is always a need for research on, and development of, efficient new infrastructure for urban water supply and new technology for the re-using of urban waste-water.

However, in most cases the technology needed to deliver fresh water and to clean waste-water already exists. The primary need is to create a public and government commitment to act and then to find creative financing mechanisms to carry out the tasks.

Project the goal of rudimentary sanitation service for the two billion without such service today plus the five billion additional inhabitants expected by 2050 and you arrive at a need to supply sewerage to almost 400,000 new customers every day for the next 50 years! Truly a monumental task.

**Agricultural needs**

Agriculture is by far the largest water consuming sector. It accounts for over two-thirds of the world's current fresh water use. However, the water used by agriculture varies considerably from country to country as the chart below demonstrates. In Europe, a region with abundant natural rainfall, a relatively small amount of irrigation is necessary. In other parts of the world, irrigation is essential to produce food. In fact, agriculture accounts for 90% of water use in many developing nations.

**Agriculture is by far the largest water consuming sector. It accounts for over two-thirds of the world's current fresh water use.**

Sectoral use of fresh water by selected countries<sup>3</sup>

COUNTRY	Agricultural	Industrial	Domestic and Commercial
China	87%	7%	6%
Egypt	88%	5%	7%
India	93%	3%	4%
France	12%	71%	17%
Netherlands	32%	63%	5%
United Kingdom	1%	78%	21%

Agriculture is also the largest polluter of water in most developed and developing countries, as a result of pollution from poor land management practices. These include the unwise use of pesticides and fertilizers, inefficiencies in irrigation, and unrealistically low subsidized water costs which encourage wasteful practices.

In the agricultural sector the major water pollution issue is often one of 'non-point' sources, where it is difficult to identify the source

3 Saeijs, H. F.L. and van Berkel, M.J. *Global Water Crisis, the Major Issue of the 21st Century, European Water Pollution Control, 1995, vol. 5.4: 26-40.*

and exact discharge points of the pollution. This is an area which UNEP and WBCSD consider to be key for the evolution of sustainable water policies.

UNEP and WBCSD can promote improved practices in environmental management and product stewardship, including fertilizer and pesticide management. In addition, industry research and development in the area of better irrigation technology is strongly supported. However, the issue of economic pricing of water, especially in the agricultural sector, is recognized as a key area for priority government attention. The Commission on Sustainable Development's *Comprehensive Assessment of Fresh Water* report has even suggested that self-sufficiency in food, a traditional nation-state response, may no longer be the most rational or logical policy for some nations. In certain circumstances it may be more effective, in terms of water management, to generate income through industrial exports and import a higher percentage of food needs.

### Environmental needs

The allocation of water for environmental needs is a growing area of investigation and policy development. The environment requires water of sufficient quality and quantity to maintain a diverse array of ecosystem functions and biodiversity resources. Moreover, it is becoming increasingly obvious that the environment is not just a sectoral user of water like industry and agriculture, but it plays a fundamental role in maintaining the quality and supply of the world's water resources used by the other sectors.

One classic example is forested watershed protection. Proper forestry management, whether done by government or the private sector, can prevent wasteful water run-off and even serve to ensure the supply of fresh water. Conversely, poorly planned clear-cutting of forests on steep slopes has led to disastrous soil erosion and flooding. Any short-term economic gains have led to dramatic social and disaster relief costs far outweighing the benefits.

Nature provides other services to man. Economists have estimated that the annual value of services provided by wetlands may be as high as US\$ 14,800 per hectare and that of rivers and lakes, US\$ 8,500 per hectare<sup>4</sup>.

**The environment requires water of sufficient quality and quantity to maintain a diverse array of ecosystem functions and biodiversity resources.**

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<sup>4</sup> Constanza et al 1997. *The Value of the world's ecosystem services and Natural Capital*. *Nature*, v. 387, pp253-260.

WBCSD and IUCN, in their joint report on *Business and Biodiversity* (June 1997), pointed out the many ways that business and society benefit from biodiversity, including food, fuel, clothes, shelter and natural medicines. It is sound business practice to conserve and use both biodiversity and fresh water resources efficiently. Biodiversity is particularly sensitive to changes in land use, reduction in size of habitats and loss of access to water. If a habitat is too small to sustain a particular species, that species will die out at that location and affect the other species dependent on it.

Possible roles for industry include the support of catchment management networks<sup>5</sup> and involving all stakeholders in a watershed to promote effective environmental management of water and land resources. This is of particular interest to those companies in the natural resources sectors of mining, forest products, paper, and oil and gas extraction operating near important natural ecosystems. The chemical and fertilizer sectors also have an important role to play in protecting environmental amenities and life-supporting ecosystems. Additionally, the continued education of industry in basic water management practices is recommended.

### Industrial needs

Currently, industry accounts for about 20% of the world's consumption of fresh water. European nations use a higher percentage for industry because so much less is needed for agricultural purposes (see chart on page 8). But, industrial demand for water, particularly in rapidly industrializing countries, is also growing quickly.

Significant progress on water conservation has been made by many companies, primarily in OECD countries. This trend will continue to grow and, in the face of increasing demand from downstream users for a greater share of water, industry must continue to adjust and develop its water management strategies.

Industry has a much larger role to play than just protecting its access to water. It also brings the technological capability to move water, treat water and manage water supplies. The development of water technology and strategies for providing clean drinking water and removing wastes is one area where industry can be intimately connected to improving the living conditions of populations in developing countries. It has an opportunity to participate in providing sustainable solu-

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<sup>5</sup> All fresh water drains downhill into specific areas defined as watersheds or areas catching the water resources in that region. These areas can be small or huge stretching across international boundaries. Integrated Water Resource Management is based on these defined units.

**Industry has a much larger role to play than just protecting its access to water.**



tions for water management, not only for itself, but also for its neighbors, local farmers and natural ecosystems as well.

When industry invests in a country, it creates employment and stimulates economic growth. In turn this creates new, more affluent customers for its goods and services. Safe drinking water and proper sanitation is part of the basic infrastructure that encourages new business investment.

The most sensitive water issue for many industry sectors is its quality. While limitation of the future supply of water for industry is a growing concern, industry is often perceived by the public as the worst polluter of water. Producing goods for consumers can generate water pollution and there remain some examples of serious 'point-source' industrial pollution in the world. Nonetheless, pollution control regulations and waste-water charges have encouraged a trend towards industry compliance with ever more stringent limitations on discharges to public waters.

This positive trend has been stimulated by increased concern by business managers and business' stakeholders, including customers, and coupled with the introduction of more effective environmental management systems. In many areas industry finds that it must clean up the intake water from public rivers, lakes and aquifers because the water does not meet quality standards required for processing finished products. Food processing, pharmaceutical, electronics and other industrial sectors require very pure water for their operations.

By contrast with the view that tends to be held by the general public, UNEP and WBCSD see pollution from agriculture and inadequately treated urban waste-water as larger problems by far – in terms of absolute quantity of pollution load generated, the geographical extent of the pollution problem and in the relative difficulty of controlling these sources of pollution.

**By contrast with the view that tends to be held by the general public, UNEP and WBCSD see pollution from agriculture and inadequately treated urban waste-water as larger problems by far.**

# Water quality

**A**long with the competition for water availability discussed above, a second crucial factor is water quality. When individuals, farmers or industry use water, they almost invariably add unwanted substances to the water they discharge. Nature itself causes some forms of pollution such as when heavy rains cause erosion or bogs and swamplands add unwanted materials to lakes or river systems.

Beginning about 1970, public and political forces within most OECD countries began to demand improved water quality. Since then there has been a virtual revolution in the way society and industry regard water. The changes began with command and control regulatory 'end-of-pipe' retrofit technology at existing industrial facilities. It was followed by massive programs to upgrade existing and install new sewage and public waste-water treatment facilities. These public facilities treated household discharges as well as discharges from businesses. The revolution continued with discharge permit requirements for new or modernized plant and equipment.

This new interest resulted in the expansion of the waste-water industry and the creation of many new service, engineering and construction companies. The world invested US\$ 335 billion in 1995 purifying drinking water, treating municipal waste-water, and treating industrial process water and fluids. Annual capital investment in this area is expected to reach US\$ 500 billion by 2000<sup>6</sup>. Providing drinking water, cleaning up waste-water discharges and preventing future water pollution is big business.

Initially there were acrimonious debates about the level of discharge controls and the time frames for compliance. It was soon concluded that pollution prevention, especially when building new facilities, was

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<sup>6</sup> McIlvaine Company - Internet: <http://members.aol.com/mcilvneweb/mcinfo.html>

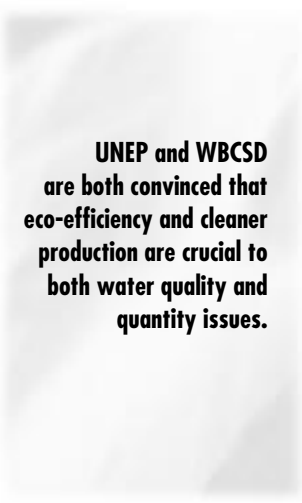
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eminently more cost-effective than cleaning up dirty water after the fact. When performance standards, rather than specified technology standards were established, industry found creative ways to protect water resources, to use less water, to recycle or reuse waste-water, to move towards zero discharge or closed loop systems and to find ways to reduce or eliminate pollution before it contacts water. This meant moving towards 'Eco-efficiency and Cleaner Production', concepts championed by UNEP and WBCSD.

UNEP and WBCSD are both convinced that eco-efficiency and cleaner production are crucial to both water quality and quantity issues. As industry is finding new innovative ways to prevent waste, to produce more with less and to discharge less waste-water, there is an inevitable decrease in water consumption by industry. Each unit of production requires less water, and the water returned to the natural cycle is also cleaner and more appropriate for reuse. This is an inherent component of sustainable development. WBCSD has developed and been a strong advocate of eco-efficiency, a concept which implies that industry must be concerned not only with economic performance but ecological performance as well.

It should be clear from the preceding discussion that industry does not necessarily oppose all government regulation. In fact, industry needs clear and consistent guidelines as well as intelligent regulation that rewards innovation and creativity. Inflexible rules that prescribe or lock in specific technology are a sure formula for stagnation. If industry is to meet the needs of eight or ten billion people, it must be encouraged to find creative solutions to produce more with less. Here it is important to avoid cumbersome paperwork requirements which provide work for lawyers rather than generating improved environmental performance.

UNEP and WBCSD agree that industry should be part of the solution rather than part of the problem. All of industry is encouraged to emulate the positive examples set forth in the case studies which follow. Sharing best practice and learning from the examples of other businesses makes sense and is good business practice. Many of the emerging water problems will require partnerships and the cooperation from all users. It is clear that sustainable use of water by individuals, farmers and business can contribute to sustainable development for all and make a contribution to poverty alleviation everywhere.



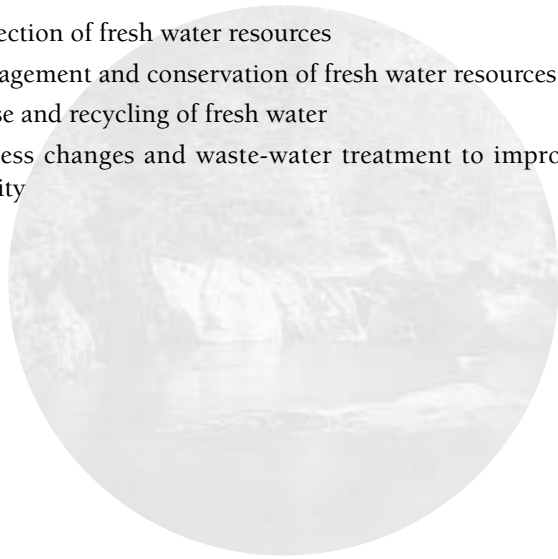
**UNEP and WBCSD  
are both convinced that  
eco-efficiency and cleaner  
production are crucial to  
both water quality and  
quantity issues.**

# Case studies

**T**his report presents a series of case studies to demonstrate how some companies have contributed to an on-going revolution in water management. Some of the cases document water protection, water conservation and the recycling and reuse of water. Others highlight significant improvement in waste-water treatment which improve water quality and permit the reuse of water by downstream users. Still other cases describe innovative uses of natural ecosystems which generate 'win-win' solutions good for business and good for the environment.

**The cases are organized into four categories as follows:**

1. Protection of fresh water resources
2. Management and conservation of fresh water resources
3. Reuse and recycling of fresh water
4. Process changes and waste-water treatment to improve water quality



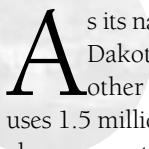
## Protection of fresh water resources

CASE

1

### LINKING INDUSTRIAL ACTIVITY TO NATURAL SYSTEMS

**LADISH MALTING**  
*United States*



**A**s its name implies, Ladish Malting, a subsidiary of Cargill, North Dakota, processes grain into malt, a key ingredient in beer and other alcoholic beverages. This facility, located in Spiritwood, uses 1.5 million gallons of water each day in its processes and then discharges most of it back into natural receiving waters. However, the water is polluted and requires treatment.

Managers were interested in low-cost ways to clean this discharge water. Local employees, working in partnership with local farmers, Ducks Unlimited (an organization dedicated to protecting wildfowl), the US Fish and Wildlife Service, the Boy Scouts and 4-H clubs (an American farm youth organization), developed a unique approach. The idea was to create a wetlands project to benefit waterfowl and other migratory birds that used the Central Flyway, a main route connecting Canada through the heartland of the United States, to warmer climes in the South.

Properly managed wetlands can serve as natural cleansing agents for water contaminated with excess biological material. Discharged into rivers, these waste-waters consume oxygen and, in extreme circumstances, pose a threat to fish and aquatic life. Discharged slowly into wetlands, their biological nutrients are used by the plants occupying this natural ecosystem.

The project began in the fall of 1992 and converted 180 acres of farmland into permanent wildlife habitat. The total cost of the project was only US\$ 125,000. Ladish paid 60%, Ducks Unlimited 32% and the US Fish & Wildlife contributed the final 8%. Ladish's wastewater now flows slowly through a man-made wetland; contaminants are removed; and then it enters a five-acre (2.1 hectares) aerated lagoon for final cleansing. The clean water is stored in special ponds with non-porous clay bottoms and concrete berms, and ultimately pro-

vides irrigation water for 2,400 acres (1,000 hectares) of nearby farm land.

This example represents a classic win-win situation. The company reduces its waste-water treatment costs, wildlife gains an enhanced habitat, and local farmers obtain low cost irrigation water. Thus the same fresh water is used three times for industrial, environmental and agricultural purposes.

**The same fresh water is used three times for industrial, environmental and agricultural purposes.**

### Results

- ◆ Ladish now dedicates 2,200 acres (916 hectares) to waterfowl habitat at its site
- ◆ 3,000 waterfowl, mostly ducks regularly nest in this area
- ◆ a pair of Piping Plovers (on the endangered species list) was spotted in 1997
- ◆ farmers pay the cost of pumping water to their fields and a higher land rent on irrigated acreage

Cargill has announced that they intend to use this model at other plant sites. It is a useful concept for symbiosis between food processing industries, natural habitat enhancement and agricultural uses.

### Lessons Learned

1. When waste-water contains only biological materials, natural or man-made wetlands can effectively remove pollutants in ways that are both inexpensive and good for the environment.
2. This example represents an interesting opportunity to reuse some industrial waste-waters for irrigation purposes.
3. Cooperation among governments, non-governmental organizations and industry can provide mutual benefits for all.


### For further information

Joseph P. Botos, Ladish Malting  
tel: (1 612) 742 6006; fax: (1 612) 742 6678  
e-mail: Joseph\_P\_Botos@cargill.com

INNOVATIVE ENVIRONMENTAL  
PROGRAMS FOR WATER  
PROTECTION AT VITTEL

**NESTLÉ**  
*France*



 **P**errier Vittel SA, a Nestlé subsidiary, is the world's number one company in the bottled water field and is present in more than 120 countries. With more than 60 bottling plants around the world, Perrier Vittel SA draws on its experience gathered in the area where the Vittel and Contrex spas are located, in order to protect the water resources.

Generally, spa resorts are located in a naturally favorable environment, as is the case of Vittel and Contrexéville, two villages surrounded by small green hills covered with meadows and forests in the French Vosges mountains. Contrexéville and Vittel Natural Mineral Waters were recognized as public interest springs in 1860 and 1903 respectively. Legal protection areas were defined around these springs to preserve the local natural environment.

However, new trends in agricultural practices, such as intensive farming, were shown to possibly endanger the natural ecological balance. Local authorities and Perrier Vittel SA decided to reinforce the natural ecosystem protection, first through systematic environmental risk analysis of human activities in the protection area.

An observation network was set up in 1975 to assess precisely the environmental impact of urbanization, industry, transportation and agriculture. Since the 1980s, a large set of innovative water protection measures involving the various actors has been successfully implemented.

In the Vittel area, the network of municipal waste water collecting pipes and the sewage plant capacity, existing since 1912, was extended to cover a larger area and to meet stricter standards than required legally, in particular for nitrates and phosphates. The corresponding investment was shared between the municipalities of Contrexéville and Vittel (75%) and Perrier Vittel SA (25%).

Industry, as well as individuals, were encouraged to replace fuel oil with natural gas for home heating and processes. Incentives were provided by Perrier Vittel SA to remove abandoned fuel oil tanks, which might rust and leak at some future date. A collection system was instituted for hazardous waste from small enterprises.

A ring road was built around Vittel to reduce local traffic and the risk of accidents and potential contamination within the city. This new road was built with an impermeable surface to ensure the recovery of possible leakages in specific collecting pits following a road accident. These actions are consistent with the precautionary principle for preventing pollution before it can occur.

Perrier Vittel SA has set up an agricultural consulting company, Agrivair, to encourage local farmers to apply farming specifications based on specific scientific studies. These recommendations include best practice in agricultural and cattle breeding, including the ban of phytosanitary products, strict limitation of fertilizers and management of compost and slurry. Long-term contracting farmers receive financial incentives and technical assistance from authorities and from Agrivair.

A better understanding of surface water flows has recently led the local Forest Office to propose the modification of the landscape with the construction of embankments and the reintroduction of trees, particularly hedge bushes slowing down the flow of surface rain water. This prevents erosion and retains more of the water for beneficial uses.

In the spa resorts, herbicides have been banned while paths and railways are weeded with heating techniques. In the rose gardens, more resistant species were selected and biological pest control has been applied successfully. As an example, ladybird breeding was set up to eliminate greenflies during the summer. To protect special-purpose turf areas from field mice, e.g. in golf and race courses, birds of prey were introduced.

All these activities in Vittel and Contrexéville are closely monitored. They represent a unique 'outside research laboratory', frequently mentioned as the best example of risk minimization ahead of its time. The studies and their results can be applied to a large extent in other places around the world to define and implement adapted water protection programs.



### Lessons Learned

1. The protection of water resources is a shared responsibility. Close co-operation between agriculture, industry, municipal authorities and local residents is necessary to ensure efficiency.
2. Innovation is a major key to protect water resources. Industry draws on its R&D skills for this purpose.

### **For further information**

Irina du Bois, Nestlé

tel: (41 21) 924 2262; fax: (41 21) 924 4547

e-mail: [Irina.duBois@nestle.com](mailto:Irina.duBois@nestle.com)

CASE

3

COPING WITH NON-POINT  
SOURCE POLLUTION **SEVERN TRENT WATER**  
*United Kingdom*

**F**ollowing almost thirty years of intensive efforts, OECD countries are now exercising regulatory control over water effluents from both industrial facilities and community waste-water treatment plants. Such discharges are emitted at discrete locations known as point sources. Surface water quality improvements achieved by such effluent treatment has made society more aware of other 'non-point' sources of pollution which are much more difficult to control. Since most point sources of pollution are controlled, these non-point sources represent an increasing proportion of pollution loads into the water environment. This pollution arises predominantly from run-off or seepage from agricultural land and road systems and can contain solids; oils; nutrients; chemicals and pesticides.

Severn Trent Water realized that the diffuse nature of these polluting discharges meant they would have to be tackled by initiatives to treat or remove pollutants at source. It was, therefore, necessary to target industries, farmers and other activities responsible for 'non-point' pollution. This case describes four programs championed by Severn Trent Water, in partnership with governmental, NGO and trade associations. These are:

1. **Spray Safe** – an awareness raising campaign addressing pollution problems arising from the use of herbicides and pesticides
2. **Chem-E-Safe** – a certified code of conduct designed to minimize the occurrence and effects of chemical spillages and accidents involving chemicals
3. **Farm Safe** – a code of conduct targeted at the farming community designed to educate farmers on how to minimize the risks of polluting watercourses
4. **C.O.P.P.I.C.E.** – a code of practice for the photoprocessing industry

**Spray Safe** was designed to persuade all pesticide users to significantly modify weed control practices in order to minimize or even eliminate excess pesticides leaching into water catchments and encourage utilization of more benign chemicals. The initial eighteen month campaign involved user surveys; conferences; media coverage and the provision of detailed advice. The main messages were published in SpraySafe Charter which includes an eight-point checklist of ways to minimize or avoid water contamination.

Over seventy percent of local authorities cite SpraySafe as an influencing factor in reviewing their policies, a measure of how well the initiative has been received. A forum of experts was convened in December 1996 to review the progress that had been made. Feedback from this event was built into an updated charter distributed with the 1997 SpraySafe questionnaire. Another project, in conjunction with other UK water companies and the Environment Agency, involves pilot trials with Railtrack, the company responsible for maintaining the nation's rail tracks. This aims to determine how track spraying procedures can best be modified in water catchments known to be highly vulnerable to pesticide contamination.

**Chem-E-Safe** contains a code for industry which sets down the key areas to be addressed to avoid risk of pollution by chemicals. The initiative is supported by the Environment Agency and the main trade associations of the UK Oil and Chemical industry. The code covers safety policy, documentation, employee training, storage and monitoring for leaks, emergency procedures and protection of drains from spillages and accidents. Companies in the Severn Trent Water catchment have been asked to sign a pledge to follow this code of good practice.

**Farm Safe** is aimed at farmers and promotes good advice and increases awareness about problems farm wastes can cause to water supplies, particularly with respect to ammonia and cryptosporidia. In the company's trial catchment area, all the livestock farmers and representatives of relevant trade and NGO groups were invited to local water treatment works to learn about and discuss the issues involved. Subsequent events have been conducted in other areas and been well received by farmers keen to gain a better understanding of their role in safeguarding water supplies.

**C.O.P.P.I.C.E.** provides the photoprocessing industry with the means to optimize process selection and minimize the waste streams from their business activities. The advice contained within the code of practice not only helps reduce discharges of polluting chemicals,

but it also recommends technologies for the recovery of waste materials. Suitable procedures for containing abnormal or emergency incidents are provided.

### Lessons Learned

1. Pro-active initiatives for environmental protection can be very effective when championed by water companies in partnership with other stakeholders.
2. Established working practices within industrial sectors can be improved with targeted advice in the form of codes of best practice.
3. Impacts from 'non-point' sources of pollution can be reduced by educational campaigns focused on the people and activities that cause them.

### For further information

James Lamb, Severn Trent Water  
tel: (44 121) 722 4902; fax: (44 121) 722 4909  
e-mail: [ecc@severntrent.co.uk](mailto:ecc@severntrent.co.uk)

CASE  
4

NATURE CONSERVATION IN THE OZE  
DISTRICT

**TOKYO ELECTRIC POWER  
COMPANY**  
*Japan*

**T**okyo Electric Power Company (TEPCO) is the largest electric utility in Japan. In Gunma Prefecture district about 150 kilometers north of Tokyo, the company owns some 18,000 hectares of forested land which it manages, through its affiliate Oze Ringyo (Forestry) Company, to provide natural flood control of water leading into several of its hydropower reservoirs. Included in its property is the western half of Oze Marsh, one of Japan's best known highland marsh environments, which is a habitat for animals and plants of scientific value. It has been designated as a special reservation and a nature monument in the Nikko National Park. Owing to its unique scenic beauty that is readily recognizable, this marsh attracts hundreds of thousands of people each year from all over Japan.

Just as in Yosemite National Park in California, Oze Marsh's popularity and increasing number of visitors have been threatening to destroy the very natural settings which made it so popular. As early as the mid-50s, large numbers of hikers had trampled several areas of the marshland, which consequently became devoid of vegetation.

From around 1960, TEPCO, in close cooperation with Oze Ringyo, has been constructing and maintaining special elevated wooden walkways to keep visitors from stepping into the marshland. TEPCO has built and maintains over 20 kilometers of walkways. Visitors must use the extensive network of special paths. Efforts have been made from 1969 to renovate and restore the degraded areas with local grasses and shrubs. Notices are published to keep hikers out of certain fragile portions of the marshland. To preserve the air quality of this area, photovoltaics are installed in TEPCO's Oze Cottage, used by overnight visitors.

In 1972, a campaign ("Let's bring our trash home" is the literal translation from Japanese) was initiated to urge the visitors to take their

rubbish out of the marsh. A year later all the trash baskets were withdrawn. As a part of this campaign, TEPCO and Oze Ringyo have been distributing trash bags at the starting point of the trails and at the Cottage to remind the hikers to take all their trash home for recycling.

Guests at the Cottage are requested not to use soap or shampoo when taking showers in order to prevent degradation of the water quality. Moreover, in anticipation of the risk of water contamination from the ever-increasing number of visitors, the company has installed a high-performance consolidated septic tank system in the Cottage capable of processing both food scraps and human wastes. The company maintains septic systems at all seven public lavatories in the marsh. Discharge water is of extremely high quality.

In 1995 three prefectures, adjacent to the marsh, along with other municipalities along with TEPCO established the Oze Preservation Foundation, which promises even more effective protection of Oze Marsh.

### Lessons Learned

1. Cooperation among local governments and corporations can facilitate restoration and preservation of marshlands and other areas with high value for species habitation.
2. The impact of urban visitors and hikers can be mitigated with appropriate investment in facilities and public education programs.

### For further information

Yasuo Hosoya, Tokyo Electric Power Company  
tel: (81 3) 3501 8111; fax: (81 3) 3504 1570  
e-mail: t0230714@pmail.tepco.co.jp

### Interesting Facts

The average water recovery rate for all Japanese industries increased from 36% in 1965 to 76% in 1991. Industrial water demand in Japan was 15.9 billion cubic meters in 1991, which reflects almost zero growth throughout the 1980s, despite huge increases in industrial output during the same period<sup>7</sup>.

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<sup>7</sup> Abiru, Takeshi, *The water management strategy of Japanese industry*

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## Management and conservation of fresh water resources

### MANAGING AN UNDERGROUND AQUIFER

**DANFOSS**  
*Denmark*



**D**anfoss, a manufacturer of hermetic compressors, pumps, valves, motors and other electrical control units has a major manufacturing facility located on a small island, Als, in the Baltic Sea. In 1983 the company was routinely withdrawing 2 million cubic meters of fresh water from the sole aquifer which supplies the entire island, home to 50,000 residents. This was well within the limit of 3 million cubic meters authorized by local officials.

In 1983, Danfoss discovered a crack in a settling tank in its waste-water treatment system. The company was concerned that polluted water might permeate down into the fresh water supply. The company repaired the leak immediately but began an extensive investigation of the groundwater and the aquifer. The good news was that the leak had not polluted the aquifer; the bad news was that the level of the aquifer had dropped to a dangerously low level. So low, in fact, that the risk of salt water intrusion had become a real possibility. Danfoss's management recognized that the company was the biggest fresh water user on the island and as such it had a responsibility to all the private citizens who used this common resource.

The company initiated a series of water savings programs and completely revised its waste-water treatment system. All pipes were placed above ground so that even the smallest leak could be detected immediately. In 1989, the local authorities reduced the permissible water extraction rate for Danfoss to 2 million cubic meters. This was not a problem for Danfoss because it had already reduced its consumption to below 1 million cubic meters.

Despite increasing production levels, Danfoss continued to find ways to reduce its water consumption even further. By 1994, it had cut consumption to 0.4 million cubic meters, a reduction of more than 80% compared with 1983 levels. During this same period, the level of the

**By 1994, it had cut consumption to 0.4 million cubic meters, a reduction of more than 80% compared with 1983 levels.**

## INDUSTRY, FRESH WATER AND SUSTAINABLE DEVELOPMENT

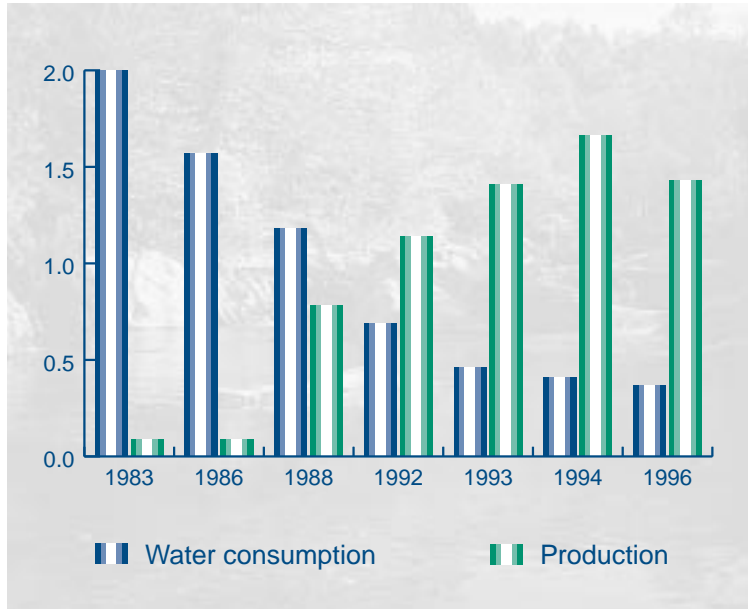
aquifer rose by 1.7 meter and the threat of salt-water intrusion virtually disappeared. The substantially improved freshwater reserves indicate a consumption level that can be sustained indefinitely. Fresh water supply was assured, both for the company, its 7,000 employees and its 50,000 neighbors on the island of Als. Results are shown below.

### Water usages

Legend	Unit	1983	1986	1992	1994	1996
Process water		0.67	0.62	0.19	0.14	0.12
Cooling water	10 million	1.16	0.78	0.10	0.10	0.08
Sanitary water	cubic	0.13	0.13	0.12	0.12	0.12
Sundries	meters	0.04	0.04	0.05	0.05	0.05
Total consumption		2.00	1.57	0.46	0.41	0.37
Upper level of lower magazine <sup>1)</sup>	Meters over sea level	0.00	0.09	1.41	1.66	1.43

<sup>1)</sup> The variation over years depends on rainfall, ambient temperature/evaporation and water consumption.

### Production and water consumption





The following lists the principle actions taken by Danfoss to reduce fresh water consumption.

### Initiatives to reduce fresh water consumption

The company's management:

- ◆ Gave priority to the water situation – including its supply, quality, consumption, and reuse
- ◆ Developed a sustainable water policy
- ◆ Sought to motivate and involve all employees in good housekeeping practices for water
- ◆ Reviewed all technical installations and processes using fresh water
- ◆ Modernized the control systems making it possible to save water and reduce effluents
- ◆ Assured the quality of recirculated cooling water to enhance cooperation between technical personnel using water and company environmental specialists

### Lessons Learned

1. Companies can continue to expand production and remain profitable while reducing fresh water consumption. This company reduced water consumption by 80%.
2. Reducing fresh water consumption involves basic housekeeping, management attention, technology innovation and commitment from all employees.

### For further information

Lars F. Jørgensen, Danfoss

tel: (45 7) 488 2266; fax: (45 7) 488 5907

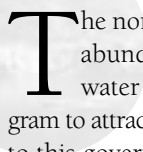
e-mail: [Lars\\_F\\_Jorgensen@danfoss.com](mailto:Lars_F_Jorgensen@danfoss.com)

CASE

6

OPTIMIZING WATER USE IN A NEW  
AUTOMOBILE FACTORY

**FIAT AUTO**  
*Italy*



The northern part of Italy is industrialized, rich and blessed with abundant water. The south is less industrialized, poorer and water is often scarce. The Italian government has an active program to attract industrial development to the south. When Fiat responded to this government challenge and decided to build a new automobile factory in Melfi (150 kilometers east of Naples in the Ofanto valley), the company knew access to fresh water would be a key factor.

In the mid-sixties, a reservoir had been built in this region to provide water for the intensive cultivation of tomatoes and other vegetables. Not only was the water supply from the reservoir inadequate, its quality was poor. Fiat realized immediately that it would have to limit its water usage at the plant and pre-treat the water to upgrade it to meet industrial requirements. The company had an added incentive to curtail its water consumption: the price was 1,000 lira per cubic meter, 50% higher than water in the north.

Fiat had already adopted a company-wide goal of reducing its water consumption by 20% by the year 2001. To attain this goal, along with other management objectives, Fiat had developed computer-assisted tools in collaboration with FISIA (a Fiat Group company operating in the field of environmental engineering). These tools were derived from Structured Activity Modeling (SAM) methods and the definition of elementary water consuming activity (EWCA). The tools are:

- ◆ WUM (water use modeling) to analyze water use and balance within a factory at any level of aggregation
- ◆ WUC (water use characterization) to characterize EWCA and then optimize water use as a function of various process parameters

In simplest terms, the objective was to use high quality water for drinking water and special production operations, while using lower grade water whenever possible for industrial processes less sensitive to water quality. One example was that 92% of all drinking water was recycled back into industrial operations, rather than being discharged as waste. All cooling water was recycled and water from various plant operations was cleaned for reuse elsewhere. Thus, high quality water could be used and then recycled for other operations, always keeping in mind that any water finally discharged would have to meet strict environmental standards.

The primary objective was to limit water consumption to less than 6 cubic meters per car. By the end of 1996, consumption was only 5.5 cubic meters per car and the factory was recycling over 200 cubic meters of water per hour internally. As a result the company reduced its annual water bill by 2 billion lira.

### Lessons Learned

1. New industrial facilities offer opportunities to reduce water consumption through recycling water used both for cooling and for production processes.
2. Specifically defined computer assisted tools facilitate optimal water use and management.
3. Fiat reduced its water consumption by 34% in the new Melfi factory, primarily through recycling efforts. This case provides one model for locating industrial operations in water-limited areas.

### For further information

Pietro Gabriele, FIAT

tel: (31 11) 683 3403; fax: (31 11) 683 4792

e-mail: dapi\_eep\_coper@auto.fiat.it

**By the end of 1996, consumption was only 5.5 cubic meters per car and the factory was recycling over 200 cubic meters of water per hour internally. As a result the company reduced its annual water bill by 2 billion lira.**

CASE  
**7**

REDUCTION IN FRESH WATER USAGE  
IN SAN DIEGO

**MONSANTO**  
*United States*

**S**outhern California is a drought prone area. From 1988 to 1995, it had below average rainfall and water shortages became a recurring problem throughout the region. The mayor of San Diego, California's second largest city, urged all citizens to voluntarily reduce fresh water consumption by 30%.

Monsanto's NutraSweet Kelco plant has been located in San Diego since 1929. It produces algin products used as a stabilizing, thickening and suspending agent in foods, pharmaceuticals, personal care products, paper and textiles, paints and coatings, oil field drilling fluids and cement materials. During normal operations volatile organic compounds (VOCs) are produced. Monsanto had installed packed-bed scrubbers to prevent these VOCs from being released to the air.

Because these scrubber systems used large quantities of freshwater, Monsanto engineers decided to evaluate whether ubiquitous ocean salt-water could be substituted for scarce fresh water. But they had to overcome the fact that salt water is corrosive and can foul the scrubbing system and so lead to a failure to control air emissions. The engineers succeeded in making major design changes that allowed the substitution of salt-water without degrading the effectiveness of the scrubbers. Several thousand feet of high-quality corrosion-resistant copper/nickel alloy pipe were installed to carry the water from the Bay to the four scrubber units. Special strainers were included in these new lines to further reduce the potential for fouling the scrubbers. Savings were well over US\$ 1 million as fresh water, which is expensive in San Diego, was displaced. The project also qualified for modest rebates on water rates from the city.

Following completion of the modifications at the end of 1995, annual fresh water consumption dropped by 150 million gallons a year. This was a reduction of about 20% of total water usage in the factory.

**Annual fresh  
water consumption  
dropped by 150 million  
gallons a year.**

Monsanto was the first San Diego company to convert packed-bed scrubbers from fresh water to sea water. Three years later the scrubbers are still operating effectively and Monsanto has made a social contribution to the well being of the entire community.

**Lessons Learned**

1. There are opportunities for companies to substitute abundant sea or saline water for scarce fresh water.
2. The company was able to reduce its fresh water usage and contribute to a city wide conservation program advocated by the local mayor.
3. The capital cost of the project was recovered totally from savings in the costs for fresh water.

**For further information**

Dallas Meneely, Monsanto

tel: (1 314) 694 3862; fax: (1 314) 694 3889

e-mail: [damene@monsanto.com](mailto:damene@monsanto.com)

CASE

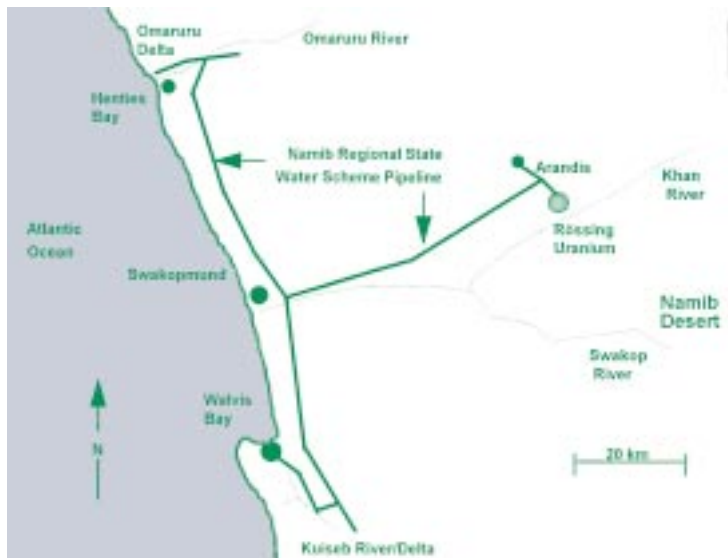
8

WATER MANAGEMENT IN A DESERT  
MINING OPERATION

**RÖSSING URANIUM**  
Namibia

Minerals, like copper, silver, gold or uranium, are valuable but often difficult to find in commercial quantities. Often one has to move, crush and sift through tons of rock or soil to find ounces of the desired substance. Water is a crucial ingredient in the separation processes by which minerals are extracted from the bulk ore. Then the wet residues also must be moved to safe disposal sites. In this case, Rössing, a subsidiary of Rio Tinto, is conducting uranium mining operations in the Namib Desert, an area of low and erratic rain-falls, extreme temperatures with cold nights and hot days and strong seasonal winds. Rössing processed 100 tons of ore to produce 3 tons of uranium oxide.

A schematic map which locates the Rössing Mine along the Atlantic coast of Namibia

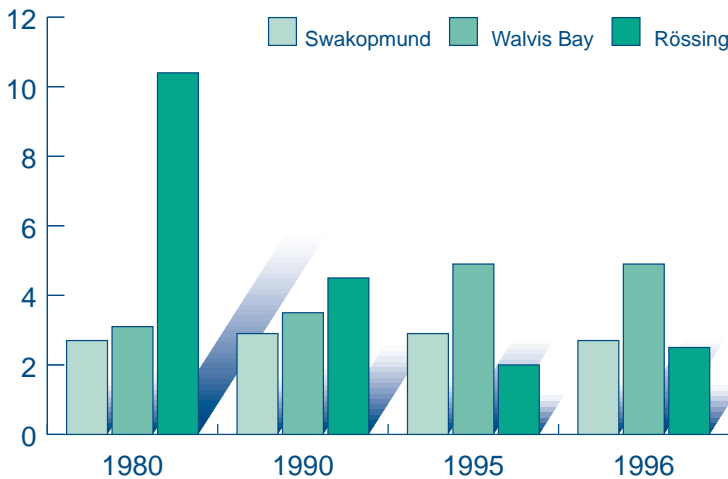


Rössing had two sources of water:

1. Fresh water from NAMWATER, the public water supplier extracting water from underground aquifers of the Omaruru and Kuiseb Rivers. It is important to note that NAMWATER also supplies drinking water to the coastal towns of Walvis Bay and Swakopmund less than 70 kilometers west of the mine site.
2. Brackish water from the Khan River immediately adjacent to the mine site.

In 1980 the company used more water than the towns Swakopmund and Walvis Bay combined (over 10 million cubic meters per year). By 1996 the company had reduced its consumption to 2.6 million liters, less than that used by either coastal city. This case describes how Rössing achieved this success through improved water management and tailings disposal methods.

**Rössing water usage as compared with Swakopmund and Walvis Bay**



The company could conserve fresh water on the input side by restricting the use of this high quality water for domestic purposes and limited plant operations while maximizing the use of brackish water or recycled water for all other purposes. One specific example was the total replacement of rodmill fresh water by water recycled from the dam drainage solution.

On the output side, the company had to address two main losses:

1. **Entrainment** – the process by which water is trapped in the disposal tailings with historical experience indicating that approximately 150 liters of water are lost for every ton of ore milled; and

2. **Evaporation** – in the hyperarid Namib Desert climate, excess water from the pond and tailings impoundment area was lost rapidly. Every hectare of wetted area could result in a daily loss of up to 72 cubic meters, that's 72,000 liters.

Rössing management was convinced evaporation was the primary target. In the original tailings deposition configuration, there was an evaporation pond of 150 hectares at the center and 1,000 hectares of wetted area around the pond. In 1985, the tailings deposition system was reorganized to reduce the impoundment area to 760 hectares (a 24% decrease in surface area) and the pond to 60 hectares (a 60% decrease). Evaporation rates decreased and more water was available for re-use.

Then in 1988, the company introduced an improved system in which the impoundment area was divided into small deposition segments called paddocks. The liquid from each 40 hectare paddock was drained by a penstock system and excess water shipped to the pond from where it could be recycled to other processes. In 1995, the penstock was upgraded with special decanting pump systems and the pond eliminated, increasing the recycling rate further, with the water going directly back into operations.

The results were startling:

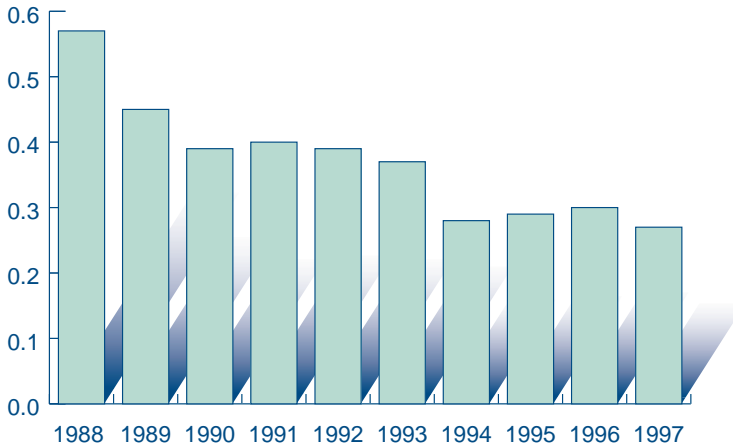
- ◆ evaporation decreased by 87.5% below 1988 levels (0.29 m<sup>3</sup>/metric ton in 1988; 0.036 m<sup>3</sup>/metric ton in 1995)
- ◆ fresh water use decreased by over 50% below 1988 levels (0.55 m<sup>3</sup>/metric ton in 1988; 0.27 m<sup>3</sup>/metric ton in 1995)
- ◆ fresh water saved is conservatively estimated at 71 million cubic meters between 1981 and 1995

The paddock system and the decanting also reduced seepage levels. Further, the company constructed several cut-off trenches to capture any seepage and recycle it back into operations. Monitoring wells were drilled to record any seepage flows back into the Khan River. The decanting and paddocks systems lowered company costs, since the number of pumps was reduced from 60 down to 20.

Over 15 years, the company invested Namibia\$ 53.7 million with cumulative operating costs of Namibia\$ 117.8 million during the same time frame. The company estimates resulting benefits, primarily from reduced water charges, recapture of uranium and acids, and reduced use of pumps, at Namibia\$ 185.4 million – more than enough to cover all capital charges and operating costs.



Trend of fresh water usage rate in m<sup>3</sup>/metric ton milled between 1988 and 1997



**Fresh water use decreased by over 50% below 1988 levels.**

### Lessons Learned

1. Modification of its waste tailings system and recycling of water claimed from this operation enabled the company to reduce its fresh water consumption by over 50% – ensuring sustainable operations over the lifetime of its mine.
2. The company program resulted in more fresh water available for urban needs and for future economic development in the coastal region of Namibia.
3. The company's investment saved over 71 million liters of scarce fresh water between 1981 and 1995.
4. The investment and operating costs were totally offset by benefits accruing to the company.

### For further information

John R. Tjirare, Senior Metallurgist, Rössing Uranium  
tel: (264 64) 520 2209; fax: (264 64) 522 026  
e-mail: JTirare@rossing.com.na

CASE



PRIVATE SECTOR INVESTMENT  
IN PUBLIC WATER SUPPLY     **SEVERN TRENT  
INTERNATIONAL AND TARMAC**  
*Trinidad and Tobago*

**M**any developing countries have difficulty in supplying fresh drinking water to their populations for a wide variety of reasons. Lack of capital for new investment and lack of cash flow to maintain and operate existing systems are often at the root of the problem.

In the island nation of Trinidad and Tobago, water service was erratic and often poor. Some areas lacked basic connections; in others, the service was intermittent with water being available for less than 7 hours per day. In early 1996, a survey revealed that 20% of the electrical pumping and mechanical equipment was in urgent need of refurbishment or replacement with nearly 25% of all plant unserviceable due to cannibalization of equipment. The water system had been out of action an average of 54 days each year (16% of the time or once every 6 days). Unaccounted water was excessively high and too much valuable and scarce fresh water was being lost to the ground.

Everyone recognized that new resources and better management were essential. The World Bank was reluctant to make new loans or guarantees without private sector involvement which would also establish specific 'service quality' objectives.

After extensive negotiation, the government of Trinidad and Tobago and its Water and Sewerage Authority (WASA) entered into a three-year management agreement with a new joint venture company, Trinidad and Tobago Water Services (TTWS). The TTWS partners were Severn Trent Water International and Tarmac Plc. Severn Trent supplied its water management skills and Tarmac, the largest construction firm in Trinidad and Tobago, supplied the construction skills necessary to begin the upgrading of the entire system.

TTWS arranged for a loan of US\$ 75 million funded by City Bank to provide new operating funds over a three year period. The World Bank committed to lend US\$ 60 million for new longer-term capital investment.

The leakage problems were tackled through the implementation of an extensive repair program. The missing electrical and mechanical equipment was replaced and a regime of regular maintenance was instituted for all water service equipment. New work practices were instituted including training for all service personnel.

Within one year the results were significant:

- ◆ The average system downtime plunged from 54 to only 4 days per year.
- ◆ In the core service areas, water delivery was increased significantly above the 7 hours per day and certainty of supply increased.
- ◆ Additional water supply was extended to areas which had poor service.
- ◆ A 24-hour customer service telephone line was added; complaints successfully resolved increased from 40% to 84%.
- ◆ Meter reading was augmented by 20% and payments for service increased from 81% to 88% of billable amounts.
- ◆ A consumer survey indicated that 60% of the population thought water supply was 'definitely getting better'.

**These improvements occurred without the long-term capital improvement program.**

The US\$ 60 million World Bank loan will finance:

- ◆ The design and replacement of over 100 kilometers of pipes in the core water distribution system.
- ◆ The rehabilitation of 11 service reservoirs.
- ◆ The drilling of 9 new water wells and the rehabilitation of another 6 wells.
- ◆ The installation of approximately 60,000 water meters throughout the country.

This last point is instructive. The World Bank, the government and the service contractor all recognized that enormous amounts of water were being wasted since individuals had no incentive to conserve water under existing schemes. After metering, individuals and firms will pay for the water they use, thereby providing an economic incentive to fix internal leaks and wasteful practices. Use less, pay less.

The performance of TTWS will be evaluated at the mid-term of the initial three years service contract. If judged to have performed adequately, the contract could be renewed for a longer term. This provides an incentive for the private sector to deliver value which justifies the cost of the service. The present contract with TTWS includes performance-based payments. Payments are contingent upon attaining specific service targets and goals.

### **Lessons learned**

1. There are significant opportunities for public-private sector cooperation; in this case the World Bank provided incentives to foster such cooperation.
2. There are significant opportunities for service improvements through better management, maintenance and operating procedures.
3. Private sector contracts can include built-in performance standards which ensure value for cost.
4. Water metering and pricing can motivate conservation and wise use of fresh water.
5. There are opportunities for local private sector companies to participate in joint ventures to provide water service.

### **For further information**

Severn Trent International

tel: (44 121) 722 6130; fax: (44 121) 722 6138

e-mail: [stwi.headquarters@severntrent.co.uk](mailto:stwi.headquarters@severntrent.co.uk)

CASE  
**10**

## WATER CONSERVATION IN THE KERN RIVER OIL FIELD

**TEXACO**  
*United States*

**S**ometimes oil rushes out of wells due to natural underground pressure. In other cases the oil has to be pumped to the surface. In still others, oil companies must create artificial underground pressure to flush oil out of porous underground structures and up to the surface. Texaco forces steam down into its Kern River oil field in California and produces 92,000 barrels of oil each day. It is one of the world's largest steam-flood oil projects.

About eight barrels of fresh water are produced along with every barrel of oil. Thus the company finds itself with 730,000 barrels or 31 million gallons of water each day. Texaco reclaims almost half of this water to generate new steam to enhance oil production. However the remaining water represents a costly treatment problem along with a potentially wasteful use of water.

Texaco treated the excess water to remove oil and sediment to meet California's discharge standards. Then the state charged a fee to discharge the clean water into a canal where it was mixed with pure Kern River water running down from the Sierra mountains. On occasions the canal could not accept all the water and Texaco then had to spend even more cash injecting it into deep underground disposal areas where it was lost to further use.

Just a few miles away in the fertile Central Valley, farmers needed new water for irrigation. In 1994 Texaco signed a 15-year conservation agreement with the Cawelo Water District which recognized Texaco's excess water as a safe and reliable water asset. Cawelo built a 7.6 mile pipeline to connect its local reservoir with the Kern River oil field. Texaco invested US\$ 1.8 million in a pumping station to deliver the water through the pipeline. In 1996 the water district bought 155 million barrels of water at a competitive price.

**“This is a major conservation project for us. It’s a resource that we knew was there. And the farmers in Cawelo Water District worked with Texaco to develop this win-win relationship.”**

Farmers in this arid region of California use the water to irrigate 45,000 acres of crops, including grapes, citrus, almonds and pistachios. This innovative project achieves the mutual goal of Texaco and Cawelo to create long-term, economical use of excess produced water. It also stresses the importance of maximizing fresh water resources through cooperative efforts between public agencies and private industries. As John Jones, manager of the Cawelo Water District, said: “This is a major conservation project for us. It’s a resource that we knew was there. And the farmers in Cawelo Water District worked with Texaco to develop this win-win relationship.”

#### **Lessons Learned**

1. Water produced as a by-product from oil extraction can be treated and reused for irrigation purposes.
2. Cooperation between public agencies and industry can maximize the use of limited fresh water resources.
3. Texaco reduced its costs, turning a liability into an asset, and local farmers obtained water at low cost.

#### **For further information**

James Pinto, Texaco

tel: (1 914) 253 7046; fax: (1 914) 253 7895

## MANAGING THE GREAT ARTESIAN BASIN

**WMC**  
Australia

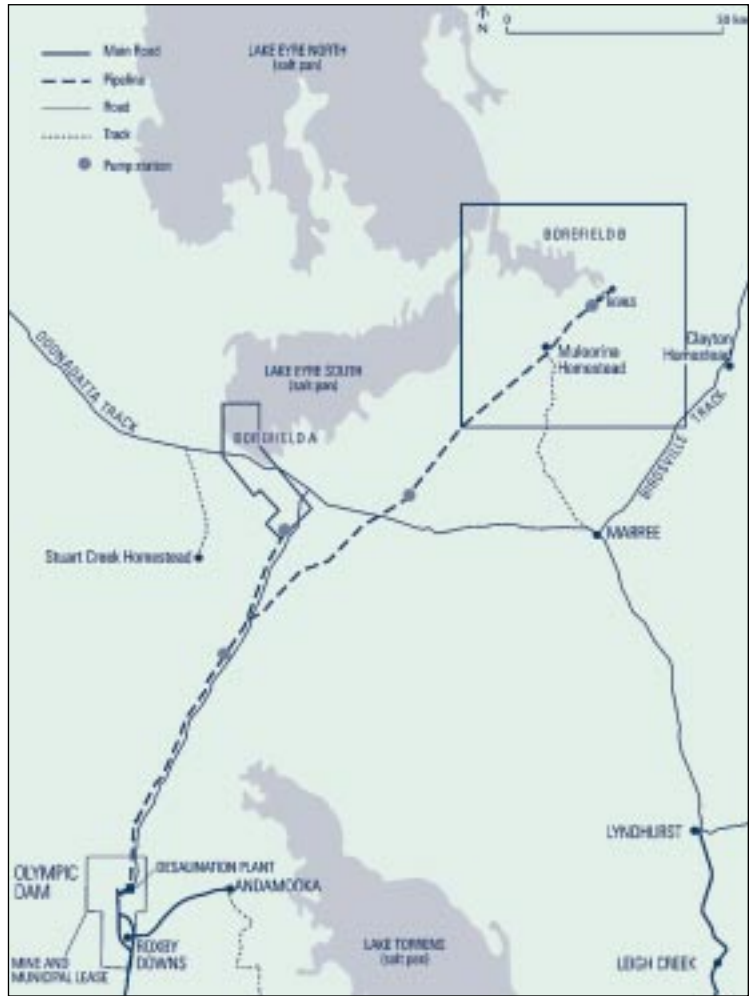
The Great Artesian Basin covers 1.7 million square kilometers in the Northern Territory and three Australian states, and is one of the largest sedimentary basins in the world. Rainfall in Queensland and the Northern Territory constantly recharges this enormous underground water resource, estimated to be 8,700 million megaliters (8,700 million million liters) of water<sup>8</sup>. It is estimated that 425 million liters of water flow into the South Australian section of the Basin each day, and overall flow through the Basin is estimated to be 2,630-2,930 million liters per day. This flow is so large that water under pressure seeps to the surface in mound springs throughout several regions of arid South Australia. It is estimated that 66 million liters per day well up in these mound springs across South Australia and create unique habitats for wildlife and vegetation. The mounds, some as high as 30 meters, have grown up around the southern rim of the Basin over many years.

### Olympic Dam location



<sup>8</sup> Department of Industry, Science and Tourism, Prime Minister's Science and Engineering Council. 1996. «Managing Australia's Inland Waters»

Water supply system site plan



One hundred kilometers south of the Basin, a second exceptional natural resource can be found in the form of huge underground reserves of copper, uranium, silver and gold. WMC Limited has invested over a billion Australian dollars at its Olympic Dam integrated underground mine and processing plant to extract these valuable resources. It produces refined copper, gold and silver, and uranium oxide concentrate. The company is currently spending in excess of a further one billion dollars to significantly expand the operations.

The mining operation uses 13.4 million liters of water a day, while the nearby town of Roxby Downs, where the workers live, uses another 1.6 million liters. Initially in the 1980s, this water was



extracted from a single borefield located 110 kilometers from the mine and town. The water requires desalinization before it is suitable for human consumption or for some processes of the Olympic Dam plant. An extensive monitoring program ensured that impacts on mounds springs from extracting the water were minimized.

In 1995 the company applied for permission to begin drawing water from a second borefield a further 90 kilometers into the Basin. The goal was to reduce withdrawal pressures on the original borefield and to ensure an additional water supply for expansion of mine operations. The project was approved and implemented in 1996. WMC now has approval to abstract water within licensed draw-down limits, which have been estimated by hydro-geological modeling to be equivalent to approximately 42 million liters a day from the Great Artesian Basin. One of the conditions of the approval was that WMC should monitor carefully the water flows to nearby water mounds. Further, the company is committed to minimize its withdrawals, to conserve water and to recycle whenever possible.

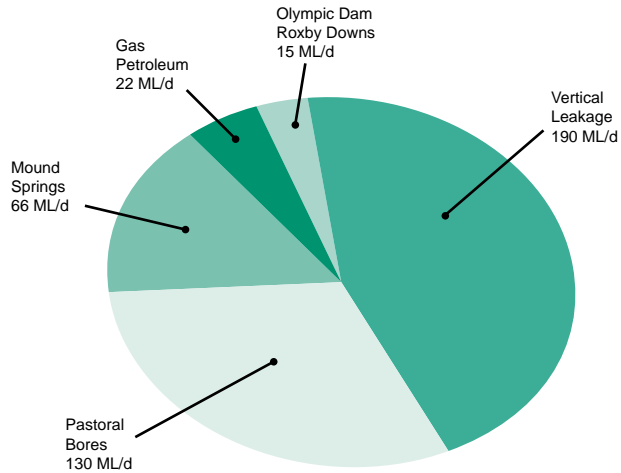
The following chart shows contributions to water extraction from the South Australian sector of the Great Artesian Basin.

Great Artesian Basin usage, South Australian sector, January 1996

User	Outflow (million liters a day)	Percent of Total
Pastoral bores – includes towns and homesteads	132,000	31.1 %
Mound springs	66,000	15.5 %
Gas & Petroleum	22,000	5.2 %
Olympic Dam/ Roxby Downs	15,000	3.5 %
Unused balance	190,000	44.7 %
TOTAL	425,000	100 %

Measures introduced by WMC between 1989 (the first year of full production) and 1996 have resulted in a reduction in water usage from 2.10 kiloliters per ton of ore milled to 1.50 kiloliter per ton, a reduction of 29 %. This was achieved by modifying various processes so that less water was used in flotation and separation of the minerals from the ore, by recycling the acidic liquids from mine tailings that historically had been evaporated, by using highly saline water which seeps from the mine for dust control because water quality is of lower concern in such instances, and by several other water conservation programs.

Total Great Artesian Basin discharges in South Australia



**With these improvements water usage per ton of ore milled is expected to be reduced further from the present 1.50 kiloliter per ton of ore milled to 1.24 kiloliter per ton following completion of the expansion in late 1998. This corresponds to an overall reduction of 41% since 1989.**

As part of the current design for expansion, further water conservation measures will be introduced, including using high density thickeners to maximize water recovery, substituting lower quality water wherever possible, and developing more efficient work practices. With these improvements water usage per ton of ore milled is expected to be reduced further from the present 1.50 kiloliter per ton of ore milled to 1.24 kiloliter per ton following completion of the expansion in late 1998. This corresponds to an overall reduction of 41% since 1989.

The unit cost of water for the project is AUS\$ 1.13 per kiloliter for general process water, and AUS\$ 1.68 per kiloliter for potable quality water. This compares with the cost, i.e. AUS\$ 0.62 per kiloliter, charged by the government to other users. By policy decision, water is sold to Roxby Downs residents at the same rate as paid elsewhere in the state. Because of the relatively high cost of water, WMC has considerable incentive to minimize its own use, and to encourage residents also to be water conscious.

As a result, WMC has worked closely with the 3,000 residents of Roxby Downs in water conservation activities, such as:

- ◆ providing trees, plants and drip irrigation systems to households
- ◆ encouraging use of and providing advice on arid zone gardens
- ◆ fostering mulching to retain garden moisture
- ◆ introducing low water consumption trees and shrubbery
- ◆ recycling treated town effluent to the local golf course and sports grounds

- ◆ introducing synthetic turf for recreational areas
- ◆ capturing and reusing storm water

Beginning in 1977, Mines and Energy, the responsible South Australian unit of government, began a program of repairing and plugging old boreholes in the Great Artesian Basin which had been flowing to waste in arid unused lands. This program has seen 192 bores repaired or plugged, saving an estimated 105 million liters of water previously wasted. WMC has cooperated with the government to ensure that its production and monitoring bores are in top condition and it has provided extensive monitoring data and a comprehensive hydro-geological model of the South Australian sector of the Great Artesian Basin. It has also provided advice and assistance to live stock farmers on the more efficient use of their water.

As can be deduced from the above chart, saving 90,000 liters a day by plugging old uncontrolled boreholes is equivalent to 20% of the daily average recharge rate for the entire flow of the Basin into South Australia. For individuals and companies living and operating in an arid climate such as South Australia, water conservation and management is an important consideration.

### Lessons Learned

1. Management of large systems such as the Great Artesian Basin requires cooperation among state and national governments, farmers, ranchers, towns and industrial users, especially those in extractive industries.
2. In this case, WMC assisted the local community by supplying water at the same cost as for other users in the state who are connected to the government's mains water supply, and by managing its community water conservation programs.
3. WMC has progressively introduced process changes to reduce its water consumption per unit of production, and is continuing to investigate further water conservation possibilities.

### For further information

Kristina Ringwood, WMC

tel: (61 3) 9685 6000; fax: (61 3) 9685 6265

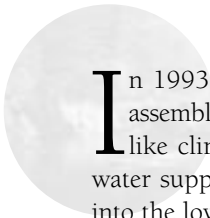
e-mail: [kristina.ringwood@wmc.com.au](mailto:kristina.ringwood@wmc.com.au)

CASE  
**12**

## Reuse and recycling of fresh water

### OPERATING IN AN ARID CLIMATE

**CHRYSLER AND US FILTER**  
*Mexico*



In 1993, Chrysler Corporation constructed a new pickup truck assembly plant in Saltillo, Mexico. The plant was located in a desert-like climate and so special attention had to be given both to its water supply and to the discharge of its waste-water. Discharging it into the low flowing local river was an environmentally unacceptable alternative.

Water is pumped from deep underground wells but needs to be pre-treated, both for drinking and for industrial use. Chrysler's water subcontractor, US Filter, uses reverse-osmosis to remove dissolved solids and turbidity from the well water. Eighty-eight percent of the water is then usable and the remainder is sent to on-site evaporation ponds. These ponds are clay-lined to prevent contamination of land and groundwater.

All sanitary waste-water is fully treated in a separate facility. Biological oxygen demand is reduced by 90% to less than 30 mg/l and total suspended solids by 90% to 25 mg/l. This treated effluent is then used to water lawns, and the digested sludge is used for soil enhancement.

The industrial waste-water system can treat 165 gallons per minute (gpm) and is designed to maximize water reuse. Seventy percent of the water is recovered and recycled as industrial process water. This amounts to slightly more than 100,000 gallons of water a day. And the quality of this recovered water exceeds that taken from the original deep-well water system. All excess rejected water is sent to evaporation ponds.

This industrial facility has attained zero water discharge since it was inaugurated in 1993.


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### Lessons Learned

1. Zero water discharge is a feasible goal for some industrial applications when water use and water quality are an integral part of the design and planning process for new facilities.
2. The capital cost for water supply and waste-water treatment was US\$ 10 million in this case. In return the company avoided the need for effluent discharge permits and added no environmental stress to the low flow local river.
3. Reverse osmosis technology can be used to clean partially contaminated water.
4. More than 100,000 gallons of water were recycled each day.

### For further information

This case was extracted from a report in *Water & Waste-water International*, page 20, Vol. 12, Issue 3, June 1997.

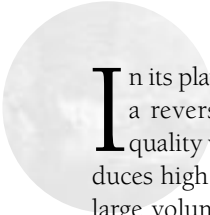


**Zero water discharge  
is a feasible goal  
for some industrial  
applications.**

CASE  
**13**

RECYCLING INDUSTRIAL PROCESS  
WATER

**JOHNSON & JOHNSON MEDICAL**  
*Australia*



In its plant at Sydney, Australia facility, Johnson & Johnson (J&J) uses a reverse osmosis water purification system to produce high-quality water for manufacturing pharmaceuticals. This system produces high quality filtered water for its processes but also generates a large volume of discharge water as a by-product. Depending on the output of the factory, between three to four million liters of water went to the municipal sewer system each year.

The company also used six million liters of town-water each year for its extensive lawns and gardens. During a prolonged drought, it carefully analyzed the chemical composition of its discharge water and found that it was perfectly adequate for its landscaping irrigation needs; a new water recycling project was therefore conceived.

J&J installed two storage tanks to accumulate its waste-water. The internal watering system is controlled by a computer which regulates the delivery of water to specific zones in terms of amount and time of day. The company's gardeners use a variety of plant types, each with unique water requirements. As part of the project, the gardeners substituted indigenous Australian species for European plants that were less well suited to the local conditions. These native plants required less water and fewer chemicals, and proved to be more pest-resistant. The new system includes a detector to prevent watering during periods when natural rainfall is adequate to meet the vegetation's needs.

**Results**

- ◆ A 4-million liter reduction in fresh town-water use
- ◆ A 4-million liter reduction in water to municipal treatment facility
- ◆ Economic payback on the investment in less than 2 years (by reducing the volume of water bought and paying less in sewerage fees)

A related study indicated that 60% of total town-water use in the Sydney area was for irrigating suburban gardens, suggesting the J&J model was a good one for emulation by individuals and other companies.

### **Lessons Learned**

1. There are common sense 'low-technology' options for recycling industrial process water which can ease pressure on both water supply and sewerage systems.
2. These options are cost effective, and save both money and water.
3. There may be opportunities for households to reuse some of their 'gray' water.


### **For further information**

Peter Britton, Johnson & Johnson  
tel: (1 908) 524 3773; fax: (1 908) 524 2039  
e-mail: PBRITTO@CORUS.JNJ.com

CASE  
**14**

FRESH WATER USAGE AT A LARGE  
POWER STATION

**POWERGEN**  
*United Kingdom*



**P**ower stations are large users of water for cooling purposes most of which, apart from evaporative losses, is returned. However, in common with other process industries, power stations are large users of process water. This case study presents the progress made in the reduction in the use of process water at one of PowerGen's 2000MW coal-fired power stations at Kingsnorth, Kent, UK.

Kingsnorth power station (4 x 500MW) was commissioned in the early 1970s, and is unique in PowerGen's portfolio in that it has a once-through cooling water system using sea/estuary water and therefore does not have any cooling towers.

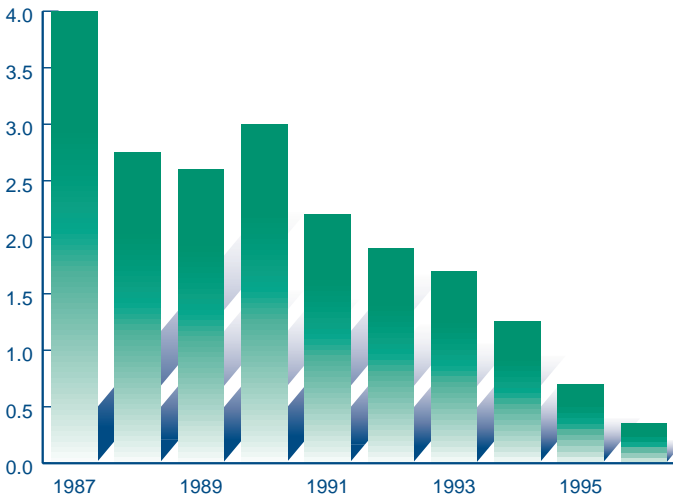
Kingsnorth, as have other PowerGen power stations, has been seeking to reduce its use of fresh water. The vast majority of fresh water is used to produce ultra-pure boiler feedwater. Each boiler at Kingsnorth produces half a ton per second of steam at high pressure and temperature which means that good control of the chemical properties of the water is required to prevent corrosion or scaling of the boiler and turbine plant. To maintain an acceptable chemical purity requires blowdown of boiler water and the dumping of condensate on unit start-up.

Substantial reductions in the use of town-mains water have been achieved through process changes including the recovery and recycling of dump water, the use of reverse osmosis and the substitution of town-mains water by saline borehole water for fire and general washdown systems. The success of this program in reducing town-mains consumption can be seen from the following graph.

These reductions in town-mains water consumption have been matched by equivalent reduction in the use of caustic soda and sulphuric acid in the ion exchange water treatment plant. Water consumption has been reduced by 90%.



### Water Consumption at Kingsnorth



**Water consumption  
has been reduced  
by 90%.**

Kingsnorth has over the last few years substantially reduced its fresh water demand and its water and water treatment costs by about 75% resulting in an on-going saving of about UK£ 0.8 million per annum through the remaining life of the station with improvements from capital expenditure giving a capital payback period of less than two years.

Further improvements are planned for 1998.

#### Lessons Learned

1. Thermal electric generating stations can reduce fresh water consumption significantly through recovery and recycling of processing water and substitution of lower quality water for general purposes.
2. The required capital investments were repaid within two years and the company now saves UK£ 0.8 million per annum which accrues directly to the bottom line.

#### For further information

Dr. William S. Kyte, Head of Corporate Environment Unit, PowerGen  
tel: (44 1203) 424225; fax: (44 1203) 425226  
e-mail: Dr-William.Kyte@Westwood03.powergen.co.uk

CASE  
**15**

RECYCLING PROCESS WATER IN THE  
ELECTRONICS INDUSTRY

**SGS-THOMSON MICROELECTRONICS**  
*Malta*

**M**alta, surrounded by the Mediterranean Sea, has been short of fresh water throughout its history. Rainfall is low and population density high. Residents try to capture every precious drop of rainwater. Underground aquifers provide some fresh water but cannot keep pace with demand. The water table under the island keeps falling. In recent years almost 50% of water is obtained from sea-water by reverse osmosis plants. However, reverse osmosis requires significant quantities of electricity to drive the water through the filtration units. Ironically more water is required for cooling in the thermoelectric power plants generating the electricity.

SGS-THOMSON Microelectronics operates a highly efficient silicon chip manufacturing plant on the island. Two years ago the company began examining opportunities to reduce its internal water consumption. Large volumes of water were used during silicon wafer-cutting. This waste-water was clean except for the silicon dust produced during the slicing process. Unfortunately this silicon dust was too fine to be captured by conventional filters.

The company needed to install a microfiltration unit to remove the fine particles. Then the water was further purified by passage through ion-exchange resin columns. It was then clean enough to be recycled to operations requiring 'high purity' water. As a result, SGS-THOMSON Microelectronics reduced its consumption of city water by 13,000 cubic meters per year. Engineers also incorporated an automatic protection device that would automatically divert the recycled water back to the company's waste-water treatment plant if any accidental spills of solvents or other chemicals were to occur.

Engineers also developed a system for recycling the waste brine discharged by the plant's Electrodialysis Reverse water purification system. The waste concentrate was collected and, after filtration and

chlorination, this water was suitable for non-potable use in toilet flushings. A separate storage and distribution system now directs this recovered water to over ninety toilet units in the facility. City water consumption dropped by a further 6,500 cubic meters.

Next the company made a major effort to recycle waste-water from its electroplating operations. During electroplating operations, residual metals always contaminate the water. It makes sense to recover the valuable metal and clean the water for reuse whenever technically and economically feasible. The new design will use ion-exchange resins to recover the metals and reverse osmosis to further purify the water. Eighty percent of the waste-water effluent will be recovered for a saving of 60,000 cubic meters annually, equivalent to 50% of the present water intake. This project will come on line in the first quarter of 1998.

The corporate water conservation program also involved replacement of older plating equipment, where water recycling was not cost-effective. The final component of the comprehensive water conservation strategy involved installation of a rainwater capture and recycling system for the entire facility. By April 1998, the facility will have reduced its consumption from city mains from 183,000 cubic meters per year down to 52,000 cubic meters, a remarkable reduction of 72%.

There is an interesting twist to this case. The company saved only US\$ 41,000 per year in reduced costs by purchasing less public water. The savings were modest since the Malta government traditionally subsidizes water for all. SGS-THOMSON Microelectronics invested over US\$ 1.1 million in its water conservation program. So the payback period would be almost 25 years, not a good economic return on investment. At the actual cost of water to Malta the payback period is just over 3 years. But as Murray Duffin, Vice President for Total Quality and Environment says: "Our plant in Malta is efficient and important to the company, but the water supply is ultimately limited, regardless of how costs are charged. Without these water savings we might not be able to continue our technical progress in Malta. The ultimate result of not making these investments could be the relocation of the plant at much higher cost, so a pure payback justification is not really meaningful, quite apart from ethical considerations related to continuing employment and the cost to society, which are also important considerations."

**Eighty percent of the waste-water effluent will be recovered for a saving of 60,000 cubic meters annually, equivalent to 50% of the present water intake.**

**"The ultimate result of not making these investments could be the relocation of the plant at much higher cost, so a pure payback justification is not really meaningful, quite apart from ethical considerations related to continuing employment and the cost to society, which are also important considerations."**

### Lessons Learned

1. There are a variety of opportunities to recycle and reuse water within factories. In this case SGS-THOMSON Microelectronics managed to reduce consumption by 72%.
2. Direct economic payback is not the only, or even the most important, criterion to consider in making responsible investment decisions.
3. Companies can save money by reducing water purchases. In this instance the savings were modest, but the savings to society were significant.
4. Companies can contribute towards broader social goals such as conserving scarce fresh water resources and creating employment and improve competitive advantage simultaneously.
5. A company must consider the cost to society of its operations, not simply its direct expenses.

### **For further information**

Murray Duffin, SGS-THOMSON Microelectronics  
tel: (33 4) 50 40 26 84; fax: (33 4) 50 40 27 50  
e-mail: murray.duffin@st.com

CASE  
16

## RECYCLING WATER IN SUGAR FACTORIES **COOPERATION BETWEEN UNIDO<sup>9</sup>** **AND THE CANE SUGAR INDUSTRY** *Mexico*

**U**NIDO, as part of its waste minimization program, initiated a program called CLEANSUGARTEC. This program focused on the sugar cane industry in Mexico. This case describes the reduction in fresh water consumption which was achieved at one firm as a result of this partnership effort.

Sugar production from cane can use large quantities of water. At the San Francisco Ameca plant in the State of Jalisco, as many as 111 cubic meters of water were consumed for every ton of sugar produced. After an intensive review, a comprehensive list of waste minimization actions were taken. The net effect was to reduce water consumption to only 5 cubic meters per ton of sugar – a reduction of over 93%. Further, the pollution-load entering the water was cut by 20%. And making it a ‘win-win-win’ situation, the company managed to recover all its capital investment and reduce its operating costs.

During the annual harvest season, called the *zafra*, the plant processes 4,800 tons of sugarcane producing about 500 tons of standard sugar each day. In 1994, between the harvests, a series of technical improvements were implemented including:

- ◆ segregation of sanitary sewage from process waste-water
- ◆ installation of hygienic floors to improve cleanliness
- ◆ construction of new hygienic installations for all employees
- ◆ installation of confined areas for all equipment to prevent discharges of oil or grease into drains
- ◆ installation of a cooling pond to receive all boiler condensing waters and make it available for recycling
- ◆ a mill-designed system to cool and recycle water in the cane processing area
- ◆ recycling wash water used in chimney cleaning to remove fly ash

**The net effect was to reduce water consumption to only 5 cubic meters per ton of sugar – a reduction of over 93%.**

<sup>9</sup> UN Industrial Development Organization - Sugar Industry vol. 1 & 2 1997

In aggregate, new investment of US\$ 1,700,000 was made. The return on investment was US\$ 780,000 a year, giving a payback period of just over two years. In addition to the capital investment, a series of new housekeeping measures was implemented. They included:

- ◆ cleaning all drains, inside and outside the plant, once each day
- ◆ replacing floor washing at different stations with dry cleaning processes
- ◆ checking regularly all flanges, valves, pipes and pumps, and putting in hand immediately repair procedures for any leakage found
- ◆ checking cooling water systems and condensers to ensure water circulation meets design specifications
- ◆ introducing procedures for coping with accidental overflows – never allowing any such overflows to mix with effluent streams

**Characterization of waste-water  
from the San Francisco Ameca Mill**

Characteristic	Water supply	Process water	Condensers	Mills & Batey waste-water	Exit waste-water	Norms for waste-water
Volume flows, l/sec.	2500	30.00	700.00	15.00	60	na
Settleable solids, ml/l	0.3	40.0	0.1	1.7	75.2	1.0
Total suspended solids, mg/l	40.0	571	74.0	83	176.4	200.0
Grease and oils, mg/l	25.0	91.5	40.0	48.5	36.5	10.0
Total coliforms MPN/100 ml	26.0	0.024	2.4	46.0	16.0	0.01
Dissolved biochemical oxygen demand in 5 days, mg/l	124	4,550	1,157	1,755	782	200.0

Since the introduction of the concept of clean technology requires a continuous improvement approach, the company, San Francisco Ameca Mill, is still in the process of complying with all norms for waste-water established by the Mexican National Water Commission.

**Lessons Learned**

1. Partnerships among international, national governments, industrial trade associations and local firms can find cost-effective techniques to reduce water consumption.
2. Many of these investments in new techniques pay for themselves and generate environmental benefits in addition.
3. Common sense low-cost housekeeping activities can reduce waste of water resources and improve industrial operations.

4. Despite great improvements, including an 80% reduction in organic matter, this smaller company still needs to install 'end-of-pipe' waste-water treatment in order to comply with national guidelines.

**For further information**

Sergio Miranda-da-Cruz, UNIDO, Vienna  
tel: (43 1) 21131 3807; fax: (43 1) 21131 6849  
e-mail: [smiranda-da-cruz@unido.org](mailto:smiranda-da-cruz@unido.org)

CASE  
**17**

## Process changes and waste-water treatment to improve water quality

### TREATING BREWERY

### WASTE-WATER **COORS SHENANDOAH RIVER** *United States*

**A**erobic and anaerobic are complex words with rather simple meanings. The first means ‘with oxygen’ and the latter means ‘in the absence of oxygen’. Biological wastes can be broken down by either process. Mixing and stirring oxygen-rich air into waste-water is the more traditional method. But anaerobic digestion of wastes can be interesting because methane gas, produced during the decomposition, can be used as a free energy source.

Coors, with headquarters in Golden, Colorado, built a large brewery along the Shenandoah River in Virginia to meet increasing east-coast demand for its beer. Constructed in the 1980s, the brewery used conventional aerobic waste-water treatment technology, which complied with stringent state rules. However, demand continued to grow and management needed to expand capacity. Company engineers were concerned that treating large volumes of high carbohydrate nutrient deficient brewery waste-water would require alternative technologies.

An unusual factor made anaerobic digestion an attractive alternative. The Coors’ aerobic waste-water treatment facility was generating low but measurable levels of volatile organic compounds (VOCs). The facility was located close to the Shenandoah National Park, a Class I pristine area, and these minor VOC levels might violate the extremely strict air emission regulations designed to protect the park. Anaerobic digestion would virtually eliminate VOCs.

Upflow Anaerobic Sludge Blanket (UASB) technology was widely used in the brewing industry. However, Coors’ engineers were intrigued with a new patented Bulk Volume Fermenter® (BVF) system used to treat confectionery waste. After extensive analysis and experimentation with a bench scale pilot plant, Coors chose the BVF technology. In 1994 Coors entered into a contract with ADI Systems of Canada to build a new system.



The BVF system requires more physical space but it offers significant advantages over the more compact UASB technology:

- ◆ capital costs are about 50% lower than those for UASB
- ◆ operation is simplified: the system requires very minor maintenance
- ◆ the system generates methane gas which is used within the plant
- ◆ the system enables Coors to take and use waste sludge from a local secondary waste-water treatment plant (the local authority pays Coors US\$ 64,000 per year to take this unwanted sludge)
- ◆ the system provides an equalization capacity to stabilize flows from variation in production levels
- ◆ the system reduces costs for purchasing settling aid chemicals and coagulants and electricity – Coors saved \$35,000 per year
- ◆ the BVF system meets or exceeds all waste-water treatment parameters: it removes 95% of COD, and eliminates ammonia previously released into the atmosphere associated with land disposal of solids

### Lessons Learned

1. Anaerobic digestion is an interesting and cost-effective technology for controlling biological waste-water from brewing and food processing industries.
2. Bulk Volume Fermenters may be an appropriate lower-cost technology in developing countries where land is available for construction of these systems.
3. Anaerobic digestion produces methane gas which can be used to conserve use of expensive fossil fuels.
4. Anaerobic digestion is more robust and less susceptible to upset conditions.

### For further information<sup>10</sup>

Cary Baird, Coors Brewing Company

tel: (1 303) 277 2276; fax: (1 303) 277 5723

e-mail: cary.baird@coors.com

Jim Burke, Coors Brewing Company Shenandoah Plant

tel: (1 540) 289 8321; fax: (1 540) 289 8363

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*10 Much of this case is extracted from a report compiled by Warren Heidt and James Burke, Bulk Volume Fermenter® Technology for Anaerobic Pretreatment of Brewery Wastewater, Coors Brewing Company.*

CASE  
**18**

A ZERO-EFFLUENT PAPER  
PULP MILL

**MILLAR WESTERN**  
*Canada*

**T**he most challenging environmental problem for pulp mills is polluted effluent discharged into natural water systems. When Millar Western decided to build a new chemi-thermo-mechanical paper pulp mill at Meadow Lake, Saskatchewan, in western Canada, it faced an unusually difficult situation. The area was blessed with high quality aspen pulpwood, access to power, good transportation and a high quality work force. But one piece of the puzzle was missing. The Beaver River, the only water source available, had an extremely low flow and in winter the entire river froze. It was also a virtually pristine water body which could not accept effluents from a pulp factory, no matter how clean.

The company therefore made a strategic decision to try to close the loop completely and go for zero-effluent discharge.

Water recycling is extensively practiced in the pulp and paper industry. But the degree to which water systems can be closed is always limited by the build-up of contaminants in the system. The bleached chemi-thermo-mechanical pulp (BCTMP) used by Millar Western allowed organic extractives and inorganic salts to enter the waste-water at the rate of 200 kilograms per ton of pulp. In order to recycle waste-water, these residues had to be removed.

The company chose the evaporation process. Every drop of waste-water is collected and solids are removed, first by sedimentation and then by aeration/floitation. The clarified liquid is then evaporated to produce clean distillate which can be recycled back into mill processes.

The solid residue removed from the water is then concentrated and burned in a recovery boiler. The inorganic fraction, 84% sodium carbonate, is solidified into ingots and stored at a secure land fill. The company is currently working with research organizations to find ways

**Water recycling  
is extensively practiced  
in the pulp and paper  
industry.**

to convert the salt into caustic soda or peroxide which could then be recycled back to the mill.

Millar Western and its consultant, NLK Consultants Inc., chose the evaporative process in 1992. Just 24 months later, the plant came on line and within budget. Four months after that, it was producing high quality pulp at an average rate of 710 tons a day, in excess of the design capacity of 680 tons a day. Now, five years later, production and quality have never been affected by the zero-effluent treatment system. Company officials say that the reliability of their treatment system exceeds that of biological control systems and that operating costs are competitive with conventional treatment.

The company takes pride in never having to worry about upgrading its effluent control systems to meet new legislative requirements. As Peter Knorr, Executive Vice President and Chief Operating Officer, says: "It's kind of hard to beat a zero effluent discharge rate!"


NLK and Millar Western are now exploring modifications to the process to permit its use in kraft pulping and other non-pulp industrial applications.

### Lessons Learned

1. Dedicated management, supported by competent consultants and outstanding staff enabled one company to reduce plant water effluents to zero.
2. This innovation may give the company a competitive advantage and even create new market opportunities.
3. It was possible to keep the low-flow Beaver River pristine despite siting a major industrial facility next to it.

### For further information

Janet Millar, Communications Manager, Millar Western  
tel: (1 403) 486 2444; fax: (1 403) 489 0512

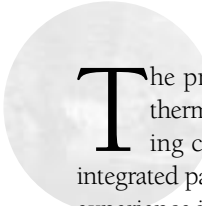


**"It's kind of hard  
to beat a zero effluent  
discharge rate!"**

CASE  
**19**

WATER MANAGEMENT  
AT A PAPER MILL

**UPM-KYMMENE**  
*Finland*



The previous case dealt with a new pulping mill using a chemi-thermomechanical process. This case deals with an older mill turning chemical (sulphite) pulp into thermomechanical pulp and integrated paper. The Jämsänkoski mill has more than one hundred years experience in making high quality paper. The mill takes its water from the Kankarisvesi lake in central Finland. The water flows from peat bogs and is contaminated with decaying biological matter. Although the incoming water quality is judged satisfactory by Finnish government standards, it must be pretreated to meet the mill's demanding production standards.

Discharge water from the mill flows into the Jämsä river, a major tributary to Lake Päijänne, the second largest lake in Finland and a major source of drinking water for the Helsinki metropolitan area. In 1980 it was determined that water quality in the upper reaches of the Lake was poor or barely passable. There was no immediate threat to the drinking water supply, but this condition could not be allowed to expand or even continue.

In 1981, the feedstock for the paper mill was changed from chemical to thermomechanical pulp. This allowed the mill to reduce its water consumption by 75%. The mill then began investing in processes for the efficient removal of suspended solids and a biological waste-water treatment facility. The table on page 64 shows the dramatic improvements both in reduced water usage and in three measures of waste-water quality.



Water consumption and effluent quality at Jämsänkoski

		1980	1985	1990	1995
<b>Paper production</b>	tons/year	110,000	292,000	338,000	705,000
<b>Waste-water</b>	m <sup>3</sup> /day	110,000	23,800	19,900	28,700
	m <sup>3</sup> /ton	226	30	21	15
<b>Suspended solids</b>	tons/day	4.5	3.0	1.6	0.6
	kg/ton	9.3	3.7	1.7	0.3
<b>Biological Oxygen Demand</b>	tons/day	11.8	8.5	5.3	0.2
	kg/ton	24.3	10.6	5.7	0.1
<b>Phosphorous</b>	kg/day	62.9	18.3	10.0	7.3
	grams/to	84.0	22.8	18.3	3.8

**Despite the mill expanding to become the largest in Finland, water consumption declined dramatically. In 1995 the mill used 93% less water for each ton of paper produced compared with 1980 levels.**

Despite the mill expanding to become the largest in Finland, water consumption declined dramatically. In 1995 the mill used 93% less water for each ton of paper produced compared with 1980 levels. Simultaneously, the quality of the water effluents improved significantly – 96% reduction in suspended solids for each ton produced, 99.5% reduction in BOD (biological oxygen demand), and 95% reduction in phosphorous.

These technical results are displayed vividly in the figure on page 63 which displays improved water quality in Lake Päijänne. By 1996 all segments previously classified poor or only passable had been completely upgraded. The vast majority of the lake now has water designated as excellent or good. Only one small segment has water regarded as ‘only’ satisfactory. UPM-Kymmene has demonstrated that good water management can make a difference.

**Lessons Learned**

1. It is possible to produce high quality paper profitably and still protect downstream water quality.
2. Good water management can reduce water use per unit of product and reduce pollution to very low levels.
3. Lake water quality can improve rapidly when pollution levels are reduced.

**For further information**

Hannu Nilsen, Vice President, Environment, UPM Kymenne  
 tel: (358 20) 416 111; fax: (358 20) 416 2219  
 e-mail: hannu.nilsen@upm-kymmene.com

## INNOVATIVE BIOLOGICAL TREATMENT OF WASTE-WATER FROM A SHELL REFINERY

**DEUTSCHE SHELL - UNIVERSITY OF HARBURG**  
*Germany*

**C**rude petroleum is a black, sometimes viscous, smelly liquid that can be distilled or cracked in an oil refinery into a wide range of valuable products. There is an old adage that oil and water do not mix and it is certainly true that we all want to keep crude oil, petroleum products and the by-products of refining out of water.

Petroleum has one good thing going for it – it is a natural biological product and all such products can be taken apart by biological processes. It was this simple fact that led to a partnership between Professor J. Sekoulov from the Technical University of Harburg and the Shell refinery in Hamburg-Harburg.

The waste-water from the refinery processes contained high levels of ammonia, hydrogen sulfide, a wide range of hydrocarbons and other pollutants. Professor Sekoulov, in cooperation with the technical staff of Shell, designed a new multi-step biological treatment process which virtually eliminated pollutants and used very low energy input.

In the first step, special microorganisms in an unaerated reactor use the energy content of hydrocarbons and hydrogen sulfide for denitrification, the removal of nitrate fed in from the aerated stage. In the second step nitrates are produced in an aerated reactor and this begins biological decomposition of ammonia. Then the cleaned water enters a settling basin and the remaining microorganisms and solids sink to the bottom in sludges. Surplus sludge is de-watered and then disposed of through incineration.

Then 100 cubic meters of rainwater are mixed with every 300 cubic meters of clean process water. This solution goes to a fixed bed reactor with special clay and a fine sand filter. Finally the treated water is discharged into the Elbe River.

### Results

- ◆ 360 tons of ammonia are removed each year
- ◆ trace levels of ammonia never exceed 2 parts per million – the allowable EU standard is 60 parts per million
- ◆ biological oxygen demand is reduced to less than 3 milligrams of oxygen per liter
- ◆ nitrogen reduction exceeds 85%
- ◆ total suspended solids are less than 5 milligrams per liter
- ◆ hydrocarbons in the effluent are less than 1 part per million

The German government contributed DM 6.2 million out of the total investment of DM 28 million to support this new innovative technology. This system came on line in October 1993 and has been operating successfully since that date.

### Lessons Learned

1. Partnerships among governments, academia and industry can produce innovative technology for treating industrial waste-waters.
2. Specially designed microorganisms can be used to decompose biological materials efficiently, with low energy requirements and at lower costs than conventional treatment systems.
3. Potentially hazardous substance such as hydrogen sulfide and ammonia can be radically reduced with new biological treatment systems.

### For further information

Ranier Winzenried, Deutsche Shell AG  
tel: (49 406) 324 5650; fax: (49 406) 324 5652  
e-mail: shellpress@aol.com



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Tel: +41 22 839 31 00  
Fax: +41 22 839 31 31  
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**UNEP**

PO Box 30552  
Nairobi, Kenya  
Tel: +254 2 621 234  
Fax: +254 2 624 249