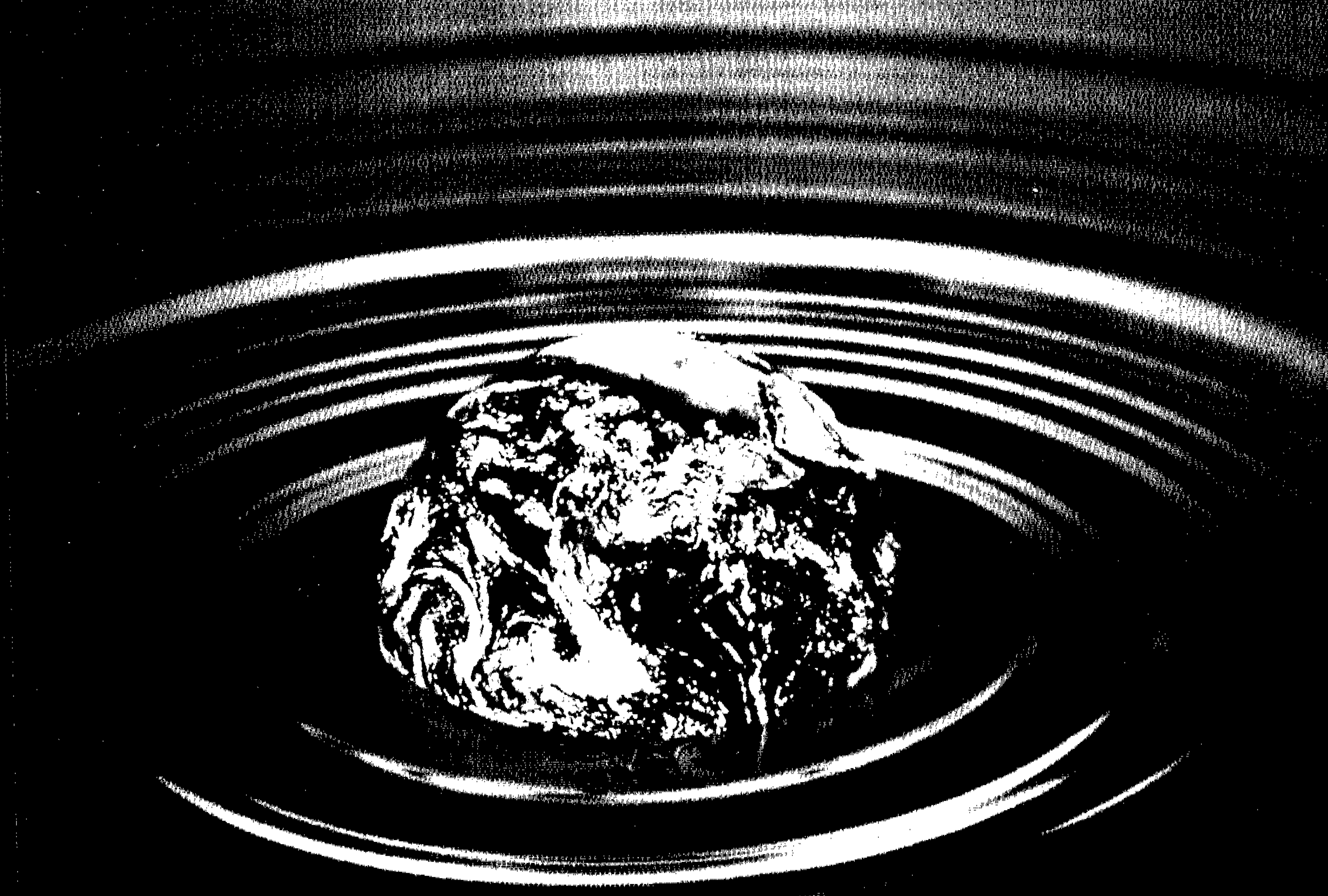
NEW WORLD WATER 1996

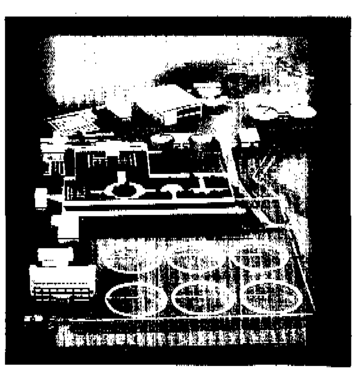


AS BLUE AS THE SEA

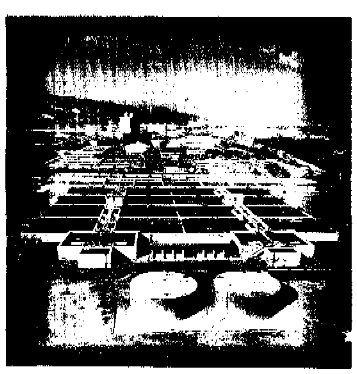
Dahin, a growing force in the environmental engineering industry, is opening a new chapter in the water treatment history...

Service Items :

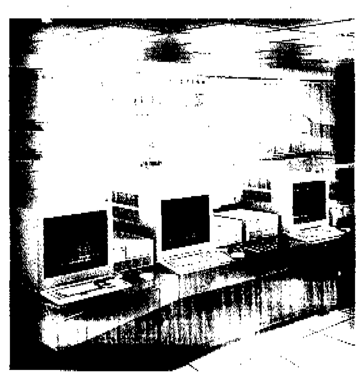
- City sewage treatment
- Solvent recovery
- Drinking water treatment



Model of the city sewage treatment plant



Drinking water treatment plant



Control system of the drinking water treatment plant

BRILLIANTLY EFFECTIVE... DECEPTIVELY SIMPLE THE JUMBO BOX ...SIMPLY THE BEST ALTERNATIVE!

Thermoplastic boxes are so effective that one simply forgets the specialised technology that makes them work. Designed and developed by Davis and Deale, the durable range of thermoplastic water meter, valve and hydrant boxes:

- Can be installed by untrained personnel
- Cost-effective
- Easy to handle
- The answer to theft and vandalism.

Davis & Deale IRRIGATION

For a Simply Better Solution

141 Elsburg Rd Germiston • PO Box 5070 Delmenville 1403, South Africa
Telephone (011) 827-2460 • Fax (011) 827-2498

NEW WORLD WATER

1996

Published by
Sterling Publications Limited
a subsidiary of
Sterling Publishing Group Plc
55a North Wharf Road
London W2 1XR
Tel: +44 (0) 171 915 9660
Fax: +44 (0) 171 724 2089

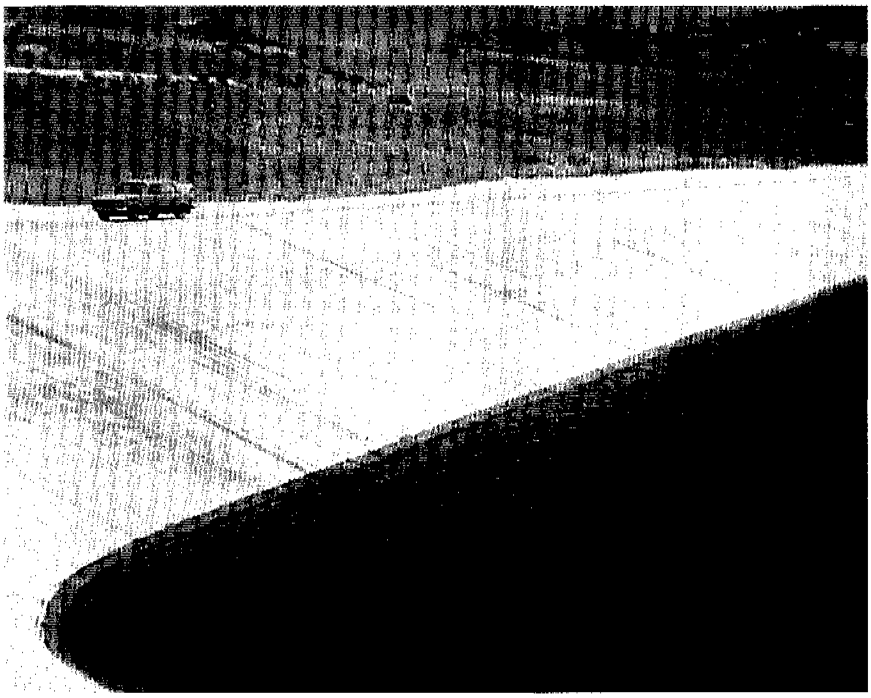
ABC
ANNUALS

Managing Director Michael Summers **Publishing Director** Julie Wedd
Production Director Daniel Coughlan **Sales Director** Laurence Garman **Editorial Director** Molly Fox **Art Director** Henrik Williams
Divisional Sales Manager Carl Everett **Sales Manager** Andrew Fields **Production Manager** Roy Taylor **Circulation Manager** George Waga
Typesetting Manager Graeme Dobby **Sub Editor** Jane Williams **Layout** Gordon Southgate **Production Controller** Phil Kenneth-Taylor

Printed in Malaysia by Times Offset (M) SDN BHD

ISSN 1353-5536

CONTENTS



Foreword

"Water is regarded by virtually every community in the world as one of the most vital of all natural resources; the irony is that it is the cause of so much illness and death." This situation, pinpointed by Jon Lane, director of WaterAid, provides the impetus for *New World Water 1996.*

SYLVIE AUBRY *Commissioning Editor*

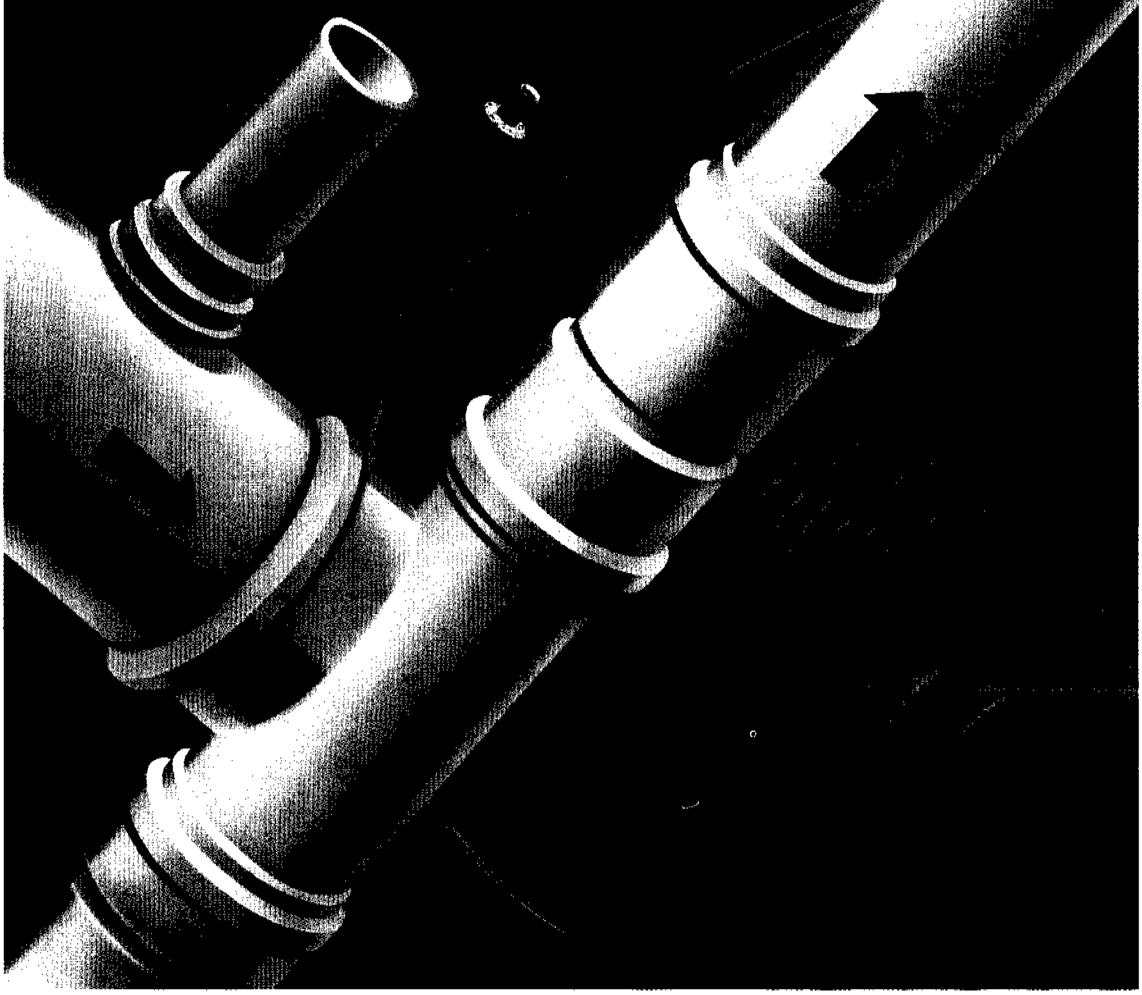
This publication has invited experts working in the field, and informed commentators, to share their thoughts about possible remedies to the problems of water supply and wastewaters treatment and to address the challenges that lie ahead.

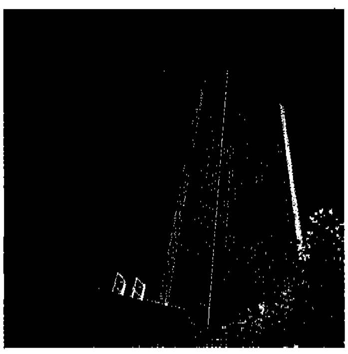
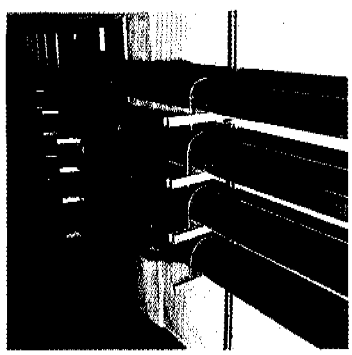
Jamie Bartram, manager, Water and Waste, at the Rome Division of the European Centre for Environment and Health, reports on the problems related to drinking water in Europe; and Guy Le Moigne, senior water resources adviser at the World Bank, discusses the Bank's history of involvement in water projects throughout the developing world.

The regional development section focuses on specific local issues such as Unicef's emergency water programme in Somalia, the status of irrigation and drainage in India, and water supply and treatment systems in rural areas of Latin America. This section also includes a review of the participation of the European Bank for Reconstruction and Development in the development and financing of emergency programmes in Azerbaijan.

New World Water 1996 also covers many major technical advances in the water industry in areas such as water treatment, sanitation and pumping is improving water service.

We hope that *New World Water's* in-depth research will not only be informative but will set the scene for further changes that will continue far into the future. ■



Supply and sanitation services for all?

Human suffering caused by lack of water and sanitation led to the 1980s being declared the International Drinking Water Supply and Sanitation Decade. Yet at the end of it, a report by the UN Secretary-General concluded that the decade's achievements amounted more often than not to standing still or falling behind.

Pierre Najlis, *UNITED NATIONS SUB-GROUP ON WATER RESOURCES*

Concerns about the environmental and health effects and the human suffering brought about by the inadequacy of water supply and sanitation services worldwide grew during the 1970s. These concerns were voiced at the UN Water Conference held in Mar del Plata, Argentina, in March 1977. Following the recommendations of the conference, the UN General Assembly, in November 1980, through resolution 35/18, proclaimed the period 1981–90 as the International Drinking Water Supply and Sanitation Decade. Governments assumed a commitment to bring about a substantial improvement in the standards and levels of services in drinking water supply and sanitation by the year 1990.

At the end of the period in 1990, a report by the Secretary-General to the 45th session of the General Assembly on Achievements of the International Drinking Water Supply and Sanitation Decade estimated that over that time about 1348 million people in developing economies had been provided with safe drinking water, of which 368 million were in urban areas and 980 million in rural areas. The total number of people enjoying access to safe water was estimated at 2.8 billion, while the number of people without such access was estimated to have decreased from 1.8 to 1.2 million.

Some 748 million people were provided with sanitation facilities, making a total of 2.3 billion with access to them. Of that number, an additional 314 million were urban dwellers and 434 million were located in rural areas. During the decade, the number of people in developing countries without access to sanitation remained unchanged at 1.7 billion. In terms of reducing the number of people without access to safe water and suitable sanitation in urban areas, the report concluded that, with the exception of western Asia, the decade showed little progress and even in some areas a deterioration. It further stated that in the case of Africa south of the Sahara, the number of urban dwellers without safe water supply had increased by 29 per cent.

In June 1995, a new report was issued to the UN General Assembly, through the Economic and Social Council, assessing the situation as of 1994. The findings of this report confirm the concerns expressed in 1990 about the overall lack of progress toward providing at least minimally safe water supplies and suitable sanitation to all by the turn of the century. Revised estimates for water supply and sanitation coverage for 1990 showed that the number of people likely to be without access to a safe water supply by 1990 was about 1.58 billion, rather than the 1.2 billion previously estimated. The revised number of people without access to sanitation was about 2.59 billion, rather than 1.7 billion. These increases in the number of people deprived of suitable services is due to the use of more stringent criteria by a number of reporting countries as to what constitutes safe water supply and suitable sanitation facilities.

An additional 783 million people in the developing economies of Africa, Asia, Latin America and the Caribbean, and in western Asia, were provided with safe water supplies between 1990 and 1994, but some 1.11 billion people still lack access to safe water. Approximately 2.87 billion people are without sanitation.

The challenge of providing full water supply and sanitation coverage to the urban populations of developing countries remains daunting. The goal of achieving full service coverage in developing countries is as elusive today as it was at the time of the UN Water Conference in 1977. Despite all the calls to action dating back to the conference and all the efforts at national and international levels to accelerate the rate of service delivery, the situation of urban water supply and sanitation so far seems to have followed a steady path of deterioration.

Sanitation for urban areas

In the face of high rates of population growth and urbanisation, the total number of urban dwellers without safe water increased by some 32 million, in spite of a total increase of 172 million in the number of people joining the ranks of those being provided with safe water. In Africa, where the annual rate of urban population growth for the period 1990–95 is estimated at 4.38 per cent, the addition of 19 million to the number of people having access to safe water led to an equal increase in the number of dwellers devoid of such services. For the developing countries of Asia and the Pacific, with annual urban population growth rate of 3.71 per cent, the addition of 117 million people with safe water supplies was also accompanied by an increase of 9 million in those lacking it. In Latin America and the Caribbean, the provision of water supply services kept pace with a much lower rate of urban growth. Only the western Asia region appears to be on its way to achieving full urban coverage.

The situation concerning the provision of sanitation services to urban areas is downright alarming, as little if any progress has been evident in recent years. The number of urban dwellers reported to have access to sanitation facilities stands at 1 billion, leaving some 588 million deprived of services. In all four regions, the proportion of urban dwellers with access to safe sanitation remains considerably lower than in the case of water supply.

The neglect of urban sanitation has been particularly critical in Africa, where the addition of 1 million people receiving access to services over the four-year period resulted in a swelling of the ranks of those without services by as many as 36 million. Relative coverage dropped from 65 to 55 per cent of the urban population.

In the developing countries of Asia and the Pacific, relative coverage remained static at about 61 per cent. An increase of some 70 million in the number of urban dwellers with access to services was accompanied by an increase of 55 million in the number of people lacking suitable sanitation. In spite of the addition of 5 million to those having access to sanitation, 2 million people have been added to the number of urban dwellers lacking services in western Asia.

Estimates for Latin America and the Caribbean, where approximately 73 per cent of the urban population has access to services, indicate that some 94 million people in urban areas are still in need of sanitation facilities.

Except for western Asia, a continuation of the current trend in the provision of services would be insufficient to prevent an increase in the number of people in urban areas not having access to safe water by 2000. A doubling of the current rate of increase in the provision of water supplies would be required in Africa simply to keep pace with urban growth. A more than fivefold increase would be required to achieve full coverage. In terms of a longer time horizon, the achievement of full coverage by 2020 in Africa would still require more than a trebling of the current rate. Latin America and the Caribbean and Asia and the Pacific would need more than twofold increases in their current rates of expanding services to achieve full service coverage within that time-frame.

The situation concerning the provision of sanitation services to urban areas is downright alarming

The continued neglect of urban sanitation gives rise to serious concern. The lack of suitable sanitation facilities, particularly in large urban concentrations, together with inadequate attention to waste-water treatment and urban pollution, is likely to have major health and environmental consequences. The current rate of service increases in all regions is insufficient to prevent an increase in the number of dwellers without access to suitable facilities. Asia and the Pacific would require as much as a 5.6-fold increase in the current rate to achieve full coverage by the end of the century. A fourfold increase could be needed to achieve the same objective by 2020. Latin America and the Caribbean would need to add some 24.5 million people a year if total coverage were to be achieved by the end of the decade. A fourfold increase would be required for western Asia to achieve full coverage. In Africa, the rate of expansion would need to be 80.6 times higher to the end of the century. Within a longer time horizon, a rate of expansion 46 times higher than the current rate would lead to sanitation for all by 2020.

Rural areas

Progress with regard to the provision of clean water to rural areas has been significant in Asia and the Pacific, where some 582 million people were provided with services, thus reducing the number unserved by 513 million. In Latin America and the Caribbean, the provision of services to an additional 6 million resulted in an equivalent decrease in the number of unserved. In western Asia, the increase of 3 million in the number served resulted in a reduction of 1 million in the number of people without safe water. In Africa, however, in the face of an annual rate of population increase in rural areas of 2.03 per cent, the increase by 20 million in the number of people having access to safe water was accompanied by an increase of 16 million in the total number lacking services.

With the apparent exception of western Asia, where the proportion of rural dwellers with access to sanitation is reported as 64 per cent, the level of sanitation services to rural areas elsewhere in developing countries remains dismally low, ranging from a minimum of 15 per cent in Asia and the Pacific to a maximum of 34 per cent in Latin America and the Caribbean. Little or no progress seems to have been made in recent years.

Under current criteria as to the suitability of services in terms of quality and distance to water supply sources, a continuation of the rate of progress reported to have taken place in the provision of safe water to the rural populations of Asia and the Pacific would yield full coverage to the region before the end of the century. This is not the case for any of the other regions. Africa would need to provide water to 58 million people a year to supply everyone with safe water.

This would require an almost 12-fold increase in the current rate of progress. The rate of increase would need to be 6.5 times higher than the current rate in Latin America and the Caribbean, where almost 9 million people a year would need to be added to those having access to safe water. In spite of the projected decrease in rural population, the current rate of expansion in services would be insufficient to achieve full coverage by 2020. The rate of progress in western Asia would need to be 2.6 times the current rate to achieve full service coverage by the end of the decade.

Under the current conditions of neglect, a solution to the problem of providing sanitation facilities to rural areas in developing countries is unlikely to be at hand in the near future. In the African region, a rate of progress almost 21 times higher than the current rate would be required to achieve full service coverage by the end of the century. An almost fourfold increase in the current rate would be needed in western Asia. The Latin America and Caribbean region would need to provide sanitation to 13.4 million rural dwellers each year to the end of the century. Asia and the Pacific would have to provide sanitation to 320 million rural dwellers a year to achieve full coverage by 2000. An increase of 75.5 million a year would achieve this objective by 2020.

The problem of providing water supply and sanitation services to all is inextricably linked to poverty in peri-urban and rural areas. Solutions to the problem of reaching the millions of people worldwide who lack suitable services will be found only within a framework of poverty alleviation. The impact of water resources development projects, including water supply and sanitation, is likely to remain limited unless they become agents of development, employment and income-generation, particularly among those living at or below the absolute level of poverty.

It is clear that no real solution to the problem of water supply and sanitation is at hand without very significant increases in the level of progress and an infusion of funding into the sector several times larger than the funding devoted to it at the present time. In the case of urban water supply, the problem is compounded by increasing costs in the light of a growing demand for water from rapidly expanding cities. Ultimately the solution will depend on people's ability to pay for services and on the ability of utilities, whether public or private, to provide such services in an efficient and environmentally sustainable form.

Traditionally, the delivery of water supply and sewerage systems has been provided through public utilities, financed and heavily subsidised through the public sector. It has now become increasingly evident that this approach alone cannot generate the level of funding required to achieve full coverage at any time in the near future. Ultimately the solution will depend on people's ability to pay for services and on the ability of utilities, whether public or private, to provide services in an efficient and environmentally sustainable manner. While pricing policies aimed at cost recovery must take into account the ability of the urban and rural poor to pay for the provision of services, the provision of subsidies should not be carried out at the expense of the financial viability, autonomy and accountability of the public or private utilities that provide services. Experience has demonstrated that the involvement of communities in the design and management of delivery systems must be considered as an important component in efforts to generate financial resources.

It is clear that no real solution to the problem of water supply and sanitation is at hand without significant funding

A massive infusion of funding is particularly needed to provide sanitation services and treat urban effluents that are polluting rivers and groundwater basins. Yet the lack of effective demand for sanitation services among the peri-urban and rural poor, compared with the demand for water supply, hinders the acceleration needed in the provision of such services. The need for sanitation services is not perceived as having the same life-or-death urgency as water. Consequently, urgent attention needs to be given to public hygiene education, to the design of systems that find widespread public acceptance in terms of convenience and cost, to the generation of financial resources and to the formulation of effective tariff policies for sewerage and waste-water treatment facilities.

The problems of providing adequate water supply and sanitation services to all was the subject of an in-depth review at a ministerial conference on drinking water supply and environmental sanitation convened in March 1994 by the government of The Netherlands to provide inputs to the second session of the Commission on Sustainable Development in its review of Chapter 18 of Agenda 21. The conference issued a set of proposals contained in its Action Programme, which in turn were endorsed by the commission at its second session. The action programme represents the latest stage in the evolution of concepts since the UN Water Conference, the Global Consultation on Safe Water and Sanitation for the 1990s, held in New Delhi in 1990, and the UN Conference on Environment and Development held in Rio de Janeiro in June 1992.

Because of the increasing scarcity of water resources relative to the demand for them, the ministerial conference stressed the need for dealing with drinking water supply and sanitation within the context of a holistic approach to the management of fresh-water resources. As stated in Chapter 18 of Agenda 21, water is to be viewed as a finite and vulnerable resource that is a social and economic good. The conference recommended that governments undertake a water resources assessment in order to produce an inventory of the current situation and to identify problems and constraints in providing water supply and environmental sanitation services. It also called on governments to develop, review or revise, in the context of a national sustainable development strategy consistent with Agenda 21, measures for water resources management, including drinking water and environmental sanitation, and to develop, review or revise by 1997, and implement, measures aimed at achieving a rational and effective provision and use of drinking water and environmental sanitation. The conference reiterated the importance of reliable national data on various aspects of water supply and sanitation and recommended that governments establish nationwide monitoring systems. It is also recommended that governments develop detailed guidelines for investment to rationalise resource generation and use, and that they explore and develop new and innovative financial mechanisms, including private funding and harnessing of local resources, to the maximum extent possible.

To date, available information suggests that progress towards the integrated management of water resources has been slow. The weakness of information management systems remains a major constraint in all but a few countries, and much more needs to be done in terms of the quality, reliability, timeliness, level of detail and geographical coverage of data, including information on gender issues.

The effective involvement of urban and rural communities in policy formulation and in the planning, development and management of water supply and sanitation facilities has been recognised as essential. The action programme of the ministerial conference stresses the need for a partnership approach and for dialogue about the needs and capabilities of people in urban and rural communities in relation to the management of delivery systems and their ability to pay for services. It also emphasises the importance of capacity-building programmes aimed at empowering communities, and women in particular.

With regard to action at the international level, the ministerial conference made a number of recommendations concerning the support needed for capacity building programmes, and support to the governments of developing countries in the formulation of national strategies and the formulation and implementation of programmes for community participation and exchange of information and experience, particularly in respect of training, education, research and technology, and on modalities of project design and implementation. The conference also noted that to prevent a water crisis there was an urgent need to mobilise, within the framework established by Chapter 33 of Agenda 21, adequate financial resources through using all available sources and mechanisms and maximising the availability and smooth flow of additional resources to execute the action programme.

After reviewing the report of the Secretary-General, the Economic and Social Council, at its substantive session in July 1995, decided to recommend to the General Assembly, at its 50th session, the adoption of a resolution by which the Assembly would express deep concern that at the current rate of progress the provision of water will be insufficient to satisfy the needs of a very large number of people by 2000, and that lack of progress in the provision of basic sanitation services is likely to have dramatic environmental and health consequences in the near future. The General Assembly would call on governments to implement fully the provisions contained in Agenda 21 and the recommendations of the Commission on Sustainable Development at its second session, including those contained in the action programme of the ministerial conference on drinking water supply and environmental sanitation.

In particular, the Assembly would call on governments to develop, review or revise by 1997, and implement, in the context of a national sustainable development strategy consistent with Agenda 21, measures for drinking water supply and sanitation; to undertake, as appropriate, legal, regulatory and institutional reforms designed to bring about the management of water resources at the lowest appropriate level, including stakeholder participation and the involvement of the private sector; assign high priority to basic sanitation and excreta disposal systems in urban and rural areas, and to the treatment of waste waters; formulate investment strategies and cost-recovery polices, taking into account the needs and conditions of the peri-urban and rural poor; and establish water and sanitation monitoring systems.

The Assembly would call on the organisations of the United Nations system and other relevant organisations to intensify their efforts to provide financial and technical support for developing countries and countries with economies in transition. It would also urge donor governments, multilateral financial and development institutions and non-governmental organisations to give favourable consideration to requests for grants and concessional financing, particularly with regard to environmental sanitation and sewerage, as well as waste-water treatment projects. ■

Author

Pierre Najlis is secretary of the United Nations sub-group on Water Resources.

Drinking water and health in the wider Europe

Microbiological pollution of drinking water from lack of sanitation facilities has long been recognised as a major cause of many communicable diseases and is still widespread.

Jamie Bartram *World Health Organisation, European Centre for Environment and Health*

Contamination of drinking water is typically more common in private sources and smaller supply systems and occurs in such supplies worldwide. Nevertheless, piped water systems have the potential to distribute pathogens to many people rapidly and so cause outbreaks of communicable diseases. Such outbreaks, with their associated economic costs, continue to be reported across Europe.

Straightforward sanitary intervention and complementary hygiene are necessary to prevent these diseases and are highly effective. Accumulated scientific and engineering knowledge and experience, with behavioural and technological interventions, can be used to optimise policy.

The present water distribution and treatment infrastructure in Europe as a whole is inadequate. Action is necessary to prevent deterioration and harm to health. This is because insufficient supply and increasing contamination lead to the occurrence of additional numbers and types of water-borne diseases, some of which will occur only when very many microbes are present.

Reliable estimates of the extent of health effects due to contamination of water supply are rare, but evidence indicates that disease resulting from microbiological pollution of drinking water is far greater than that from chemical contaminants.

Assessment needed

The extent of human exposure to chemical contaminants in Europe — and in some cases the magnitude of their health effects — still needs to be assessed to clarify their potential impact on European populations. Few chemical constituents of water can lead to acute public health problems except through massive accidental contamination of water supplies, which often renders water unpalatable in any case. One important exception is nitrate, high levels of which may cause methaemoglobinaemia in bottle-fed infants.

Among chemical contaminants, of particular concern therefore, are those with cumulative toxic properties, including lead from water pipes and solders, nitrates and pesticides from agricultural and livestock practices and naturally occurring substances such as arsenic and fluoride. Chemical contamination of groundwater, which provides drinking water for 65 per cent of the European population, is difficult to clean up. Purification techniques are being developed but are costly, and natural regeneration of groundwater is extremely slow.

The great public awareness regarding the possible risks of chemicals in many parts of the world is often not matched by knowledge about the extent of human exposure or in some cases the nature and magnitude of health effects.

This article focuses on microbiological contamination of drinking water because it is known to cause a large amount of communicable disease, which can be effectively prevented by the observance of straightforward sanitary and water-related hygiene. This prioritisation does not detract from the importance for human health of obtaining and maintaining quality water sources in both microbiological and chemical terms.

Causes of water access problems

It has been estimated that 12 per cent of the population in the World Health Organisation's European region, mainly in rural areas or eastern countries, lack access to safe drinking water and that a greater proportion is not served by adequate excreta disposal. Domestic water supply acts not only as a potential vector of communicable diseases but also as a protective barrier against infections by facilitating personal and domestic hygiene. Populations with no organised water supply, such as many rural ones in Europe, are thus at high risk.

Water must be safe at source (well, spring, water-works), but that does not mean it will be free from microbiological contaminants. Deterioration of water quality can occur in the distribution system and because of the way water is stored and handled within the household. Within Europe there have been many reports of breakdowns in the water distribution system and interruptions to supply, with consequent faecal contamination of drinking water, especially in countries of central and Eastern Europe (CCEE) and the newly independent states of the former USSR (NIS).

Cholera outbreaks continue to be reported in several countries (Albania, Romania, Russian Federation, Ukraine), and hepatitis A is endemic, with a high prevalence in many areas of CCEE and NIS. These often result from microbiological contamination of drinking water due to breakdown in the supply system. Western Europe is not free of such concerns, as recent threats from Cryptosporidium have, for example, demonstrated.

The risk of water-borne infection depends on the dose of pathogens ingested. Different pathogens have different infective doses. While millions of Vibrio cholera organisms (108–1011) are needed to cause an infection (cholera), fewer (103) are necessary in the case of Shigella, which causes bacillary dysentery, and fewer still (less than 102) are suspected for viral agents. Effective doses tend to be smaller for infants, the elderly and those who are sick or debilitated. In the USA, for example, most recognised water-borne outbreaks were due to typhoid and cholera in the 1920s, to hepatitis A in the 1960s and to Giardia since the 1970s, in part reflecting improvements in the water supply system. Better reporting systems in some European Union (EU) countries are able to identify outbreaks of organisms more resistant to chlorination, such as Cryptosporidium, but the extent of these problems in the East is not yet known.

Additional causes of disruption to water supply systems and other environmental services are armed conflict and natural disaster, which have recently afflicted Europe again. Water shortages in arid or vulnerable areas — perhaps aggravated by industry, agriculture and tourism — increase the pressure on water supplies, and treatment may be required for lower-quality sources at additional cost, with less availability or continuity of supply. Restrictions to supply, whether long-term, seasonal, or provoked by conflict or disaster, may lead to increased incidence of water-washed diseases (including eye and skin infections and infestations) as well as those transmitted by the faecal-oral route.

Consequences

The most important diseases transmitted through microbiological contamination of water in Europe are diarrhoea and dysentery of various types (including cholera), typhoid and hepatitis A. Other water-borne and water-washed diseases include skin infections, intestinal infestations and trachoma. The public health impact of these diseases in Europe is due largely to morbidity and temporary disability rather than to mortality, with such economic consequences as lost productive and leisure time and strain on health services — which can be extensive and unpredicted in the event of disease outbreaks.

Information on water-related disease in Europe is poor, and does not, for example, employ standard case definitions. International comparisons of disease levels and trends cannot be made unequivocally, yet a qualitative estimate of water-borne diseases in Europe can be reached because some diarrhoeal diseases, including cholera and typhoid, are required by law to be reported — though some reporting may substantially underestimate the incidence. A number of recent outbreaks of cholera in CCEE and NIS indicate a level of microbiological contamination of drinking water that is likely to be associated with a substantially greater burden of water-borne diseases than elsewhere in Europe. This assumption is supported by the fact of higher mortality rates for diarrhoeal disease in Eastern Europe — more than twice those of Western Europe.

Other water-borne diseases such as hepatitis A are exceedingly common in parts of Eastern Europe. A population survey in Romania in 1990 indicated that 77 per cent of children and 36 per cent of adults at low risk had evidence of recent infection by hepatitis A, and that 52 per cent of children and 88 per cent of adults had developed antibodies to hepatitis A. Many other countries such as Tadzhikistan, Kazakhstan and the Russian Federation report many thousands of cases every year through their surveillance systems.

The large human and financial costs of water-borne epidemics are well documented in Western Europe and the USA. One Cryptosporidium outbreak in the USA, spread through the water supply, affected 200 000 people and cost approximately US$177 million. A simple gastro-enteritis outbreak in a small community near Copenhagen in 1991 led to a loss of work-days worth about US$300 000.

Strategy

Reducing diarrhoeal disease. Improvements in water quality, availability and excreta disposal have been shown to yield major reductions in diarrhoeal disease morbidity (around 20 to 25 per cent when implemented separately or 37 per cent if implemented jointly), as well as improvements in nutrition and reduction in communicable diseases.[1] Increased water availability and excreta disposal are more effective than water-quality improvements alone. Effects of interventions are maximised by jointly addressing hygiene practices.[2] Exclusive breast-feeding (that is, when it is not supplemented at all by bottled milk or other feeds) protects against diarrhoea where water is contaminated, but the addition of even small amounts of contaminated water will greatly increase the risk of disease in breast-fed infants.[3]

Transmission of microbes occurs through drinking water, person-to-person contact, aerosols, and food intake. The effectiveness of intervening in each of these channels of transmission to reduce the total number of microbes transmitted to the host has been extensively tested, and the evidence shows that while improving water quality may not be sufficient to protect against diarrhoeal and other communicable diseases it is a necessary step toward implementing further protective barriers. Greater water availability will facilitate washing of hands (and may reduce hand faecal contamination), proper cleaning of food, utensils, home environment and personal hygiene.

The impact of water and sanitation and behavioural interventions to reduce diarrhoeal and other infectious diseases have been demonstrated to be greatest among those living in worse sanitary conditions (less access to water and more contamination of water and environment). Targeting this group for water and sanitation interventions is ethically desirable, politically acceptable and administratively possible. The option of focusing on only individual characteristics, such as feeding practices or levels of education is of little overall benefit in those circumstances.[4]

Contrary to what was sometimes previously claimed, populations living in unserved urban (generally low-income) areas and arid rural areas have been shown to be willing to pay for water supply, and those in urban areas for basic sanitation.

The benefits of improved water and sanitation are likely to have a multiplier effect by acting on the morbidity and mortality rates of different diseases and age groups. This is suggested by studies showing much greater impact of water and sanitation improvements on life expectancy than could be expected on only the basis of reduction in one cause of death.[4]

Most of the interventions in countries with a high level of risk factors for diarrhoea, including water contamination and high diarrhoeal disease mortality rates, have shown a greater impact in reducing mortality than reducing morbidity. As water quality improves, the impact of further improvements will be detected in reductions in the incidence and severity of disease.[2] This is what can be expected in Europe. To measure the impact of eventual interventions, appropriate study methods have to be used; otherwise, benefits could be substantially underestimated.

Interventions at household level. Two types of intervention to improve water quality beyond organised source-treatment-supply have been practised in Europe: the purchase or provision of bottled water to high-risk populations, and household water treatments. It is important to remember that bottled water is a short-term measure that does not address the cause of contamination. Bottled water is subject to food regulation criteria in many countries, and they may be considerably more lax than drinking water criteria in respect of chemical content.

The efficacy of household treatment devices varies widely. In addition, some are oriented toward improving chemical and aesthetic aspects while the public health threat may be principally through microbiological contamination. In all cases, except disinfection with a residual disinfectant, (such as chlorine or iodine), the water is subject to re-contamination. The use of these devices may therefore, in some cases, lead to a false sense of security. The widespread adoption of household-level treatment represents a cost to society that might be better diverted to establishing or improving reliable piped water supply.

Purchase of bottled mineral water or of household treatment devices could be seen as an indication of willingness to pay (by government and individuals) for adequate water and sanitation interventions, and such financial resources could arguably be better used for securing an adequate water supply system.

Legislation

Guidelines for minimum drinking water quality to protect public health against microbiological and chemical contamination have recently been updated by WHO, and serve as a reference for setting national standards (WHO 1993). They are based on toxicological studies, estimates of human exposure and, more rarely, on epidemiological data. In developing national standards from such guidelines, care should be taken in selecting substances requiring standards, taking into account, for example, geology and human activity. Care should also be taken to ensure that scarce resources are not diverted to developing standards and monitoring substances of only minor importance for health.

As already mentioned, availability of water is a major protective factor for health, enabling hygiene to be practised. So, standards should not be allowed to limit the availability of water, and the public should be kept informed as to the quality of water supplies. In general, national standards for drinking-water quality should be a tool for progressive improvement in safe water availability to consumers, not an instrument to close imperfect supplies.

Monitoring. The use of indicators of pollution, focusing on the water in distribution — such as thermo-tolerant or total coliform count at central points of distribution systems — does not provide sufficient information for effective decision-making. First, assessment of pollution should be accompanied by assessment of causes, and sanitary inspection is therefore a vital complementary measure. Furthermore, analysis alone may give the impression that a "chemical fix" through water treatment is required when source protection may in fact be more effective and less costly. Also, since contamination in the home may be the principal source, the relative importance of improving central supply quality and household treatment, storage and handling should be considered.

Finally, a significant proportion of the European population, largely in rural areas, is not supplied with drinking water through a centralised public system. Such populations may be at special risk and should of course be considered in any monitoring scheme. Even for areas with piped supply, the reliability of that supply is an important consideration, and assessment of continuity and accessibility should be included in any monitoring scheme.

So far there is little harmonisation of water supply and utilisation of data collection methods in Europe. The use of standard definitions and collection methods, and an agreed minimum set of information to be systematically collected, are essential for estimating the type and extent of water problems affecting Europe today as well as the size of exposed populations, to monitor trends and progress.

More emphasis needs to be given to considering all aspects of water contamination together with a comprehensive approach encompassing water from source to point of use.

Investigating chemical contaminants. The effects of chemical contaminants in drinking water on human health are difficult to detect, due to the potential for various confounding factors and the need to conduct large studies. Guidelines for minimum drinking-water quality to protect public health against microbiological and chemical contamination have recently been updated by WHO. They are based on toxicological studies, estimates of human exposure and, more rarely, epidemiological data. The latter are often lacking or poor. Uncertainty factors are included to account for these limitations where appropriate.

Water quality concerns among the public, politicians and scientists across Europe often revolve around issues of chemical contamination of drinking water — sometimes even where the principal public health priority is undoubtedly infectious water-borne disease.

Nitrates

Of the chemical pollutants of drinking water of wide importance, nitrate is the one of most concern. High levels of nitrate in the drinking water used to make up bottled feeds for babies may cause methaemoglobinaemia (Blue Baby syndrome). Exposure to nitrate concentrations in drinking water well above the WHO guideline levels and high enough to cause cases of methaemoglobinaemia are found in large areas of Belarus, Bulgaria, Hungary, Lithuania, Romania and the Slovak Republic. In the Czech Republic and in Poland, high levels are also reported in the Danube river bank filtered waters used for drinking.

Public concern about pesticides is also high, and evidence relatively sparse, to some extent because sampling and analysis are more demanding and costly than for many other chemical constituents of water. Some pesticides have been shown to cause cancer toxicity in laboratory experiments. Evidence of effects in humans is lacking except for acute toxicity, largely found in occupational or accidental settings.

The effects of ingestion through drinking water on humans have not been extensively investigated. However, accepted levels of pesticides in food are far higher than in water, so food is a more likely vehicle for causing disease. High levels of pesticides are recorded in some parts of Europe, including the Russian Federation, along the river Danube, in Italy and France, and better monitoring has led to finding contamination in larger numbers of samples.

Some chemicals in drinking water are naturally occurring at concentrations high enough to endanger health. This may be the case with arsenic and fluoride, for example. Arsenic in drinking water has been demonstrated to cause skin cancer and be associated with internal cancers. It is known to cause vascular problems in certain parts of the world but not in others. Its suspected effects on miscarriages and on vascular disease in Central Europe are being investigated. Naturally occurring arsenic in drinking water is found in parts of Hungary and Romania, and affects around 500 000 people. It is also produced by industrial pollution in Bulgaria. Fluoride, which may lead to dental and, much less often, skeletal fluorisis when it occurs in drinking water in high concentrations, is found in many parts of Northern, Southern and Eastern Europe and Central Asia.

Threat from lead

Especially troublesome are substances that enter drinking water from the supply system itself. This is so, for example, with lead, which is found in the plumbing of old buildings and in some pipe solders. WHO tightened its value for lead in drinking water when it last revised its Guidelines for Drinking Water Quality, and the EU has acted similarly with its drinking water directive. But the cost of removing old pipes is high, and responsibility for it is a major issue for supplier, government and household.

Lead has been associated with long-term neurological and cognitive problems in young children, but epidemiology could not demonstrate evidence for a safe lower limit. The WHO guideline value was therefore decided on the basis of levels that do not cause its accumulation in internal tissues.

Human exposure to lead in drinking water arises mostly from old pipes or solders. Levels depend on the degree of stagnation of water within the pipes and whether people have the habit of letting the tap run before using water from it for drinking. Most human exposure to lead tends to result from ingestion of food, soil or dust, and, where petrol is still leaded, through the air, but water's contribution can be high where old housing is involved. ■

References

1. Esrey SA, Feachem RG, Hughes JM (1985) Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities. *Bulletin of the World Health Organisation*, 63 pp747–72.
2. Esrey SA,Habicht JP, Casella G (1982) The complementary effect of latrines and increased water usage on the growth of infants in rural Lesotho. *American Journal of Epidemiology*. 133 pp659–66.
3. VanDerslice J,. Popkin B, Briscoe J (1994) Drinking water quality, sanitation and breast-feeding: their interactive effects on infant health. *Bulletin of the World Health Organisation*, 72 pp589–601.
4. Briscoe J (1987) A role for water supply and sanitation in the child survival revolution. PAHO Bulletin, 21 pp93–105.
5. Bern C, Martines J, de Zosa I, Glass RI (1992) The magnitude of the global problem of diarrhoeal disease: a ten-year update, *Bulletin of the World Health Organisation* , 70 pp705-14

Author

Jamie Bartram is manager, Water and Waste, of the European Centre for Environmental Health, Rome Division.

Change of emphasis in World Bank lending

The World Bank is the major lender for water-related projects in developing countries, but its emphasis in both policy and lending has shifted from large stand-alone infrastructure projects to those that encourage sustainable water resources management.

Dr Guy Le Moigne *WORLD BANK, WASHINGTON DC*

Professionals in all areas of water resources management should be aware of the World Bank's new approaches and how they will affect the financing of water resources in developing countries and elsewhere.

From its inception in 1948 until today, the World Bank has lent about $40 billion dollars for water projects or related activities. By 1998, the total should reach some $52 billion. Since it began lending for water, the bank's emphasis has changed several times. Broadly, its role in water resources has shifted from financing large infrastructure projects to encouraging the kinds of activity that will make water resources management "sustainable" in developing countries. This includes focusing on policies and strategies that encourage a holistic, or comprehensive, approach to water resources management in client countries.

The World Bank's activities in water projects cover many areas, and financing takes many forms. Traditionally, the Bank's lending for water has been characterised by sector. The two major sectors are irrigation and drainage, and water supply and sanitation. Other major areas of Bank activity in water are hydropower, flood control and drainage, multipurpose projects (including dams), inland navigation, fisheries, and port development.

Irrigation and drainage is by far the largest of the sectors, accounting for about 7 per cent of World Bank lending. From 1950 to the present, the bank lent roughly $21 billion for various forms of irrigation in some 630 projects. In terms of number of projects, the Asia region has dominated lending in irrigation and drainage. In hydropower, the bank has in the past financed a number of large dam projects, many with multi-purpose objectives. Although the Bank has been criticised in recent years for involvement in some large dam projects, it must be pointed out that in any one year it has financed less than 3 per cent of all large dams (those more than 20 metres high), a relatively insignificant portion of the total. Also, it is hoped that the bank can exercise some beneficial influence on aspects of projects that might not be considered at all were the bank not involved.

Recently, the Bank has become involved in pollution-control projects that cover both industrial pollution and environmental protection. Also, some aspects of lending have related to water in a broad sense, such as lending for macro-economic structural or sector adjustment. Such loans may include conditions related to water.

Finally, the Bank has financed projects tied to water in sectors not already mentioned; for example, watershed management and reafforestation, and fishery development in reservoirs linked with the resettlement of displaced populations.

Apart from lending directly for projects, the Bank also provides funds for technical assistance.[1] Directly financing assistance from experts during a project is by far the most important form of technical assistance. Borrowers receive it from the Bank under two main categories: technical assistance financed through Bank loans and credits, which are repaid by the borrower; and that provided at no direct cost to the borrower.

In the first category, World Bank lending for technical assistance is to facilitate implementation of the projects and programmes it finances, and the funds may be provided as a component of a development project, from free-standing multi-sector technical assistance loans, or from the Bank's project preparation facility (made before loan/credit approval and subsequently refinanced under Bank loans/credits, or repaid).

Lending for technical assistance has the following characteristics: the borrower uses the funds provided to procure services in the open market under a contract between the borrower and the supplier, and the borrower exercises considerable discretion regarding the nature, cost, and source of the technical assistance, subject to provisions of the loan agreement and the bank's guidelines on the use of consultants.

There are two sub-categories of technical assistance provided free of charge: that supplied by the Bank as a development institution through its staff and directly employed consultants, and that funded by other donors or agencies on a grant basis and administered by the Bank. The second category of free technical assistance includes Bank-executed UN Development Programme (UNDP)-financed projects and those financed under member-country trust funds administered by the Bank.

The World Bank does not really have a budget for water projects. They are initiated at the request of client states, although they may have been suggested by or developed with bank staff in consultation with client governments. The basis for the Bank's involvement in all areas of lending, including water, are the country assistance strategies developed in consultation with governments. Each individual project or loan must be approved by the Bank's board of directors, however, and this process can take from two months to two years. The process involves extensive economic and financial analysis as well as the technical analysis that each project entails. In addition, Bank staff must address a number of operational directives in preparing a loan or project, such as those ensuring that the environmental aspects of a project are considered. Disbursement of funds might take years.

Since water covers many sectors of World Bank lending, people in the Bank felt that the institution should have a policy to cover water resources lending and management, so that projects or programmes proposed by countries were financed on a consistent basis.

In the mid and late 1980s, a series of reviews of World Bank lending for water (particularly irrigation) uncovered a number of issues. The reviews coincided with growing awareness among water resources professionals that water is a finite resource and that, to ensure its availability for future generations, water resources management within countries should be undertaken on a comprehensive or holistic basis. What has emerged is a consensus among the international development community on the problems of water resources management and some of the solutions countries ought to consider. These issues should interest all water resources professionals, whether in water supply and sanitation or in irrigation, for the issues will shape the direction of efforts in water resources management, which will in turn shape the requirements for professionals. Specifically, engineers, chemists, health workers, and others will need to become aware of the effects their efforts will have on other areas of water resources management and on the maintenance of safe and sustainable supplies of water.

Internationally, about 69 per cent of fresh water is used for agriculture, while 23 per cent is for industry and some 8 per cent goes to domestic use. Water use patterns reflect, of course, the degree of industrialisation. Africa, for example, uses 88 per cent of its fresh water resources for agriculture, some 7 per cent for domestic use and 5 per cent for industry. Europe, on the other hand, uses 50 per cent of its fresh water for industry, while 42 per cent goes to agriculture and 8 per cent is used domestically.[2]

These patterns of use, however, fail to reflect a deeper need. Despite considerable progress in the 1980s, more than one billion of the world's 5.4 billion people lack access to safe drinking water, and 1.7 billion people lack adequate sanitation. The toll in suffering and loss of economic potential because of water-borne disease is tremendous. The world's population is projected to reach 8 billion people by the year 2025, creating greater demand for water for both urban use and agriculture.

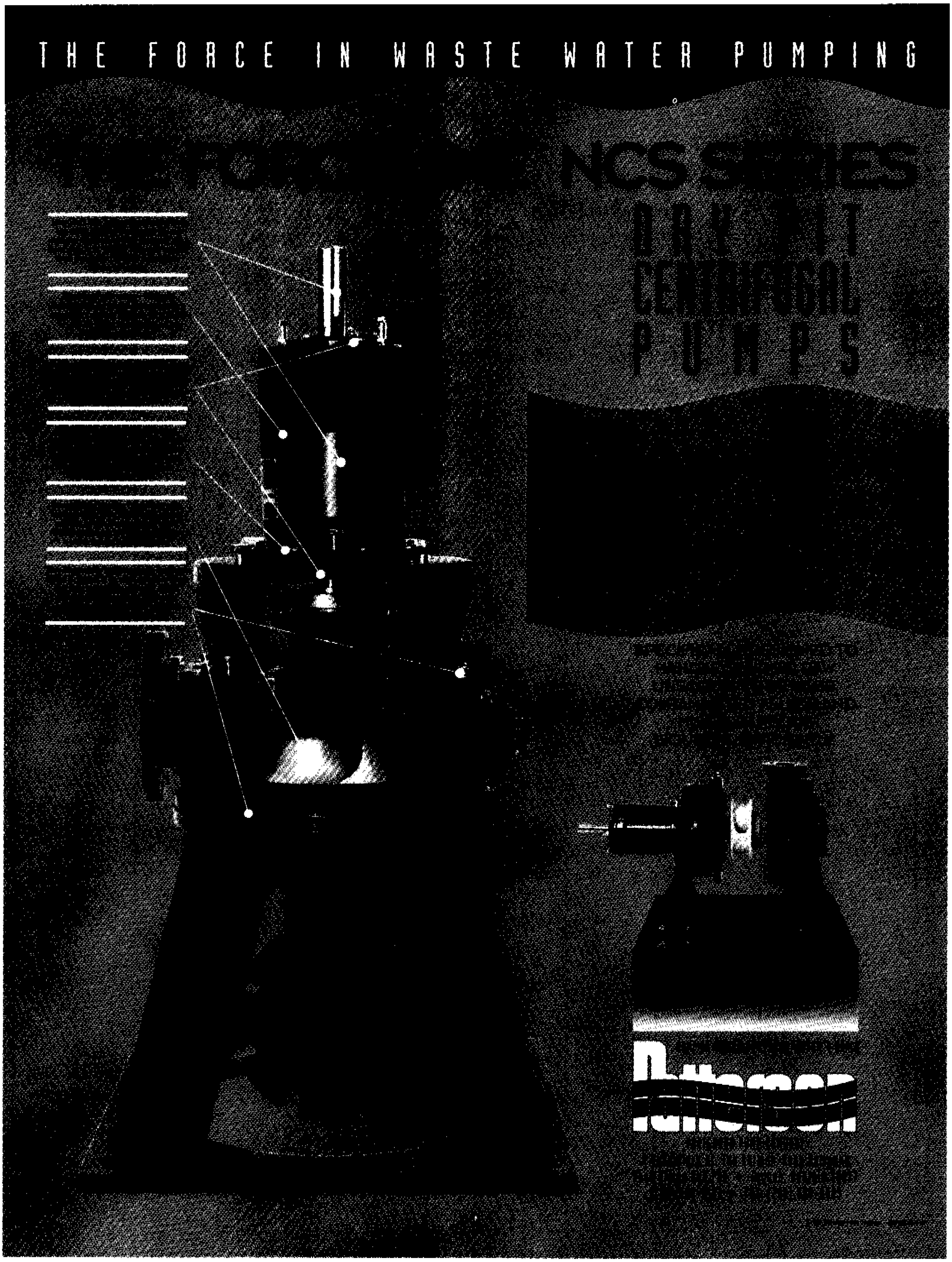
Increasing scarcity of clean water threatens to worsen the quality of life, impair the potential for economic development and endanger vital ecosystems. Investments in water have often encountered implementation, operational and social problems, most of which stem from weaknesses in current water resources management. The consensus about these problems is partly reflected in the World Bank's 1993 policy paper *Water Resources Management,*[3] which will influence the bank's future lending. Some of the principal overall problems identified in that paper are:[4]

Fragmented management of water resources. Governments are usually organised so that each type of water use is managed by an independent department or agency — such as irrigation, municipal water supply, power and transportation. This has often resulted in failure to consider the cross-sectoral effects of water activities.

Over-extended government agencies. Especially when water is scarce, governments tend to base allocations on political and social considerations rather than on economic criteria. There is an understandable concern that unregulated markets would not generate the best allocation of water. The result has been that in many countries central government has taken responsibility for developing, operating and maintaining water systems, with a noticeable absence of incentives for profitability and efficiency. Also, in most cases users have not been consulted or involved in planning and managing water resources.

Under-pricing of water and lack of cost recovery. Water is priced below its economic value in many parts of the world, sometimes for cultural or religious reasons. This often results in misallocation and inefficient use. Pricing and demand have received much less attention than has expanding the supply of water. Relatively low-value uses often receive more water than relatively high-value uses. Charges for water used by urban households are often low; a recent review of World-Bank-financed municipal water supply projects found that the price charged for water covered only about 35 per cent of the cost of supply.

Neglect of public health, water quality, and the environment.


THE FORCE IN WASTE WATER PUMPING
NCS SERIES
CENTRIFUGAL
PUMPS

Countries have generally paid too little attention to water quality and pollution control. Besides contributing to public health problems, poor water resources management causes widespread degradation of land and water. Many countries do not have standards to control water pollution adequately or the capacity to enforce existing legislation. Many environmental resources, such as estuaries and coastal zones, are suffering from the effects of pollution or ill-designed water projects.

Inadequate service delivery to the poor. All the foregoing weaknesses have a particularly bad effect on the poor. Paradoxically, large numbers of the poor rely on water vendors, thereby paying a higher price for water than the middle class.[5]

At the June 1992 United Nations conference on environment and development in Rio de Janeiro, member countries endorsed policies that stressed integrated water resources management "based on the perception of water as an integral part of the ecosystem, a natural resource, and a social and economic good". The focus of efforts in the United Nations and the World Bank is changing from developing new sources of water — a "supply" focus — to economic behaviour, policies to overcome market and government failures, and technologies for increasing the efficiency of water use — a "demand" focus. Eight significant recommendations of the World Bank's policy paper are given here.

First, to overcome the problems of fragmented management, the UN and the World Bank have endorsed a comprehensive analytical framework incorporating cross-sectional and environmental considerations. Water resources should be managed in the context of a national water strategy that reflects a nation's social, economic, and environmental objectives and is based on an assessment of its water resources.[6] Often, the most appropriate management unit under a comprehensive framework is a river basin. Jordan is an example of a water-scarce country that has recently completed a comprehensive cross-sectoral water strategy.

For its part, the World Bank is organised in six regions (Africa, East Asia and the Pacific, South Asia, Europe and Central Asia, the Middle East and North Africa, and Latin America and the Caribbean), and each has produced or will produce its own strategy for water resources, outlining the priorities for Bank water activities in that region over the next several years.

Greater emphasis on incentives for efficiency and financial accountability is the second tenet of the new approach to water resources management. Establishment of proper incentives induces better performance by providers of water services and efficient use by consumers, leading ultimately to better allocation of water for various uses. A component of an appropriate incentive system is the pricing of water. For example, when the city of Bogor, Indonesia, increased charges by 30 per cent, consumption of water declined by a similar rate, and expensive investment in new supply sources was postponed.

Ideally, the price of water should reflect its opportunity cost (that is, its value in the best alternative use). In many countries, however, political obstacles allow only gradual moves toward this objective. Water prices or charges that cover the costs of water service entities would be a good alternative starting point. Such charges ensure the sustainability of financially autonomous entities.

Third, the best water management strategies would mean little without laws and regulations that can be enforced. Several countries, including Mexico and Peru, have examined their legal and regulatory structures with special attention to water ownership and rights.

A fourth measure advocated for effective water resources management is to decentralise water service delivery to the lowest possible level. Many countries are encouraging users' associations to take more control of water management. In an effort both to decentralise and involve beneficiaries, Mexico has transferred management of 78 irrigation districts (covering more than 1.8 million hectares) to water users' associations that will be responsible for operating and maintaining all canals and water distribution.

Fifth, prescribing and encouraging the participation of water resources "stakeholders" — individuals and institutions that would be affected by decisions — is not only good management practice but also helps to build necessary social and political consensus. In projects in Bangladesh and Kenya, water users not only participate in establishing rural water and sanitation systems, but also manage them.

Sixth, protecting existing ecosystems is typically less costly than attempting to restore water quality or to restore valuable ecosystems once damage has been done. For example, until the 1960s the Aral Sea was environmentally stable and had a thriving commercial fishing industry. Massive diversion of the lake's water resources to expand irrigated cotton production eventually shrank the lake by 66 per cent, with disastrous consequences for ecology, economy and health.

Seventh, assigning greater priority to the provision of adequate services for the poor will help stop the spread of disease in crowded low-income areas. Besides building water delivery infrastructure, fee schedules can be structured so that consumers receive a limited amount of water at low cost and pay a higher fee for additional water. For example, the Istanbul Water and Sewerage Authority has instituted block volumetric water charges to meet the dual objectives of raising funding while ensuring that the basic water needs of the population are met. It is important, however, that water entities not be driven to financial destabilisation by being charged with social objectives. These should be funded directly from the public budget.

A final recommendation is for countries to support research, development, and adoption of low-cost technologies to conserve water and enhance its quality. Simple measures can often have dramatic effects. The use of water-saving devices, plus leak detection and repair and more efficient irrigation in its parks helped the city of Jerusalem reduce its use of water per capita by 14 per cent from 1989 to 1991.

The World Bank's involvement in water issues extends to co-operation with a number of outside institutions on initiatives that support aspects of comprehensive water resources management. Among the most important of these are UN agencies, particularly the UNDP, with which the bank has been active in support of capacity-building — encouraging countries to take measures in the areas of institutional and human resources development that can support technical advances or projects in water resources management.

Some initiatives in which the bank has been active recently include specifically a global water partnership with the UNDP to ensure that water resources management in the field — that is, in countries where the UNDP or the bank has water resources staff stationed — takes a comprehensive approach across many sectors. Two of the highly visible sectors are, of course, water supply and sanitation and irrigation. In a second initiative, the bank has been active in exploring the need for and potential activities of a world water council that would bring together public and private-sector organisations in all fields of water resources development to co-ordinate activities and help to make sustainable water resources a high priority for the public and for leaders in many fields of endeavour.

Every country will, of course, tailor new approaches in water resources management to its own situation. The challenge of meeting the water requirements of the planet is enormous. It is impossible to guess with any accuracy what the world total financial needs for water investment will be. The World Bank will provide some $18 billion for water resources investment over the next five years, but, since the needs will be far greater than that, domestic resources must also be set aside. In the long run, the comprehensive framework for water resources management and the attendant policies outlined here will be crucial for countries to sustain this economic growth. ■

References

1. Fredericksen HP, Berkoff J, Barber W (1993) *Water Resources Management in Asia.* World Bank Technical Paper No. 212.
2. World Resources Institute (1993) *World Resources 1992/93.* Washington DC.
3. World Bank (1993) *Water Resources Management.* Washington DC.
4. Feder G, Le Moigne G (1994) Managing water in a sustainable manner. *Finance and Development.* June.
5. Briscoe John (1992) Poverty and water supply: how to move forward. *Finance and Development.* December. See also Briscoe-John (1993) When the cup is 1 half full: improving water and sanitation services in the developing world. *Environment.* May, Vol 35, No. 4.
6 Le Moigne G, Ashok Subramaman, Mei Xie, Sandra Giltner, eds (1994) *A Guide to the Formulation of Water Resources Strategy.* Washington DC: The World Bank.

Author

Dr Guy Le Moigne is senior water resources adviser at the World Bank in Washington DC, USA.

WaterAid: doing the almost impossible

Water is one of the most vital of natural resources, yet 2 billion people lack access to drinkable supplies of it within reasonable walking distance of their homes, and more than 3 billion are without any form of sanitation.

Jon Lane *WaterAid, UK*

Under the International Classification of Diseases, Z59.5 is the code given to the world's biggest killer and the greatest cause of ill-health and suffering. Z59.5 stands for extreme poverty. For those working in the water and sanitation sector it will come as no surprise that high on the list of factors affecting poverty come access to safe water and effective sanitation.

Water is regarded by virtually every community in the world as one of the most vital of all natural resources, but the irony is that it is associated with so much illness and death. Diarrhoeal diseases, resulting from unsafe water and inadequate sanitation combined with poor food-handling practices, are responsible for three million deaths a year among children aged under five in the developing world. Poverty allied with lack of education in hygiene combine to kill a child every 10 seconds.

Grassroots work

WaterAid was created in 1981 by the British water industry in response to the UN-sponsored International Drinking Water Supply and Sanitation Decade to do grassroots work among some of the world's poorest communities. The aim then, as now, was to tackle one of the root causes of poverty through the provision of safe water and effective sanitation.

The need is immense. Two billion people lack access to potable water supplies within reasonable walking distance of their homes. More than 3 billion lack any form of sanitation. The result is that hundreds of millions of women and children walk miles every day to fetch and carry water, frequently from polluted sources. Quite apart from the appalling burden and drudgery involved, the price paid is enormous: 25 000 children die every day from water-related illnesses.

The experience of the world's richer countries shows that something can be done to improve water and sanitation. The issue for organisations like WaterAid is how such improvements can be made in an affordable, lasting and sustainable manner.

WaterAid's approach has been to focus its efforts in a very particular way. Projects are implemented not by WaterAid itself but by local organisations. These may be non-governmental organisations (NGOs), including churches and women's groups; sometimes they are departments of central or local government. WaterAid has a member of its salaried staff based in each country where it is working. He or she supervises funding, and where necessary gives technical or management advice to strengthen these partner organisations.

All projects require major and active participation on a self-help basis by those who will benefit from them. WaterAid has found that such

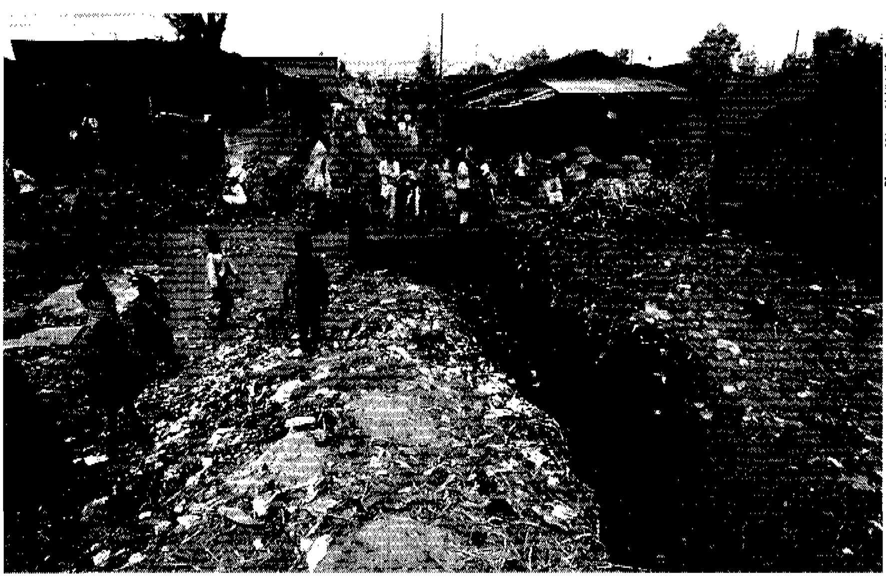
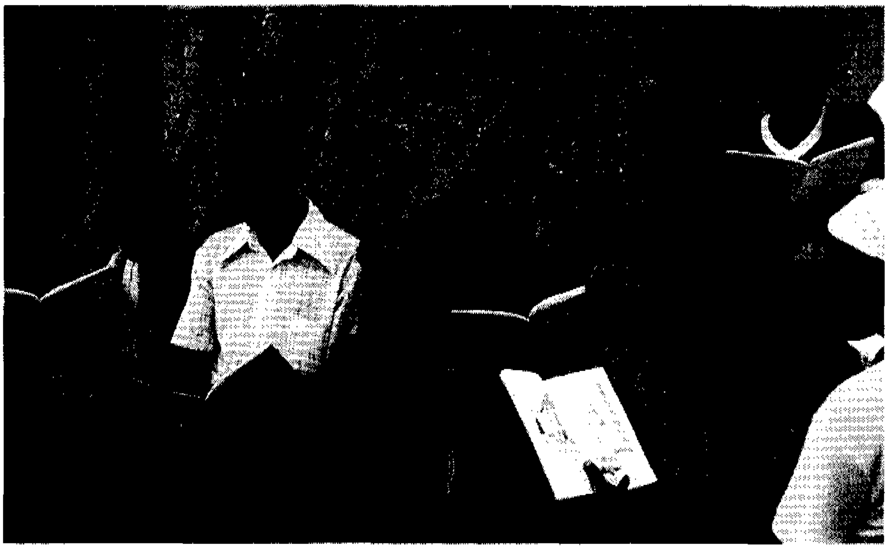


Photo: WaterAid/Neil Cooper.

Addis Ababa, Ethiopia. An open sewer runs through one of the kebeles, or slum areas, that surround Ethiopia's capital.

Photo: WaterAid/Caroline Penn.



Yorogo village, Bolgatanga, Ghana. Health education is a fundamental aspect of all WaterAid-funded projects. Here, health education supervisor Rita Azie, bottom right, is teaching health to village children.

Poverty allied with lack of education in hygiene combine to kill a child every 10 seconds

participation is readily forthcoming. To insist that responsibility be taken in this way by local people and local organisations is, in WaterAid's view, to contribute towards a situation where eventually aid organisations will no longer be needed.

WaterAid funds work in 12 main country programmes: those of Bangladesh, Ethiopia, Ghana, India, Kenya, Mozambique, Nepal, Nigeria, Tanzania, Uganda, Zambia and Zimbabwe. Smaller amounts of work are funded in several other countries, most notably Pakistan, Sri Lanka and The Gambia.

Photo: WaterAid/Caroline Penn.

Bugya Tinkura village near Walwale, Ghana. A team of villagers construct a hand-dug well. *The men in the foreground are mixing cement and aggregate, which has* been broken by hand, to make concrete for caisson rings to line the well, seen in background.

Small player

WaterAid is a small player on the global stage. With an annual income of some £7 million, its direct support can only ever have a modest influence. However, the style and type of work funded can have a radical impact on the policies of other much larger organisations. That has been seen to best effect in Ghana, where WaterAid has funded work since 1984. The approach has been to help local organisations improve drinking water and sanitation through low-cost, appropriate technologies in line with the government of Ghana's rural water programme. Here the preferred technology is hand-dug wells, the traditional source of water.

Some 1000 wells have been completed to date in communities of 500 people or fewer. This model of work has been developed openly, and WaterAid, with its Ghanaian partner ProNet, has encouraged the Ghanaian government and others, such as the World Bank and bilateral agencies, to be involved actively in the programme. The result is that the government of Ghana has now negotiated a loan from the World Bank to help extend and meet rural water needs. As part of that agreement the World Bank recommended that the model to be employed should be on the lines of that pioneered by WaterAid and ProNet.

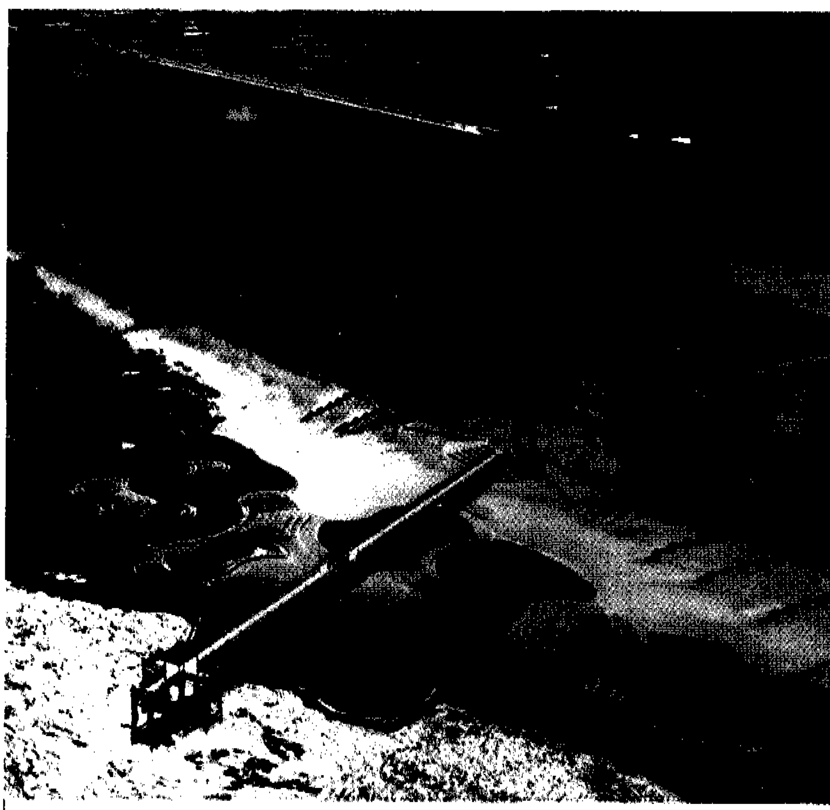
Between 1984 and 1995, WaterAid spent £3 million developing the Ghanaian programme — money invested in simple and practical water systems built and maintained by local organisations and benefiting tens of thousands of people. That investment has produced a very beneficial dividend: US$28 million from the World Bank to help many more Ghanaians gain access to safe water and sanitation.

To date, most of WaterAid's experience has been gained in rural areas where the majority of people in the developing world have lived. That is changing. By the turn of the century, half the 6.2 billion population of the planet will be urban.

An important shift is taking place in the Third World, where urban populations are growing at fantastic speed — much faster than the parallel shift in the industrial world. By the

Sludge Blanket Upflow Clarifiers - up to 15 mld.

Package Pressure Purification Plant - 2 - 20m³/h.



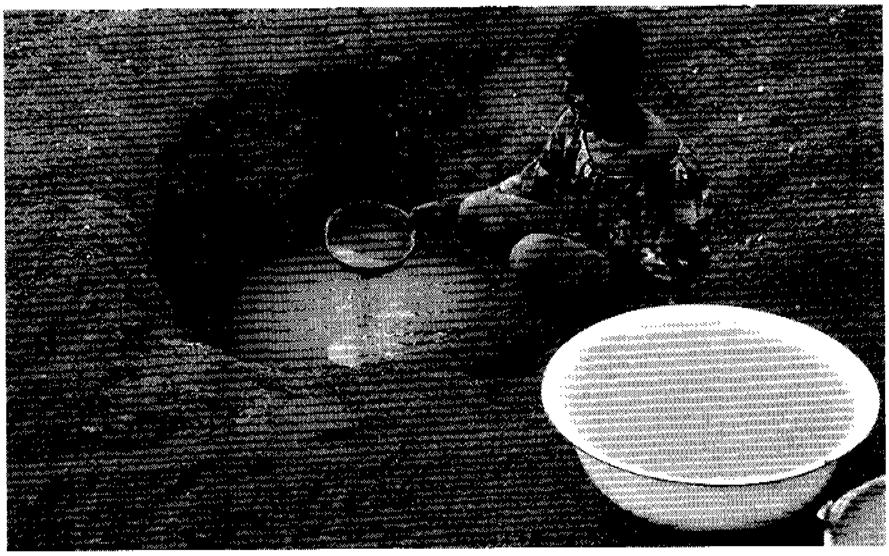


Photo:WaterAid/Caroline Penn.

Kumbosko Kulaa village, Bolgatanga, Ghana. In the dry season, women have to collect water from holes dug by hand in river beds. Animals use the same water source.

year 2000, 23 cities will have populations of at least 10 million people and 18 of these cities will be in developing countries.

The unplanned and often chaotic growth of these mega-cities will mean that at least half of their inhabitants will live in crowded tenements, shanty-towns and slums without basic amenities. Overcrowding, filth and squalor will encourage the spread of infectious diseases and pose massive threats to urban health.

WaterAid must build on its experience to date to make an even greater contribution to meeting global water and sanitation needs in the years ahead in both rural and urban areas. To be able to rise to these challenges and to make an effective contribution, WaterAid must continue to rely on the dedication and hard work of its supporters in the UK and the quality and strength of the work funded overseas. To date, such support and work has enabled WaterAid to grow steadily and with purpose.

Sources of income

Funding for projects comes from a variety of sources. Though the British water industry has always been a major supporter, it was never intended that WaterAid should be under its control. From the outset, other people of relevant interest and experience were drawn into its governance and day-to-day running, and WaterAid became a self-governing, not-for-profit organisation registered in the UK as a charity.

A network of supporters throughout the UK helps to raise awareness of developing country needs and raise money for projects supported by WaterAid. In each UK region, the company or public authority with overall responsibility for water and sewerage has established a WaterAid committee initiating and co-ordinating a wide variety of educational and fund-raising activities. Income has grown from a first-year total of £23 718 in 1981-82 to more than £7.6 million in 1994-95. About one-third of current income results directly from initiatives by the water industry and its staff. More than 15 000 of those staff give personal support by regular weekly or monthly deduction from pay. More than 20 million WaterAid appeal leaflets are mailed each year to customers in England and Wales with their water bills.

This has led to growing support from the general public through donations, covenants and other means, and from various trusts and community groups, now in total producing a further one-third of all income. The remaining one-third is provided by the British government and the European Union from their co-funding schemes. Administration costs (including all expenditure on publicity and fund-raising) are kept as low as possible. Currently 86p in every £1 donated is spent directly on meeting the organisation's aims. The challenge for WaterAid is to raise yet more funds in the UK and to influence the major funders in the water and sanitation field.

WaterAid itself will, in the years ahead, put more of its resources into sanitation and hygiene education. As with most organisations working in the water sector at the beginning of the 1980s, its early work was dominated by water engineering considerations. Improvements to the water supply alone can achieve valuable gains in time and convenience, but there is now substantial evidence that it is the combination of sanitation, hygiene education and adequate clean water that improves people's health.

WaterAid will also increase its involvement in the urban and peri-urban environment. Most of its experience to date relates to rural communities, but WaterAid must acknowledge that urban poverty and deprivation in developing countries are growing faster than rural.

The Water Decade ended in 1990. Despite population growth, it succeeded in reducing by several hundred millions the number of people without reasonable access to potable water. But huge water needs remain, and the number of people without effective sanitation is still increasing.

WaterAid alone cannot meet that need, but we can seek to influence others. The example of the World Bank in Ghana has been cited already. Another example is the awarding of the 1995 Stockholm Water Prize to WaterAid. It is fitting recognition of the immense amount of work undertaken by grassroots organisations throughout the world to tackle global water and sanitation problems.

It is those organisations that will turn the rhetoric of the international summits on poverty and the environment into real and lasting change for the better. ■

Author

Jon Lane MA MICE has been director of WaterAid since 1994. A chartered civil engineer, he is a member of the Water and Sanitation Collaborative Council.

There's more to Hach test kits than meets the eye.

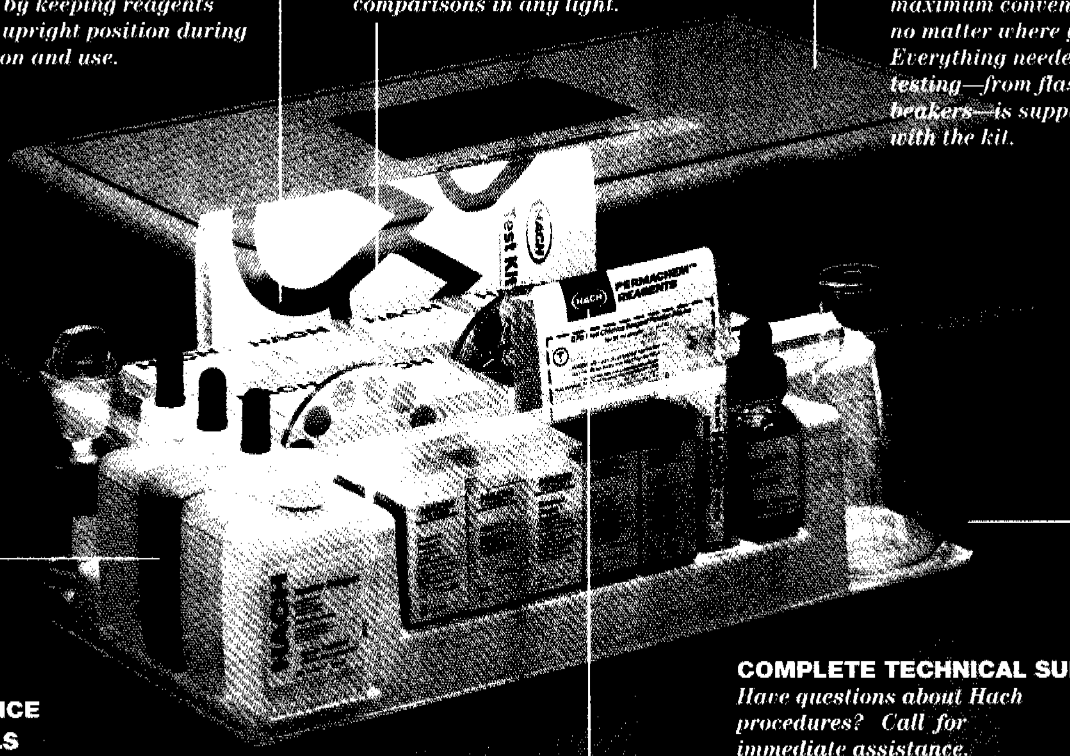
STEP-BY-STEP INSTRUCTIONS
You don't have to be a professional to get professional results with Hach's proven methods. Kits are supplied with detailed instructions to guide you step-by-step through each procedure.

RUGGED, CHEMICALLY-RESISTANT CASE
Hach kit cases are molded from durable polypropylene to stand up to the harshest conditions.

SUPERIOR COLOR MATCHING
From color cubes to color wheels, nobody knows color better than Hach. Comparator color gradients are computer formulated to ensure accurate comparisons in any light.

UPRIGHT REAGENT STORAGE
Our reagents never lay down on the job. Custom case inserts prevent messy spills by keeping reagents stored in an upright position during transportation and use.

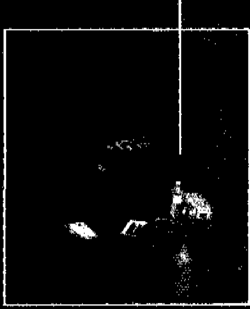
FIELD-ORIENTED LABWARE
Hach test kits offer maximum convenience no matter where you go. Everything needed for testing—from flasks to beakers—is supplied with the kit.



COMPLETE TECHNICAL SUPPORT
Have questions about Hach procedures? Call for immediate assistance.

WIDE CHOICE OF MODELS
Hach offers over 200 single- and multi-test kits for measuring everything from acidity to zinc.

PREMEASURED REAGENTS
Save time and money every time you test. Since Hach powder pillows contain the exact amount of reagent required for one test, there's no mixing and no measuring.



Emergency still reigns in Somalia

The water and environmental sanitation sector in Somalia has suffered cruelly since civil war broke out in 1991. Almost 90 per cent of its water sources, particularly mechanised ones, were damaged beyond repair.

Mohamed El-fatih Yousif Mohamed *UNICEF SOMALIA*

Most of Somalia is arid or semi-arid, with average day temperatures of 25–35°C. Humidity is high, particularly along the Indian Ocean and Gulf of Aden, and varies seasonally — 63 per cent in the dry season and 82 per cent in the wet. Variations in the annual rainfall cycle come from shifting monsoon winds, which govern the two wet and two dry seasons. In December and January, dry winds throughout the country bring drought and hardship to people and livestock living on the plateaux and competing for diminishing resources of water and pasture. In April and May, heavy rains fall over most regions, with more in October and November.

Most areas of Somalia get much less than 500mm of rainfall annually, although the lowlands between the Shabelle and Juba rivers may receive up to 600–700mm in some areas.

Less than 1 per cent of the annual rainfall of Somalia is caught in man-made reservoirs and natural depressions. A constraint is the cyclical irregularity of rain from year to year.

Two drought cycles have been identified. The first 2–3-year cycle is characterised by a sharp reduction in October-November rains and a second 8–10-year cycle in which rainfall is extremely low during both rainy seasons. This alternation between years of relative plenty and years of drought has become a key climatic and cultural focus for the Somalis, especially for the nomadic majority.

Reasons for emergency

First, the nature of the crisis. Before vandalism and destruction by the warring factions rendered 90 per cent of all pumps and deep wells useless, more than two-thirds of Somalia's potable water was drawn mechanically from deep boreholes. The looting and destruction of water sources during the civil war led to an enormous gap between the need for potable water and public access to it. This forced many people to use contaminated water sources, leading to a substantial increase in waterborne disease, and eventually, in February 1994, a water-related health crisis of national proportions.

Improved water quality and sanitation reduce child illness and death, increase the time and energy available to women as the primary collectors of water and the mainstay of economic activity, and foster community development.

Unicef's water and sanitation programme was designed to respond to the critical immediate need to provide better access to clean water and adequate sanitation as well as the long-term need to build local capacity to establish sustainable water and sanitation systems.

The water programmes focused on rehabilitating existing water facilities throughout the country, reactivating traditional water supply systems and supporting low-cost community-based interventions (such as hand-dug wells and open ponds or *berkeds*) that can be built and maintained by communities. In central and southern Somalia emphasis was placed on increasing access to low-cost potable water and sanitation facilities for displaced persons camps, rural areas and marginal urban slums, as well as for institutional support to health facilities. In the north, Unicef aimed to rehabilitate urban water supply systems in collaboration with local non-governmental organisations (NGOs) and local authorities.

Italian help

In the north-west the Italian government contributed toward the successful restoration of two urban water systems, at Boroma and Hargeisa. Fully rehabilitated by Unicef during 1992–95, the two systems now provide potable

Facts: Somalia

Land area: 637 657km2

Population: 5–6 million (based on 1993 estimate)

Population under 5 years old: 1 million (16 per cent)

Adult literacy (percentage 1990): Male, 18; female, 6

Infant mortality rate: approx 20 per cent in 1992

water for up to 250 000 people.

Unicef was able to rehabilitate deep wells, pumping stations and reservoirs, and in the towns to construct standpipes from which inhabitants could collect water. The Hargeisa project was the first urban water system to be rehabilitated since the end of the war in Somalia and was subsequently handed over to the Hargeisa Water Agency to manage.

The water system continues to sustain itself, surviving on revenues collected from water sales, and has even expanded throughout the city. In June 1995, water taps were re-introduced to locations with the most urgent requirements, including Hargeisa hospital. Unicef, with funding from the Italian government, carried out an independent evaluation of the Hargeisa water project and system, resulting in adoption of recommendations that have led to implementation of urban water projects.

Farther south, attention was primarily focused on provision of potable water to displaced communities and for health facilities, including the construction or rehabilitation of more than 75 shallow wells in Mogadishu, Afgoi, Kismayo, Hoddur, Baidoa, Bur Hakaba, Belet Weyne, Jowhar and Eldeere. Many of these wells were provided with Afridev handpumps and members of the local community were trained to maintain and protect the systems and chlorinate the sources.

By February 1995, Unicef and NGO partners had constructed more than 215 new wells in all zones of Somalia and rehabilitated 380 shallow wells, 12 boreholes, 49 traditional water storage ponds and 8 urban water systems. Nine submersible pumps, 12 generator sets, 134 handpumps and several kilometres of pipe were provided to support these restored water sources, and more than 250 well caretakers and 149 village health committees were trained to look after them.

Crucial to health

The civil war and its aftermath led to the collapse of environmental sanitation, particularly in urban areas, which are marred by huge accumulations of garbage and a general lack of sanitation facilities. The influx of thousands of displaced persons to urban areas made problems even worse. Unicef promoted sanitation, hygiene education and garbage disposal to reduce outbreaks of disease, particularly cholera, typhoid and diarrhoeal disorders. Its sanitation component was designed to complement water-sector initiatives by concentrating on building pit latrines, community showers and garbage disposal facilities, and promoting health education. Community clean-up campaigns were supported through provision of sanitation tools and social mobilisation, using local radio, newspapers, street banners and megaphones.

During 1993 and 1994, Unicef carried out extensive sanitation projects in Hargeisa, Mogadishu, Berbera, Bosasso, Kismayo, Baidoa and other regional capitals. In Mogadishu more than 350 low-cost pit latrines were constructed near health facilities and displaced persons' camps, and a total of 9000 tonnes of garbage and solid waste was removed to out-of-town sites. In Hargeisa, 53 garbage collection pits, 48 public showers and latrine units were constructed, and 20 donkey carts were provided for refuse collection. Unicef supported 10 sanitation projects in the north-west during 1993, working in collaboration with communities and local NGOs. In addition to financial assistance, the agency provided wheelbarrows, shovels, pick-axes, vehicles, donkeys and carts, cement and food-for-work.

Epidemic flared

In February 1994, a cholera epidemic broke out in the Bosasso area of north-east Somalia and rapidly spread throughout the country, demonstrating the critical need for safe water and improved sanitation. Unicef took the lead in a countrywide campaign of water chlorination and social mobilisation aimed at improved water hygiene, while continuing to construct, rehabilitate and protect water sources. At the height of the campaign more than 4000 water sources were being treated daily by volunteers and members of district and village water and environmental sanitation committees. Unicef supported the construction of 300 latrines, 900 household latrine slabs, 130 garbage drums, showers and incinerator pits, and increased social mobilisation activities during 1994 and early 1995 to help prevent a recurrence of cholera and other waterborne diseases.

During the civil unrest in 1991–95, Somalia witnessed the complete collapse and physical destruction of administrative institutions and the degradation of services affecting all sectors, and especially water. Virtually all public well fixtures ceased to function because of massive destruction and looting of equipment, resulting in hundreds of thousands of people facing water shortage and thus catastrophe. The incidence of waterborne and water-related diseases was high, though statistical data are not reliable. The existing water sources are open springs, wells, natural ponds, artificial ponds, *berkeds* (large cement-lined excavations), *mugiciid* (resembling dry open wells) and deep boreholes.

Beyond repair

More than 80 per cent of existing boreholes were destroyed. Most are far beyond repair. Some 20 per cent of the boreholes are equipped with motorised pumps that require major overhaul.

The traditional hand-dug wells vary in depth from 1.0m to 1.5m, and might reach more than 35m or, exceptionally, 100m in depth. Most of the hand-pumps were out of order through lack of spares.

Open wells are used for animal watering as well as domestic water supply, resulting in unsanitary surroundings. Catchments of surface run-off are traditionally accumulated in *wars*, *balleys*, *berkeds* and *mugiciid*, which dry out in a very short period. Over the years they have silted up, resulting in reduced capacity, and above all they are contaminated by faecal materials; indeed, faecal coliform bacteria are found in all catchments of surface run-offs.

A cholera epidemic in 1994–95 and cases of typhoid, dysentery and diarrhoea underline the poor sanitary situation aggravated by severe shortages of water. Recurrent droughts in areas of the country contributed heavily to the outbreaks.

Disparities in the availability of water in Somalia are reflected in the distribution of the two competitors for available water: livestock and people. In the urban centres, there were concentrations of displaced people fleeing the war, usually sick and exhausted, and the very limited sources of water led to outbreaks of disease. In the nomadic areas, destruction and failure of water sources increased the strain of operating wells as livestock and people converged on them. Loss of livestock and human lives became an inevitable consequence of competition for scarce resources.

A major stumbling-block to expanding and accelerating water projects in Somalia is the severe logistical constraints, which have at times disrupted transport of supplies from the ports of entry, Mombassa and Djibouti, shifting the whole logistical exercise across the border to be done mostly by air — which consumed a high proportion of the funds to cover transport.

Opportunities

It should not be overlooked that while emergency interventions and short-term solutions were needed to save lives, at the same time the concentration of displaced populations offered an opportunity for more effective service delivery through well-defined interventions, targeting larger numbers of affected lives and displaced people.

The complex emergency provided the opportunity for concentration of activities; standardisation of equipment; advocacy and acceptance of low-cost technology; realisation and acknowledgement of the inter-relationship between hygiene and sanitation for improved water supplies; building the software-hardware partnership of the water sector; capacity-building and restructuring of the sector's priorities and needs; the saving of time and energy that helped link water benefits to the health, nutrition and education sectors; and partnership with NGOs and other agencies.

Attracting donors' attention provided, at least in the medium-term, a sounder response to the plight of those under threat. Sustained service delivery within a complex emergency saved mothers and children from the immediate effects of drought, thirst and water-related diseases and provided some hope that there would be a future beyond the emergency intervention, with rehabilitation leading to more developmental and long-term projects.

Objectives

The overall objectives of Unicef in water and environmental sanitation are to contribute to child survival, the protection and development of access to safe water supply services as a basic need and right, and promotion of the behavioural changes needed to realise the full benefits from such activities.

The uncertainties of a fluid and unprecedented situation shaped the objectives to be achieved through interventions that met only immediate emergency needs (if sustainable in the short-term), though always with a view to laying a foundation for building long-term sustainable systems managed by the communities themselves.

Specific objectives were to:

- Provide basic water needs as survival assistance to vulnerable groups of the population, particularly those displaced and otherwise affected by conflict
- Help stabilise populations and enable the displaced to return home, and
- Re-establish access to basic water supply services.

Water projects

Intentional consensus, as well as Unicef's water programme experience, provided a wealth of lessons for leading this sector in Somalia. It managed throughout the years of civil unrest to keep a continuous and effective presence, maintaining a balanced strategy for the provision of water supply services to urban and rural areas.

Within circumstances in Somalia Unicef managed to implement emergency activities designed not only to relieve the most immediate problems, but also to provide a solid foundation for post-emergency recovery and long-term development.

Since 1992 the situation in many parts of Somalia has deteriorated, resulting in further large-scale displacement of population. Severe problems developed in northern Somalia because of inter-clan fighting in areas that had long been quiet, and where Unicef had initiated big projects that either came to a halt or shifted to other areas for security reasons. In other cases Unicef completed projects for a certain number of the population, but found that after a time those installations became inadequate because of the influx of displaced people forced into the area.

By June 1995, more than 250 new open wells were constructed in all 5 zones of Somalia, and 430 shallow wells, 18 boreholes, 8 urban water systems and 55 traditional water storage ponds were rehabilitated. Some 15 submersible pumps, 14 generator sets, 6 turbine pumps, 4 centrifugal pumps, 154 handpumps and several kilometres of pipes were provided by Unicef to support these restored water sources.

Today, many boreholes remain in need of rehabilitation while others are beyond repair and must be replaced. Insecurity in many locations and the high cost and risk of losing appropriate drilling or service equipment slowed the effort in 1994. Unicef's 1995 plan of action for water systems included deep borehole projects in critical locations throughout the country. Special emphasis has been directed toward semi-urban area water projects that include piping systems, motorised pumps and public standpoints.

Mogadishu water supply

Unicef supported rehabilitation of Mogadishu's piped water system in 1992. The system brings water from Afgoi well field 18km outside Mogadishu. Eighteen boreholes were equipped with submersible pumps to boost water along 17km of pipeline.

Hargeisa, in north-west Somalia, receives its water from Ged Deble well field, which is about 23km from Hargeisa and was rehabilitated by Unicef in 1993. Pumps installed in deep wells boost the water into the town through public distribution points. Unicef supported the project with supplies and cash. It is also helping Hargeisa water agency set up appropriate management and a tariff system for cost-recovery. The number of beneficiaries is estimated at 200 000, mostly returnees and displaced persons.

Boroma, capital of Awdal region in the north-west, receives its water supply from four wells 5km outside the town. The water is pumped from the wells into a tank and boosted to the town reservoir, which feeds public kiosks through gravity. The water system, refurbished by Unicef, benefits 80 000 people.

Las Anod, capital of Sool region, has a population estimated at 5000. Unicef rehabilitated one deep borehole and installed a submersible pump that lifts the water to an elevated tank from which it is distributed by gravity to public water points. Work on the system was completed in 1994.

Today the people of Baidoa (estimated water-reliant population 110 000–130 000) are mainly served by open wells and the Isha spring, both of which have received limited rehabilitative support during the past two years. The borehole system collapsed during the war, with most of the deep wells beyond repair.

A two-phase rehabilitation is proposed for the entire Baidoa water supply system, involving restoration of all three water sources. The first phase, to develop and protect the Isha spring source and rehabilitate open wells, has been prioritised because of the town's urgent need for water, and has already received funding from the UK government. The second phase, involving rehabilitation of between four and seven boreholes, is seen as a long-term solution to water shortages. Recurrent drought in the area over the past decade, allied to rapid growth of the population through both births and returnees, has resulted in a reduction of water from the spring and shallow wells, confirming the need for boreholes as both a supplementary source during the wet seasons and the main source during the dry ones.

Unicef has successfully completed a number of similar urban water projects, particularly in the north-west, and gained much experience through major borehole rehabilitation work.

Main problems and needs

Each potential source of clean water is valuable in Somalia, and there is a need for three sources in Baidoa town to ensure adequate provision throughout the year. Depending on season and the amount of rainfall, the sources fluctuate in their importance and utilisation. The Isha spring and the open wells fail to provide adequate water during the dry season. There is an urgent need for a longer term solution to the water supply problem, and borehole rehabilitation represents that solution, offering clean water from an aquifer that is recharged every year.

The Isha spring is the town's major spring, located near the centre and developed in 1974–75. Two other springs, one about a kilometre upstream and the other the same distance downstream, support the town's horticultural plots.

During 1994 Unicef constructed two elevated steel tanks, each of $30m^3$, and water from the ground tank is piped into these elevated ones, which distribute by gravity to two water points for donkey carts and trucks. Also in 1994, Unicef helped the local community to cover the main stream channel with concrete slabs to prevent pollution. However, this is seen as a temporary measure, because direct access by water vendors and animals, people washing there and the dumping of garbage and defecation around the spring have made the water a major source of pollution and a potential carrier of water-borne diseases. There is an urgent need for further protection measures to ensure that the water, which is pure and clear at source, reaches its destination in that condition.

There are at least 170 open wells in the four villages that make up Baidoa town (43 in Isha, 55 in Horsed, 30 in Hawal Wadag and 42 in Berdale), ranging in depth from 3m to 20m. Some 95 per cent of these wells are privately owned, although access for individuals is free. Of all the wells surveyed, no more than 10 were considered deep enough to produce adequate water ($4m^3$/hour) during the dry season. There is a need to rehabilitate up to 10 shallow wells, located in all four villages of Baidoa, and to equip them with motorised pumps; and to rehabilitate 50 open wells and equip them with hand-pumps.

All the boreholes in Baidoa are half-cased, or open-bottomed, thanks to the stability of the limestone in the area. In the boreholes that Unicef proposes to rehabilitate, about half the steel casing already exists, making them cheaper to restore and provide with pumps and engines.

These boreholes would then be linked to the existing elevated tank that previously supplied the northern end of the town through pipelines. The whole network requires minor repairs.

A calculation of resources includes the Isha spring and open wells and the potential of the boreholes, assuming that five wells will each produce $200m^3$ of water a day. Exploiting them would almost double the output of water available to the town during the extended season.

Prospects

If all three water systems are functioning:

- During a good rainy season the needs of the population are met and there is surplus water available
- During an average rainy season the needs of the population are met and there is surplus water when $3000m^3$ are required, and virtually met when the need is $4000m^3$, and
- During extended dry seasons 66 per cent of the needs are met when $3000m^3$ are required and 49 per cent if the need is $4000m^3$.

Shallow wells are clearly the most important source of water at present, although a large proportion of the population uses the Isha spring because of its central location and accessibility.

There is an increasing importance of the boreholes as rainfall decreases. The borehole option could contribute the most significant yield during extended dry periods, ensuring that other sources are not over-used and people forced to use potentially polluted sources.

There is a clear need to rehabilitate the boreholes to support the Baidoa population during the dry season and in the long term.

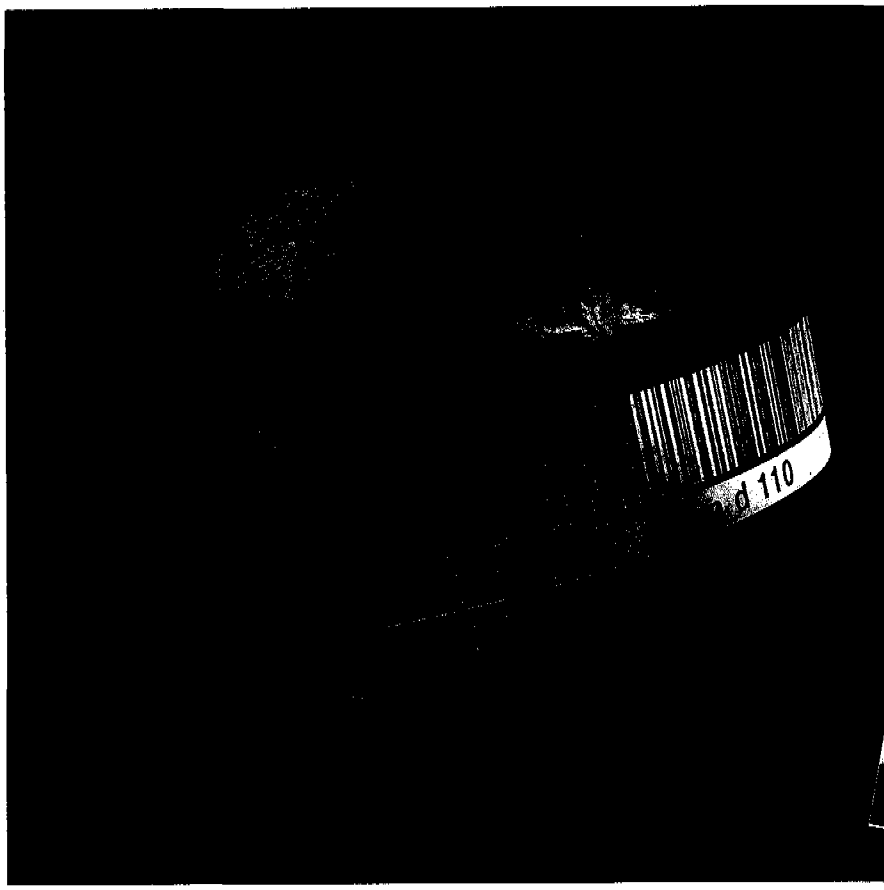
Unicef has already received US$750 000 from the British government to rehabilitate phase I of the Baidoa water supply system, which includes the Isha spring and the open wells. Unicef in Somalia, throughout the years of civil strife and under very hard security conditions, managed to provide vital and essential assistance that helped save the lives of hundreds of thousands of Somalis. It has invested a total of $13 million in the years 1992–95 out of $47.7 million initially requested. It will continue to support the water and environmental sanitation needs for the vulnerable population of Somalia, particularly mothers and children. ■

Author

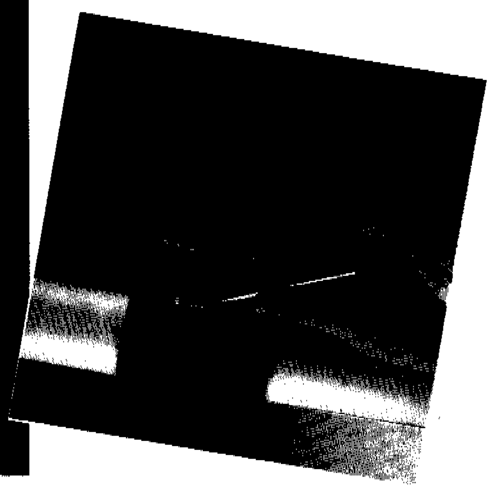
Mohamed El-fatih Yousif Mohamed is WES project officer for Unicef in Somalia.

FRIATEC LTD

FRIALEN®



TK 351 e



The technology for the future
(the bar-code label on every FRIALEN® fitting)

You don't need to read between the lines!

Nowadays, everyone is using it: bar-code technology for controlling electrofusion operations is THE internationally recognised "state of the art". Someone had to be at the forefront of technology, someone had to be the market leader. Who? Well, as you probably guessed, it was FRIALEN® – who else could it possibly be?

It's logical after all, as everything we do as the leading manufacturer is driven by the quest for reliability and user benefit. Today and for the future, your satisfaction is our concern.

FRIALEN® – the tried and tested connection – recognised worldwide.

FRIATEC AG, Technical Plastics Division, PO Box 71 02 61,
D-68222 Mannheim, Germany, Telephone (6 21) 4 86-0, Fax (6 21) 4 86 15 98.

FRIATEC

THE LESOTHO HIGHLANDS WATER PROJECT

ITS BENEFITS, AND ITS SOCIAL AND ENVIRONMENTAL IMPACTS

1. What are the benefits of this project and how are the benefits shared between South Africa and Lesotho?

The aggregate benefits to both countries have a net present value of about US$1 billion for phases 1A and 1B combined. This is the difference in cost between the Lesotho Highlands Water Project and the next cheapest scheme for augmenting the Vaal River (the Orange Vaal Transfer Scheme).

South Africa is fully responsible for all costs associated with the project, including cost overruns, and in return receives 44% of the savings between the cost of this project and the next lowest project to supply water to the Gauteng Region. These savings (to South Africa) amount to about US$45 million per annum on average. The vast majority of the incremental water supplied by this project will go to meet municipal and industrial needs. For the most part, these needs are driven by the need to ensure a reliable source of water supply for the newly enfranchised black majority in South Africa.

56% of the cost savings go to Lesotho, in the form of royalties for the "sale" of water. Lesotho bears no costs or risks from the water transfer component of the project. The project royalties to Lesotho of US$55 million p.a. for phases 1A and 1B will account for 25% of Lesotho's total annual export revenues, and 14% of the Government's public revenues. These royalties will also correspond to about 3-5% p.a. of GDP, between 1990 and 2044. In addition to royalties, benefits for Lesotho include infrastructure components like roads, clinics and telecommunication facilities. Currently, more than 3 000 jobs have been created for the indigenous Basotho people by the LHWP. The opening up of the isolated mountain region has increased tourism, even during the present construction stage. Travel time between Highlands villages has been greatly reduced and the taxi industry is thriving.

The project has an estimated real economic rate of return of 15% for the water transfer component, and a 15% combined real rate of return for the water transfer and power components.

2. How important are these benefits for Lesotho?

These benefits are immensely important to Lesotho. In 1995, GNP per capital was about US$610. Lesotho's economy is largely dependent on the RSA as a source of income, employment and foreign exchange. Most trade - 95% of imports and 85% of exports - is with South Africa, and nearly all commercial fuel and capital goods are imported. Half of Lesotho's income is derived from remittances from 110 000 Basotho migrant workers who work in the coal and gold mines of RSA.

But the numbers of migrant workers in South African mines are declining because of the difficulties facing the industry, overall employment has fallen in four years from 500 000 to 350 000. Thus royalty revenues from the project are critical to Lesotho to compensate for declining migrant miners' remittances, as is the increase in employment opportunities and training the LHWP provides to Lesotho's unemployed.

Due to the risks inherent in such a financial windfall, the GOL has created a Development Fund to help ensure that LHWP funds will be used to create productive investments from which future generations of Basotho will benefit. Much of these funds will be directed to poverty alleviation projects.

3. Who accrues these benefits in each country?

The population of Lesotho at large, and the people of the Highlands in particular, accrue benefits from this project in many ways. The main vehicle through which funds are being distributed to the communities of Lesotho is the Development Fund. The fund was established in 1991 and to date has had M154 million (US$ 42.7 million) of advance royalties deposited into it. The GOL established this fund to make sure that the project's royalties are effectively used for the development of Lesotho, and not spent on consumption. With the limited resources that the fund has already accrued, investments have already been made in labour intensive infrastructure projects in rural and peri-urban areas.

Community involvement is crucial to the success of the Development Fund. The fund is community driven and builds on local institutions which already exist, such as the Village Development Committee. The fund has established a Board which selects projects presented by these committees and other entities in Lesotho. Currently, the GOL is consolidating a set of written guidelines on how a project is chosen to be funded. These guidelines are being published in simplified form throughout Lesotho so that the communities are aware of how to obtain access to these funds.

South Africa benefits from the project through lower capital investment in water development and thus lower tariffs than would otherwise be the case without the LHWP.

4. What is the current status of the Development Fund?

Advance deposits of project royalties have been made into the Development Fund from the South African Customs Union (SACU) revenues associated with the project. To date M154 million (US$ 42.7 million equivalent) has been deposited into the fund.

The GOL is now working on turning a large part of the fund into a flexible, community driven Social Action Fund. It is envisaged that this will be the centrepiece of Lesotho's poverty reduction strategy.

5. What types of adverse impacts will the project have on different people in the Highlands? How many people are involved?

The project is resulting in the loss of both arable and grazing land, as well as resettlement and relocation of households. These impacts come from the creation of two reservoirs during Phase 1A and from the advanced infrastructure preceding construction activities on Phase 1A.

About 26 households have been involuntarily resettled due to the inundation of the Katse Reservoir. They have been relocated to sites of their choice, often close to their current location. A further 46 households have been voluntarily resettled since they would be located dangerously close to the reservoir, or because other members of their community will be relocated. Furthermore, due to advanced infrastructure (e.g. roads, power lines), about 240 houses have been or will need to be rebuilt, usually close to their current location. All replacement houses will be paid for by the project and will be at least as good as, if not better than current housing.

About 2 300 ha of arable land will be lost as a result of the project, affecting about 2 600 households. Of this, 1 300 ha has already been lost due to the advanced infrastructure, with the balance of 1 000 ha projected to be lost due to the inundation of the reservoirs. This land is typically used for maize, yielding about 500-600 kg/ha. Small amounts of pulses and vegetables are also grown. Although most of the families are engaged in subsistence agriculture, more than half of the family income on average, comes from off-farm sources (wages and remittances) from migrant miners. Since the income from wages and remittances will not be affected, the loss of land will have less impact on each household.

The loss of arable land will be directly compensated for, with compensation in kind exceeding the typical yield of such fields. (See part 6). Of those losing arable land, about 210 households (or less than 10% of those losing land) will receive priority attention from the Rural Development Programme (RDP) in addition to receiving maize and pulses over a 15 year period for their lost crops.

About 3 400 ha of grazing land are projected to be lost in total, of which just over 1 000 ha have been lost to date. In the Highlands, grazing land is communal property. As a result, about 680 households will be affected by these losses, which will be compensated for by the provision of fodder to the affected households for their animals, and maize and pulses for themselves.

6. What compensation is being provided to the people affected by the project? Will the people receiving compensation simply be welfare recipients?

The overriding philosophy of the project, as embodied in the Treaty, is that those adversely affected by the project should be compensated so that their households "shall be maintained at a level not inferior to that pertaining prior to project implementation". The project provides two types of compensation, namely: Direct Compensation and the Rural Development Programme.

Direct compensation is intended to compensate households for the specific losses incurred as a result of the project. It is not intended to increase the overall standard of living of house holds in the area.

- People who are relocated have had new houses built for them. If possible, they are built within the same community and, in all cases, within the same chieftainship.
- People who have lost land are receiving maize and pulses for themselves, and fodder for their animals as compensation. The compensation is based on the hectarage lost and the average yield of such land. In the Phase 1A area, each household has been receiving 970kg of maize and 30kg of pulses/hectare. This is more than the average household's yield of 500-600kg of maize/hectare.
- Those losing trees, or small pieces of land, or who have incurred other smaller losses, have been compensated in cash.

The Compensation Policy is based on the idea that those households losing arable land will receive the equivalent volume of food for 15 years. The policy is subject to review every three years. However, the policy is being amended to provide compensation for as long as necessary or until the household is generating the equivalent income by itself. Since the inception of the project, 104 houses have been built (for 62 households), over 5 500 households have received compensation and 1 200 are receiving grain payments.

The Rural Development Programme is designed to enable those people adversely affected by the project to generate incomes and not be on welfare. Furthermore, it is intended to raise the standard of living of people in the project area via three related components:

Income Restoration: First, the Skills Training Centre is retraining people, teaching new skills and providing strategies to develop alternative employment. Its ultimate aim is to ensure that all seriously affected people will be able to restore their own income generating capabilities. The LHDA has surveyed those people deemed "seriously affected" by the project, i.e. those resettled people who have lost more than 25% of their arable land. Income Restoration Plans are being prepared for each household, taking into account their needs and preferences regarding income generating activities.

Agriculture: Secondly, the RDP, through its agriculture and forestry component, provides a form of "extension programme" for the affected Highlands population. This is intended to increase agricultural intensification of the remaining lands so as to maintain and enhance incomes. To date, the following activities have occurred: farmers planted and harvested maize and seed potatoes; fruit trees were planted; irrigation systems installed and a nursery constructed.

Infrastructure: Thirdly, the RDP will enhance the level of basic infrastructure through three components. The Rural Feeder Roads Project will expand the network of roads and tracks in the project area (to improve access to basic services and markets) through community driven labour based methods. The Village Water and Sanitation Project (VWSP) will supply piped water and improved sanitation facilities to 88 Highlands villages by 1999. The Construction Communities Project will provide the seven villages most directly affected by the main construction sites with infrastructure, including water supply, sanitation, roads, bus stops, schools, creches, and refuse dumps. This component should be completed by mid 1997.

7. How was this package determined? Is it adequate? Are the affected people satisfied with the compensation package?

The Compensation Policy was established following community pitsos and meetings with local chiefs in the project area. At the time, an overwhelming majority of the people (65%), wanted compensation in kind, 15% wanted annual compensation in cash and 10% wanted to be resettled. LHDA recognizes that the consultation process employed in Phase 1A will need to be significantly strengthened for Phase 1B.

- Complaints from the community initially centred on the late delivery of grain and fodder. This problem has been rectified and in the last two years complaints in this area have been limited.
- Subsequently, complaints centred on the lack of, or delay in, responsiveness of the LHDA to "adhoc" compensation issues. LHDA recently completed a "sweep up" operation to address outstanding compensation claims overlooked when construction took place. 570 individuals received supplementary compensation of various sorts as a result of this exercise.
- Finally, complaints have focused on the compensation policy itself. These concerns focus mainly on the nutritional content of the package, and on what happens after the initial 15 years of compensation (if incomes have not been restored under the RDP). A recent review of the compensation policy has led to a revised policy being implemented on a pilot basis.

Because of complaints about the low level of public consultation and participation, LHDA has embarked upon a pro-active Public Information Policy. It has also developed a close working relationship with NGO's in the area, including the Highlands Church Action Group. More importantly, it is in the process of establishing a decentralized field structure to be more responsive to the needs of the community.

8. Have houses been rebuilt for households that were affected by the building of power lines in 1990/91?

As a result of the construction of power lines during Phase A, LHDA agreed to replace 103 households and 136 "housing structures" that were located under or close to these power lines. 19 houses, between the Mabote and Maputsoe sub-stations, were completed in 1991. Unfortunately, the building of the other houses has been seriously delayed. However, LHDA has now accelerated its progress and a number of contracts have been or are about to be signed. 22 houses were scheduled for construction starting in mid-September. Another 78 replacement houses were scheduled to be rebuilt beginning in October.

The remaining 17 houses are being built by local contractors or by the householders themselves, and construction was planned to begin by the end of 1995. The World Bank informed the LHDA that progress in building these houses was crucial, and that progress must be made before appraisal of Phase 1B begins.

9. What are the adverse environmental consequences of the project?

A project of this magnitude inevitably has an impact on the environment. However, the LHDA is making efforts to prevent unnecessary environmental damage from occurring and to mitigate the adverse environmental impacts of the project that do occur. The following is a list of the potential adverse effects and the measures taken to mitigate them:

- A great deal of information on rare and threatened habitats and flora species is available for the Phase 1A project area. Baseline studies for wildlife and fauna were done, and an ongoing monitoring programme for rare and endangered fish species and birds was established in 1995.
- The Maloti minnow (classified as endangered) is not found in the waters of Phase 1A, although it is found in the waters of Phase 1B. In order to ensure its survival, a research study is currently being conducted to re-establish the species in a suitable habitat.
- The spiral aloe (classified as rare and threatened) is found in small numbers in the Phase 1A project area, and in larger numbers in the Phase 1B project area. Many plants have been transferred to the Herbarium at the National University of Lesotho in Roma. A conservation programme is planned, and all known locations of the spiral aloe are being recorded and mapped.
- The bearded vulture (classified as rare and threatened) is found in both the Phase 1A and Phase 1B project areas. The LHDA has established three nature reserves in the Phase 1A area, one of which (at Bokong), contains a bearded vulture habitat. This should assure the continued survival of the bearded vulture.
- The LHDA has done an excellent job protecting Alpine wetlands (or sponges) found in the project area. For example, it has suitably modified drainage structures on the Northern Access Road.
- Nature reserves have been established in order to protect the unique mountain and valley eco-systems and to enhance environmental awareness among the Basotho population.
- Sites of historical and archaeological significance found in the project area, such as fossils and cave drawings, are being protected. Rock art has been photographed, and in some cases removed and stored to prevent vandalism. Fossils found in the project area have been removed and analysed.
- Some environmental damage is caused by the local population, e.g. the bearded vulture is regarded as a nuisance and shot, while herdsmen deface cave drawings. In order to enhance environmental awareness among the public as well as construction workers, LHDA has stationed environmental officers at the project's two main field sites. It has also mounted an educational programme both for construction workers and the public.

The only areas of possible environmental impact that have not been effectively mitigated to date are soil erosion and sedimentation within the catchment. However, a contract has been tendered for the monitoring of soil erosion and sedimentation, and work was planned to begin at the end of 1995. While combating soil erosion is an important part of environmental management, it is believed that sedimentation does not pose an engineering threat to either the reservoir or the tunnels. An expert panel of engineers visited Lesotho to address this issue.

10. Was an action plan designed to deal with the environmental damage? Has it been successfully implemented for Phase 1A?

Yes, an Environmental Action Plan (EAP) was designed to deal with the environmental impacts of the project. It comprises four main parts: a Natural Environment and Heritage Plan, a Compensation Plan, the Rural Development Plan, and an Environmental Awareness Programme.

Implementation of the environmental aspects of the plan have been largely successful. As mentioned above, a monitoring programme for soil erosion and sedimentation remains to be put in place.

11. Is a new Environmental Impact Assessment (EIA) being produced for Phase 1B?

The LHDA is preparing an EIA and an EAP for Phase 1B, which will include a downstream impact analysis. The downstream impact analysis will be an integral part of the proposed EIA requirements. The World Bank has made the funding of Phase 1B conditional upon receiving an acceptable EIA and EAP. Furthermore, the Bank will not appraise Phase 1B until acceptable EIA and EAP drafts have been received and reviewed.

12. Won't Lesotho be overwhelmed by a project the size and complexity of LHWP?

While the project is very large relative to Lesotho's economy, the risks to Lesotho are minimal. Firstly, RSA bears all financial risks, since debt service for the water transfer component will be met fully by the RSA. Secondly, while the project has employed several thousand Basotho workers, this represents a very small proportion of Lesotho's labour force. Therefore, the project has not distorted Lesotho's labour market. Thirdly, the project's expected net royalties are large relative to GOL's export revenues and fiscal revenues. Thus, they are unlikely to disrupt Lesotho's Balance of Payments or Government Finances. The Development Fund is being used to mitigate against adverse macro-economic impacts of the windfall gains from the project.

Lesotho Highlands Development Authority
P.O. Box 7332, Maseru 100, Lesotho
Tel.: +266 311280, Fax: +266 310060, Telex: 4523 LHDA LO

Integrated information systems in Botswana

Modern advances in Information Technology have made it possible to design and implement Integrated Information Systems with sufficient functionality to cover most requirements in the areas of maintenance, operation, monitoring, management, design and planning of water supply systems.

Dr D Constantinides, Dr P Kolovopoulos *HYDRO-COMP ENTERPRISES LIMITED, SOUTH AFRICA AND CYPRUS*

A modern integrated Information System has been created by Hydro-Comp Enterprises in South Africa and is being implemented in various countries, both developed and developing. This article describes the implementation of the system in 17 major villages in Botswana for the Department of Water Affairs (DWA), the authority responsible for the water supply of the villages.

Study area and the old system

The population of villages varies from 3500 to 37 000 people. Almost half of the villages are located in the vicinity of Gaborone (the capital). Others, however, are far apart (Tsabong, Ghanzi, Maun, Kasane), with distance being a limiting factor to direct interaction and support from DWA.

The number of meter connections in villages varies from 400 to 3000. A large percentage of the population is not within the water boundary areas. Supply of water to the un-metered population is supported by metered standpipes. There is rapid population expansion, some villages averaging more than 7 per cent annual growth.

Operational control of DWA is decentralised at the villages, where DWA offices perform the billing and the operational control of the networks. Decision-making on personnel allocation and new works, however, is centralised.

A preliminary analysis of the study area revealed the following operational problems in the existing system:

- The billing system at the villages is manual, with a monthly billing cycle
- The cycle is often delayed, compromising results
- Meter readings are inaccurate and unreliable
- Existing controls for revenue collection are unsatisfactory
- Officers at villages spend much time generating monthly summary reports for Headquarters
- Meter replacement is performed on an ad hoc basis only
- Office space is inadequate for the operations at villages
- Policies on debt recovery and disconnections are inefficient, and
- Villages are not operating as profit centres.

Engineering-related problems of the existing system:
- The high quantity of unaccounted-for water (over 30 per cent)
- Inadequate supply at peak times in terms of storage and pressure
- Gradual depletion of aquifers
- Inadequate networks to cover all potential consumers, and
- Lack of network data, field instrumentation, proper zoning.

Management-related problems of the existing system:
- Lack of reliable information to manage and control the operations effectively, and for establishing statistically important parameters to assist in effective future planning, and
- Lack of policies and programmes for pipe replacement, network expansions, meter replacement and so on.

There is rapid population expansion, some villages averaging more than 7 per cent annual growth

Scope of work

Hydro-Comp Enterprises in conjunction with DWA launched a three-year programme for upgrading the organisation, encompassing the following:

- Computerisation of operations
- Hand-held meters and metering procedures
- Computerised billing
- Management Information Systems (MIS)
- Geographical Information Systems (GIS), and
- Engineering Analysis Systems (EAS).

The approach maintained in the project is that there should be an integrated information and management control system covering the organisation as a whole. Such a system should support the management of DWA in controlling, organising, planning and directing all operations.

The following stages were defined and carried out:

1. Preliminary stage, including the formal identification of all the problem areas, human resources analysis, the development of information policy alternatives at all levels, the formulation and development of policies regarding different operational activities and necessary engineering studies, the formulation of alternative solutions and recommendations, and system design specifications.

2. System components identification, in which tender documents were prepared, proposals were evaluated and sub-contractors were appointed to implement different components of the system, such as meter auditors, hand-held units for meter reading, the billing system, and MIS and EAS integration with GIS.

3. System implementation, in which groups of villages were identified for simultaneous implementation of the system. A number of stages were adopted:

Preliminary stage. Including labelling of all connections, preparation of village offices (air-conditioning, GPS masts, telephone lines, and so on), installation of hardware (networks) and software, stationary, and so on.

Data capture and transfer. Including billing capture of ledger books, preparation of meter audit field books, preparation of meter reader walks, preparation of maps, collection of and tabulation of network data, and so on.

Meter audit. Including two walks, the first with manual records, the second using the hand-held units, capture of meter positions using the GPS, correcting discrepancies and transferring the data to the billing system.

Billing system. Including system installation, capturing the ledger, addressing discrepancies from the meter audit, setting up new procedures and guidelines and producing invoices for two cycles.

MIS/EAS/GIS. Including setting up the system, producing monthly management and discrepancy reports, and optimised walk routes and maps.

Engineering studies. Including zoning, water demand analysis, statistical analysis, definition of range of design standards, system component evaluation and preliminary network analysis.

4. Ownership stage, in which daily and monthly activity cycles were prepared. Personnel were allocated new job descriptions, assigned duties and received training both at the villages and at headquarters. New job positions had to be created, as in most cases they had been filled by existing personnel.

At villages: technical officers were appointed to follow up discrepancies and handle the computerised meter reading.

At headquarters: technical officers were appointed to handle the MIS/GIS/EAS systems as well as the GPS and map production.

Problems encountered in implementation

Various problems were encountered during implementation, the main ones being:

Meter audit. Meter connections not tagged (numbered on site), resulting in discrepancies of up to 40 per cent. A tagging system was introduced at all villages before the audit, lowering discrepancies to below 3 per cent.

Meter positions. Outdated topographical maps and lack of town planning made it difficult to pinpoint meter positions. A global positioning system (GPS) was introduced, used during the meter audit and designed to operate thereafter for new connections achieving sub-meter accuracy.

> **Classroom and on-site training was intense during implementation, conversion and the subsequent ownership stage**

Introduction of computerised billing. Initial negative reactions were noted from consumers faced with "real" bills and arrears. Flexibility by DWA in terms of arrears and public relations had to be adopted.

Dissemination of knowledge

Classroom and on-site training was intense during implementation, conversion and subsequent ownership stage. A full-time training officer was hired, and support is being maintained by on-site full-time personnel for both financial and technical systems. Operational manuals explaining activities and giving operational procedures were designed for all personnel ranging from senior management to meter readers.

Conclusions

Although the system is still being implemented, it is already functional in many areas and has satisfied many of the objectives, both in terms of tangible and non-tangible financial benefits, such as:

- Improved data collection resulting in better data quality
- Better operational and maintenance procedures
- Better accounting and management controls
- Improved debt recovery and consumer confidence in the billing system
- Identification and monitoring of unaccounted-for water, and
- Effective monitoring, control and management of the water supply networks. ■

The Baku water-supply rehabilitation project

The water-supply system in Baku has suffered from lack of investment and substandard management, but the World Bank, EBRD and the government of Azerbaijan are collaborating on renewing the system that serves more than 2.5 million people.

Dr Johan Bastin *EUROPEAN BANK FOR RECONSTRUCTION AND DEVELOPMENT*

In October 1994, the government of Azerbaijan requested that the European Bank for Reconstruction and Development (EBRD) participate, together with the World Bank, in the development and financing of an emergency investment programme for the rehabilitation and improvement of water supply services in the capital city of Baku and surrounding region. The water supply system, which serves a population of more than 2.5 million, is in poor operational condition as a result of inadequate system design, substandard management and chronic under-investment in asset maintenance. Over the past decade, in the wake of the gradual collapse of the communist economic system, no investments for capital improvement have been made.

In July and October 1995, the government of Azerbaijan signed loan agreements with the World Bank and the European Bank to finance a programme of investments and corporate measures that will help improve the quality of water services in the Baku metropolitan area and that will reform the financing and organisation of the water services delivery system there.

Azerbaijan

Azerbaijan lies on the south-eastern flanks of the Caucasus mountains and borders the Caspian Sea. It is bounded by Georgia, the Russian Federation, Iran and Armenia. The country has a population of around 7.5 million and is approximately the size of Austria. While Azerbaijan assumed independence in 1991, it remains economically and to a certain extent politically tied in with the countries of the Former Soviet Union and in particular with Russia. Over the past decade, the country has faced a difficult economic situation. The cumulative decline in economic output between 1989 and 1994 is estimated to be over 40 per cent. This stems from the difficult transition from a command economy, the dislocations in trade links among the Former Soviet Union republics, the aftermath of the conflict over the rebellious Nagorno-Karabakh area, and the decreasing oil production as a result of the depletion of existing oil fields.

Despite Azerbaijan's present difficult situation, however, it has a strong basis for future economic growth. The country is endowed with fertile agricultural land and natural resources, including large oil reserves. It has also a diversified industrial structure and a relatively well educated labour force. Building on the country's entrepreneurial tradition, over the past three years there has been a rapid expansion of private trade, services and construction giving rise to the emergence of an active private sector.

Following independence in 1991, the government has started taking policy measures to liberalise the economy and promote the transition to a market economy. The government has accepted that the major task it confronts in the immediate future is to stabilise the economy and to undertake a comprehensive programme of structural reform. In 1994, Azerbaijan signed an agreement with international oil companies to develop its off-shore oil fields in the Caspian Sea, reportedly one of the world's largest known reserves.

The Baku metropolitan region

The greater Baku region is home to one-third of the country's population and forms its unrivalled centre of government, culture, education, trade

Following independence in 1991, the government has started taking policy measures to liberalise the economy and promote the transition to a market economy

and commercial activity. Although the roots of the capital city date back to the fifth century, its development as an urban centre really started in the middle of the nineteenth century when the first oil well was drilled. By the turn of the century, Baku was the oil capital of the world, accounting for more than 50 per cent of world crude oil output.

Oil wealth sparked the development of Baku as a metropolis with the construction of stylish mansions, hotels, museums, parks and an opera house. The city's first public water supply system was constructed in the heyday of development in 1917. Ironically, it is these elements of the urban fabric that pre-date the communist revolution that have best weathered time and that give the city charm. Present-day Baku has all the attributes of a big city, including a metro system, an international airport and the largest port on the Caspian Sea. Many of these facilities, however, like the water-supply system and the vast fields of dilapidated nodding donkeys on the western promontory of Baku Bay, are in a bad state of repair.

Water supply system

About 95 per cent of households in the Baku metropolitan area are connected to the piped water distribution system. In addition, there are 1000 industrial users hooked up to the system. It is widely assumed, however, that there are many illegal industrial and commercial connections.

The quality and reliability of water and sewerage services in Baku are poor and rapidly deteriorating due to deficient physical infrastructure and severe under-resourcing of the water supply organisation. The supply of water to households and commercial consumers is unreliable and around 70 per cent of households get water for at best only part of the day. Because of low pressures in the distribution system, consumers living in elevated parts of the city or on top floors of apartment buildings frequently have no services at all.

Levels both of consumption and unaccounted-for water are excessively high. Overall per capita consumption averages between 400 and 600 litres a day — two to three times the level of most Western European cities. Although, by Western standards, the total design capacity of water production exceeds needs by a factor of close to three, water supply is notoriously unreliable and, on average, services are provided for only three weeks a month and for a maximum of 11 hours per day. Indications are that physical losses in the distribution network amount to 40–60 per cent of total water production.

Due to sewage and groundwater ingestion into the distribution network caused by leaks, there is contamination of drinking water supplies. The incidence of waterborne diseases is high and in 1993 Baku experienced a severe outbreak of cholera, which was ascribed to the poor condition of the water system. A recent survey indicated that almost 90 per cent of the population do not consider the water to be safe and over three-quarters of households boil their drinking water.

A socio-economic survey of water consumers, carried out in September 1994 under the supervision of the World Bank, showed that most households have taken alternative (and often expensive) measures to cope with the insufficient and irregular supply of water from the public distribution system. These measures include the installation of storage tanks, the drilling of wells and the purchase of drinking water from vendors. It appears that domestic consumers spend about 17 times more on alternative water supplies than on their regular water bills, with the poor spending a significantly higher proportion of their income than consumers in higher income brackets. Not surprisingly, the water services survey showed that domestic consumers would be willing to pay substantially higher tariffs for a more reliable water supply.

Oil wealth sparked the development of Baku as a metropolis with the construction of stylish mansions, hotels, museums, parks and an opera house

Organising water supply

The single most important reason for the inadequate quality of services is prolonged excess of capital consumption over gross investment. Because of lack of capital resources and poor revenue generation from operations, no investments for capital improvement or heavy maintenance have been made over the past decade. A second reason is the institutional organisation of water supply responsibilities which impedes operational efficiency. Until recently, a department within the ministry, called *Kommunpromvod*, was responsible for water production and bulk supply outside of the administrative area of Baku, while a subsidiary was responsible for distribution within it.

The finances of *Kommunpromvod* are plagued by difficulties common to most water enterprises in the former command economies of Central and Eastern Europe. Due to the absence of economic pricing, gross undercharging of consumption and inadequate revenue collection, operating income just covers cash expenses, without any allowance for heavy maintenance and capital charges. Lack of access to long-term capital sources and absence of cost recovery caused by resistance to paying for the economic cost of poor quality services combine to undermine the financial feasibility and sustainability of water supply in Baku.

The Baku water supply rehabilitation project

Over the past year, the European Bank and the World Bank have closely co-operated with the government of Azerbaijan in the development of a project to address the problems described above. The project, for which loan agreements were signed in July and October 1995, consists of programmes to finance the most urgent investment needs and strengthen the water company's financial and operational performance.

The total project cost amounts to 73 million ecu (US$95 million), of which the EBRD will finance 18 million ecu and the government of Azerbaijan 8 million ecu. The World Bank is contributing 46 million ecu ($60 million) in the form of a credit on highly concessional terms from the International Development Association (IDA).

The project's investment programme focuses on water demand management and on the improvement of maintenance and operations. It aims at enhancing revenue generation, decreasing operating costs, and increasing the proportion of revenue water. The water demand management component will reduce leakage and wastage at consumer level through in-house repairs and a metering programme involving the installation of 15 000 water meters. This component will be implemented in conjunction with the revision of billing and revenue collection practices.

The operations and maintenance improvement component will strengthen the water company's technical ability promptly to repair major leaks and bursts in the main distribution network. It involves the procurement of equipment, pipes, goods and facilities. The water production and supply improvement component, finally, aims at increasing the reliability and quality of water supply from the treatment works. It involves the rehabilitation of drinking water treatment plants and main pumping stations and the installation of system flow meters.

A key component of the project is the corporatisation of *Kommunpromvod*, the government department that is responsible for Baku's water supply. As a first step, the government has decentralised the organisation of municipal water services in Baku. In May 1995, it created the Apsheron Regional Water Company (ARWC), a joint stock company to which all responsibilities and assets related to water supply in Baku have been transferred. The ARWC is set up as a managerially, operationally and financially independent water utility with sole responsibility for the production and distribution of water in the Baku metropolitan area.

Under the project that is supported by EBRD and IDA loans, ARWC will establish a corporate partnership with an experienced, private Western company, to help it to strengthen its financial and operational performance and to bring improved water services to consumers while keeping tariff increases within affordable limits. This arrangement is to enable ARWC to establish water balances, develop leakage control strategies, and improve financial programming, planning and budgeting. The corporate partnership arrangement will be financed from the loan proceeds. The selection process of a partner is now in its final stages following the submission of technical and financial proposals from a group of short-listed water enterprises.

Conclusion

With Azerbaijan's economic prospects improving as a result of the government's economic policies and the signing of agreements that will allow it to exploit its mineral wealth, the country is now able to start paying more attention to improving living and environmental conditions. The Water Supply Rehabilitation Project will help improve living conditions in Baku and address the problem of water-borne diseases.

Most households have taken alternative measures to cope with the irregular supply of water

Besides its obvious effects in terms of improvement of water services, the project is expected to contribute to the process of economic transition in Azerbaijan. The adequate provision of basic public services, such as water supply, is critical not only for the welfare of large parts of the population, but also for the emergence of competitive small and medium size enterprises.

Moreover, the project encourages reform in the funding and provision of municipal services. It will introduce the loan financing of public investments and the provision of municipal services on the basis of cost recovery. As such, and by supporting the corporatisation of the country's largest water utility, the Baku Water Supply Rehabilitation Project is expected to have a long-term impact on the way in which Azerbaijan organises the financing and provision of public and municipal services. ■

Author

Dr Johan Bastin is director of the Municipal and Environmental Infrastructure Team at the EBRD. The team is responsible for the development and financing of municipal and environmental infrastructure investments in the countries of Central and Eastern Europe, the Commonwealth of Independent States and the Baltic states. The EBRD supports both public and private sector projects.

Bandung project lifts quality of life

Samoja, Indonesia, is one of several kampungs, housing mainly urban poor, that have been improved under Bandung's urban development.

Carola Molitor *ASIAN DEVELOPMENT BANK*

The Second Bandung Urban Development Project (BUDP II), which aims at improving the environmental sanitation of low-income households and providing safe water, is supported with a US$132.4 million loan by the Asian Development Bank (ADB). The loan became effective in May 1986 and the project was completed in December 1993. The Kampung Improvement Programme (KIP), one of seven components of the project, is focusing on those areas in the kampungs with the worst environmental conditions. Around 130 000 people are directly and more than 215 000 indirectly benefiting from improvements under the KIP.

Regular flooding

Betty Pahri, 59, beams proudly from the doorstep of her home. The house borders a small river flowing through Samoja, a kampung or unplanned neighbourhood in Bandung, West Java. It is the rainy season. For many years Betty Pahri's house was regularly flooded, sometimes up to the roof. She and her family were often forced to abandon their home and find temporary shelter elsewhere during the monsoon rains.

This year the rainfall will not disrupt their lives. "No more flooding here," she says. "There are also fewer mosquitoes around with the drainage system in place. Some years ago my grandson contracted dengue fever in the rainy season and almost died from it, like many other people here in the kampung."

Says Hj Siti Azizah Hasan, Betty's neighbour: "Apart from the many dengue fever cases, almost everybody in the kampung suffered from skin diseases during the rainy season. Diarrhoea was also common, even typhoid, and in some years we had an outbreak of cholera here."

Inadequate sanitation

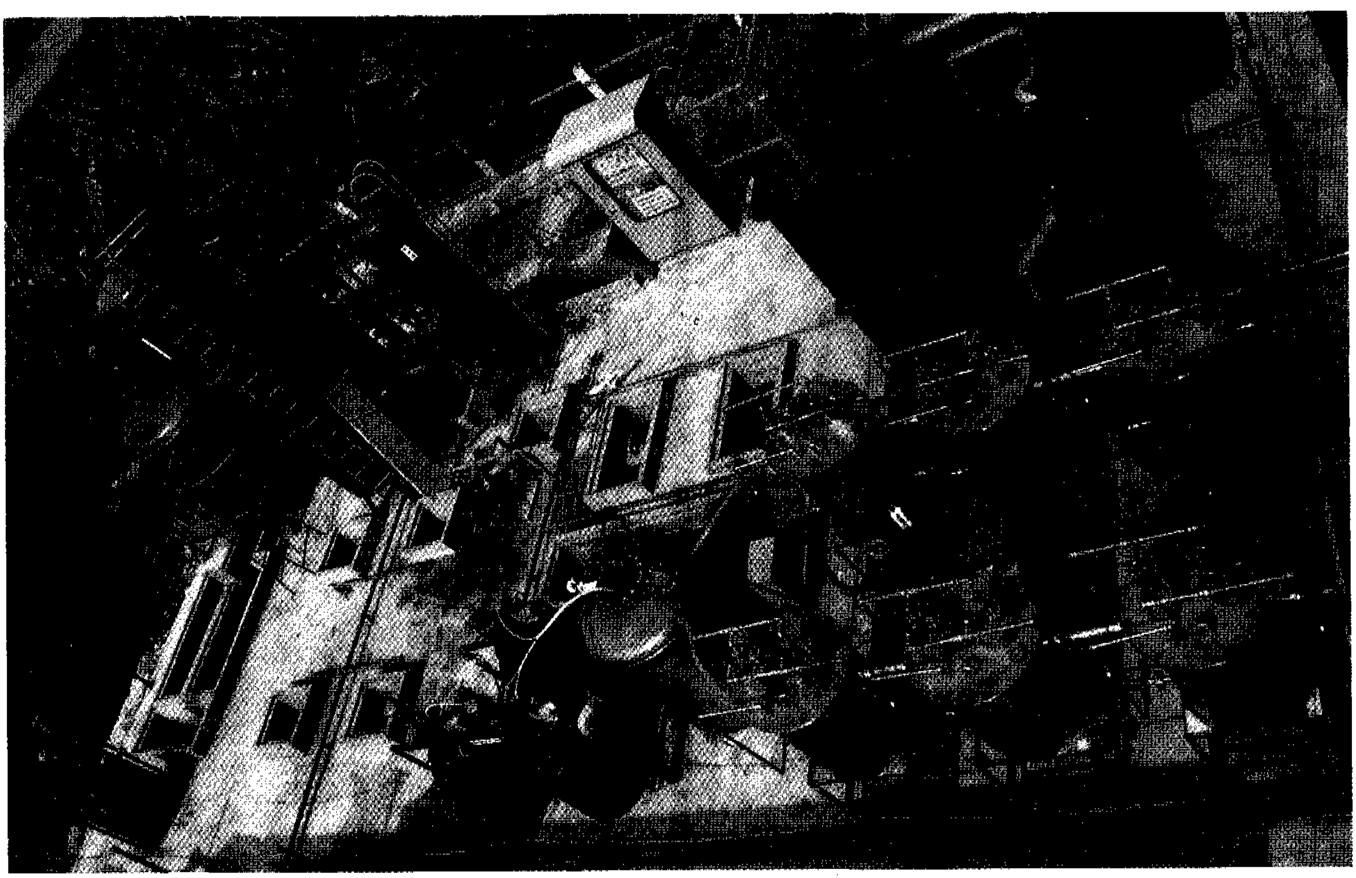
About 75 per cent of Bandung's population lives in kampungs, which are characterised by a pattern of poverty and high population density. They usually suffer from inadequate sanitation, polluted water supply and poor access roads, and often lack social facilities.

Kampung Samoja covers an area of 85 hectares and has a population density of 700 people per hectare. "Before the project was started, we had no sewerage in the kampung, no solid waste removal system, and no drainage system," explains Oman Hermawan, head of the sub-district. "Garbage was thrown in the river, which caused annual floods of up to three metres during the rainy season. Houses were regularly flooded. But the flooding stopped once the drainage channels were completed in 1989."

Under the project, more than 1600m of drainage channels were provided to kampung Samoja. A bridge spanning four metres over the small river was built and the river bed widened. More than 1500m of water pipes were laid, and four kilometres of footpaths, seven of foot-drains and 630m of access roads were constructed. Public baths, toilets and washing areas were also provided.

Apart from the many dengue fever cases, almost everybody in the kampung suffered from skin diseases during the rainy season

"Around 14 000 people in the kampung, many of whom run small cottage industries, are benefiting from the project. Now we have piped water here, and the garbage is being removed regularly," says Oman Hermawan. "Water-borne diseases have declined considerably."



Forty-year-old Sajum, a small-scale entrepreneur, and his family used to fetch water from a well that was often polluted, but was recently connected to a water pipe provided as part of the project. "More families in the kampung have access to piped water now. There was a water pipe here before the project started, but no public taps. There are 12 public taps now," he says.

Sajum's fortunes rose when the flooding stopped as a result of the new drainage system. A small garment business he had established six years ago in his house then picked up. "Before, with the recurrent flooding of the house, the business was very vulnerable," he explains. "Often we could not produce in time and I was not able to hire any employees. Only family members were helping out with the production, which had to be seasonal because of the floods."

Income boosted

Now Sajum's business has taken off. He has bought 13 sewing machines, hired 11 employees and produces clothes and school uniforms all year round. For Sajum, the improvements made in the kampung under the Second Bandung Urban Development Project have not only boosted his income considerably, but have also helped improve the health of his family and its members' quality of life.

As in other large cities in the Asia-Pacific region, rapid urbanisation has led to major demands on infrastructure and services in Bandung, which is facing widespread poverty, environmental degradation and enormous challenges in urban management. Bandung developed from a small town that was the centre of the surrounding tea and coffee estates. In 1906 it had 38 000 inhabitants. By 1949 it had grown to be the third-largest city in Indonesia, with almost 600 000 people. Today Bandung has more than two million inhabitants.

The most densely populated areas, the kampungs, have all been suffering from poor environmental conditions. In 1978 the city's water supply system reached only about one-fifth of the total kampung population by private tap or public standpipes. Most households fetched their water from wells in often polluted shallow underground aquifers or bought it from vendors.

Less than one-third of the kampungs were served by solid waste management services. Most human and liquid industrial wastes flowed untreated down the rivers, and solid wastes were often dumped uncovered. Many kampung residents did not have access to toilet facilities and a large number had to share private or communal facilities. Only about 10 per cent of the residents were served by a combined open drainage and sewerage system. An old and inefficient trunk sewerage system served only a small part of the city.

For Sajum, the improvements made in the kampung have not only boosted his income considerably, but have also helped improve the health of his family

In the 1970s, when the problems of the unplanned and mostly unserviced kampungs became increasingly critical, the Government approached the ADB to finance improvements in the urban environment in Bandung. The Bandung Urban Development Project, approved in 1979 and completed in 1987, was the Bank's first, integrated urban development operation.

The project comprised five components. Under the KIP, the living conditions of 108 000 people in three kampungs were improved. More than 900 000 people were to benefit from the second component of the project, a solid waste management system, the first solid waste entity in Indonesia and a model for several others like it. About 380 000 lower- and middle-income earners were serviced by a sewerage system by the time the project was completed, and 230 000 inhabitants are benefiting from drainage facilities to prevent frequent flooding. In Antapani, just outside the city, sites and services with 7600 core houses were to be provided, and sites for social, commercial and economic activities improved.

"Urban development projects have the advantage of simultaneously improving a number of urban infrastructure services and avoiding the problems of ad-hoc, sector-by-sector investments," says Bong Koo Lee, ADB's senior urban development specialist. "All these services are overlapping. For example, improper solid waste collection may lead to a blocking of the drainage system, pollute the aquifer, which affects the water supply, and so on." Up to the 1970s, for health reasons and to fulfil basic needs, it was necessary to support slum upgrading and water supply, but the need to include other urban services was not yet widely accepted.

Integrated project

The pilot BUDP I was a physically integrated project with several components. Its relatively successful implementation gave rise to the integrated urban infrastructure development approach (IUIDA), which goes much further. The IUIDA approach also emphasises policy. It incorporates institutional strengthening within a medium-term investment programme for municipality development based on a bottom-up planning process, and takes into account the priorities of local authorities and the needs of potential beneficiaries. Decentralisation and municipal finance are part of the approach. Bong Koo Lee points out: "Integrated urban development projects differ from country to

THE GREAT FORM OF TECHNOLOGY

Cast Resin - Industrial Products

DALLAGO

Only the best quality, sound economic structures and the trouble-free running of plants under the most extreme conditions guarantee economic efficiency.

DALLAS was founded due to the continuously increasing requirements and demands of the market for effective, high quality products with an extremely long service life even under high mechanical and chemical stress.

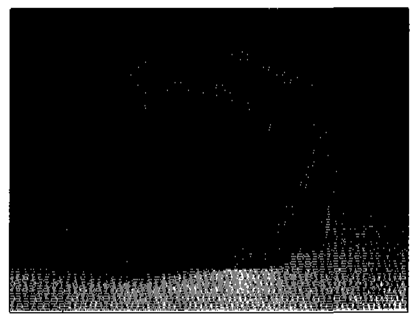
Today, DALLAS, Peggau / Austria, presents itself as a private, dynamic company which runs the most advanced and improved production facilities for the manufacture of high-quality cast resin-industrial products.

When we specialised in this field of industrial engineering, we steered towards the principles of both tradition and progress, for the benefit of all our customers.

Safety and economic efficiency require strong components.

Computer-integrated production represents an essential part of the flexibility necessary to fulfil our customersí special needs for the processing of epoxy cast resins.

We , the DALLAS-team, aim at obtaining these objectives in research, development, and production. Already today, the technological achievements of cast resin technology offer a wide range of applications which are far from being used sufficiently. The well-founded and advanced know-how of the DALLAS-product-management team enables us to cope with the technological potential behind this dynamic development. Thus we manage to give decisive and powerful impulses to put new ideas into practice. This is also efficiently applied in close cooperation with our customers.

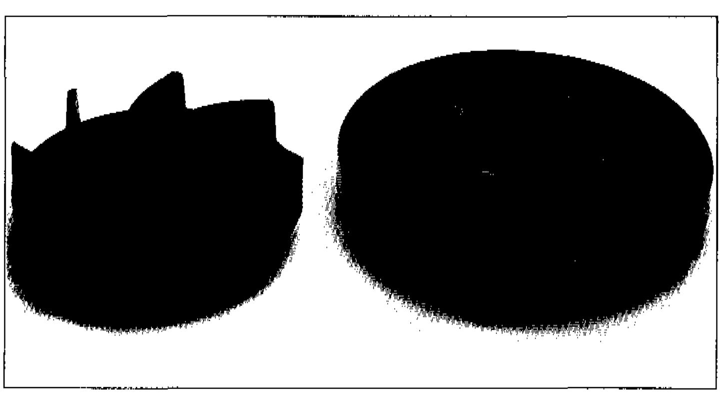


Together with the client, our special tool-making department obtains the very best solutions for small and large-scale productions, whilst at the same time offering speedy delivery dates and minimum investment requirements. The results of this excellent cooperation range from particularly advanced and improved constructions such as pump parts, valves, agitators, pipes, containers and components to customersí specifications. Together with these and other special services, we have successfully managed to become an internationally competent partner renowned for putting innovative solutions into practice.

The guarantee of quality.

Strict production controls guarantee the permanent quality of our products beginning with the inspection of all delivered materials through all production stages to the final inspection. Naturally, all DALLAS-products comply with the present and relevant standards or even exceed them in major fields.

DALLAS. Research, development and production for individual solutions.



A-8120 Peggau 84, PO Box 19 - Austria
Tel: +43 (3127) 28722,
Fax: +43 (3127) 2355
Telex: 31 2637 TBT

country. In Indonesia, urban development nowadays goes even beyond the IUIDA approach by incorporating a regional planning framework. Urban development in this sense also includes a network of smaller towns surrounding the big cities, as they are functionally interrelated."

Financial management

In BUDP II, much of the IUIDA approach is anticipated and incorporated. The project also aims at strengthening financial management, project planning and implementation as well as operation and future growth of municipal services. "Institutional co-ordination was one of the problems encountered during the early stages of implementation of BUDP I, with its innovative features and inherent complexity," says Hiroyoshi Kurihara, an urban development specialist at the ADB. In response, a local project management unit (PMU) was set up in 1981 within the ministry of public works to co-ordinate project components and facilitate bank assistance. Since a variety of implementing agencies has been involved in both projects, the PMU has provided a ready forum for resolving conflicts where they have occurred among project components. All involved agree that this structure is part of the reason why the Bandung urban development projects turned out to be so successful.

In all, 90 000 people outside Bandung are directly benefiting from the two components of the project

A further 750 000 people will have a piped water supply once the water supply component of BUDP II is completed. More than one million will benefit from an extended solid waste collection and disposal system. About 500 000 more inhabitants will be better off with sewage removed and a new sewage treatment plant. Also, it is estimated that the number of kampung dwellers benefiting from drainage works under the drainage component and city-wide drainage system rehabilitation programmes will exceed 240 000.

With the inclusion of the small towns development and flood control components, the scope of BUDP II is no longer limited to the urban boundaries of the city. The second project not only improves the infrastructure of six small towns in the vicinity of Bandung, but also tackles the flooding problem before the rivers enter the city. Rivers flowing through Bandung, already carry waste and silt when they enter the city. The KIP component alone cannot always alleviate the flooding situation.

In all, 90 000 people outside Bandung are directly benefiting from these two components of the project. In six small towns outside Bandung, KIP programmes will be providing or improving drainage systems, simple sanitation facilities and a solid waste management system. In addition, public markets are being rehabilitated and access roads built. "Improving the basic infrastructure in small towns surrounding the big cities helps prevent migration and consequently more slums in the big city," says Sutikni Utoro, head of PMU. "We have developed the concept of KIP 'core areas'. Only those areas in a kampung which are exhibiting particularly poor environment conditions are being improved."

In Dayeukolot, a small town near Bandung, 65-year-old Amir can now market by tricycle the bean-curd he produces at home. "Before the access roads were built and foot-drains completed, the mud in front of our house was more than half a metre high during the rainy season," he says. "No vehicle could pass the area, since the footpaths were not paved." Bean-curd production has increased tenfold in the meantime, and he has been able to hire four employees. His newly acquired affluence shows in an improved house: brick walls have replaced wooden panels, a metal fence has replaced one of bamboo, a stone floor was laid on top of the loam and the house now has a roof.

Improving the basic infrastructure in small towns surrounding the big cities helps prevent migration and consequently more slums in the big city

Cleanest part

Quasim Mokhm, head of the sub-district, says: "This kampung, improved under BUDP II, used to be a slum area. Many people who lived here wanted to leave, but with the infrastructure development 2500 more people have already moved here." This is no surprise: the sub-district has won the annual competition for the cleanest and nicest part of Dayeukolot every year since 1988. ■

Author

Carola Molitor is an information officer at the Asian Development Bank (ADB). She has a bachelor's degree in communications and a master's degree in economics from Ludwigs-Maximilian's University in Munich. Before joining ADB, she was a journalist and financial editor for major newspapers and business magazines in Germany and France.

Land and water resources in the Mekong Delta

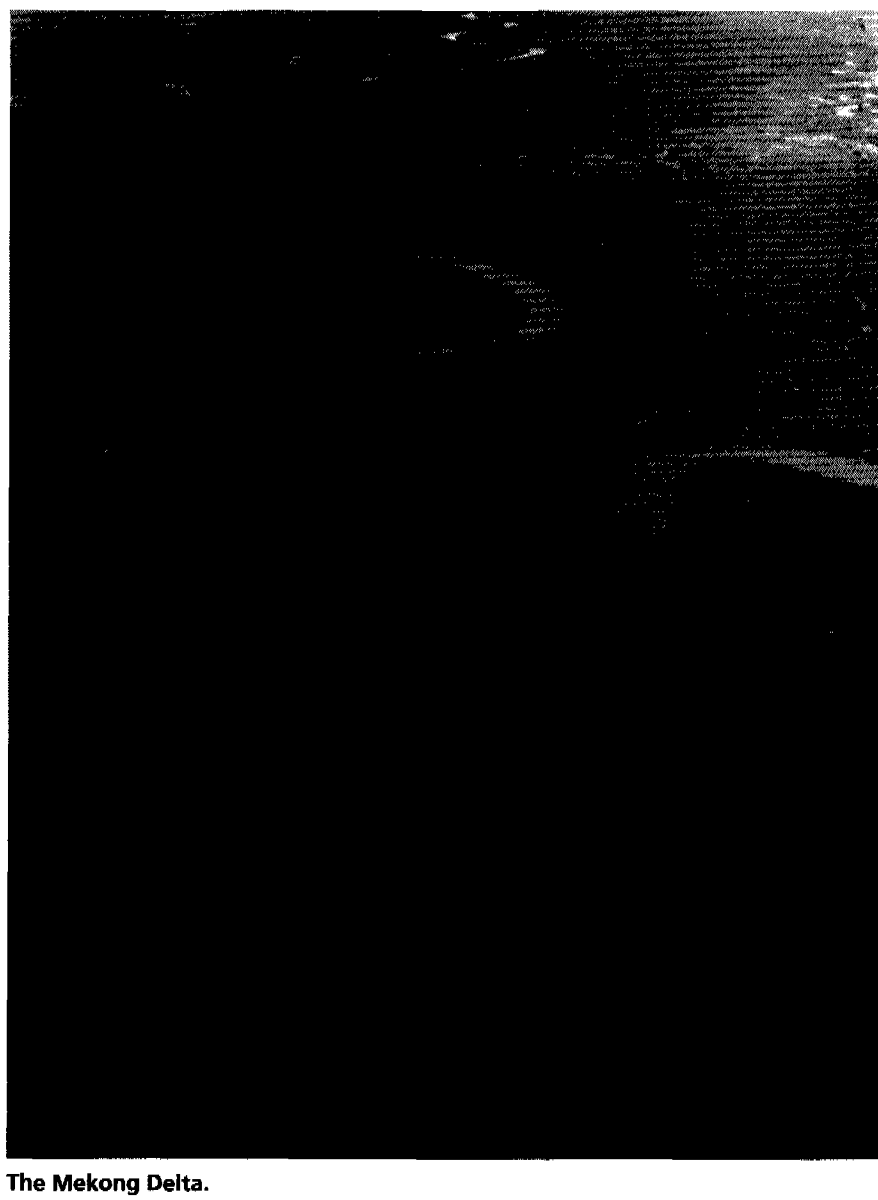
In 1990, Nedeco was contracted by the World Bank to help develop land, water and other resources in the Vietnamese part of the Mekong Delta. The massive undertaking was completed in 1993.

W H van den Toorn, G J Sluimer, L P van Lavieren *NEDECO GROUP, THE NETHERLANDS*

Over the past decade, Vietnam has been swept by political, social and economic change. The Doi Moi policy formulated in the late 1980s triggered a process of transformation almost unrivalled in depth, speed and range. Its ambitious long-term objectives may be summarised as fast economic growth, wide international partnership and an increasingly prosperous and peaceful society.

In 1990, the World Bank contracted Nedeco (Netherlands Engineering Consultants) to help Vietnam's state planning committee programme the development of the Vietnamese part of the Mekong Delta, and especially its land and water resources. The project was huge. Preparation of the plan involved a modest foreign input (from Nedeco Group companies Euroconsult and Haskoning) combined with hundreds of man-months of local expertise from national and regional institutes, including central and provincial government.

The plan proposed was the focus of the national conference on the Mekong Delta Master Plan (MDMP), held in Ho Chi Minh City in September 1993. Major elements of the plan were discussed at the UN-sponsored round table conference on Vietnam in November 1993. The final version of the plan was completed by the end of 1993, and some feasibility studies under it continued until mid-1994.



The Mekong Delta.

Sustainable development

The subtitle of the Mekong Delta Master Plan is: a perspective for sustainable development of land and water resources. During master planning two guiding principles were taken into consideration:

- All developments have to be environmentally sound, not resulting in serious negative impacts on the physical and biological environment of the Delta, and
- Developments have to be sustainable, meaning that they can be continued over an extended period of time without depleting the resource base and without decreasing the socio-economic feasibility.

Adherence to these principles has yielded project proposals in which due attention is given to the long-term effects of proposed development interventions, to pollution prevention and control and to the maintenance of the natural ecosystem in which the development will take place. It has also resulted in projects in which environmental protection measures are included as an integral part. Some examples illustrate this approach.

For flood control, the designed measures would not obstruct annual deposits of sediment and nutrients on floodplains, and the flushing of acidity from acid soils by seasonal flooding would be maintained. Further, flood control structures would not block seasonal access of fish to spawning grounds on the floodplain, thereby affecting fishery production. Other factors taken into account in the design of flood control measures and structures include the conservation of the Delta's biodiversity (for example, important bird santuaries) and ensuring that they should not result in deeper flooding upstream in Cambodia during the peak-flow season of the Mekong River.

Similar enviromental protection considerations dictated the approach to fresh water intake from the main river system for irrigation development. For instance, the project rejected irrigation schemes that would require large intakes during the low-flow season, since this would result in a serious increase in seawater intrusion into the river, with serious consequences for domestic and irrigation water quality in upstream areas.

The master plan also emphasised the need for re-establishment of the coastal belt of mangrove forests. These forests, which had suffered greatly from the defoliant spraying during the war, and from subsequent clearing for shrimp farm development, plays an essential role in coastal protection and in maintaining coastal fisheries production. The development of semi-intensive shrimp farms in conjunction with reafforestation of a protective mangrove belt is one of the projects in the master plan that received appreciable support from the donor community because of the sound environmental approach.

A large body of enviromental information was collected before development planning. A five-volume thematic study on enviromental impacts, including an environmental profile for the entire Delta, forms part of the fundamental information on which the master plan is based. In addition, environmental impact assessments have been prepared for each feasibility study pertaining to major projects in water resource development (irrigation and drainage), flood control, salinity control, shrimp farming and waterway transportation.

The MDMP has five main components:

- A long-term perspective on the Delta's development potential
- A short-term (1994–2000) development and investment plan
- A concurrent programme of studies and investigations
- Proposals to strengthen the planning and institutional environment, and
- In parallel, feasibility studies prepared by Vietnamese institutions for high-priority projects involving total investment of US$300 million.

Downstream

The Mekong Delta is the most downstream part of the lower Mekong basin.

The Mekong River flows from the mountains of Tibet to the South China Sea. Over time, the river has created a large delta covering 49 500km^2, three-quarters of it in Vietnam and the remainder in Cambodia. The Bassac, Vai Co and Mekong itself are the most important Delta rivers.

The Delta is inevitably susceptible to developments upstream: deforestation increases flood peaks, water abstraction leads to salinity farther inland and reservoir construction could attenuate flood peaks and increase low flows.

The Delta is an important region for Vietnam. It covers 12 per cent of the country's total area, provides 11 million tonnes of paddy (50 per cent of national production), accommodates 15 million people (22 per cent of the population), and contributes just over 30 per cent of the gross national product. The economic development of the Delta is therefore a major factor influencing economic growth and prosperity in the nation as a whole.

The 1990 regional gross domestic product (GDP) was estimated at $2.3 billion, or about $160 a person. This estimate excludes a range of informal activities as well as a considerable sum in remittances from abroad. The foregoing figures must therefore be used with some caution in cross-country income comparisons.

From January to May the Mekong's discharge drops sharply and salinity intrudes many miles upstream, particularly in the Vai Co. During the flood season, discharges of 40 000 m^3 per second are recorded and vast tracts of land are flooded every year. The Delta's water resources are exploited through its dense network of thousands of kilometres of waterways, which serve as transport links, supply irrigation water, drain the Delta and provide water for domestic uses.

The area's total land resources amount to 3.9 million hectares, 2.4 million of which are currently in cultivation. The scope for agricultural expansion is limited, so primary sector development focuses on the intensification and modernisation of resources already in use. Changes in cropping patterns, farming practices and the timing of irrigation water demand and supply are expected almost to quadruple primary sector output without unduly increasing water abstractions during the low-flow season. At the same time, during the high-flow season, flood protection must be increased without inducing increased flooding upstream in Cambodia.

	Growth path RED			Growth path PSD	
	1990	2000	2015	2000	2015
GDP US$ billion	2.3	4.7	14.8	4.3	11.1
GDP per capita US$	160	260	620	240	470
Annual capital US$ billion	0.3	1.0	4.7	0.7	2.3
Share in GDP					
Primary sector	54	43	25	46	33
Secondary sector	8	9	12	9	13
Tertiary sector	38	48	63	45	54

Table 1. Projected economic growth. GDP = gross domestic product. RED = rapid economic diversification. PSD = primary-sector-driven growth.

Major changes

The Sixth Party Congress of 1986 brought major changes in the economic development of Vietnam. The country has set out to become a modern growth- and market-oriented economy, successfully building on its strengths: considerable natural resources, high levels of literacy and education, good organisational capacity, a widespread drive for change and recovery, and a reasonable road, waterway and port infrastructure.

The Delta responded fast to deregulation of the economy. Between 1986 and 1989, annual economic growth may have exceeded 10 per cent; it then slowed to 6–9 per cent, and is now accelerating again.

So far, growth has, to a large extent, picked up the slack between the pre-1986 and post-1986 economic orders. It relates basically to primary sector development with positive concurrent increases in the secondary and tertiary sectors. Future growth will be less easy to achieve. It will demand not only increasing capital formation and political dedication, but also incisive changes in public sector management and the overall institutional setting.

Growth paths

The studies indicate two alternative growth paths, corresponding to contrasting alternative government policies: rapid economic diversification (RED) and primary-sector-driven (PSD) growth. RED calls for an interventionist government successful in stimulating secondary and tertiary sector development in addition to fast primary sector development. PSD is a more modest trajectory focused on primary sector development. The RED growth path projects a sustained 8 per cent growth of GDP per year by the late 1990s; in the PSD perspective, development takes a less tempestuous course.

The Delta, at present hardly urbanised (16 per cent), faces rapid urbanisation in the years ahead. The capacity of the primary sector to generate employment is limited, while the fast growth of the secondary and tertiary sectors will both demand and offer employment generally seeking an urban environment.

In principle, Vietnam has opted for the RED growth path, but, being aware of the vast implications, is currently studying the possibilities. The country also wishes to be known as a trustworthy international partner, with strategic objectives and targets for national employment generation and food production. The Delta's development should be viewed in that context, and the process can be summarised as follows:

- Primary sector productivity in the Delta must increase rapidly
- The target rate of growth of the Delta's regional product exceeds that of the primary sector, so the contribution of the non-primary sectors must increase sharply
- Urbanisation will rapidly gain momentum, with growing technological, managerial and institutional sophistication, and
- For this complex process to succeed, the Mekong Delta must be able to become a diversified and powerful economic and institutional region in its own right.

New policy

Across the economy, new policy must be formulated and implemented with a sense of purpose and political will. In all sectors, access to capital, to rapidly increasing levels of technical and managerial skills, and to increasingly efficient physical and non-physical infrastructure are to be ensured. Environmental considerations have led to prudent approaches to the development of the Delta's natural resources. Most incisive of all policy implications are those connected with the establishment of "the Delta as an economic and institutional entity", as the final report says.

Many countries can testify that a single big thriving growth area tends to reduce its surroundings to subordinate economically stagnant hinterland. This is a real possibility for the Mekong Delta in relation to the thriving Ho Chi Minh City/Bien Hoa/Ba Ria-Vung Tau triangle. To obviate the risk and enable the Delta to play its part in supporting overall national economic growth, the government needs to protect the Delta's development in the early stages.

In line with emerging government policy to identify growth areas, the Mekong Delta should be designated a multi-sectoral growth area, on a par with the Ha Noi/Hai Phong/Hon Gai and Ho Chi Minh City/Bien Hoa/Ba Ria-Vung Tau triangles, and with the intended growth area in central Vietnam around Da Nang. This would make the Mekong Delta one of four development regions in the country, each with its own potential and constraints and with its own specific role to play in national development.

A further unequivocal decision is required to grant the Delta a regional centre of its own: a first category national city. Given its location, existing regional function, size and existing facilities, a logical choice would be Can Tho. A number of second echelon cities will need to be re-ranked and upgraded to establish a coherent urbanised system in the Delta, not unlike that in the triangles already mentioned.

The foregoing considerations apply most strongly to the Trans Bassac area. The Delta east of the Mekong would respond naturally to Ho Chi Minh City. The area between the Bassac and the

Rice planting in the Mekong Delta.

Mekong rivers would, to some extent, be undetermined, and the same might apply to the north-eastern provinces.

Projects

The Mekong Delta Master Plan identified a large number of projects. Those best fitting the selection criteria have been retained in the investment plan until 2000. Projects are currently being prepared or appraised for early implementation with multilateral or bilateral financial assistance — such as a drinking water supply and sanitation project for two provincial capitals, a mangrove rehabilitation project and a wetland protection and management project, and the rehabilitation and improvement of selected inland waterways.

Accelerated growth

Nedeco's analyses of the potentials, constraints and both regional and national objectives and desires indicate that accelerated and ambitious growth in the economy of the Mekong Delta is indeed feasible. Such growth will not necessarily require massive hydraulic construction works, but does demand wise and prudent management of the economy and its physical resources, and of the society of the region.

From the point of view of national economic and administrative management, perhaps the most incisive policy recommendation in the report concerns the establishment of the Mekong Delta as a strong economic and institutional entity in its own right. Its recommendations deal with such issues as:

- The establishment of a regionally based urban system with Can Tho City at its core, and
- The relocation of government services from Ho Chi Minh City and Ha Noi to the Delta. ■

The original from which this article is adapted appeared in *Land & Water International.*

Authors

Dr W H van den Toorn is managing director of BMB Management Consulting for Development, an affiliated company of Euroconsult, a Nedeco Group company.

G J Sluimer MSc is project manager for Haskoning Royal Dutch Consulting Engineers and Architects, another Nedeco Group company.

L P van Lavieren MSc is senior ecologist at Euroconsult.

Irrigation and drainage in India

With more agricultural land under irrigation than any other country, India depends on water for its future growth.

N Suryanarayanan *INDIAN MINISTRY OF WATER RESOURCES*

At the time of independence, India's food grain deficit was almost 4 million tonnes, but today they are self-sufficient. Production of food grains, which was only 50 million tonnes annually when the series of five-year plans was launched in 1951, now exceeds 175 million tonnes. Development of irrigation has been the principal force behind this agro-revolution.

Irrigation in India has been practised since the dawn of history. In the initial stages of irrigation development the basic philosophy concerned protective irrigation. This has now changed to productive irrigation.

Potential

The five-year plans initially stressed irrigation development through the creation of storage reservoirs and canal networks. The potential increased from an original 19.5 million hectares (mha) in 1947 to about 84.9mha at the end of 1993–4. The increase in the potential created over the plan periods is given in Table 1.

Projects classification

In India, irrigation projects are classified into three categories — major, medium, minor — depending on the cultivable command area. Major = more than 10 000ha; medium = more than 2000 but less than 10 000ha; minor = 2000ha or less.

Minor irrigation projects have both surface and ground water as their sources, while major and medium projects exploit surface water resources.

Development of irrigation began with emphasis on run-of-the river schemes, but later the need was felt for storage projects for either a single purpose like irrigation or multi-purposes such as irrigation, hydropower generation, flood control and so on. Investigation, planning and designs are carried out accordingly.

Storage capacity constructed up to 1990 was of the order of 166 cubic kilometres (km^3), with a further 208km^3 expected to be added. Some of the major irrigation projects to date are Bhakra, Nagarjunasagar, Kosi, Tungabhadra, Lower Bhavani, Mettur, Gandak, Rajasthan Canal, Parambikulam Aliyar, Kabini, Kangsabati, Bhima, Jayakwadi and Kukadi.

Minor projects generally comprise all groundwater schemes like dug-wells, tube-wells and surface water flow and lift schemes. Investment for them comes from both institutional sources such as the National Bank for Agriculture and Rural

Plan	Major-medium	Minor	Total
At the end of			
Pre-plan to 1951	9.70	12.90	22.60
First (1951–56)	12.20	14.00	26.20
Second (1956–61)	14.33	14.73	29.06
Third (1961–66)	16.57	17.00	33.57
Annuals (1966–69)	18.10	19.02	37.12
Fourth (1969–74)	20.70	23.40	44.10
Fifth (1974–78)	24.72	27.30	52.02
Annuals (1978–80)	26.61	30.00	56.61
Sixth (1980–85)	27.70	37.52	65.22
Seventh (1985–90)	29.92	46.60	76.52
End of 1993–94	31.60	53.28	84.88
Target for Eighth (1992–97)	5.09	10.71	15.80
End of Eighth (anticipated)	35.83	61.06	96.89

Table 1. (figures in millions of hectares).

Development (NABARD) and from the public sector. In the seventh plan (1985–90), investment by the public sector was 3227.8 crores ($880 million) and by the banks 3312 crores ($904 milion). [1 crore = 10 million rupees, £1 = 54.97 rupees = $1.5, December 1995].

External assistance

In the water resources development of the country, in addition to the internal resources and technical inputs, assistance is provided by external funding agencies such as the World Bank, OECF (Japan), ODA (UK), USAID, CIDA (Canada), and from countries including Germany, The Netherlands, France, Australia and Norway, and from the European Union. Assistance is provided for not only individual projects, but also for water resources consolidation, infrastructure development, water management, minor irrigation, salinity control, drainage and so on.

Besides increased agricultural productivity, irrigation has created important socio-economic benefits leading to all-round growth. It has largely rid the country of famine due to drought. Although the past 30 years have included seven of drought, no famines have occurred. Construction of irrigation projects has generated employment, facilitated the development of rural areas, increased availability of drinking water, improved health and raised standards of education and literacy. In short, its benefits have been many.

Anomalies, concerns

Although the expansion of irrigation potential is unprecedented, its pace has led to some anomalies and concerns. They include time and cost over-runs of projects, lag between irrigation potential created and utilised, waterlogging leading to soil salinity and alkalinity and sedimentation of reservoirs.

There are also certain major issues like inter-State differences, environmental concerns in large projects, ground-water development and increasing competition for water from other water-use sectors. Continued analysis of these issues leads to policy changes in the irrigation sector.

In view of all the problems that have arisen in the development of water resources, including those for irrigation, a national water policy was formulated after detailed consideration and debate by experts of various interrelated disciplines in the country. The policy was unanimously adopted in September 1987 and is at various stages of implementation. The policy has been spelt out under clauses:

- **(i)** The need for a national water policy
- **(ii)** Information system
- **(iii)** Maximising availability
- **(iv)** Project planning
- **(v)** Maintenance and modernisation
- **(vi)** Safety of structures
- **(vii)** Groundwater development
- **(viii)** Water allocation priorities
- **(ix)** Drinking water
- **(x)** Irrigation
- **(xi)** Water rates
- **(xii)** Participation of farmers and voluntary agencies
- **(xiii)** Water quality
- **(xiv)** Water zoning
- **(xv)** Conservation of water
- **(xvi)** Flood control and management
- **(xvii)**Land erosion by sea or river
- **(xviii)** Drought management
- **(xix)** Science and technology
- **(xx)** Training

Problems encountered

Various concerns that have cropped up are briefly described:

Time and cost over-runs. These are due to the continuing tendency to start more and more projects, forcing financial resources to be spread too thinly. The strategy of the eighth plan (1992–97) is therefore restricted to the completion of on-going projects, with emphasis on those that are well advanced.

The gap between irrigation potential created and used. At the end of 1993–94, while the irrigation potential created was estimated as 84.88mha, the potential used was estimated as 76.16mha, and a re-assessment of both is being carried out. While the gap is unavoidable because of sequencing and delay in the adoption of techniques by farmers, efforts have been made to reduce it through a centrally sponsored command area development (CAD) programme since 1974–75.

Waterlogging and salinity. Waterlogging has been witnessed in numerous irrigation projects. The total area affected by it under major and medium irrigation may be about 10 per cent. Measures to counter it are being taken by constructing field channels and drains and identifying problem areas by remote sensing to check the spread of affected areas. The combined use of surface and ground water is being encouraged to reduce the problem, and guidelines have been prepared.

Sedimentation of reservoirs. To mitigate the problem of sedimentation, catchment area treatment is being implemented in the projects.

Maintenance of irrigation systems. Provision made for the upkeep of irrigation projects in operation is limited by certain constraints. A solution could lie in rationalising an increase in water rates, and in better recoveries.

Inter-State co-operation. Irrigation being a State subject in India, with the role of central government confined to co-ordinating overall development of water resources, differences often arise between the States over the sharing and development of inter-State rivers. So far as possible these differences are being resolved through mutual discussion and co-operation, or by tribunal awards under the Inter-State Water Disputes Act 1956.

Environmental concerns. While there are substantial positive impacts on the environment through irrigation projects, there are also some negative ones, the worst including population displacement, waterlogging, loss of valuable forest and cultivated lands and the incidence of water-borne diseases. Pragmatic and humanitarian approaches are being made to reduce the adverse environmental impact of large irrigation projects.

Competition from other water users. There is keen competition for water between irrigation and other uses, such as municipal and industrial, and with rapid growth in industrialisation and urbanisation the competition will become increasingly severe.

Ground-water development. Ground-water extraction has two major constraints — the energy needed for extraction, and over-exploitation that could lead to permanent depletion of the water table. The annual replenishable groundwater resources of the country have been assessed as 45.33Mham a year, out of which 6.98Mham is assessed for drinking water and industrial uses and the remainder for irrigation. In coastal areas salinity adds to the problem.

Policy measures

Sustainable development of irrigation, with cautious and careful investment, will be a challenging task. Various policy measures are being implemented:

Basin planning and management. These include resource planning at basin or sub-basin level, setting up organisations for the purpose, transferring water from surplus basins to areas short of water and the recycling of water. In-service engineers are being trained in integrated river-basin planning and management through a central training unit.

Improved water management. Through World Bank assistance, Phase I of the national water management project was completed in March 1995. It covered rehabilitation of deteriorating irrigation systems and the preparation of an operational plan for each scheme to define principles of water distribution and allocation of responsibilities. Water-saving devices such as sprinkler and drip irrigation are also being adopted.

Irrigation management policy. For optimum use of available water, an irrigation management policy has been prepared. The main strategic adjustments envisaged under this policy are participatory (by farmers) irrigation management, operational and procedural changes, a programme of training and action research, revision of water rates, combined use of surface and ground waters, and such technological improvements as drip and sprinkler irrigation, a data storage system and canal automation.

Among the main adjustments would be the formation of water users' associations, co-operatives and societies, with bulk supply of water at tertiary level to the associations and further retailing of water by them to individual farmers. To motivate farmers, non-governmental organisations, social research institutions, water and land management institutes and so on would be involved. Women's participation is also receiving attention.

Greater accountability and transparency would be instilled in the irrigation departments by restructuring to replace administrative hierarchical bias with functional management re-oriented to an inter-disciplinary and more holistic approach. Human resources development of farmers and irrigation and agricultural staff would be accelerated through the 11 major water and land management institutes. Action research programmes based on diagnostic analysis of existing irrigated areas have been taken up in a number of commands.

Water rates would reflect the scarcity value of water and be rationalised at least to meet the maintenance cost of the system. Guidelines on the complementary use of surface and ground waters have been prepared and farmers' representatives are to be motivated. Adoption of drip and sprinkler systems will be encouraged with subsidies.

A policy of environmental impact assessment, resettlement and rehabilitation will be formulated for project-affected persons, with compensatory afforestation and the services of the 1990 Environmental Monitoring Committee.

Efforts to evolve policies and guidelines to overcome the ill-effects of anomalies and concerns are continuing, as is attention to research and development. India's Ministry of Water Resources is funding various schemes in collaboration with national committees on subjects such as irrigation and drainage, hydraulic research, hydrology, construction materials, rock mechanics and tunnelling. Follow-up action on schemes suggested through the International Programme on Training and Research on Irrigation and Drainage (IPTRID) is being taken.

Helping others

With the expertise and knowledge gained over the years, India is imparting knowledge on irrigation development to other developing countries by means of training programmes and consultancy services in India and abroad through government undertakings and private companies. The feasibility of private-sector participation in irrigation and multi-purpose projects is being examined.

Efforts at standardising all segments of irrigation development continue through the Bureau of Indian Standards and collaboration with the International Standards Organisation.

Flood control and drainage

Floods beset vast areas of the country, transcending state boundaries and affecting an average area of around nine million hectares a year. According to the National Commission on Floods, the area susceptible to flood is around 40mha. Waterlogging is caused by both surface flooding and seepage from over-irrigation.

Approach to flood management is co-ordinated and guided at national level. Attempts are continuously being made to mitigate the waterlogging problem by judicious combination of surface drainage, lining of canals, sinking of tube-wells and other means. Until the seventh plan (to 1990) an amount of 2704.35 crores was invested in the flood-control sector of the country and for the eighth plan (1992–97) 1623.37 crores were budgeted.

On the flood management side, both structural and non-structural methods are followed. The network of flood forecasting and warning centres that has been established has afforded much help in timely warning for evacuating people to prevent loss of life and minimise damage to property. Enactment of suitable flood zoning laws has been recommended to the States. Measures on the structural side include construction of embankments, revetments and spurs, channel improvements and selected storage reservoirs.

To improve drainage facilities, stress is laid on research and development efforts, which include determination of effective drainage materials and layout of both vertical and horizontal drainage systems. The Rajasthan Agriculture and Drainage Project funded by CIDA of Canada is expected to give a lead in tackling drainage problems.

Universities, research institutes and government departments are also engaged in the task. Manuals on flood forecasting and guidelines for using surface and groundwaters have been prepared. Regional seminars and workshops have been held through ESCAP. ■

Author

N Suryanarayanan is in charge of policy and planning in India's Ministry of Water Resources. He obtained a post-graduate diploma in water resources development and has had 32 years of experience in all aspects of that field. He is a member of the United Nations Committee on Natural Resources, and is the author of a manual on barrages and weirs on permeable foundations.

Rural water supply in Latin America

In Latin America, the trend toward the decentralisation of water supply management is placing an increasing burden on local government and water committees in rural areas.

Jan Teun Visscher, Gerardo Galvis, Edgar Quiroga and Nicolette Wildeboer, *INTERNATIONAL WATER AND SANITATION CENTRE*

Lessons learned during the International Drinking Water Supply and Sanitation Decade (1981–90) show that water committees can only perform their tasks successfully if the interface between the environment, technology and the community is taken into consideration. Since 1988 CINARA and IRC have been implementing learning projects in Colombia which integrate these three elements. The first projects focused particularly on water supply systems which include multi-stage filtration as a treatment process, but because of the encouraging results the concept is now also being applied to other water supply and sanitation systems.

Operating a water supply and treatment system in rural areas of Latin America is often like gambling against the odds. Supply of chemicals cannot be guaranteed, and designs are often inappropriate and cannot respond to rapid changes in water quality. Those responsible for the water supply systems are seldom properly trained. This is the situation faced by the majority of the water committees in Latin America: willing individuals, often community leaders, asked by their community to take it upon themselves to run the water supply system. In Colombia, water committees were legalised in May 1974 as autonomous entities charged with the administration, operation and maintenance of water supply and sanitation systems constructed by the National Programme for Basic Rural Sanitation. These and water committees in other countries have received some back-up support in the past, but they have not acquired the necessary skills to manage their systems. The limited support they do receive is now at risk, as staff cutbacks are becoming the order of the day in government organisations in many countries. More and more governments, such as Colombia in 1987 and more recently Ecuador and Bolivia, are adopting decentralisation strategies. This implies that municipalities are charged with the responsibility of providing adequate water supply and back-up support to their communities — a difficult assignment without adequate staffing or easy access to the necessary credit lines.

The trend toward decentralisation appears to be the result of two driving forces. On the administrative side it is argued that the present, often centralised, government structures are inherently incapable of responsive administration. Rondinelli, for example, argues that incentives rarely exist for central government ministries to perceive citizens as their clientele. The other, stronger argument for decentralisation appears to be the present loss of the centralised state's political credibility and the demand for power by groups that have historically been denied influence. As a result the process is not a carefully designed sequence of reforms aimed at improving public sector performance, but rather a reluctant and disorderly series of concessions by central governments attempting to maintain political stability.

Important lessons from earlier decentralisation efforts elsewhere are not sufficiently taken into account, in particular that:

- Lower levels of government should have the power to mobilise resources, a high degree of autonomy in staffing decisions, and an ability to control budgets, and
- Organisational units that specialise in water and sanitation activities should be created at multiple levels in decentralised structures (for example, a state water department and a regional water department), and the units roles must be separated and defined carefully.

Merely passing the challenge to municipalities and water committees is not enough. Unleashing local effort through decentralisation requires creating new technical and institutional capacity, as many communities lack requisite expertise. Access to engineering, project development and administrative skills is crucial. In this we can draw lessons from the Water Decade and the way communities have been involved in projects. In Latin America their involvement has a long history, particularly in the construction phase. However, in the selection, planning and development of solutions involvement is marginal. This limited involvement, lack of back-up support, and poor performance of water supply systems has resulted in low credibility and poor recognition of sector institutions, sector professionals and politicians, limiting their potential to implement new projects. Thus communities, water committees and municipalities have to become better prepared to face the challenge ahead, and governments must invest in applied research and human resources development to stimulate the development of sustainable solutions. Foremost, this implies that they have to cope with the human dimension of the problem and with an integrated approach to development of sustainable services, with emphasis on water resources management, as suggested at the Ministerial Conference on Drinking Water and Environmental Sanitation held in Noordwijk, The Netherlands, in March 1994.

With some 80 countries, comprising 40 per cent of the world's population, already suffering from serious water shortages, it is now becoming widely accepted that water is not an infinite resource and needs adequate protection and management at the lowest possible level. The question then is how to enable the water committees and the municipalities to adopt these management skills and how to support them in this important task. Projects implemented in Colombia seem to provide some answers. It is interesting to note that the Americas have always been forerunners in the development of new approaches and strategies for solving water and sanitation problems. They triggered, for example, the first nationwide actions to improve water supply by setting regional targets in a meeting of Latin American countries in Punta del Este, Uruguay, in 1961.

Behind the coverage figures

Before reviewing possible solutions, let us have a closer look at the situation that municipalities have to face. The 1990 coverage figures for rural water supply systems in Latin America are as low as 52 per cent, whereas for urban systems they reached up to 90 per cent. This difference is not surprising, as even during the Water Decade more than 80 per cent of the funding was geared toward the urban population.

Water supply coverage in Colombia was estimated at 66 per cent in 1991, but in the communities with less than 12 000 inhabitants this was only 24 per cent. Furthermore, only half of the water supply systems in these communities have partial treatment and even fewer, some 4 per cent, have complete treatment. Water with a low hygienic risk is thus rare. In Ecuador the 1990 rural water supply coverage was estimated at 39 per cent, but a 1992 evaluation of 50 systems indicated that all produced bacteriologically contaminated water containing 2 to 1600 faecal coliforms per 100ml. This situation was confirmed by another study in 1995, which indicated major problems in operation and maintenance in 40 systems, of which 50 per cent have trained operators but only one has adequate equipment to do the job properly. These systems also have important water treatment problems, and major leakages result in only 40 per cent of the water put into the systems eventually reaching the consumers. The 1992 coverage in Bolivia was estimated at 57 per cent, but for dispersed rural areas it was only 19 per cent. More than 90 per cent of all systems in Bolivia provide water with a considerable hygiene risk. Lloyd and Helmer (1991) indicate that in Peru no single small community water supply system produces water meeting WHO standards. So, despite Decade efforts, sustainability of systems is not at all guaranteed, and we cannot expect water committees and municipalities to perform optimally.

The need for an integrated approach

From experiences in Colombia, where water projects have been implemented as a collaboration between agencies and communities for many years, and through review of other experiences, it has been established that to reach more sustainable solutions three main factors — environment, technology, and community — need to be combined, and their interfaces need to be optimised in the local political, institutional, socio-economic and cultural context (Figure 1).

The environment: balancing the hygiene risk. The interface between the community and the environment determines the hygiene risk which must be overcome by the required water supply system. Many communities in Latin America depend on surface water sources which are bacteriologically unsafe and occasionally carry high loads of suspended solids. This calls for a multi-barrier treatment system, which needs to be complemented whereever possible with disinfection. Whereas the potential risk of disinfection by-products should not be ignored, they are often outbalanced by the benefits disinfection provides in reducing the much larger threat of waterborne infectious disease. Chlorination is often the only treatment mechanism used in many countries, but it cannot be relied upon, as in many cases treatment results are poor or totally ineffective when peak loads in suspended solids reach the system. Emphasis thus needs to be placed on the previous barriers, including the protection of the catchment area, which is often more effective than treatment . A lack of catchment protection in the past has caused major water quality and quantity problems, in some cases so severe that systems have been abandoned because the water sources have dried up.

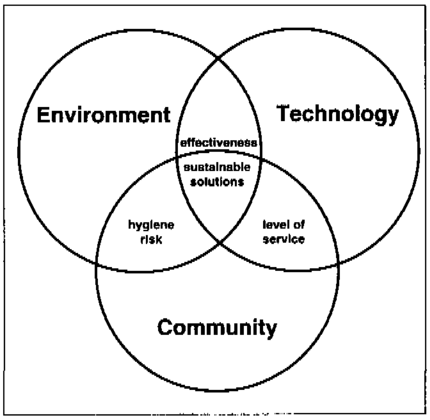


Figure 1. Toward sustainable solutions (taken from unpublished reports by CINARA and IRC).

Selecting the technology

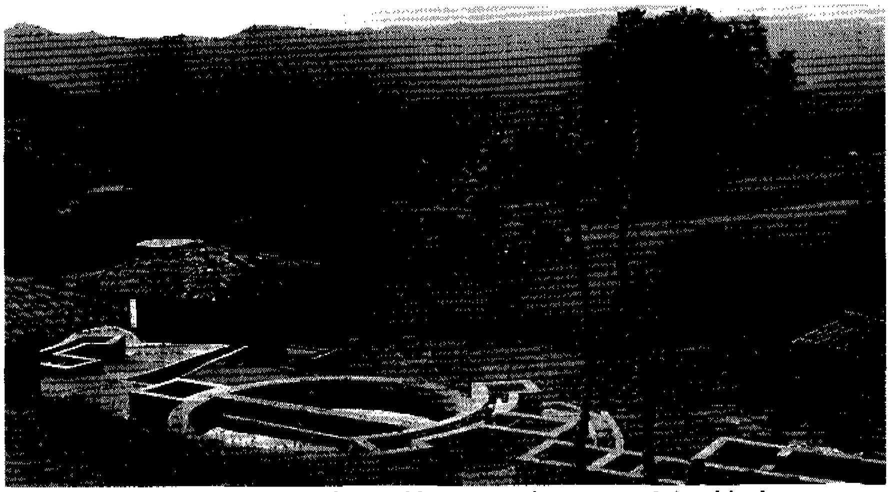
The technology needs to match the environmental conditions and must be efficient. Local conditions in most rural areas do not allow the reliable supply of chemicals, nor are operators available who can cope with the relative complexity of chemical water treatment. Research by CINARA and IRC has shown that multi-stage filtration (MSF), provides a very good alternative which can cope with most water quality problems prevailing in the region. This research programme was initiated in 1988 in Cali, Colombia to compare different pre-treatment systems to overcome the limitations of slow sand filtration (SSF), which caused major problems in Brazil and Peru. The project results show the great promise of a combination of dynamic roughing filtration, upflow roughing filtration and

SSF, both at technical scale and in full-scale plants with capacities ranging from 0.5 to 40 l/s. The systems are being used for different raw water qualities with average turbidities ranging from 10 to 150 and peaks over 2000 nephelometric turbidity units (NTU), average faecal coliform counts between 40 and 100 000 with peaks over 300 000, and true colour between 5 and 115 and peaks over 300 TCU (true colour units). All are able to produce an end product meeting drinking water quality standards. The project has caused an important upheaval internationally among sector professionals in their attitude toward MSF, which can treat lightly to heavily polluted surface water as well as groundwater. In many cases MSF provides strong competition for package plants. It is a more reliable alternative which does not require the continuous dosing of chemicals. The research results and design guidelines coming from the most recent phase of the programme are being compiled for publication.

The community: identifying the service level. The interface between the technology and the community determines the highest suitable service level that the community would like to obtain and is able to manage and willing to pay for. This requires a dialogue with the community and the presentation of different service level options, as for example planned in the PROSABAR project (one of the major rural water supply and sanitation projects in Bolivia). Participatory techniques are needed to assist in this process, as communities are heterogenic groups with different interests which need to be clarified and mediated. In particular techniques such as Venn diagram, social mapping and ranking matrixes may help communities to clarify their problems and initiate a dialogue on solutions, as recently found in a participatory evaluation in Ecuador.

How to introduce change

Change is required, with governments and NGOs trying to modify their role from provider to facilitator and municipalities and water committees trying to adopt new roles. Learning projects such as those that have been implemented by CINARA and IRC in Colombia since 1988 provide a promising approach for agencies and communities to learn new roles and attitudes. These inter-institutional and inter-disciplinary projects provide a systematic learning environment for introducing new approaches and technologies and are being implemented in parallel with mainstream projects. Project staff have a double role, one in which they carry out projects along lines learned before and the other where space is provided to reflect on results and try out new methods and technologies. The projects combine two key elements: training of different levels of staff who can develop new programmes and joint development of demonstration projects which serve these staff members as learning-environment and dissemination tools.



The multistage filtration plant located in Paispamba, Cauca, Colombia, has a capacity of 540l/s.

The programme in Colombia was financially supported by the governments of The Netherlands and Colombia and comprises 16 learning projects in eight regions. These projects were primarily set up to introduce MSF in these regions, but gradually the much broader focus of community-managed water supply became the issue. Results are very encouraging as can be seen from some of the findings. All systems provide gravity water supply with a very low hygiene risk due to MSF treatment. They are operated by local caretakers who also carry out monitoring with simple equipment. In several systems the communities, on their own initiative, are installing water meters to enhance control. Water tariffs are established by the community and in certain cases the introduction of the treatment has increased their tariffs substantially — sometimes tenfold — without major objections. Projects are used to show results to politicians, other agency staff and community leaders. Agency staff who have been involved in the project apply what they have learned in other projects. This learning project approach is currently being documented as it provides a very good methodology to facilitate the introduction of new approaches and technologies, and to build capacity in projects parallel to mainstream projects. New learning projects are now being established in other regions, also concentrating on other problem areas including sanitation. ■

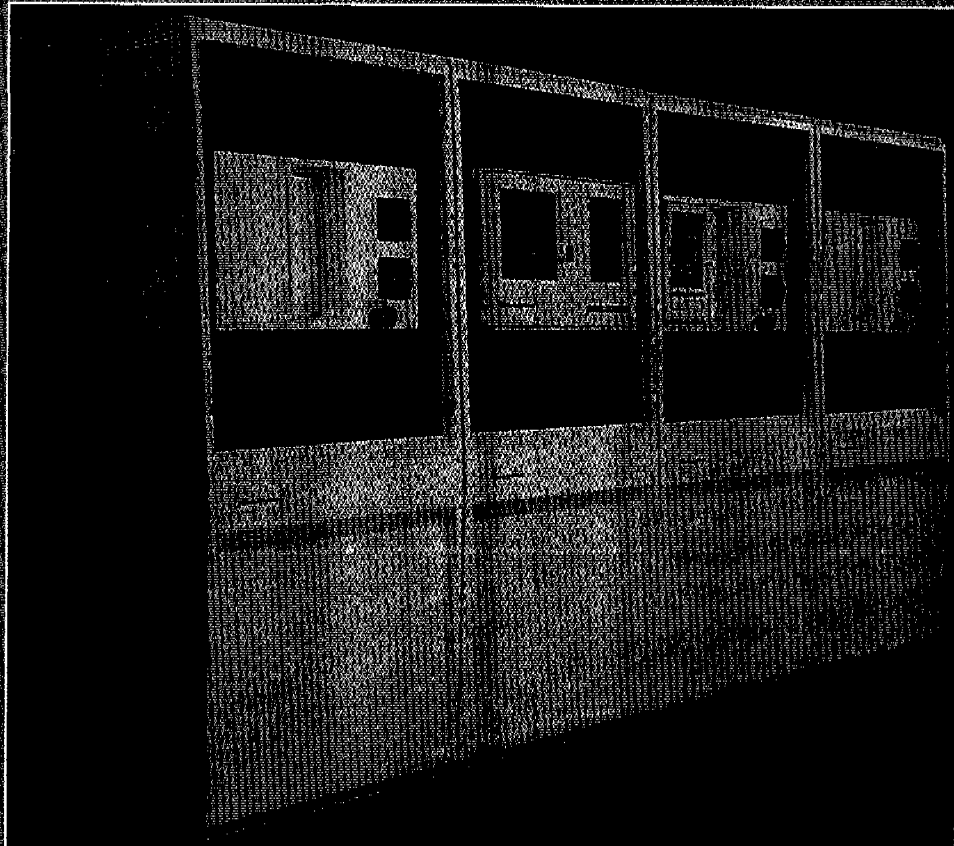
A full list of references is available on request from the authors.

Author

Jan Teun Visscher is senior programme officer at IRC International Water and Sanitation Centre, The Hague, The Netherlands.
Gerardo Galvis is director of CINARA (Centro Inter-Regional de Abastacimiento y Remocion de Agua), University of Valle, Cali, Colombia.
Edgar Quiroga is a senior staff member of CINARA (Centro Inter-Regional de Abastacimiento y Remocion de Agua), University of Valle, Cali, Colombia.
Nicolette Wildeboer is public relations officer and editor at IRC International Water and Sanitation Centre, The Hague, The Netherlands.

Queridos amigos de América Latina:

WALLACE & TIERNAN



Planta

Oficina Cuernavaca

Oficina Monterrey

F. Bartolomé de Las Casas 739, Col. Roble Norte, 66150 Sn. Nicolás de los Garza, N.L. Tel. 91 (83) 32 11 24. Fax 91 (83) 32 11 22.

Oficina Coatzacoalcos

Oficina Guadalajara

The new way for water projects: individualisation

Water mega-projects are no longer justified. Solutions at an individual level are more economical and efficient and provide benefits where they are needed.

Antonio Ertze *WALLACE & TIERNAN DE MEXICO*

One of the largest gaps in economical, educational and cultural differences that separates the developed and developing countries is the outlook in regard toward their natural resources. It is common for developed countries to have implemented programmes to conserve and protect their precious natural resources such as water. These programmes basically consist of regulations and anti-pollution laws in assuring natural resources management at a fair price to consumers.`

On the other hand, the under-developed countries have been trying to catch up with the examples set by developed countries, and as a result it has become almost twice as costly to drink healthy water as to drink milk.

While a majority of inhabitants in developing countries believe that "water is sent by God from heaven", their authorities argue that "God does not treat, pipe and distribute that water to their homes." As the populations of such countries grow, public health and the quality of life deteriorate in the same proportion. This must be stopped by means of the most efficient, though not necessarily the most costly, investment.

Ismail Serageldin, vice president of The World Bank, which is the largest international investor in potable water and wastewater projects, told a recent water conference in Stockholm that water must assume its true place in society as a valuable economic commodity; and rightly so, since without this precious liquid neither life nor health can survive.

Yet to supply the precious liquid to each inhabitant is extremely expensive. It is here that a change of approach is needed. The World Bank signalled as much at the same Stockholm conference when Mr Serageldin agreed that although for the past half-century the Bank had been constructing mega-dams and financing mega-projects, today the problems for most countries came principally from inefficient and unaffordable use of water.

It is in this context that the company Wallace & Tiernan de Mexico, a member of North West Water Group, which operates at world level, has invested huge financial resources in research into new technologies directed toward solving the problem of potable water on a new basis: to produce the precious liquid in totally healthy conditions and at a cost that can be afforded by the inhabitants of not only big cities but small communities as well.

1. The new concept involves various elements among which is the designing of potable systems at individual level so that each home may have an assured supply of healthy water at the lowest possible price, a substantial part of the water being recycled and redirected to homes perfectly fit to drink.

2. The multiple-use system should be designed at municipal level so that with low investment it can be installed and run with assurance of sufficient flow of low-cost drinkable water.

3. The useful life of purification equipment already in operation should be extended by an in-plant refurbishing and updating programme to make the equipment functionally new. This means that initial investments made by governments or municipalities can be recovered by extending the plant's useful life to 10 or more years at a cost comparable with that of maintenance and enabling water to be distributed for a price consumers can pay.

4. Individual purification of water would reduce the number of treatment plants constructed and make them more efficient. On new urban developments each house would have its own treatment system, while individual treatment systems would deal with the polluted and poisoned effluents from each industry. Individual wastewater plants that recycled part of the water treated would cost substantially less than mega-plants that treated the mixed effluents from 40 or 50 different industries.

This new approach is becoming a reality. The individual concept benefits the local authorities, consumers and society in general. It is fundamental to encourage an educational effort toward new cultural and health practises, educating citizens to care for the environment and their water. We all must contribute to improve our quality of life by managing our natural resources at the lowest possible cost. ■

Author

Antonio Ertze is president of Wallace & Tiernan de Mexico, a manufacturing arm of Wallace & Tiernan International and part of the North West Water Group.

Cairo wastewater project yields sustainable benefits

In the mid-1970s, Cairo had a sewerage system that could serve only one million of its eight million inhabitants, and there was no effective sewage treatment.

David Kell *BINNIE BLACK & VEATCH, UK*

By 1975, Cairo's infrastructure was suffering from the dual effects of long-term under-investment and rapid population growth of some 300 000 inhabitants a year. The sewerage system was essentially unchanged from that which had been installed in the early part of the century to serve a population of one million and which had by then reached almost eight million. It was at this time that President Sadat announced his open-door policy, inviting Western nations back to Egypt to participate in developing the country, and especially to help modernise the infrastructure of the major cities.

As a consequence, the Greater Cairo Wastewater Project was initiated. The first step was to carry out a master plan for the phased development of the city's sewerage facilities. Funding was provided by the Arab Fund and, following an international competition, Taylor Binnie and Partners (TBP), a UK consortium of consulting engineers comprising Acer Consultants and Binnie and Partners, was awarded the consultancy in 1977. The master plan was completed and accepted in early 1978, but the project could not proceed for lack of funds. The following year America's USAID and the UK's ODA decided that they would jointly support the project.

That support has continued to this day. In view of the American funding, the US consultants Black and Veatch and Camp Dresser and Mckee joined TBP to form Ambric, which was appointed as engineer to the newly-established Cairo Wastewater Organisation (CWO).

Master plan

Ambric's first task was to review and update the master plan. It was completed in 1981, and substantially endorsed the intentions that followed the original findings: to establish two separate sewerage systems on the east and west banks of the River Nile to convey sewage to large treatment works located well outside the urban area. It was recognised that the major new works needed to supplement existing facilities would take a long time to design and construct, but there was an urgent need to improve existing conditions in which raw sewage regularly flooded into the streets in many parts of Cairo.

A priority programme involving sewer cleaning and the rehabilitation of major and subsidiary sewage pumping stations was put in place. The works were carried out between mid-1983 and mid-1986.

In parallel with the rehabilitation programme, design and construction of the Nile's east and west bank schemes proceeded. Substantial portions of the schemes were commissioned and put into service from January 1992 on the east bank and from October 1992 on the west bank. A supplementary programme to provide first-time sewerage to two million inhabitants on the west bank started in 1989.

In addition to implementation of the physical works, a post-construction support programme was initiated in 1987. This has involved training all levels of staff in the operating authority, the general organisation of sanitary drainage (GOSD), the institutional strengthening of GOSD, and the letting of operation and maintenance contracts for some of the facilities.

Outline of the project

Physical. The project is divided into two separate schemes on the east and west banks of the River Nile.

The main elements of the works on the east bank are:

- A 12km long, deep spine tunnel of 4m and 5m diameter, with 35km of interconnecting branch tunnels, flowing in a north-easterly direction to Ameria pumping station and generally routed under main streets below the existing sewers and metro system at depths of up to 22m, so that most of the existing sewers can drain by gravity into the tunnel system
- Two new pumping stations at Ameria,

one 32m deep and with a pumping capacity of 2.2 million m^3 a day serving the spine tunnel, the other, a screw pumping station of 0.56 million m^3 a day serving existing high-level collectors

- A 14km conveyance system from Ameria to Gabal el Asfar that allows the wastewater to be carried through large multi-barrelled box culverts and be lifted at intermediate screw pumping stations at Kossous and Khalag, and
- A one million m^3 a day capacity secondary treatment plant located at Gabel el Asfar beyond the urban boundary that will treat the east bank flows before discharge into the existing Belbeis drain, which flows 160km to Lake Manzala on the Mediterranean coast.

The west bank works comprise:

- A new Giza relief collector sewer discharging to the existing 0.33 million m^3 a day secondary treatment plant at Zenein that has been completely rehabilitated
- A new north-west collector from Embaba to Abu Rawash using multi-barrel culverts and pipes and with five in-line screw pumping stations
- A western collector serving the Pyramids area connecting into the new north-west collector at Junction pumping station,
- A new treatment plant at Abu Rawash, initially treating 400 000m^3 a day to primary standards and discharging its effluent into agricultural drains leading to the Rosetta branch of the Nile
- Sludge disposal lagoons located in the desert some 30km west of Abu Rawash and receiving raw sludge from both Abu Rawash and Zenein, and
- An extensive programme of property connections and lateral sewers covering an area of 1500 hectares in the unsewered areas of Pyramids, Zenein and Embaba and serving an eventual population of two million.

Organisational. The implementing authority for the project is the CWO, which was set up for the purpose by the Ministry of Housing and Utilities. The organisation responsible for the operation and maintenance of the facilities once they have been constructed, commissioned and handed over is the GOSD, which comes under the Ministry of Local Affairs. Ambric has acted as the engineer to it since CWO was formed in 1981, and has provided services comprising project management, studies, designs and tender documentation, tender assessment, construction services, training and operations and maintenance assistance. Ambric works in conjunction with two firms of Egyptian consultants, Sabbour Associates and Arab Consulting Engineers.

Financial. The project was able to proceed in 1979 when the governments of the USA and UK agreed to provide approximately equal grants of $100 million and £50 million respectively to assist the government of Egypt. The funding committed to date totals some $1.6 billion, made up as follows:

- Government of Egypt — 1.4 billion Egyptian pounds for all aspects of the work
- UK ODA grants — £70 million for consultant support and some east bank construction
- UK bank loans — £185 million for east bank construction
- US aid grants — $743 million for consultant support and west bank construction
- Italian grant/loan — $97 million for construction of Gabal el Asfar WWTP, and
- Euro loan — 53 million ecu for east bank branch tunnel construction.

Technical challenges

When the initial surveys of the existing system were carried out at the commencement of the project it was found that many of the main collectors suffered from chronic problems of siltation, necessitating a continuous programme of sewer cleaning. Deposition of silt had been a problem throughout the history of Cairo's sewerage system, although the sewers had been designed using internationally recognised hydraulic criteria that had been successfully applied elsewhere. Further investigation showed that Cairo's sewage contains an unusually high concentration of silt — up to 200mg/l compared with concentrations of one-tenth of this amount that are common in most Western countries.

Existing sewers had been designed too flat to be able to carry the silt loads

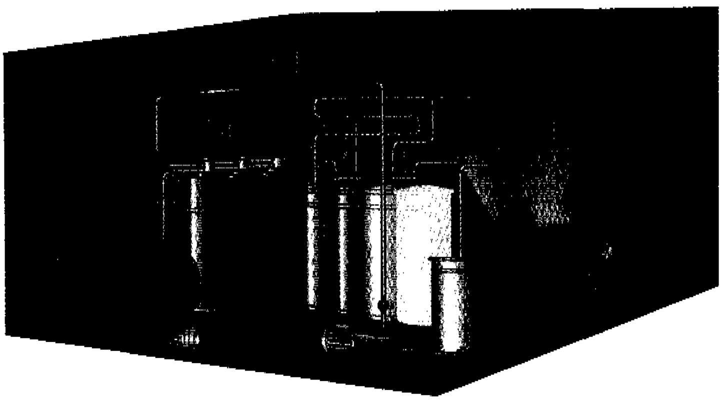
The conclusion reached was that the existing sewers had been designed too flat to be able to carry the silt loads experienced. The hydraulic design of the new works took advantage of recent developments in sediment transport theory and its application to piped systems. The Ackers White formulae were adopted and a computer program was developed for use on the hydraulic designs for the project. Using these criteria, minimum gradients of 1 in 1090 were established for the largest tunnels of 5m diameter and 1 in 950 for the smallest of 1.2m diameter. For comparison, the first main collector completed in the year 1913 with an internal diameter of 1.6m has a gradient of 1 in 2500.

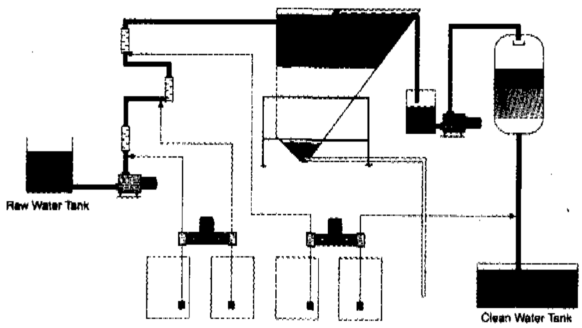
One of the effects of this increase of gradient for the sewers in a place like Cairo, with its very flat natural gradients, was that the sewers quickly became too deep for them to be constructed in open cut. The traditional solution was to design the system by dividing it into a large number of small drainage areas each served by a subsidiary pumping station to lift the sewage into a main collector. This was unsatisfactory, as the GOSD had great difficulty in keeping the stations operational, and costs were high.

Another major factor to be considered was the enormous disruption to traffic caused by the construction of large sewers by cut-and-cover methods. After a review of these matters it was determined that the major new collectors needed for the east bank would be chemapan c.c.

AQUAPAK

PACKAGE WATER TREATMENT IN AN ISO CONTAINER.
EASY TO SHIP/TRANSPORT. CONTAINER ACTS AS A PLANTROOM.
SYSTEM CAN BE RELOCATED.





Typical flow diagram of a drinking water plant

FLOWRATES:

6 metre (20 foot) 7 to 15m³/hr (Trailer systems are also available)

12 metre (40 foot) 18 to 36m³/hr

AREAS OF OPERATION:

- Raw river or dam water to drinking (potable) water.
- Brackish borehole/river water to drinking water.
- Large construction sites.
- Hotels.
- Factory effluent.
- Metal finishing effluents.
- Bottled water systems (including packaging.)

PROCESSES AVAILABLE:

- Pre-conditioning, clarification, filtration, chlorination/ozonation.
- Pre-conditioning, dissolved air flotation, filtration, sterilisation.
- Pre-conditioning, filtration, pH correction and desalination.

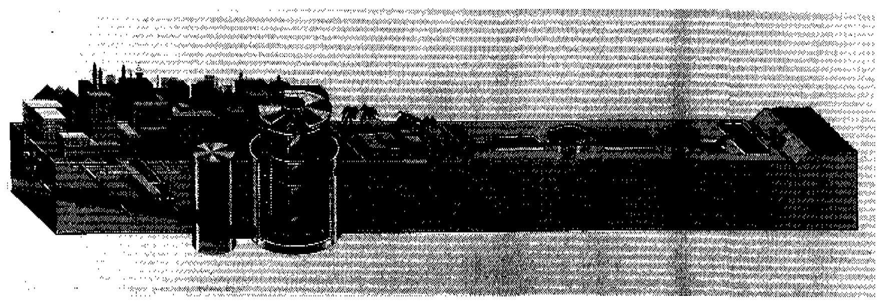
UNIT OPERATIONS AVAILABLE:

- Chemical make-up systems, agitators, metering pumps and inline mixers.
- Anionic or Non-Ionic polyelectrolyte twin chamber continuous make-up systems.
- Complete lime feeder, mixing and dosing systems.
- Unique conical sludge blanket settlers, with turbo design - up to $4m^3/m^2/hr$.
- Inclined plate settlers capable of rise rates of up to $8m^3/m^2/hr$.
- Single and dual media filtration.
- Cartridge filtration (Spun polypropylene cartridges/stainless steel housings).
- Activated carbon filters.
- Chlorination/bromination/ozonation.
- Reverse osmosis of brackish water.

PROCESS CONTROL:

- Process logic controller.
- Telemetry from remote sites for monitoring.

39 Naomi Street, Florida, Roodepoort, 1710, P.O. Box 6333, Ansfrere 1711, South Africa
Tel: 2711-674-4742, 2711-472-5789, 2711-472-2712 Fax: 2711-674-4743



Drawing of the Cairo wastewater project, showing the Ameria pumping station.

constructed in tunnels at a depth that would be below all existing services and below the planned metro. This strategy had the advantages that not only would disruption to traffic and the general life of the city be avoided, but all existing secondary sewers could drain into the new tunnel system by gravity, thus allowing the decommissioning of most of the subsidiary pumping stations.

As Cairo is located in the valley of the River Nile, most of the city is constructed on alluvial deposits of layers of sand, silt and clay. The water table is high, generally within one or two metres of the surface. The construction of tunnels up to 25m deep in these conditions is technically difficult and can be attempted only by contractors having the appropriate experience and expertise. The construction of the tunnels in Cairo has made use of the technology of slurry shield and earth pressure balance machines, combining the long experience of British tunnelling contractors with the latest technical developments from Germany, Japan and Canada.

Sustainability

It is now recognised by funding agencies giving assistance to major infrastructure projects that if the funds provided are related only to the capital works programme, the project might not meet its objectives. Much more emphasis is now being placed on ensuring that projects are sustainable in the long-term. Factors affecting sustainability are considered at all stages of the process, from planning through design and construction to operation and maintenance. The many provisions that have been made during the course of the Cairo Wastewater Project to ensure its sustainability include:

- Using deep gravity collectors with steeper slopes and fewer pumping stations to reduce problems of operation and maintenance
- Lining the major collectors with blue bricks to provide long-term maintenance-free protection against corrosion
- Locating treatment facilities at a few major works well outside the urban boundary so that they will not be in the way of building development and need to be relocated
- Institutional development of the operating authority, GOSD, and the training of its staff at all levels to ensure that the works can be operated and maintained in a proper manner, and
- The review and gradual raising of tariffs so that the operating authority will generate sufficient funds to meet the costs of operation and maintenance.

Benefits

Surveys carried out at the start of the project showed that regular flooding of raw sewage was occurring at more than 100 locations, mainly on the east bank of the city. This flooding was not only in residential areas but also in commercial and business districts. The commissioning of the new collection facilities in 1992 has had a dramatic effect on the frequency of flooding, which is now largely eliminated from most areas. This clearly has been of benefit both to the health of the population and to business and tourism. It is notoriously difficult to quantify such benefits; in particular, it is almost impossible to determine how much of the improvement in public health can be ascribed to the effects of the wastewater project and how much to other factors.

However, the environmental improvement due to the wastewater project now makes it much easier to mount an effective health education campaign. On the west bank, the provision of first-time sewerage to large areas has provided similar improvements to the public health and well-being of the population.

Although the River Nile provides a large and regular supply of water for the domestic, industrial and agricultural use of the people of Egypt, there is a continuing growth in demand. This, coupled with fear that additional upstream abstraction might reduce the availability of water to Egypt, has made the conservation of water resources a major factor in Egyptian government planning.

Although small in relation to the river flow, the effluent discharged from Cairo's wastewater treatment works nevertheless has significant potential for reuse in agriculture. The Egyptian government has adopted a policy to make use of this effluent, although the first-phase schemes involve discharge of the effluent into the agricultural drainage system. Some preliminary studies have been carried out that have looked at the options of either using the effluent for the reclamation of new areas of agricultural land from the desert or mixing the effluent with irrigation water to supplement existing supplies.

To date no firm conclusion on the best way forward has been reached, and further studies are planned to determine the most appropriate scheme, taking into account agronomic, economic and health factors. ■

Author

[illegible] is a senior partner of [illegible] Black & Veatch, in charge of the [illegible] environmental work in Africa, the Middle East and Central Asia. [illegible] involved with the [illegible] [illegible] project since its [illegible] [illegible].

Ozone generators for the next century

The main purpose of the industrial branch of Dixwell is to design, manufacture and sell ozone generators and asepticisation appliances.

DIXWELL INDUSTRIE

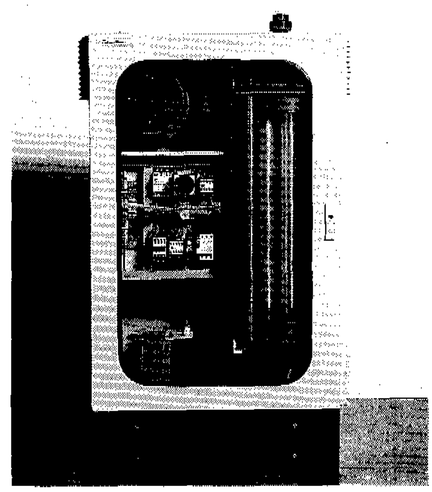
From the feasability study carried out in its own laboratories to the achievement of the plant, by way of a test-pilot if necessary, Dixwell has the ability to meet your company's requirements.

The ozone generators are available in two versions:

- Air cooling generator — from a few grams to 100g/h, and
- Water cooling generator — from 100g/h to 3kg/h.

The generators are used in the following sectors:

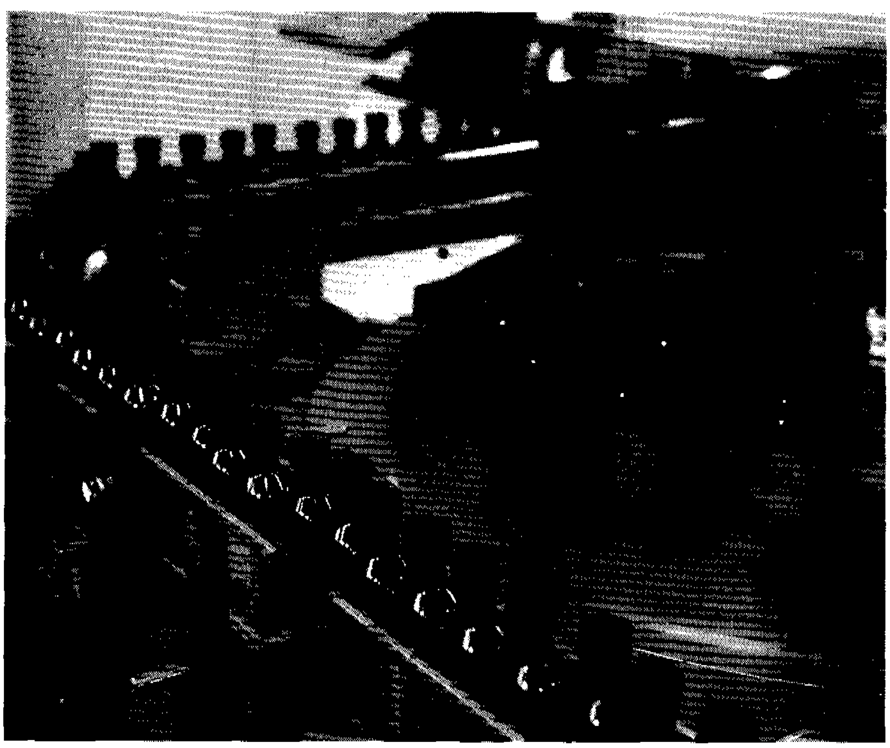
- Discolouration of wasted water, food processing industry, inks, papermaking industry
- Disinfection: security laboratories, pulling water, elimination of virus, bacteria, algae
- Reduction in COD: all kinds of wasted water
- Process: organic synthesis, elimination of dissolved metals (iron, manganese)



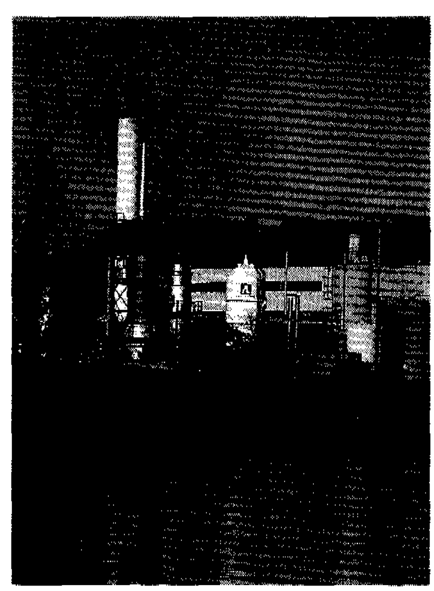
The Ozone generator.

- Aquaculture: fish farming, aquarium, and
- De-odourisation: sewage treatment plants, factories, industries.

The quality system developed by Dixwell conforms to the requirements of the standard ISO 9001 under AFAQ rules (No. 1995/3895). ■



Water - bottling plants use Dixwell Technology.



Sewage works with Dixwell.

Automatic pressure filtration by Larox

A Finnish company with headquarters and main production facilities in Lappeenranta, Larox is an international designer and manufacturer of environmentally friendly and energy-saving machinery and equipment for process industries and water treatment plants. It specialises in methods and equipment for solid/liquid separation, and valves and flow-systems for handling difficult fluid, slurry and bulk material.

LAROX GROUP

Automatic pressure filtration by Larox is a technically advanced and effective dewatering technology. The main advantage from the process point of view are dry cake, clear filtrate and effective cake washing ability. Larox equipment has sucessfully been used in mineral processing and metallurgical industries, in chemical and foodstuff industries, as well in pharmaceutical and pulp and paper industries throughout the world. Also in special, demanding, effluent-treatment aplications this technique has shown its capabiltiy to cost effecient, high-quality dewatering.

More than 440 Larox filters are currently in operation in different dewatering applications around the world.

Waste treatment

With industrial effluents, the problem is to separate liquid from solid. Pressure filtration technology creates possibilities for treating industrial and municipal sludges. Due to improved separation, handling of filter cake is easy. A bonus is efficient cake wash, keeping harmful substances from the environment. Companies throughout the process industry have raised production and lowered costs by using Larox pressure filters.

New Research Centre

Larox puts 10 per cent of its turnover into R&D. Its new 10 million FIM Research Centre contributes to an improved research service for customers, and to product development. The Centre supports both the solid/liquid separation business of Larox Oy and the valve business of Larox Flowsys Oy.

Better test filtration

A new laboratory will improve the capacity of Larox Oy's separation business by offering clients more versatile and reliable test filtration and research. In addition to laboratories, a mobile filtration unit and a Larox PF filter have been purchased to perform test filtrations at client sites.

Valves laboratory

Larox Flowsys Oy has always invested heavily in R&D for Larox valves, as demonstrated by the establishment of a new fully-equipped research laboratory. Its R&D equipment ensures development of better pinch valves for current applications and encourages study of new applications before field tests. The valve laboratory has pumping apparatus with an automatic data collector that improves testing and development of valves in flow situations resembling natural conditions.

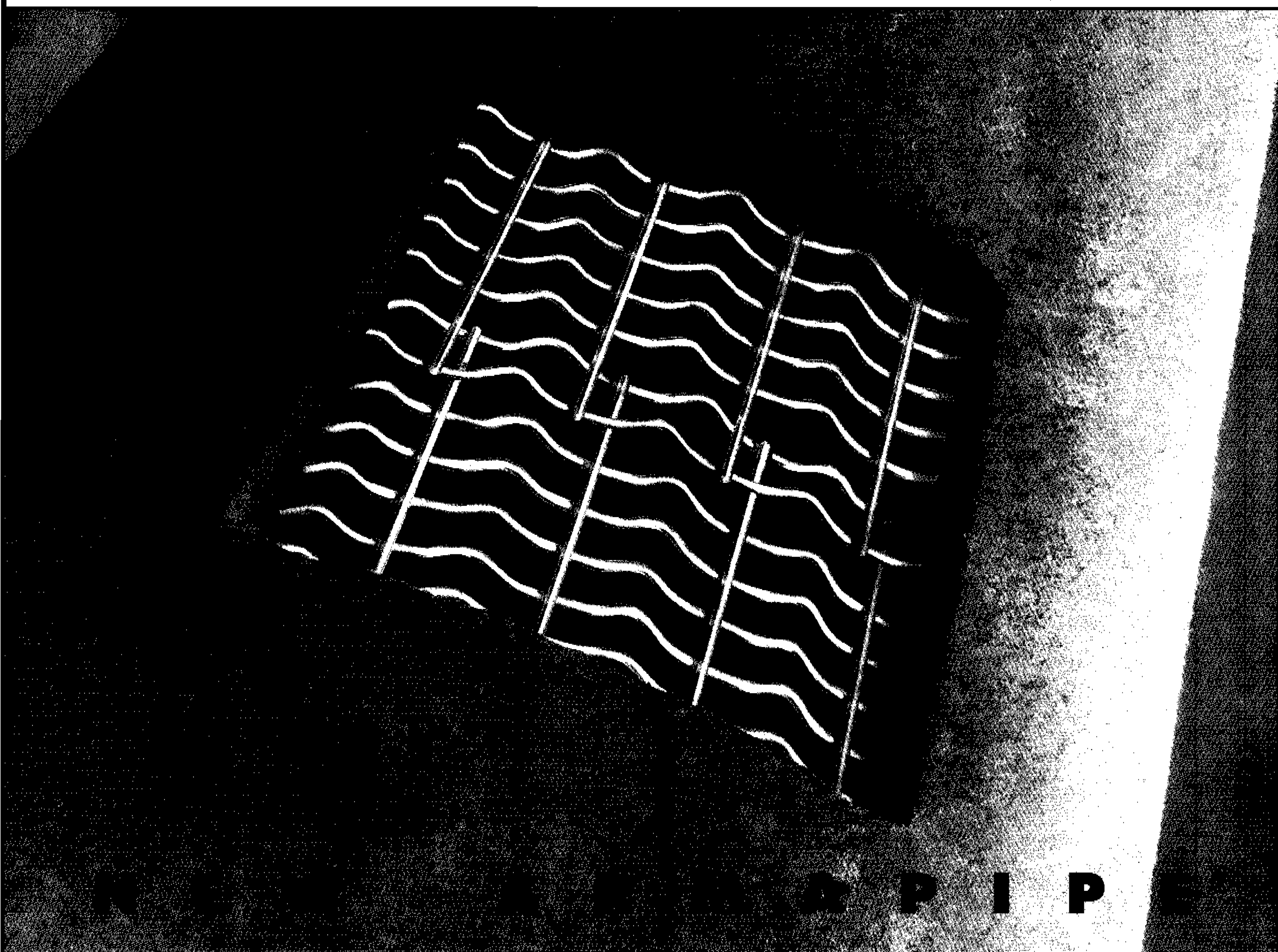
The Larox Group

Larox designs and manufactures equipment for the process industries. In addition to production units in Lappeenranta, Larox Group has subsidiaries and sales offices in Germany, England, France, Poland, USA, Canada, Mexico, Peru, Chile, Thailand, Australia and South Africa, and representatives in 34 other countries.

Larox Flowsys Oy

Larox Flowsys Oy, established in July 1993, has assumed operation of the valve department of Larox Oy as its subsidiary. The subsidiary makes it possible to focus on marketing valves for new client groups, improve R&D aimed at extending the range of products and their uses, and increase sales. Main market areas are Europe, North America and Australia. In the past year valves have been shipped to more than 30 different countries. The sales network for valves includes 40 countries, and is expanding. ■

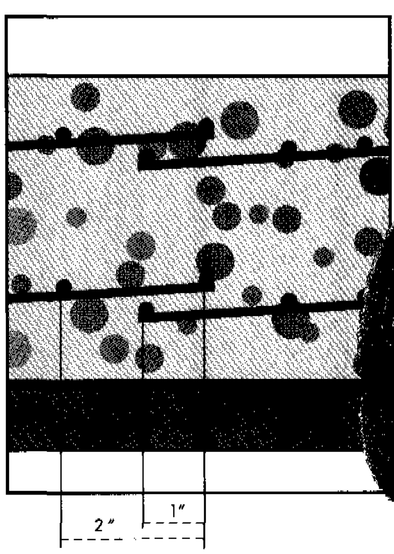
BEKAERT



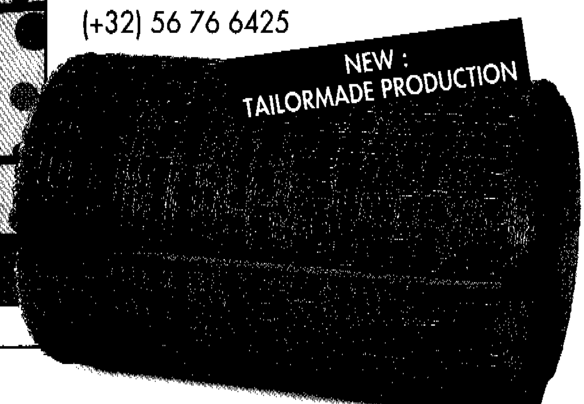
TAILOR MADE REINFORCEMENT FOR LONG-TERM PROTECTION OF CONCRETE COATED PIPELINES.

Shocks, blows, contraction and compression forces in a hostile environment, offshore as well as onshore...

NEW ARMAPIPE® offers a tailormade protection with exceptional coating advantages : • continuity uniformity and high bonding level to withstand impact • flexibility to minimize cracks during the laying of pipelines, • uniform compressive strenght, • hot-dip galvanized wire for a long lifetime of reinforcement.



For specific information and detailed technical documentation, call Marc Nys on (+32) 56 76 62 38 or fax on (+32) 56 76 6425



NEW ARMAPIPE® : A SPECIAL CONCRETE STORY FROM BEKAERT

NEW ARMAPIPE®: PATENT PENDING

New materials: a threat to metal tubes?

The water industry continues to be the sector in which non-metallic tubes and pipes are being applied most dramatically.

Mike Bennett *M G Bennett and Associates Limited, UK*

A 1985 survey in the UK showed that plastic accounted for just over 61 per cent of newly-laid pipes at distribution sizes and above. A similar survey compiled recently shows that plastics comprised more than 81 per cent of new installations.

Overall, the use of plastics in service-pipe applications is close to saturation at well over 90 per cent. Only for trunk mains and sewerage applications is their use still limited, but here again, the use of glass reinforced pipes is expanding.

There are four main types of plastic pipe used in the water industry and it may be useful to summarise their pros and cons, since some engineers have difficulty with the chemical names and associated properties.

1. Polyethylene (PE) has several forms: high-density PE (HDPE), which is strong but brittle, and low-density PE (LDPE), which is relatively weak but ductile. An improved form, medium-density PE (MDPE), introduced in the 1980s, is a good compromise between

Polymer designation	Polymer type	Year 1988	1989	1990	1991	1992	1993	increase 1987 to 1993(%)
HDPE	High density polyethylene	284	306	340	363	414	438	54.2
LLDPE /LDPE	Low density polyethylene	104	105	108	98	100	112	7.7
PP	Polypropylene	28	36	44	48	51	55	96.4
Pvc	Polyvinyl Chloride	1309	1285	1278	1307	1395	1390	0
ABS	Acrylonitrile Butadiene styrene	7	8	8	8	10	10.4	48.6
	TOTALS	1732	1740	1778	1824	1970	2005	15.8
	AT AN AVERAGE DENSITY OF 1.3 Kg / Tonne							
	EQUIVALENT, WEIGHT OF STEEL =	10392	10440	10668	10944	11820	12032	
	CONSUMPTION OF SEAMLESS and WELDED TUBE =				9994			
				Thousands of Tonnes				

Table 1. West European consumption of plastic pipes vs steel pipes.

POLYMER Designation	POLYMER Type	Jan	Mar	Jun	Sep	Dec	Yearly increase (per cent)
HDPE	High density polyethylene	391	376	398	559	707	80.8
LLDPE	Low-low density polyethylene	422	437	449	591	738	74.9
LDPE	Low density polyethylene	443	448	462	602	738	66.6
PP	Polypropylene	408	417	445	559	717	75.7
PS Genl purpose	Polystyrene	639	643	677	718	844	32.1
PS High impact	Polystyrene	680	684	718	760	886	30.3
PVC	Polyvinyl Chloride	496	503	529	612	686	38.3

Approximate price £ per tonne —1994

Based on information published by the British Plastics Federation.

Table 2. European prices of bulk polymers.

strength and toughness. Its site-handling and solvent-welding characteristics are good, and the joint can be stronger than the pipe, making thrust blocks unnecessary.

2. Polyvinyl chloride (PVC) is generally used in its unplasticised form (PVC-U). It is stronger than PE but more brittle, so site-handling and laying are trickier and site joints are usually of the mechanical type, requiring thrust blocks. The advantage is their light weight. There are now modified forms of PVC: molecular oriented (MOPVC) and impact modified (PVC-M or PVC-1), which is toughened by the addition of a second polymer.

Whereas metallurgists have almost exhausted the development of metallic products, polymer chemists are continuing to make big leaps ahead

3. Polypropylene (PP). Whereas metallurgists have almost exhausted the development of metallic products, polymer chemists, on the other hand, are continuing to make big leaps ahead — almost like alchemists. One such leap took place in Germany and Italy: the so-called Zeigler-Natta process for polypropylene. More recently chemists have succeeded in producing electrically conducting plastics and even plastic LEDs. The use of metallocene catalysts has even enabled "rubbery" plastics to be made, which, of course, means a very flexible tube.

4. Although glass-reinforced plastic (GRP) pipes have been around for some 40 years it is only recently that they have taken off. There are generally two types: centrifugally cast and filament-wound or pull-wound. Variable quality and susceptibility to damage was the bugbear, but modern techniques have overcome this. Lack of fire-resistance was another inhibitor to their use in such situations as oil rigs and platforms. Such resistance has been added, and GRP or GRE pipes are now used as fire mains on rigs. Their strength, lightness and chemical resistance is a big bonus in these applications. Their circumferential-to-end-load characteristic ratio can be altered by changing the filament winding angle relative to the pipe axis.

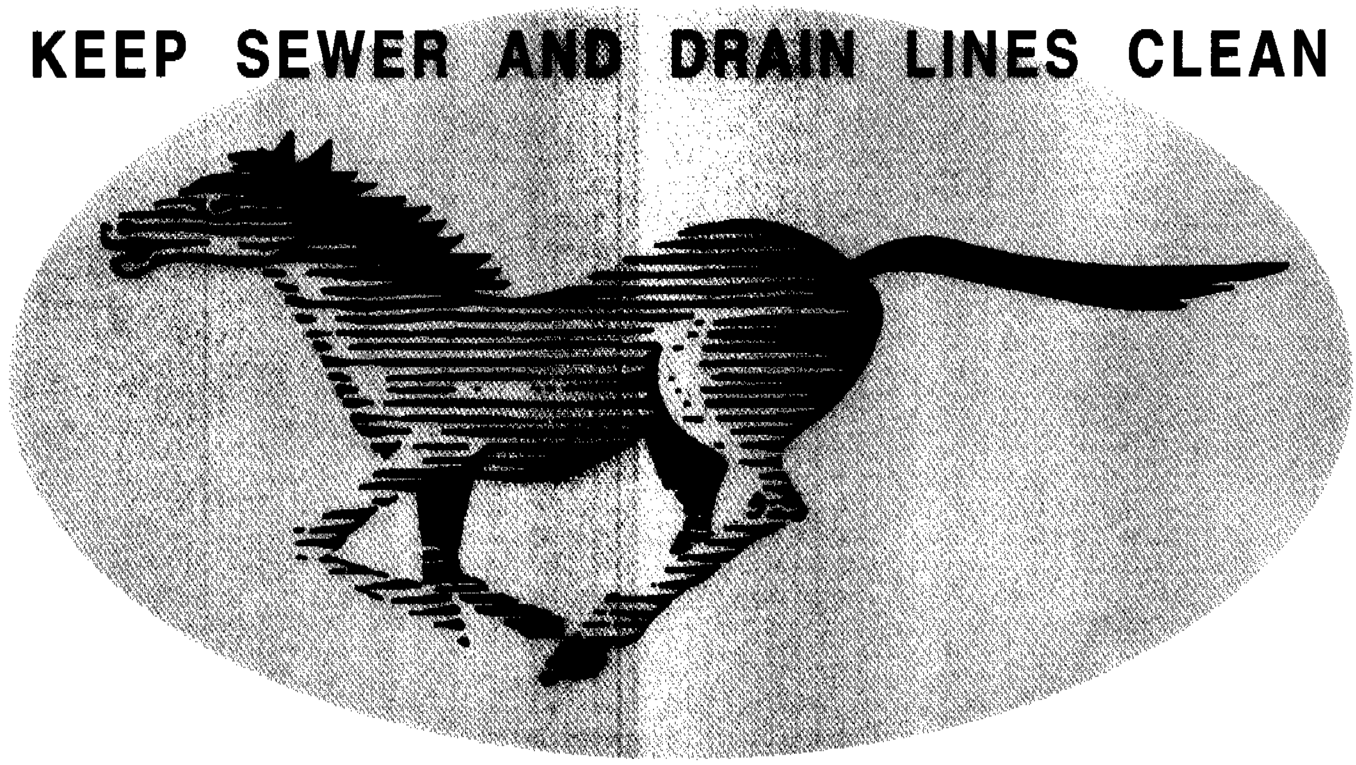
Cheaper, faster

The gas and oil industry is another application sector that is growing fast for non-metallic pipes. In the UK, gas distributors in urban areas have long been using the characteristic yellow plastic pipe, and now do so virtually exclusively. A partly government-funded development is under way in the UK to produce continuous lengths of non-metallic undersea oil and gas-carrying pipe for use on ships and on land. The use of thermoplastics permits higher production speeds and lower costs for a wide range of structural sections and pipes.

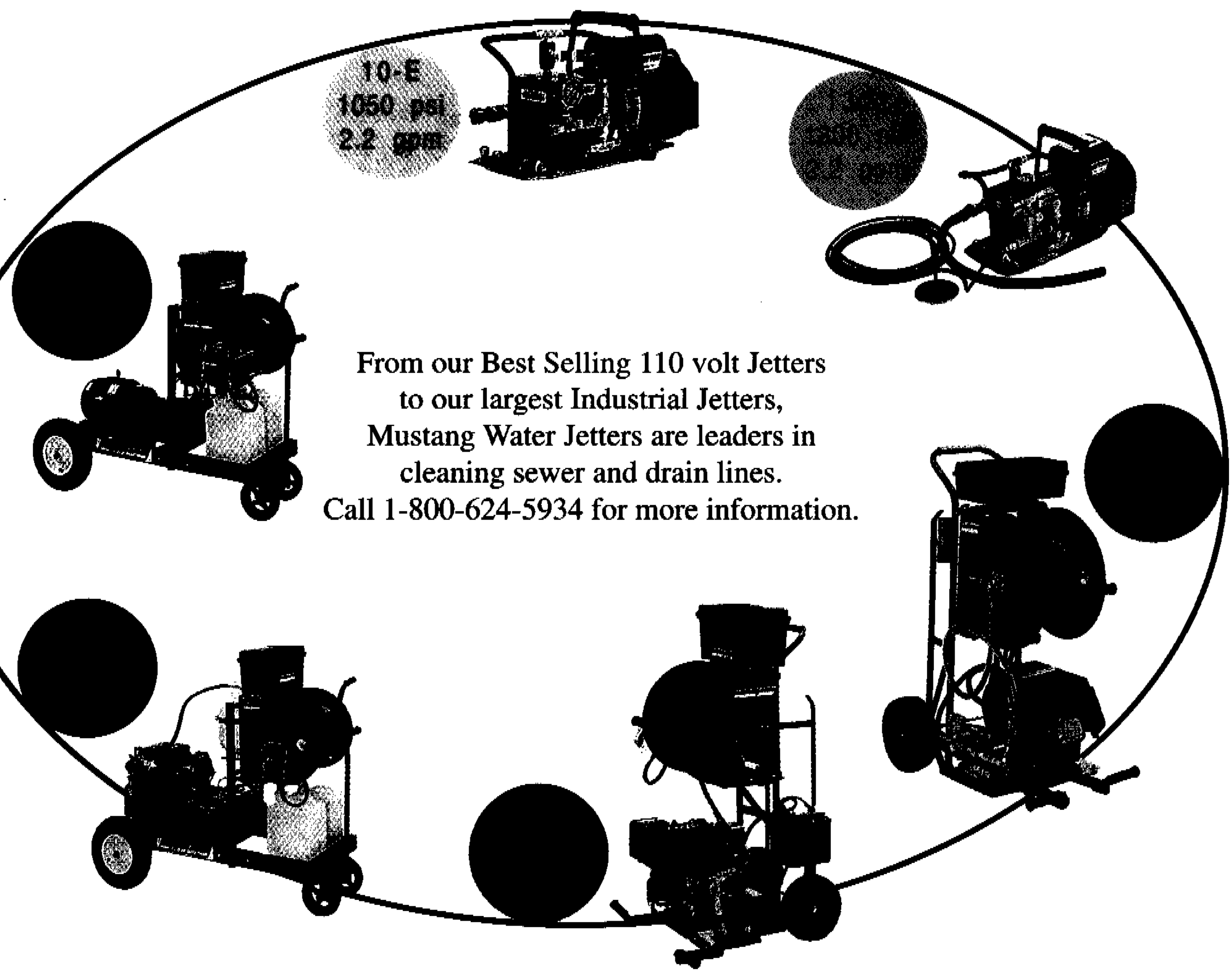
Offshore consultants MAI believe that the use of pull-wound pipelines for undersea oil transportation would lead to cost savings of about 13 per cent

The Japanese are pull-winding pipes mainly for electrical conduit, but Pultrex has made pull-wound pipe for use up to 50 bar. Up to 1.0m diameter pipe is available but at lower pressures than 50 bar. This technology should push the use of polyethylene pipes into high-pressure applications at present dominated by ductile iron.

KEEP SEWER AND DRAIN LINES CLEAN



YOU CAN ALWAYS "SPOT" A *MUSTANG*



Mustang Units Co. * 120 N. Scott Rd. * Eldridge, IA 52748 * 1-800-624-5934

Offshore consultants MAI believe that the use of pull-wound pipelines for undersea oil transportation would lead to cost savings of about 13 per cent.

Something should be said about costs, consumption and price of plastic pipes. Even in depressed times plastics production goes on upwards, albeit sometimes by only a small yearly increase, though the cost per tonne has also increased (see Table 1,2 and 3), particularly in 1994.

On the subject of plastics one should mention an interesting composite now being marketed. The trade name Kitec represents a small-diameter pipe system, which will be a big threat to copper. Kitec is light, strong, extremely malleable, retains its shape, can be buried, detected with a metal detector, comes in coils but does not have a "coil memory", will not support corrosion and overcomes problems of thermal expansion and low mechanical strength normally associated with plastic plumbing pipe. Kitec is less than half the weight of copper and much faster to install.

In the context of polymer chemistry alchemy, the following products have recently been formulated:

1. Plastics that conduct electricity — that is, the polymer itself, with a metallic atom bonded in the chain.

2. Light emitting plastic LEDs in the three primary colours. The blue plastic LED is a much more efficient emitter than current blue LEDs.

3. Truly elastic plastic — that is, having rubbery qualities.

What next? Surely a heat-conducting plastic. Such a plastic is likely to seal the death knell of copper tube and probably aluminium tube in such applications as air-conditioning units and radiators, eliminating metallic tube from the construction industry.

New ceramic composites allow hotter operating temperatures and could cut the world's energy bill by billions of pounds

Ceramics

Ceramic tubes are now beginning to impinge on the once-sure domain of metals (Table 4). Ceramics out-perform even the best metallic tube at high temperature and are becoming less brittle. Nor is it generally known that ceramic tubes transfer heat more efficiently than metals at high temperature.

To summarise the properties of engineering ceramics: they have high compressive strength, high specific stiffness and rigidity, retention of high strength at elevated temperatures, and high hardness and resistance to abrasion and corrosion.

Limitations of ceramics are that they can be brittle and susceptible to thermal shock (though this property is improving), and limited plastic deformation. They are also difficult to machine and have only fair impact resistance, though new tough varieties are being developed.

There are two main types:

1. Oxide ceramics (ionic bonding), with strongly bonded, closely packed atomic arrangements. They have high densities, strength and hardness and a very high melting point — such as 2770°C for zirconia (ZrO_2).

2. Non-oxide ceramics (covalent bonding) with very strong directional bonds and a more open atomic arrangement. These have lower density but good strength and very high hardness, with melting points around 1800–2000°C, such as for silicon nitride (Si_3N_4).

POLYMER DESIGNATION	POLYMER TYPE	YEAR 1987	1988	1989	1990	1991	1992	1993	INCREASE 1987 to 1993
HDPE	High density polyethylene	320	335	350	380	395	419	435	35.9%
LDPE	Low density polyethylene	550	550	555	540	524	524	544	-1.1%
PP	Polypropylene	416	460	500	510	500	535	568	36.5%
PS Genl purpose	Polystyrene	170	180	189	205	190	196	200	17.6%
PS High impact	Polystyrene								
PVC	Polyvinyl Chloride	550	590	620	615	566	572	604	9.8%
TOTAL of all PLASTICS		3012	3250	3446	3499	3375	3555	3668	21.8%
AT AN AVERAGE DENSITY OF 1.3 Kg/Tonne									
EQUIVALENT WEIGHT of STEEL:		18 072	19 500	20 676	20 994	20 250	21 330	22 008	
					Thousands of Tonnes				

Based on information published by the British Plastics Federation

Table 3. UK consumption of bulk polymers.

	Density gm/cm³	Flexural strength MPa	Youngs modulus GPa	Compressive strength MPa	Vicker's hardness MPa	Fracture toughness MPa/m 1/2	Poison's ratio	Melting point Deg C	Coefft. Thermal Expansion *10-6Deg C	Thermal conduction RT Wm-1per Deg K	Max useable temp Deg C
CERAMIC											
Al_2O_3	3.9	320	380	1800	1600	4.3	0.26	2050	8.3	35	1800
Si_3N_4	2.5	200	170	1000	1000	1.9	0.27	1830	3.2	10-15	1360
ZrO_2Ce-TZP	6.2	500	190		900	20	0.3	2700	10	2	800
SiC	3.1	450	410	2000	2000	4.5	0.14	2200	4.3	83.6	1400
METAL											
Aluminium	2.7	100–150	70	—	50-85	—	0.34	659	23	155	500
Copper	8.9	200–350	96	—	50–100	—	—	1083	17	144	—
High speed Steel	8	900	228	—	980	—	0.29	1400	12	50	1000

Table 4. Typical mechanical and thermal properties of engineering ceramics compared to metals ceramic.

Metallic ceramics

There are also ceramic composites such as particulate and fibre/whisker reinforced ceramics, glass ceramics and metallic ceramics including Cermet. Such ceramics allow hotter operating temperatures and could cut the world's energy bill by billions.

The race is on for toughened ceramics and, of course, at lower cost. While we may never see the old boiler tube ousted by ceramics, this phase of energy production will almost certainly be bypassed by machines burning gas directly, be it methane or gasified coal, and using ceramic components or composites.

A typical example is sialon, a silicon nitride alloy, which has a typical tensile strength approaching that of steel, a Youngs Modulus greater than steel and a Vickers hardness in the order of 2000 at temperatures greater than 1000°C. Again in 1990, Michael Breslin at Ohio University, USA, accidentally overheated a ceramic crucible full of aluminium, leading to the discovery of a composite of aluminium (25 per cent) and ceramic (75 per cent) stronger and stiffer than aluminium, especially at temperatures above 600°C: Al_2O_3. Applications are obvious, particularly in aerospace and energy. Even machinable ceramics are being developed.

Currently, weight for weight, ceramics are from three to eight times more expensive than even exotic high-temperature resistant metals (Table 5).

Thus this brief review points strongly to the fact that the metal tube market is either being taken over by plastics or being usurped by ceramics as tubes in new forms of energy production.

Strongholds still remain, such as for drill pipes and casings, engineering tubing, and air-conditioning tube, though even this might ultimately succumb.

For those die-hard metal tube enthusiasts who hope that the fossil-oil feedstock for plastic polymers will dry up in the not too distant future, it was said in the *New Scientist* recently that genetic engineering has now enabled a pilot experiment to be started — growing polymers on bushes in fields! ■

	Inconel 600	Ceramic	
	Heat resisting alloy Ni_3, Cr_{16}, Fe_8	Silicon Nitride – Si_3N_4 Reaction Bonded	
Outside diameter	7.5	5.0	8.0
Ratio	1.0	0.7	1.1
Wall thickness mm	0.7	1.0	1.5
Ratio	1.0	1.4	2.1
Weight per 10cm	12.7	3.1	7.7
Ratio	1.0	0.2	0.6
Price £ per 10cm	31.6	130	101
Ratio	1.0	4.1	3.2
Based on Goodfellow Metal's 1993 catalogue, UK.			

Table 5. Tube price comparison: ceramic vs super alloy.

Plastic piping systems for gas and water distribution

Georg Fischer can look back on more than 100 years of tradition in the field of gas and water supply. Georg Fischer played a pioneering part in the introduction of buried plastic piping systems for local supplies during the 1960s. Today, Georg Fischer is one of the most important suppliers in the world of plastic piping systems for the public utilities.

Georg Fischer *GEORG FISCHER ROHRLEITUNGSSYSTEME AG, SWITZERLAND*

Extensive knowledge of the needs and requirements of public utilities and piping system contractors have led to the provision of technically sophisticated and high quality systems for pressurised pipelines made of PVC and polyethylene (PE). Apart from selecting the suitable design and appropriate material for the pipe and fittings it is equally important to use the correct technique for laying the pipes. In the often very difficult site and weather conditions, one needs products which can be handled simply and which lead to a safe and permanent joint.

This fact is reflected in the comprehensive range of fittings and valves for pressurised pipelines made of PVC for water supply and of PE for gas and water supply.

These two ranges are supplemented by the mechanical joint products POLYRAC, PRIMOFIT, WAGA, and PVP.

The range: extensive and user-oriented

All the elements of this range are suitable for use with the pipes made of the appropriate material and in the relevant pressure stage, manufactured in accordance with the current ISO standards.

The centre piece of the range is, however, the all plastic PVC gate valve with dimensions from 63mm to 160mm. This unique product, which is available both in the push fit and the flanged version, is not limited to PVC piping systems. The use of PVC gate valves has proved successful in refurbishing existing cast iron supply networks.

This range is supplemented by the pull-out protected MULTI/JOINT coupling simplifying transitions from different pipe materials and diameters. It is used mainly for sanitation, repair and extension of gas and water piping systems.

The extensive PE range includes products for electrofusion, butt fusion and socket fusion as well as the necessary accessories.

For the PE pipelines which are now mainly used for gas distribution, Georg Fischer offers a revolutionary new range of electrofusion fittings in PE 100: ELGEF Plus. The ELGEF Plus system includes couplers, saddles with adjustable outlet, electrofusion elbows, tees, reducers, caps and transition fittings.

New standards in PE electrofusion technique

The electrofusion control unit MSA 3000, with its magnetic card control system, is based on technology of the future. By using an internationally standardised magnetic card, Georg Fischer succeeded for the first time in achieving transfer of all relevant fittings and electrofusion data from and to an automatic electrofusion unit by a single data carrier. The use of a barcode is also possible.

The EDP data storage in the memory inside the equipment makes the task of site documentation considerably easier and always guarantees that this data can be processed further at any time.

Additional functions which can be individually activated, such as the processing of the fusion record numbers or the allocation of the record data to an order number, clearly simplify site supervision, managing stores and material and site charges.

The flexibility of the magnetic card control system of the MSA 3000 control units is an additional feature of a continuous quality assurance system from resin to completed installation. The coded production series, street, location, operator also entered on the fusion record provides a continuation of the manufacturer's quality assurance on site. Thus an unbroken chain of traceability is automatically recorded.

Apart from the wide product range described, the comprehensive services offered in Schaffhausen/Switzerland and locally at the customer's is completed by intensive Georg Fischer consultancy and training services, because for Georg Fischer these services are an essential part of the "system idea". ■

A new player in water transport

Europipe, world leader in steel pipes for the manufacture of oil and gas pipelines, formally announces its entry into the water transport market.

Europipe, Water Mains

Founded in 1991 by the major French and German steelworks Usinor Sacilor and Mannesmann, Europipe is now the world leader in the manufacture of steel pipes for the transport of oil and natural gas.

In 1992 the general management of Europipe decided to diversify into the water transport market. Until that time, steel pipes had only been used on a small scale for the transport of water, in spite of their exceptional technical performances.

"We had three reasons for making this decision," explained Mr Georges Taiel, marketing director of Europipe Water. "First, we offer coated steel pipes of very high quality, particularly well adapted to the demanding market of water transport. Second, the water transport market in Europe has great potential: meeting the demands of the countries of Southern Europe, and reinforcement and renovation of the ageing networks in Northern Europe to make them safer. Third, going beyond the transport of water, the market for wastewater treatment is growing fast and represents a tremendous opportunity for the company."

With an annual capacity of 5 000km (which represents 2.5 million tons of large-diameter steel pipe), about 4.5 billion French Francs in turnover in 1994 and three production plants in Europe. Europipe intends to become one of the key players in the worldwide water supply market.

Europipe steel pipes

For many years, oil and natural gas companies have chosen steel pipes for the safety that steel provides against the often extreme risks to which a pipeline is subjected over its length and over time. Baron Haussmann made a careful choice in 1895 when he decided to use steel in the construction of the Avre aquaduct to supply drinking water to the city of Paris.

Landslides, erosion, washouts, excessive pressure, floods and other natural catastrophes, external pollution: even under the most severe conditions, welded-joint steel pipes prove their superiority.

Solutions from 80–2800mm

Europipe offers an extensive line of steel pipes with a great variety of diameters and with lengths of up to 18m in order to meet all the needs of the market for water transport and distribution.

A Europipe pipe for the transport of water consists of a steel tube (developed by Sollac in Fos-Sur-Mer or in Dunkirk), an exterior coating and an interior lining. These three elements are all made at the same production site (in Joeuf, Lorraine region) for optimal integration and are subjected to the strictest inspection procedures at every stage in their production.

The welded steel tube — the basic element of the pipe — is available in various thicknesses and can withstand high levels of pressure. It is capable of supporting the heaviest exterior loads, yet its flexibility allows it to adapt to geological movements, minimising the risk of breakage.

The interior lining of cement mortar provides passivation of the steel. It meets all standards for contact with food products and guarantees the potability of the water it carries.

The exterior coating of highly insulating thermoplastic adheres totally to the steel to supply excellent protection. It is highly resistant to shock as well as to ageing and chemical corrosion from the soil.

Pipes are assembled by interlocking and fillet welding, a system of unequalled effectiveness. Connection by slip-joints ensures the perfect continuity of the interior lining, facilities assembly and welding, and guarantees 100 per cent watertightness.

Flexibility of use

Steel can be used in many diverse applications and under any condition. This is why Europipe mains can be installed underground, overhead (overpasses, bridges, and so on) or underwater (siphon traps, drainage ditches, and so on). They can be adapted to any configuration. ■


Europipe steel tube before internal coating.


SO
LONG !
Choose
Owens-Corning
pipe for low cost.
The decision is yours.
And it's a difficult one.
So make it easy for yourself - choose Owens-Corning pipes. As soon as you're looking for the alternative with the lowest cost, Owens-Corning pipes are the obvious choice.
They come in long lengths and therefore fewer joints. Since they're so much lighter the laying costs are low. Once installed, you can forget about corrosion protection systems and their maintenance. Pumping costs will remain at a minimum level for long, long years to come. Why? Because our pipes hold their outstanding hydraulic performance over the life of the system.
If you require a superior material for water supply and sewer projects, think of us. For people like you whose decision is in the make, we make the difference.
Call Owens-Corning Pipe Operations and hear someone talking sense:
32 - 2 - 674 82 25
Fax: 32 - 2 - 674 82 23
So much longer - so much lighter.
OWENS CORNING
Owens-Corning Pipe Operations
178, Chaussée de la Hulpe
B 1170 Brussels

Reinforced polyester pipe for water and sewerage projects

Glass-reinforced polyester (GRP) pipe is becoming the material of choice for water supply and sewer projects worldwide.

R S Morrison *Owens Corning Global Pipe Operations, Belgium*

For more than 45 years, glass-fibre-reinforced plastic pipes have been used to solve the problems of corrosion in fluid conveyance. As materials technology has improved and as more advanced manufacturing processes have been introduced, glass-fibre pipe has been used in many sophisticated, demanding applications.

Oil field uses involving small-diameter pipe in pressures up to 200 bar became common in the 1960s. At the same time, the technology for manufacturing very large diameter pipe was quickly evolving. Diameters up to four metres and over are now possible. This opened the door to the power generation market, where large diameter pipes are used to convey cooling water, and to the worldwide public works market for conveyance of potable water, sewer water and other effluents.

Owens Corning has pioneered the use of a continuously advancing mandrel filament-winding process in conjunction with advanced laminate technology. These pipes have the high performance characteristics associated with all glass-fibre pipes, yet are offered at costs that are comparable to traditional materials commonly used in the price-conscious public works market. The worldwide family of Owens Corning pipe producers has now supplied over 8000km of pipe, a majority of which has gone into the public works market.

Glass-fibre pressure pipes are required to undergo long-term pressure tests to establish the hydrostatic design basis (HDB) in accordance with ASTM D2992. This involves the testing of at least 18 samples, with at least one to over 10 000 hours and statistically extrapolating the results to determine long-term (50 year) hydrostatic design stress or strain from which pressure ratings may be established. These ratings or pressure classes are determined by application of a design factor (inverse of the service factor) to the 50-year value. The minimum design factor for AWWA C950-88 is 1.8.

Glass-fibre sewer pipes (ASTM D3262 and ASTM D3754) must demonstrate long-term resistance to acid strain corrosion effects of 1.0 N (5 per cent) sulphuric acid. This concentration is representative of the most adverse conditions found in sanitary sewers, and glass-fibre pipe is able to withstand it even under considerable strain. Conventional materials deteriorate rapidly in such an environment.

A piping system includes not only pipe, but joints as well. Consequently, the performance capabilities of the joint must also be considered. ASTM D4161 gives the joint tightness requirements for the elastomeric seal used with glass-fibre pipe. The joint is subjected to a hydrostatic test pressure of twice the rated pressure class, or 70 kPa in the case of a non-pressure pipe, and to vacuum of -74 kPa gauge.

Owens Corning's joint venture operations in nine countries and licensees in five others have supplied glass-fibre pipe for many new water-supply projects around the world, including major projects in Germany, France, Norway, Spain, The Czech Republic, India, Thailand, Indonesia, China, Saudi Arabia, United Arab Emirates, Botswana, Argentina and the United States.

For example, on the new 41km Gabarone-Lobatse water-supply pipeline in Botswana, the contractor installed 400 metres per day for an average of 6km per month. According to a representative of the contractor, "That's twice the laying speed expected with six-metre lengths of ductile iron pipe".

What does all this mean to the specifier and end user? Glass-fibre pipes are easy to specify with internationally accepted standards. They are economical. They do not corrode, so costly protection systems and their maintenance are not required. They will maintain their favourable hydraulic performance over the life of the system, so pumping costs are kept to a minimum. Glass-fibre pipe's long lengths mean fewer joints, and its light weight translates into lower laying costs versus other materials. The elastomeric gasket virtually eliminates any infiltration or exfiltration through the joint. Selecting glass-fibre pipe will often represent the alternative with the lowest life cycle cost. ■

All you want to know about valves

There are at least six different designs of valve in use in the water industry each with its own specialised function. Incorrect selection of the type to be used may lead to poor performance or even mechanical damage. Valves show distinct modes of failure in drinking water. Lack of proper maintenance can lead to major operational problems.

Dr R J Oliphant *WATER RESEARCH CENTRE (WRc)*

The basic purpose of a valve is to affect the flow of liquid through a pipe. There are at least six different types of valves used in water supply, each with their different functions.

Gate valve. Commonly called a sluice valve or, when used on a pipeline which drains some form of water reservoir, a scour valve. A sluice valve is a simple on/off device used to isolate a section of line. It works by lowering a gate (or obturator) into the water channel of the valve body that forms an integral part of the pipe line. A sluice valve is not meant to act as a flow regulating device (although some people unwisely use it as such). This is because the flow of water is only reduced over the last 15 per cent of the gate's travel to the fully closed position. (Prior to that point the water disobligingly speeds up to get through the decreasing cross-section of the water channel.) The last 15 per cent of travel gives only a very coarse control and such high local water flows are generated that the metalwork suffers mechanical erosion.

Butterfly. The butterfly valve is the general purpose flow control valve for water supplies.

In this valve the obturator is basically a disc that swings around its vertical axis (it is not lowered vertically into position as in the gate valve). In some valves the basic disc shape (when viewed from the side) may have a bent gull-wing shape when viewed from above. Whatever the detailed shape, the basic idea is to produce a gradual reduction in the effective pipe bore as the disc swings through 90° from the fully open to the fully shut positions. This design of valve is far more effective at achieving this than the gate valve. Butterfly valves are used in treatment works but rarely in pipelines.

Penstock. These valves are found at the ends of pipelines. They are a form of gate valve where one half is missing, that is, the section downstream of the obturator does not lead to another pipe section. Instead, this section is open to the reservoir or whatever structure is downstream.

Reflux valve. This is often another form of terminal valve, but in this case its sole purpose is to prevent the backflow of water should the pressure in the pipe fall. This is achieved by a swinging obturator that the water pressure can push open one way but which closes when the flow reverses.

Needle valve. This is a high precision flow-control device used in such places as lines dosing treatment chemicals at water works.

They work by pushing a tapered bar (the needle) into a conforming tapered cylinder. The forward motion of the needle gradually reduces the water channel and so controls the flow. As this reduction can be made to occur over a long travel distance of the needle, a greater sensitivity of control can be achieved than with an equivalent butterfly valve.

Air valve. An air valve only indirectly controls flows in pipes; its primary purpose is to allow air bubbles entrained in the transported water to escape from the system.

These valves are situated above the pipeline at high points in the system where air in the line will collect. They contain a ball shaped float that normally, while the main is full of water, seals a vent out of the top of the valve. When sufficient air has collected, the weight of the float cannot be supported and it falls out of the vent. The trapped air immediately escapes and the rising water levels reseats the float thus preventing the loss of any water.

Mixtures of air and water can move at faster rates in pipes than water alone (the air has a lower viscosity and, in a manner of speaking, lubricates the movement of the water). Where such mixtures run into bends or restrictions in the line, they can crash into pipework with such force (waterhammer effect) that pipes can be broken. By removing the air from the line, air valve outlet, designed to achieve a constant reduced pressure at a remote point. Adjustment is made according to

A twenty-seven inch valve after 80 years in contact with an aggressive water.

flowrate, pressure at the remote point, or by time of day. The pressure modulating type allows pressures to be closely matched to the characteristics of the distribution system, and can reduce leakage further than the fixed outlet type.

The way valves deteriorate

The gate valve is the most common type of valve in the water industry. As an isolation valve, it is used infrequently and spends most of its service life in the fully open position. As a consequence, the maintenance of such valves is often neglected.

Being substantial structures with generous wall dimensions, valves rarely fail through leakage; they fail in operation by jamming. The valve's internal structures project into the water channel producing local turbulence and enhanced corrosion rates.

In gate valves, these structures not only include the lower segment of the gate, which in the older designs cannot be fully removed from the water channel, but also most crucially the gate guides. The build-up of corrosion product (tuberculation) on these internal surfaces creates a resistance to the operation of the valve and, if excessive force has to be applied to overcome this, the spindle may become bent or the guides break free of the valve body.

There is also enhanced (dissimilar metals or galvanic) corrosion between the cast iron of the gate and the phosphor bronze rings that run around the rim of its upstream and downstream faces. The purpose of these rings is to achieve a watertight seal when the valve is closed.

There are various sophisticated techniques involving the use of radioactive isotopes to assess the condition of a valve without having to remove it from the main.

Neglected valve maintenance — the nightmare scenario

A failure occurred in one of the pipes of a three main system, parts of which dated back to the third quarter of the nineteenth century. Of the 20 valves in the system, 18 were successfully closed; all the spindles were bent but the valves were closed. In the process it was discovered that some had clockwise rotating closure mechanisms but others had anti-clockwise, (it is important to be sure which way the mechanism turns before applying extra force if the gate appears stuck). Also, the pitch of the screw on the spindles of the valves varied, which again could be important where the degree of closure can only be judged by the number of times the spindle has been turned. (When the gate becomes stuck should extra force be applied or is it in fact already fully closed?)

Of the two valves that could not be closed, one controlled the supply of water to one of the unbroken mains and the second controlled one of the cross connections from this to the failed main. Thus the latter, although isolated from its direct connection to the supply, continued to leak water at a high rate. The force of this escaping water started to undermine the successfully isolated third main, so this was closed down as a safety precaution. Thus, for the want of maintenance of valves, the failure of a single pipe led to the operational collapse of the whole system.

Given the crucial part they have to play in the control of pipe systems, valves need to be maintained so as to be reliable in operation at any time. Even a moderate risk of jamming during operation is not acceptable. That being the case, the service life of a valve is probably only 60 years. ■

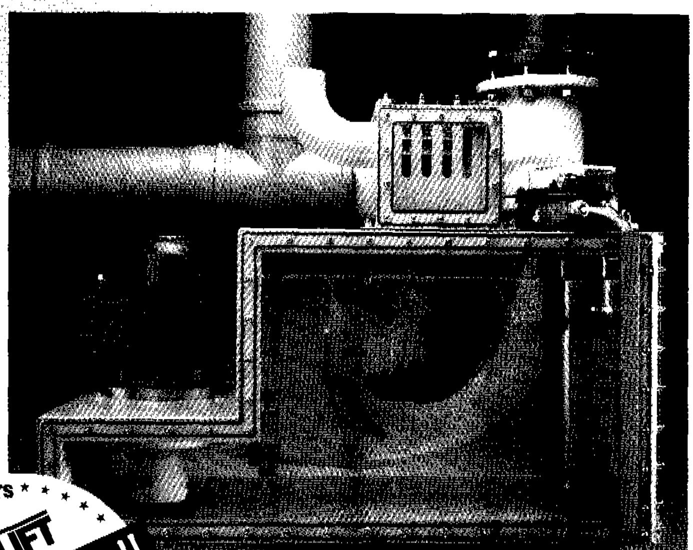
Author

Dr R J Oliphant is a technical specialist in corrosion at the WRc laboratory in Swindon. He is a contributor to various standard reference books on corrosion and has acted as an expert witness in legal disputes.

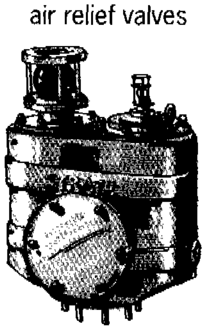
The Original!

AWALIFT

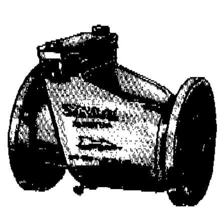
Sewage Lifting Installations.



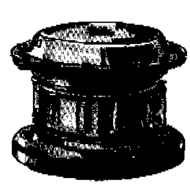
BEV
Ventilation and
air relief valves



AWASTOP
Non-return flaps



EVA
Starting relief
valves



STRATE AWALIFT sewage lifting installations are designed for use wherever there is no natural gradient to aid the feeding of sewage into the sewer network or to a central sewage works. What makes AWALIFT stand out from other systems is its special use of a rotary pump and a blocking matter receptable. This guarantees blockage-free operation and minimal maintenance costs.
Ask for further details.

STRATE GmbH
Hildesheimer Straße 350
D-30880 Laatzen · Rethen
Phone 0 10 49 51 02 70 01-0
Fax 0 10 49 51 02 70 01-12

STRATE®
Maschinenfabrik für Abwassertechnik

Sewage and stormwater pumping

Sewage and stormwater pumping stations and their systems design, including rising mains, allow for many design variations. Sewage pumping units with submersible electric motors simplify not only the whole construction but also the operation itself.

Vladimír M Vondra *SLOVAK TECHNICAL UNIVERSITY IN BRATISLAVA*

Sewage and stormwater pumping have some problems related to the design of sewage pumping units. For example, there is a limit to the total head, which is about 50m of wc at the QH-characteristic with maximum efficiency. The sewage pumping unit with submersible electric motors is designed for both wet and dry wells. These units are compact and robust with specially designed impellers for a long operating life. Where the total head to be overcome is greater than the capability of a single submersible pumping unit, two such units can operate in series. The first pump is installed in the wet well in the conventional manner and the second in the annex inside the well above normal top water level (NTWL). In this manner total heads of approximately 80m can be achieved.

The hydraulics of impellers often do not allow the reduction of the impellers diameter to exactly join the requested operating point (A) of the hydraulic system. Operating point (A) is the equilibrium between the necessary pump head (H_{man}) and the rising main total head (H) for the required nominal discharge capacity (Q_n). The impeller diameter cannot be reduced, not only because of blade design, but also due to the hydraulics of the impeller concept. If we reduce the diameter of the impeller, the hydraulics and balance will be disturbed and, as a consequence, the efficiency of the unit will drop below the expected level.

Direct and indirect throttling

In a situation where the operating point (2) has a total head (H) that is too high for smaller DN of the rising main and a total head (1) that is too low for larger DN of the rising main, it is possible to use larger DN of the rising main and by the isolating valve on the pump discharge throttle the discharge capacity of the pump into the right operating point (A). Direct throttling is expensive because it unnecessarily destroys electric energy (ΔH can be throttled). In these cases indirect throttling can be used. Two or more different DN of the rising main are used, connected in the series shown in Figure 2. This is indirect throttling. When we use the rising main with DN D_1, we will need QH-characteristic which will connect operating point 1 (with total head, H_1). If we use the rising main with DN D_2, we will need QH-curve which will connect operating point 2 (with total head H_2). It is located above our QH-curve. Therefore, we will use a compound rising main with two

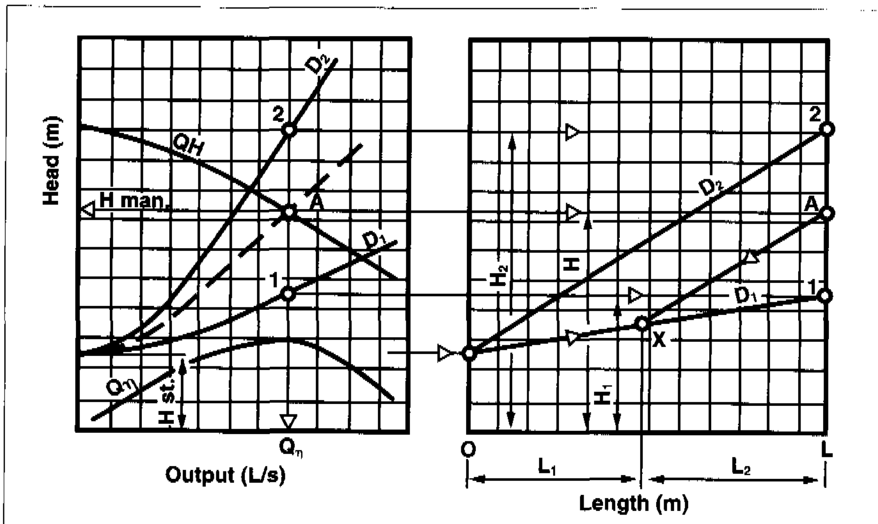


Figure 1. Typical QH-diagram of a hydraulic system. The graphic solution of indirect throttling by a compound rising main.

different DN: D_1 with length L_1 and D_2 with length L_2, as it is shown in Figure 1 with a simple graphic solution. Obviously we will save a lot of capital (initial) cost when we use a compound rising main (with operating point A). The savings far exceed the sum which will be used for pumping with a higher head (H — H_1).

Double-speed electric motors

The controlled discharge capacity of the centrifugal pump by a variable speed with frequency converter is a very economical process. But the frequency converter is still too complicated and expensive. Therefore we are looking for cheaper equipment. A cheaper alternative is to use a double-speed electric motor for the hydraulic system. In cases of sewage pumping stations it is possible to use lower speed for standard pumping between top water level (TWL) and bottom water level (BWL) and higher speed for pumping when the water level reaches flood alarm level (FAL) or maximum storm water level (MSWL). Indeed, a suction main, valves and discharge pipes and valves can be dimensioned for a larger capacity of pumps, because of flow speed. Operating point (1) is reached by solving two equations:

(1) $H_{man} = H_{st} + k.Q^2$
for the rising main

(2) $H_{man1} = n_1^2 . A + n_1.B.Q + C.Q^2$
for the centrifugal pump

and operating point (2) is reached by solving the following equations:

(1) $H_{man} = H_{st} + k.Q^2$
for the rising main

(3) $H_{man2} = n_2^2 . A + n_2.B.Q + C.Q^2$
for the centrifugal pump

The general solution of both equations for operating points with different speed are:

(4) $$Q = \frac{(n_i^2.A + n_i . B - H_{st})}{(k - C)}$$

(5) $$H_{man} = H_{st} + k.\left[\frac{(n_i^2.A + n_i . B - H_{st})}{(k - C)}\right]^2$$

where H_{st} k, A, B and C are identical constants for equations (1, 2 and 3), n_1 = 9601/min and n_2 = 1460 1/min. Total efficiency will remain the same for lower and for higher speeds (Figure 2).

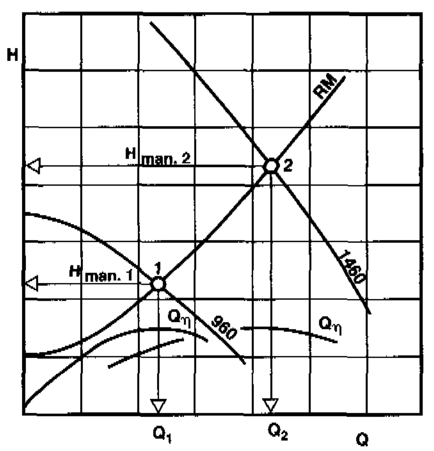


Figure 2. Typical QH-diagram of a hydraulic system where a pumping unit with a double-speed electric motor operates.

Single-speed pumping units operating in series

The controlled discharge capacity of centrifugal pumps operating independently or in series is useful when the difference between the capacity of one pump (Q_{1P}) and two pumps (Q_{2P}) is not too big. The equation for two similar pumps in series operation:

(6) $H_{man} = n^2.(2A) + n. (2B).Q + (2C).Q^2$

in cases where the rising main characteristic is steep enough (Figure 3, RMD_2). When the rising main characteristic is flat (RMD_2) units operate in series with lower efficiency than was expected (point 1 and 2, Figure 3).

Multi-speed pumping units

Previously, it was decided to use variable speed to control the discharge capacity of a centrifugal pump. We must analyse our hydraulic system (suction reservoir, pumping station, rising main, discharge reservoir) from this point of view. The operating range can be determined precisely because it depends on the rising main QH-characteristic. When the system static head (H_{st1}) is high and the system dynamic head ($H_{d1} = k_1. Q2$) is flat, the operating range is between 75 per cent and 100 per cent of speed. When the system static head (H_{st2}) is low and the system dynamic head ($H_{d2} = k_2 . Q^2$) is steep, the operating range can be between 45 per cent and 100 per cent of nominal speed. In the first example the operating range is 25 per cent. In the second example the operating range has to amount to 65 per cent. In comparison with a double speed electric motor where the operating range between both speeds represents 34 per cent. No doubt, it is not continuously running, but it is much simpler for use in heavy field conditions and it is cheaper. After this we may seriously decide whether we will use the variable speed or not. A

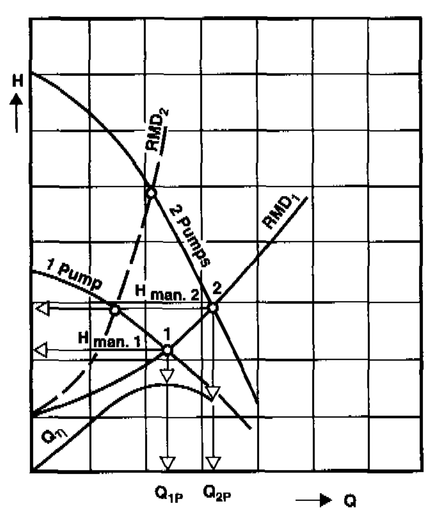


Figure 3. Typical QH-diagram of a hydraulic system of two single-speed pumps operating independently and in series.

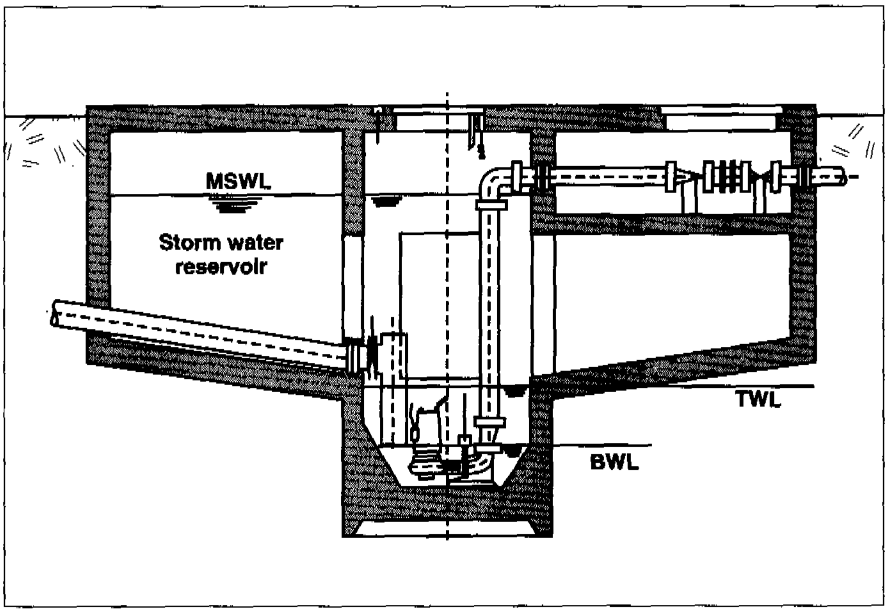


Figure 4. Typical arrangement of a sewage and stormwater pumping station with sewage pumping units with a submersible electric motors installation.

frequency converter is expensive when it is not necessary for a hydraulic system and not expensive if we need it there.

Stormwater accumulation tank

Sewage pumping stations that have installed pumping units with submersible electric motors have many advantages. For example, the pump and motor form an integral unit that operates fully submerged in the sewage collection well, and the units automatically connect and disconnect from the discharge pipework whenever they are raised or lowered from their stands.

Due to the significant economy in construction of the single well for submersible pumping units this type of station has largely superseded the wet well-dry well pump station. Submersible pumping units are generally suitable for flow rates ranging from Q = 10 l/s up to Q = 500 l/s, providing head does not exceed H_{man} = 50m. However, if it is necessary to use pumping units of much greater capacity (Q) and higher head (H_{man}) they are now available and have been used selectively.

The diameter of the wet well depends directly on the inflow rate and the number of pump starts an hour (the acceptable number is generally 10 an hour). The minimal diameter of the wet well is 1800mm, because it allows personnel to move around the machinery. The distance between the bottom water level (BWL) and the top water level (TWL) can be 1000mm at minimum. The maximum design flow to be pumped is the peak wet weather flow (PWWF) contributed by the catchment and is usually equivalent to 6–8 times the average dry weather flows (ADWF). Flows in excess of this can be pumped when stormwater accumulation tank (see Figure 4) is full at a higher speed of the double speed electric motor. The well with the additional stormwater tank (Figure 4) shows how the simple construction of the wet well can be used to solve this problem. Normal sewage water is pumped from the smaller diameter of the wet well in the bottom of a civil structure (between TWL and BWL). Pumping units are used at lower speeds which are suitable for nominal capacity (Q). When the water level continuously increases up to the maximum stormwater level (MSWL) the automatic controlling system has to increase the speed and the pumping units transport stormwater at a larger capacity.

Conclusions

Sewage and stormwater pumping stations and their systems design, including rising mains, are an interesting field even for experienced engineers because alternatives allow many design variations. Sewage pumping units with submersible electric motors simplify not only the whole construction but also the operation itself.

Demand for simple capacity control and anti-hammer protection can make some problems. The capacity controls the system because there are few alternatives and they must be selected in an optimal manner specific to each case. For example: a hydraulic system with the total head (H_{man}) where the static head (H_{st}) predominates, has only a small chance for the use of a frequency converter for capacity control. On the other hand the hydraulic system where the dynamic head (H_d losses) predominates in total head, there is a much better chance for the frequency converter installation.

Anti-hammer protection is reduced to use in a heavier class of pipeline instead of the standard one, because we cannot use the standard equipment as an air-chamber is. We can use a fly-wheel but in a very limited number of examples (up to 800m long rising mains). ■

References

1. Vondra V M (1993) *Contribution for Solution of Some Problems of Pumping Systems*, Inaugural Dissertation.
2. *Manual of Practice Sewage Pumping Station Design* (1986) PWD of NSW.
3. *Manual of Practice Sewer Design* (1986) PWD of NSW.

Author

Vladimir M Vondra received his Masters Degree (1958) and PhD (1993) in Mechanical Engineering Faculty from Slovak Technical University in Bratislava (Slovakia). He worked for more than 17 years for the biggest European pump manufacturer, Sigma (Czecho-Slovakia) and also in other parts of Europe and in Turkey, Iraq and Kuwait. In 1982, he become a director of Hydroconsult Pty Limited a firm of Consulting Engineers in Sydney (Australia). In 1992 he returned to his Alma Mater as an Associate Professor for Design of Pumping Systems and Hydro Power Plants. He is a Fellow of IEAust and IDiagE(UK) and Member of ASME and vice president of SASI.

WATER IS THE ONE THING NO LIVING CAN DO WITHOUT...

- GRUNDFOS PUMPS MAKE SURE IT'S THERE!

We all depend on access to fresh water, but not all of us have it flowing right in front of our noses.

Grundfos have developed a whole range of pumps especially for extracting fresh water from wells of any size and any depth. Grundfos pumps are designed for years of troublefree operation in the most difficult circumstances. With our solar powered pump systems we can even provide water where there is no electricity or other sources of power.

Contact us if you want to know more about Grundfos pumps for water supply.

GRUNDFOS®

Leaders in Pump Technology

Europe - Tel. +45 86 68 14 00 · Americas - Tel. +1 209 292 8000 · Middle East - Tel. +971 4 815166 · Asia/Pacific - Tel. +61 834 00200

A5 MARKETING A/S

Anniversary present: five solar units

Thousands of people in Uganda get easier access to water — thanks to donations.

GRUNDFOS

Five new solar-driven pumps from Grundfos will make life easier for at least 2500 people in Karamoja in Northeast Uganda. These solar units are paid for with money given by donations to celebrate Grundfos' 50th anniversary. Grundfos itself will donate the pumps. Many people met Grundfos request of giving money to "Folkekirkens Nødhjaelp" (The Danish Church aid organisation) instead of giving presents to Grundfos. A total of 416 000 DKK were given and it will be used for 100 solar panels which, together with five Grundfos SP3A-10, will be installed in three schools, one hospital and one health centre. The project will be organised by Grundfos, "Folkekirkens Nødhjaelp" and the Lutheran World Federation, who together have selected the five recipients on the basis of need and technical possibilities.

Two handpumps for 600 at hospital

Kizoto Hospital is situated about 35 km southeast of Moroto in dry bush-land. It has 244 beds which are always fully occupied and an unknown number of patients who arrive on foot. As the patients have to take care of their own cooking and washing, each of them brings along at least one relative and so at least 600 people use the hospital's water supply every day. This consists of one well and two handpumps which will now serve as a supplement to the solar unit in case of cloudy weather.

650 pupils save one kilometre

The 650 pupils of Kangole Girls Primary School in Kizoto, run by a Catholic organisation, have to fetch water from two wells about one kilometre from the school. A pump driven by a generator in one well is functioning successfully but it costs about $1000 a month to keep it going. The other well is connected to the school with a pipe system but the electric pump in the well is defective. Fortunately the hole is ideal for a solar unit.

Health centre gets running water

Nabilatuk Health Centre is situated in a very dry area about 65 km south of Moroto. This protestant health centre, run by the Church of Uganda, houses 500 people who share one hand pump with the people living nearby. A solar unit will make it possible to run water through pipes into the centre. Nabilatuk also has a school, the Namalu Mixed Primary School, with 400 pupils. This school and a village nearby are provided with water from three hand pumps. Some 100m from the school there is a reliable well with a high water level. This means that only a few solar panels are needed to provide plenty of water. The Headmaster of the school is very interested in the solar project as he wants to have water installed in the school building when pupils will live at the school from the start of the next school year.

School wants to grow vegetables

St Mary's Primary School in the opposite part of Nabilatuk has 230 pupils. However, when teachers, craftsmen and gardeners are included 360 persons are connected with the school. They are all interested in getting a solar unit which will only need a few panels as this well, too, is reliable with a high water level. A solar unit would facilitate systematic watering which would make the school self-sufficient in fruit and vegetables. ■

Photo by Arne Skov Ladegaard.

The solar units will primarily replace handpumps.

Mission-Fluid King

MISSION-FLUID KING

A tradition of excellence
Mission-Fluid King has earned its reputation through decades of manufacturing quality pumping products.

The toughest jobs
Mission-Fluid King pumps and expendables have proved themselves superior in difficult applications entailing extreme pressures, high temperatures, and corrosive environments.

Comprehensive support for the groundwater industry
Mission-Fluid King supplies a broad selection of duplex mud pump fluid end expendables including pistons and rods, liners, valves, seats, seals and packing.

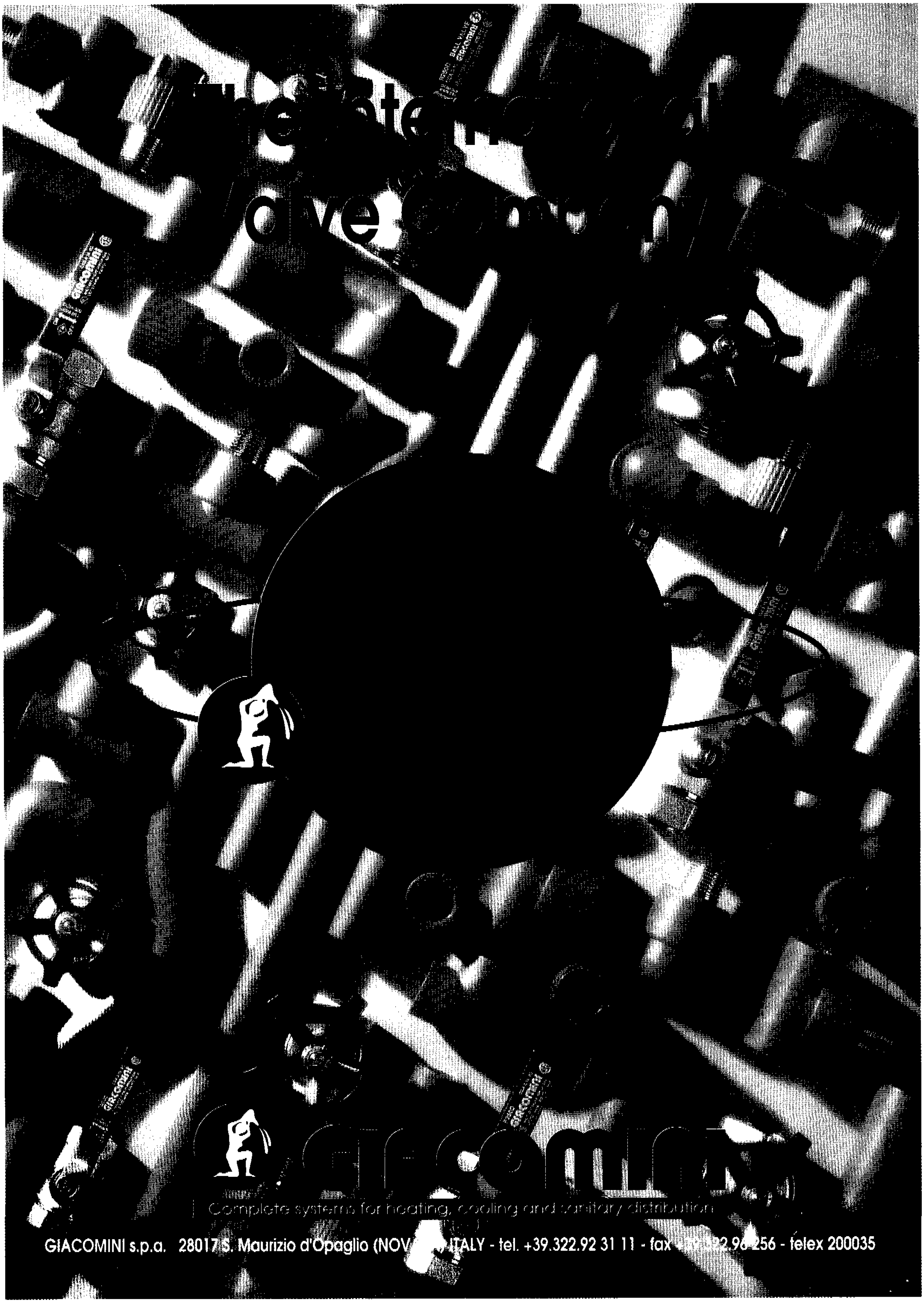
Parts plus
Mission-Fluid King expendable pump parts are offered in a selection of designs and materials for extended service life in water well drilling applications. Parts are offered for the most popular makes and models of duplex mud pumps.

Pumps too
Mission-Fluid King also offers a line of centrifugal pumps. This line ranges from the nine models of S & W Pumps to the new-generation Magnum Pumps.

Slurry/diaphragm pumps
Mission-Fluid King is a unit of National Oilwell, which has manufactured, for more than 30 years, a range of pumping equipment for moving solids through pipelines. Since then, most of the distance and volume breakthroughs have been accomplished with our pumps.

Some of the products being transported through pipelines include coal, iron ore, bauxite, potash, kaolin, and other minerals. With years of experience, special fluid ends for specific fluids, pressures, and temperatures have been developed. For slurry applications, our diaphragm pumps have proved especially cost-effective.

The multiplex range of pumps can be supplied as a unitised package to meet any customer specification or requirement. ■


giacomini
Complete systems for heating, cooling and sanitary distribution
GIACOMINI s.p.a. 28017 S. Maurizio d'Opaglio
ITALY - tel. +39.322.92 31 11
telex 200035

The highest quality in valve manufacture

Giacomini SpA are one of the largest valve manufacturers in the world, producing 70 million valves and associated articles each year.

GIACOMINI SPA

Mr Alberto Giacomini formed the Giacomini SpA in 1951. Since that time Giacomini has grown to become one of the world's largest valve manufacturers.

Giacomini now has branches in the Benelux countries, France, Germany, Switzerland and Spain, all employing around 1000 personnel, distributing some 70 million valves and associated products made during each year. This, in turn, necessitates that the company process more than 100 tonnes of brass a day.

Quality

Giacomini are one of the few companies which initially receive the raw material then press, machine, test (100 per cent of production), assemble, pack and distribute the product. This ensures quality control from beginning to end and explains why Giacomini holds more than 30 certifications worldwide and various quality system assessments such as ISO 9000, BS 5750, and EN 2900, confirming a dedication to making an extensive range of brass and plastic products to the highest possible standards of quality and reliability.

Training

In order that the various sectors of the trade can familiarise themselves with their products, Giacomini have created a training school with classrooms and workshops holding both practical and theoretical courses for heating engineers, plumbers, merchants, designers, specifiers, and sales and marketing personnel. During 1995 more than 4000 students attended the school ensuring that the end-user receives not just a quality product, but professional information about the company and its product.

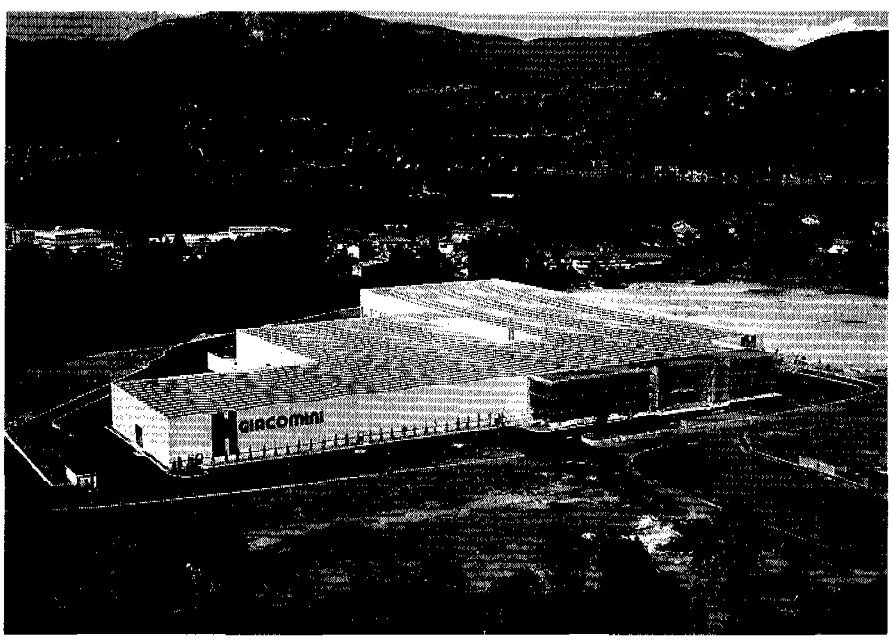
Exports

From their headquarters in San Maurizio d'Opaglio, North Italy, they export approximately 80 per cent of their total production, confirming the wealth of experience they have gained in satisfying overseas customer is requirements for the control of both hot and cold water distribution.

Environmentally friendly products

More recently Giacomini, recognising the need to produce environmentally friendly products, have built a new factory which will make plastic tube and fittings to meet with the increased demand for articles of a green nature.

Despite the innovations, growth and development over the past 45 years, Giacomini remains a family firm and their chairman, Mr Alberto Giacomini, recently honoured by the Italian president for his services to exports, still has overall responsibility. ■



Giacomini headquarters in Italy.

FLO VAL

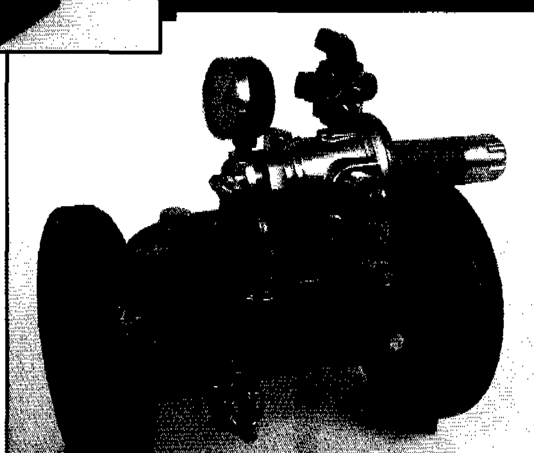
Performance, Design & Service

FLOVAL
CONTROL VALVES

"PHOENIX MFC"
MULTI FUNCTIONAL CONTROL

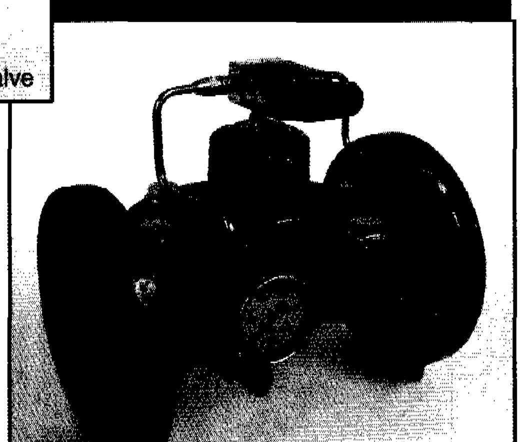
Pressure reducing

"PHOENIX"
VALVES
YOUR BEST
CHOICE FOR
LIQUID CONTROL
APPLICATIONS



Auto Sensing Valve

Manufactured and supplied in response
to demand for
SIMPLICITY, VERSATILITY,
RELIABILITY
at a minimal cost.



Solenoid Control

Multi-functional control valves

Floval is a wholly owned subsidiary of Process and Allied Contracting Equipment (Pty) Limited — a Johannesburg-based company established as a major supplier of industrial valves in the South African market.

PROCESS AND ALLIED CONTRACTING EQUIPMENT (PTY) LIMITED

Floval was formed a number of years ago to develop and manufacture a range of multi-functional, self-actuated control valves marketed under the name of Phoenix MFC. The design uses a common main valve body rated at 25 bar with various pilot configurations, to provide control functions for a wide range of water and liquid applications; that is, pressure reducing, sustaining, relief, level control, auto on/off solenoid-operated, and various deluge valve types to suit fire protection systems. The valve is used in mining, power generation, steel manufacturing and other industries where water reticulation or treatment plants form part of the process.

The Phoenix MFC is a direct sealing diaphragm valve which consists of only three main components: body, bonnet and diaphragm. The valve can operate in any of the following modes:

- Closure — with drip tight shut off
- Full open — free flow passage, and
- Modulating — restricting flow as dictated by the pressure in the control chamber.

A stable throttling position is obtained when pressure is retained in the upper chamber. It is this volume in the upper chamber that determines the position of the diaphragm. This control volume can be filled or exhausted to achieve the desired operating condition.

The attraction of the valve to end-users is its simplicity (its one moving part being the diaphragm) its versatility due to its wide range of uses, and its reliability (as no close toleranced parts prevent freedom of operation).

Other features of this valve include:

- Low energy losses at high flow rates
- Easy in-line maintenance, one spare part and no special tools required
- Smooth frictionless and fault free operation, simple diaphragm movement
- Sturdy construction without crevices or intricate contours, and coated internally and externally to prevent corrosion
- Controllable opening and closing speeds prevents water hammer
- Internal surfaces unaffected by precipitated deposits, such as dissolved minerals in water, which cause conventional valves to jam due to close fitting parts, and
- No sticking, even after prolonged periods in the open or closed position.

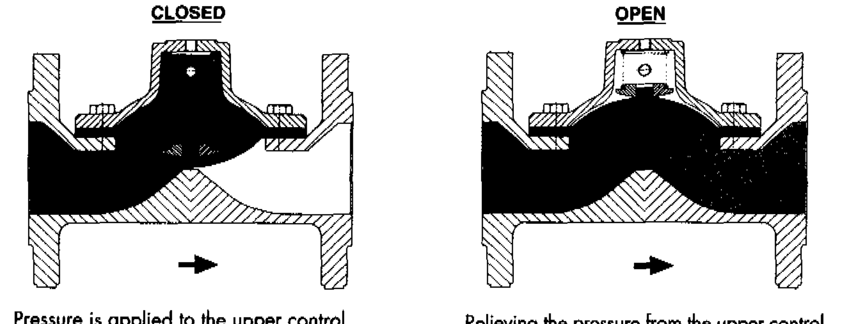
The Floval Phoenix MFC valves were recently exhibited at the 20th International Water Supply Associations Congress where they attracted a lot of interest both from engineering decision makers and from companies wishing to represent the product throughout the world.

Manufactured in South Africa, the Phoenix MFC has been flow tested using the latest draft European standard Pr EN1267. These tests were carried out by the South African Bureau of Standards. The valves have also been submitted to the Joint Acceptance Scheme for Water Installation Components which entails arduous performance testing at full differential pressure, with valves operating from open to closed position over cycles up to in excess of 500 000.

This reliability has been one of the many reasons that the product has achieved such wide acceptance in the critical area of fire control throughout South Africa's power stations. The most recent project executed was for the supply of solenoid operated deluge valves, manufactured in special duplex stainless steel, to provide a planned 50 year life expectancy.

Process & Allied Contracting Equipment (Pty) Limited also offers a wide range of gate, globe, check, butterfly, ball and plug valves to suit all requirements and is well situated to serve certain markets in Africa from its headquarters. The company provides the expertise to assist customers in the selection of valves for specific applications and supplies these fit-for-purpose valves at an economical price and with the necessary back up.

Contact from international companies interested in representing the Floval Phoenix MFC valves would be welcomed as the company intends to export the product worldwide. ■



Pressure is applied to the upper control chamber, pressing the diaphragm sealing rib closed and drip tight against the valve seat.

Relieving the pressure from the upper control chamber permits the line pressure to lift the diaphragm open allowing free flow.

On-line monitoring of water quality

While new systems of water control and the instruments that go with them are widespread in advanced countries, developing ones cannot yet afford them, though it is hoped that soon all countries will have access to the latest improvements in water and wastewater treatment plants.

W D Meredith *BOURNE CONSULTANCY, UK*

For many years we have seen the gradual introduction of automatic control schemes and their evolution throughout the water industry. The impact of micro-electronic developments has been a major contributor to the increased use of instruments and their application in information-gathering, transmission of data, computation and process control.

Plant design features have changed, some changes having been brought about by the availability of real-time information provided by new instruments. Many of these new systems have become commonplace in the developed countries, but the costs related to such changes have in many cases been relatively high. Developing countries would have difficulty in finding the money to implement many of these improvements in their water and wastewater treatment plants.

In time, it is hoped, the technical and financial advantages resulting from the use of new sensor techniques and automated control systems will become available to developing countries as purchase and maintenance costs are reduced.

Technique must pay

The need for reliable instruments for monitoring and control of water and wastewater treatment plants has never been greater, especially with tighter consent limits being applied and the introduction of pollution prevention regulatory bodies in many developing countries. In applying a new technique on a plant, the overriding factor is that it must show a cost benefit.

Developed countries over the past few years have experienced an increasing unskilled labour surplus, higher energy costs and a decrease in available capital. Developing countries are also experiencing similar situations. Such constraints must be considered when any new monitoring or control scheme is introduced. Future instrumentation developments must address the question of "cost of ownership" of the system, and not just the capital cost of the equipment.

Obviously there will be some high-cost systems that help reduce running costs on large or difficult works, but for the great majority of moderately sized plants the cost of ownership of "new technology" instrumentation will decide how extensively they will be accepted.

The trend for some years has been to concentrate analytical facilities for water quality into central laboratories. From these units information is relayed back to local control points, usually from the sample source. This method of screening can take an amount of time that is unacceptable to plant operators attempting to control discharges to within consent limits. Real-time measurements are therefore required on important quality parameters.

The laboratories use high-technology state-of-the-art instrumentation, and the equipment is operated in a controlled environment by skilled staff. The monitors required for on-line work must either be suitable for working in inhospitable environments or analyser housings be built to control the environment around them. Both methods can incur high costs. The monitors should be capable of working for extended periods (preferably 30 days or more) without manual intervention.

Reliable signal

Real-time information from the plant, to be effective in automatic control, depends on a reliable sensor signal. Failure here makes the control system suspect. Although sensor systems have improved over the past two or three years, there is still far to go before satisfaction is achieved in monitoring many analytical parameters on a long-term basis without a great deal of manual intervention.

Fouling of the sensor is still a major issue on many applications. Some monitors used in particular applications have proved satisfactory, usually when the sample has been relatively "clean". But problems still occur all too frequently when an attempt is made to use the same monitor on an application where the sample contains solids of varying size and consistency. The development of sample preparation systems, for use with on-line monitors, is an area sadly neglected by both manufacturer and end user. The end user expects the instrument manufacturer to have sorted out all sample preparation problems, but normally it is only the end user who knows the complexity of the sample. Problems can be solved only when both parties combine efforts to develop a filtration system that suits the particular application they have in mind.

High volumes of reagent and calibration solutions can result in high maintenance costs — in preparation, carriage-to-site and manual labour. Future monitors should be designed with this in mind. Technical competence of the personnel maintaining the monitors has also been of concern, though this fault could be as much in the monitors' design as in the technicians carrying out the maintenance. The aim in future for all new sensor and control systems must be to keep them as simple and inexpensive as possible so that their maximum deployment is assured.

Fouling of the sensor is still a major issue on many applications

Accuracy is sometimes misguidedly placed high on the priority list in considering on-line monitors. Stability and reliability should be the prime considerations. In many cases, where monitoring for out-of-consent limit alarm is needed, such as at plant outfalls, the accuracy of the monitor need not be of prime importance. Reliable trend measurements are required and relaxation in the accuracy specification could reduce capital costs appreciably. When consent limits have been breached it is usual to perform laboratory analyses on a grab sample to confirm results, and it is at this stage that high accuracy is required.

Source and receiving waters	Sewage treatment	Potable water treatment and distribution	Sludge disposal
BOD	BOD	Residual chlorine	Heavy metals
Turbidity	Turbidity	Turbidity	Pathogens
Ammonia	Ammonia	Organic material	
Dissolved oxygen	Dissolved oxygen	Colour	
Nitrate	Toxicity	Taste	
Phosphate	Treatability	Odour	
pH	Nitrate	Ozone	
Conductivity	Phosphate	Aluminium	
Trace organics	Sludge solids	Iron	
Heavy metals	TOC	Manganese	
Oil	UV absorption	Ammonia	
Chlorine		Nitrate	
Gross pollution		Heavy metals	
Algae		Toxic organics	

Table 1. The list is not definitive and the parameters are not in order of priority for all applications, but it helps to focus on areas where development of new sensors and on-line monitors could be of much assistance in pollution control.

Foremost parameters

Table 1 lists those parameters of greatest significance in water quality monitoring and control.

The BOD test was originally intended to simulate conditions in a river after the discharge of an effluent, and over the years has been a very good indicator of pollution incidents. The test uses a small culture of micro-organisms to stabilise organic material under quiescent conditions. It is performed at constant temperature with a slowly diminishing dissolved oxygen supply and with no release of the carbon dioxide being generated. This may be considered a close enough resemblance to a surface water, but it can bear little relationship to the conditions within a biological treatment plant where high concentrations of micro-organism cultures exist and an excess of oxygen is supplied.

In laboratory only

The standard five-day BOD test can be performed only in the laboratory, which unfortunately means it is five days too late if corrective action on the treatment plant is to be carried out. On the outfall, surrogate methods are now being used to give an earlier indication of plant problems. These are usually COD (chemical oxygen demand) or TOC (total organic carbon) measurements, but the correlation between these measurements and BOD has to be established by a plant-by-plant investigation.

On-line instruments measuring these two parameters have been available for some time and used to good effect. The most difficult problem to overcome in applying the instruments is sample preparation — normally filtration — down to a size that is acceptable to the analyser without affecting the true value of the "whole" sample.

Within the past few years there has been more use of respirometers, both in the laboratory and on-line — the latter giving real-time measurement of the oxygen uptake in the biomass of wastewater treatment plants. The value of the oxygen demand caused by the substrate — the true biological oxygen demand — can now be measured within an hour. Plant oxygen uptake loads can be followed with signal updating every 10 – 15 minutes using an on-line monitor, and the effect of toxic materials

entering the biomass can be followed. Laboratory respirometers are now being used to measure the treatment time of the incoming wastewater and as diagnostic tools for the process.

Suspended solids concentration — usually specified in consent conditions — employs a gravimetric method of measurement and is difficult to automate. The surrogate method used is turbidity measurement (usually a nephelometric method is requested by regulatory bodies, where the reflected beam is at 90 degrees to the incident beam). Results are quoted in FTU (formazine turbidity units) or NTU (nephelometric turbidity units). There are numerous different instruments available, many being used successfully on-line with novel ways of reducing the effects of fouling of the cell windows for reasonable lengths of time. In many cases the turbidity measurement has been a good trend indicator of BOD, and is now looked on by some regulatory bodies as a necessary measurement along with suspended solids.

On-line pH, conductivity and dissolved oxygen sensors have been in use for many years, and methods of auto-cleaning and anti-fouling have slowly emerged. For some applications there are still major problems of sensor fouling to be overcome, especially from substances like oils or fibrous materials.

Sensor fouling

Ion-selective electrodes and gas-permeable sensors have also been used to good effect for ammonia, nitrate, chlorine, fluoride and chloride monitoring both in hand-held instruments and in on-line monitors. The major problem with the latter has been sensor fouling on particular applications. Filtration systems, some with auto-backflushing or biocide-dosing, have been used in an attempt to overcome the problem, but the systems are not cheap and in some cases have resulted in higher rather than lower maintenance costs.

Colorimetric analysers are in use for a range of parameters such as iron, aluminium, manganese, phosphate and so on. On potable water applications the problem of sensor fouling, or suspended solids interference, is less than found in other applications, so their use has been limited to reasonably clean samples.

Confidence in the use of on-line monitors should improve with the introduction of instrument standards, and, eventually, certification by approved bodies. Instrument industry specifications for 11 different parameters have been produced in the UK by the Water Research Centre on behalf of the water industry. They are considered as user specifications and are being utilised more and more by the industry when new equipment is required, and also by instrument manufacturers developing new products. Pan-European specifications are now emerging, with applications forming part of the user specifications.

Recent developments

Two examples can be given of recent developments that have helped to alleviate some of the foregoing problems, first in the field of continuous monitoring for toxic substances and second in the development of a new sensor.

In the first example, the Centre of Exploitation of Science and Technology (CEST) highlighted the need for a system to allow accurate and continuous measurement of toxicity in the effluents and influents of water treatment systems. They helped to bring together a partnership of organisations to carry out the task. As a result of work done by the partnership, an on-line monitor will become available this year to fulfil the need.

The partners involved in the project are:

- Yorkshire Water plc (a UK regional water services company)
- Umist (University of Manchester Institute of Science and Technology), which carried out the initial research into the sensor development of the system
- Siemens Environmental Systems Limited, which took the development through to commercial production, and
- Microbics Corporation (USA), manufacturer of Microtox, a laboratory toxicity monitor.

The partnership took as the basic instrument a standard Microtox and developed the Microtox-Os, an on-line monitor that continuously measures photoluminescence produced by respiring bacteria. The bioluminescence decreases in proportion to the concentration of toxic substances present in the sample to which the bacteria have been added. The bioluminescent bacteria are stored in an inactive, freeze-dried state within a controlled environment, in small vials. When required by the monitor they are automatically reconstituted into a liquid suspension.

Confidence in the use of on-line monitors should improve with the introduction of instrument standards

The monitor has two main operating modes: a learning mode and a monitoring mode. The former produces an accurate database of diurnal and seasonal variations in toxicity, of the sample stream being monitored. This is formulated by diluting the sample to three different concentrations and calculating the EC_{50} concentration (the Effective Concentration that causes a 50 per cent reduction in bioluminescent output). This process is repeated to establish a mean and standard deviations for the EC_{50}.

Alarm thresholds

In the monitoring mode, samples are compared against mean levels calculated during the learning mode. Alarm thresholds are set using multiples of the standard deviations also established during the learning mode. Alarms are activated if abnormal changes occur, and can be used to trigger sample or stream diversion equipment. Correction for the presence of turbidity and colour changes in the sample are automatically made. Roughly the size of the average domestic fridge-freezer,

the unit is transportable and thus available for multi-site use.

For the numerous applications of such a monitor, the partners were conscious that most samples taken had to be automatically filtered to remove all particles down to a size that could be handled easily by the monitor. The cut-off size chosen would be such that results would not be affected by "missing" toxic substances held within particulate material.

A number of different methods of sample retrieval and filtration were devised to cover such applications as monitoring of raw sewage at works inlets, or within sewerage systems, and monitoring treated sewage at works outlets. These systems had to have a minimum of manual intervention. Addressing the thorny problem of sample filtration prior to automatic analysis has shown that there is no easy answer, that each application brings its own predicaments. However, the combined efforts of the partners have made considerable headway, and a number of solutions have been tried and tested with good results.

Simpler, cheaper

The second example shows how research and development can result in a simpler and less expensive system than those used to date to monitor a priority parameter. A new optical sensor for monitoring ammonia in the gaseous phase has been developed in the UK by M Squared Technology, a company specialising in developing new sensors for use in the water industry. It has been further developed for use in aqueous solutions for the measurement of total and free ammonia. By electrochemically raising the pH of the sample in close proximity to the sensor membrane (a technique patented by M Squared Technology), measurements can be made of the total ammonia concentration in the sample without the need to add a caustic solution.

The first obvious application for this sensor is as a hand-held instrument for field use by regulatory bodies. Ammonia measurements can now be made at source, usually without an aliquot having to be taken from the stream. As the carrying of hazardous solutions is no longer necessary, as in the case of using the "conventional" probe, it avoids health and safety problems that might arise.

On-line monitoring of ammonia using the new sensor brings about a considerable reduction in running costs. Solutions of sodium hydroxide and EDTA (a chelator used to prevent calcium/magnesium salt precipitation), which are required in present monitors, are no longer needed. Also, as there is no electrolyte within the sensor a membrane change is very simple: just a pull-off and push-fit replacement. Problems associated with electrolyte fillings have been eliminated and the response time improved, as the equilibration time associated with the electrolyte has been abolished. The pH increase, using an electrochemical technique, takes only a few seconds, and is cyclically switched on and off, readings of total ammonia being taken every two minutes. With the pH moving between a high and a "medium" value every few minutes, the membrane is kept relatively clean.

The proposed on-line monitor is a system very much simplified from existing monitors, as reagent addition has been eliminated, so reducing capital and maintenance costs. The new patent (ion manipulation by electrochemical means at a sensor surface) can lead the way to simplification of other sensor systems used for other parameters. Where pH changes in the sample are required, as in free and total chlorine monitoring, the addition of buffer solutions could become superfluous.

New sensor

Increased reliability requirement has stimulated research into non-invasive sensor techniques using laser technology, and into optical sensors. The non-invasive laser sensor has the advantage of not being prone to fouling, of freedom from electromagnetic interference, and of being less susceptible to corrosion. It could be used for the detection and possible quantification of molecular species.

Raman Scattering could produce a unique fingerprint of the species being sought, but the signals produced are of low power, and sophisticated electronics is required to separate the signals from background noise. Lasers could be employed to detect remotely specific oils, hydrocarbons, algae and other variables showing specific fluorescence characteristics. Sensors of this nature are not developed quickly and the final cost of such systems would be difficult to estimate.

Optical sensors are slowly becoming available, as the example of the ammonia sensor shows. Similar optical sensors are being developed for other parameters, such as pH and dissolved oxygen, and are reasonably close to being marketed.

Micro-engineered spectrophotometric sensors are now procurable, and it is possible that within a year or two on-line monitors using these "chips" will materialise. The aim, once again, is reduction in power consumption and cost of ownership.

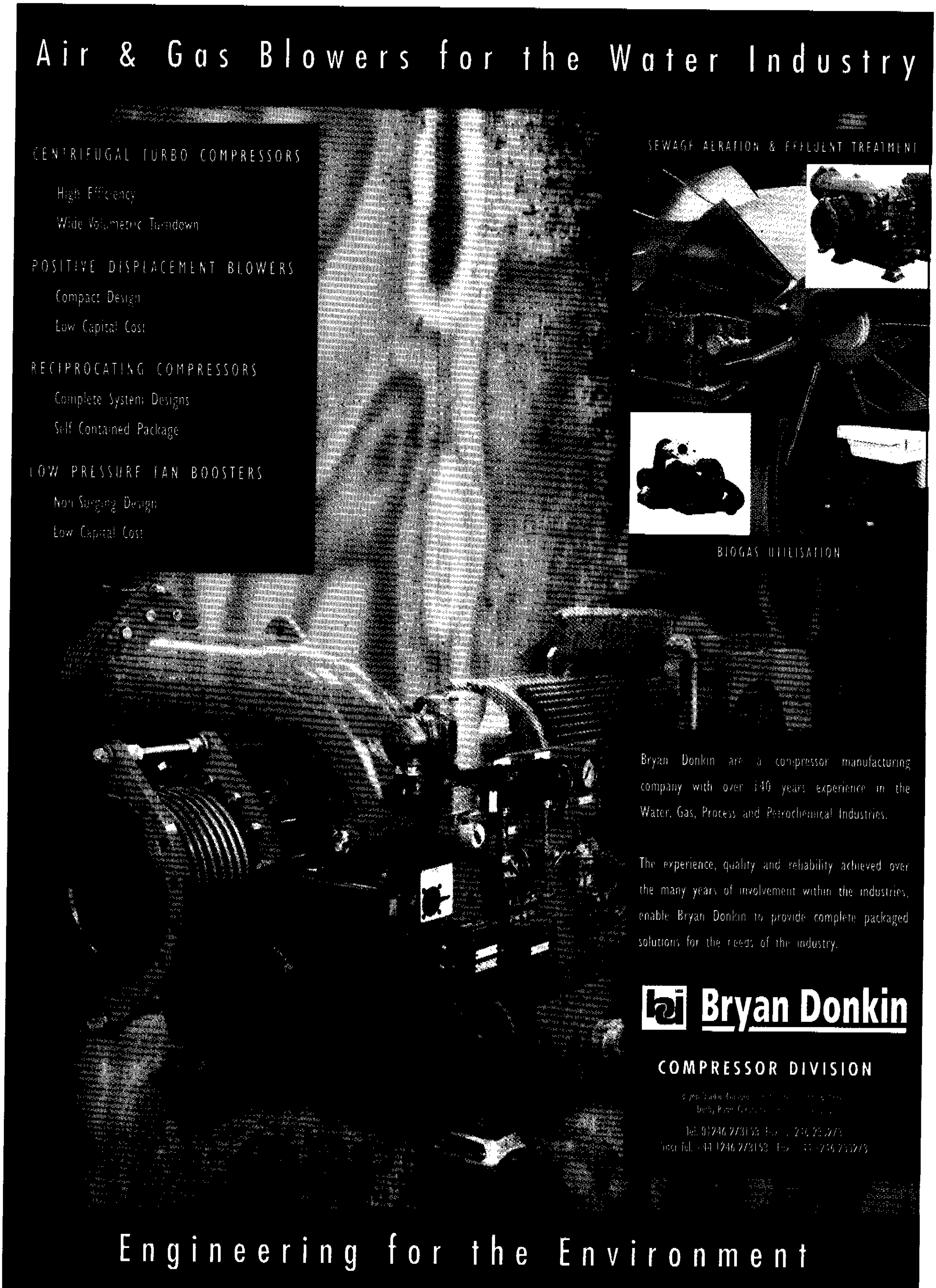
Many centres are active in the field of biosensor research and development, but to date, although some have been used in laboratory techniques and one-shot optical biosensors for immuno-assay work, none has emerged for continuous on-line use in the water industry.

Conclusion

It is hoped that new sensor studies being carried out will eventually produce on-line equipment where capital costs and maintenance are significantly reduced. They will help not only to increase the efficiency of treatment plants, but also to lower the cost burden of industries attempting to meet environmental directives. If the new technologies reduce the cost of ownership of monitors, they will find a ready market worldwide, and developing countries will welcome the benefits they bring. ■

Author

Doug Meredith is an independent consultant in instrumentation, control and automation. For 30 years he has been engaged in the application and development of sensor systems for process control and environmental systems. He is chairman of the environmental systems group at GAMBICA (trade association of instrument manufacturers in the UK), and is the Siemens plc representative.


Air & Gas Blowers for the Water Industry
CENTRIFUGAL TURBO COMPRESSORS
High Efficiency
Wide Volumetric Turndown
POSITIVE DISPLACEMENT BLOWERS
Compact Design
Low Capital Cost
RECIPROCATING COMPRESSORS
Complete System Designs
Self Contained Package
LOW PRESSURE FAN BOOSTERS
Non Surging Design
Low Capital Cost
SEWAGE AERATION & EFFLUENT TREATMENT
BIOGAS UTILISATION
Bryan Donkin are a compressor manufacturing company with over 140 years experience in the Water, Gas, Process and Petrochemical Industries.
The experience, quality and reliability achieved over the many years of involvement within the industries, enable Bryan Donkin to provide complete packaged solutions for the needs of the industry.
Bryan Donkin
COMPRESSOR DIVISION
Engineering for the Environment

Managing water for profit and quality

A leak in the water supply system is relatively easy to repair if it is at ground level, but one far beneath the surface is another matter.

ABB NETWORK PARTNER LIMITED, SWITZERLAND

Some consumers will phone the water utility and report the location of a leak. It is obviously much harder to locate an underground leak, as there is no remote monitoring (the public) to report its location. In most cases such leakage will be recognised by the water utility only when it is almost too late to avoid disturbances to customers.

It may have been noticed that the term "consumer" has become "customer". Taking into consideration the "customer view", it is essential to serve him in the optimal manner by means of the appropriate tools to monitor and control the quality of the water supply.

Of course, the customer would like to drink the water direct from the tap, which unfortunately is not possible in many parts of the world. To be able to provide water of the desired quality, dedicated monitoring and control are necessary — for example, to mix the water in the correct quantity and quality, without over-mixing, say, with chloride.

An important aspect of the use of monitoring and control functions is the minimising of operating costs by optimising plant control. The energy demand for processing the supply and distribution of water is approximately 0.6kWh/m^3. Through the optimal control of supply and operation (by taking into account an optimal use of available storage capacity) around 10 per cent of the energy demand can be put into the low tariff group, leading to cost savings that will amortise the investment after only a few years.

Protect investment

There are also other important objectives for a water supplier, whether privately- or state-owned. Its objectives are not only to provide the best possible service to customers but also to take into consideration its own commercial and environmental operating costs. The "production" of potable water, its transport and its final distribution to the end customer require many continuing expenses as well as much investment over the years.

When investment is made it is most important to protect the installed equipment, such as surge vessels, pumps, instrumentation and valves, against all possible types of damage. As well as the monitoring and control requirements, we now also have the need for commercial optimisation tools, alarms, and preventive maintenance.

Finally, the supply of potable water, which may be the most important staff of life, is getting more and more critical because of dwindling resources. This is a serious problem today for the water utilities — on the one hand to avoid losses from leakages and on the other hand to use the resources in the most successful way.

In short, the following objectives must be fulfilled by the tools of a water utility: quality, security, economy and reliability.

ABB Network Partner Limited, of Switzerland, a company within the worldwide ABB family, has been active for more than 30 years in the field of computerised systems to fulfil such requirements. During all those years ABB Network Partner has gained much experience and developed many functions up to today's state-of-the-art SPIDER family. This family comprises the following functionality:

- Monitoring and control functions — SCADA system
- Water management functions — WMS
- Data acquisition from remote sites — RTUs, and
- Communication — Radio, fibre optic.

It is our objective to provide the water utilities with a user-friendly, powerful interactive tool for handling a water system of any size. With our additional services, such as training, operational assistance, maintenance and comprehensive after-sales service, we ensure that the water utility can fulfil its objectives to the satisfaction of customer and shareholder alike.

Together with the other partners within the ABB family, using equipment such as local automation, power supply, instrumentation and so on, ABB is a reliable partner for complete computerised monitoring and controlling systems, including communication. ■

Remote monitoring

Remote monitoring systems can decrease maintenance costs, increase efficiency, and provide peace of mind for water companies and consumers alike.

Alejandro Schnyder and Antonio Royo *STL Technology Systems*

Many and sophisticated water treatment systems, such as reverse osmosis (RO), ultraviolet disinfection (UV), chlorination and desalination plants, potable and effluent treatment processes, and so on, available on the market today, must guarantee excellent performance and ability to handle the water as required.

Hand-held test equipment or "check-kits" do offer the possibility to measure periodically the quality of the treated waters. But what happens in the gaps between measurements? And who should monitor the important parameters and adjust the process permanently?

A compact on-site, intelligent device, capable of logging continuously the values of the measured parameters, controls peripheral implements such as valves and dosing pumps whenever programmed set-points are exceeded, and alerts the operator of any malfunction in the systems.

An operation manager of several water treatment stations in different sites, has responsibilities that include field service and maintenance of all installed systems. They must guarantee the supply of impeccable water quality, although many plants are unattended. Plans must be made for the event of something going wrong, and warning and alarm systems must be in place for all unattended stations.

The answer is remote monitoring. A system can monitor the treatment process automatically, provide all historical and logged data on request, and the operative can solicit the information as often as needed and at any time convenient from the control centre. This information not only gives confidence in the working of the system, but also helps optimise service and maintenance staff's schedule, reducing operational costs.

Cost improvements are achieved as well within a treatment process that uses chemicals, because only the right dosage of such additive chemicals is fed into the process.

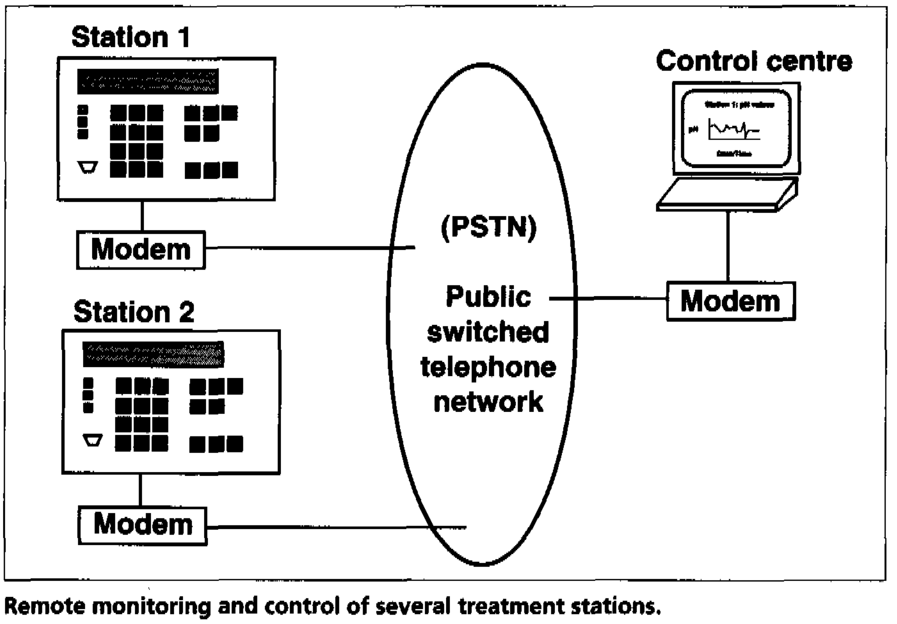
This equipment has many applications in the water treatment industry. The range goes from a simple control of chlorination and ozonisation equipment in swimming pools, up to the quality-control of a municipal water supply system, or supervision of treated effluents.

In many cases, a few monitored parameters, such as pH, redox potential (ORP), conductivity, pressure, flow rate, certain selective ions, and so on, are enough to make sure the quality of potable water or treated effluents drained to rivers, lakes or sewerage, comply with the legal and health requirements, as well as with environmentally sound perspectives.

Authorities could easily supervise and control if pollutants are dumped into rivers, and a good monitoring system could not just avoid sanctions, but also provide the pertinent government agency with the necessary statistical data and records.

Manufacturers of water treatment equipment can constantly improve their techniques used, due to the historical data provided from the monitoring equipment.

Implementation of any control system into any type of process, demands simplicity and ease of operation. No other hand-held terminal, laptop computer or other programming device should complicate the operator's tasks. That is why a new family of stand-alone monitors with integrated keyboard and display are being used beside standard PCs in the industry. These new controllers have the ability to measure the most important parameters in water processes directly. They serve as data-loggers saving stored and registered values onto a host computer daily, weekly or even monthly, depending on the user's needs. The collected information can be processed with a SCADA system, as dictated by the latest technology. The illustrative presentation is simple to interpret and administer. It is comforting to know, that the water you drink, the water in which you bathe has the necessary quality. ■



Remote monitoring and control of several treatment stations.

Anti-hammer protection for long rising mains

Water can be made available in every locality for human use on a variety of civilised levels. Yet the cost of doing so is higher than the consumer might suspect.

Vladimír M Vondra *SLOVAK TECHNICAL UNIVERSITY IN BRATISLAVA*

Water resources, from which supplies of adequate quality can be used for drinking, irrigation or industry, are usually remote from consumer sites. This makes the construction of water supply systems — pumping station, rising mains, reservoirs and other consumption equipment — very expensive.

Pipelines themselves, and their installation, constitute the largest portion of total capital (initial) cost. For that very reason it is necessary to use rising mains with smaller diameters (DN) that have higher flow velocities and consequently higher or lower transient pressures. These considerations are more important in longer rising mains with higher flow velocities and higher pressures.

Higher flow velocities can be used in modern plastic pipes (glass fibre and suchlike) because of lower friction losses along the pipeline. Thus the same value of total head (H_{man}) on a pump's discharge can be used for conveying a larger quantity of water or other liquids over the same distance.

Higher flow velocity in the rising main requires more attention to the analysis of transients, sometimes called surge analysis, and thus more attention to the anti-hammer protection design. To demonstrate, our considerations have been analysed in the following example of hydraulic system with parameters (Figure 1) $Q = 0.5m^3/s$, $H_{man} = 224m$, $H_{st} = 47m$, L = 30 000m, DN = 600mm. System characteristics (QH curves of pump and rising main) are shown in Figure 2.

Flow velocity change

Water hammer in pipelines is initiated by every sudden change in the flow velocity. Total water hammer is indicated by Zhukovskij's law:[1]

$$(1) \qquad \Delta h = \pm \frac{a}{g} . \Delta c \doteq \pm 100.\Delta c$$

which says that transient pressures increase or decrease (Δh) approximately 100 times (where $a \cong 1000m/s$, $g \cong 10m/s^2$) when the flow velocity (Δc) suddenly changes from nominal value to zero.

Standard pump startup

Pump manufacturers advised that when a centrifugal pumping unit starts up, the isolating valve (IV) must be closed on discharge. In the meantime, because the starting time of the centrifugal pumping unit is short (between 0.9s and 1.2s for a standard-sized unit), the impulse for a pump startup goes in parallel to open the IV on the pump's discharge. It takes only a few seconds; then the centrifugal pump joins the operating point (balance or equilibrium between the necessary pump head and the rising main total head for required nominal discharge capacity).

Pump head slowly decreases along the QH characteristic and the discharge flow slowly increases up to the required capacity. All this depends on the quantity of water in the rising main (DN and length of it) that can be accelerated to nominal flow velocity. The IV opening has direct influence only during 5 per cent of its strokes. This is followed by local losses falling off. The differences between the aforementioned standard pump startups are very small, especially if the rising main is long or very long.

The author's definition[7] of a long or a very long rising main is simple. It depends not only on the real length of the rising main but also on the type and size of the isolating valve, as follows:

$$(2) \qquad \frac{T_Z}{20} < T_R$$

where T_z is the isolating valve opening or closing time, and T_R is the time for the reverse of the pressure wave (= 2L/a).

If inequality is correct, the rising main is long or very long. This means that 5 per cent of the isolating valve closing time is shorter than the time for the reverse of the pressure wave. So, when the isolating valve closes before the pump stops, total water hammer is developed there.

Pump startups

Against open isolating valve. Centrifugal pump startups against the open IV on the pump discharge can cause problems, especially if the rising main is short and the static head (H_{st}) of the hydraulic system is small. It may initiate

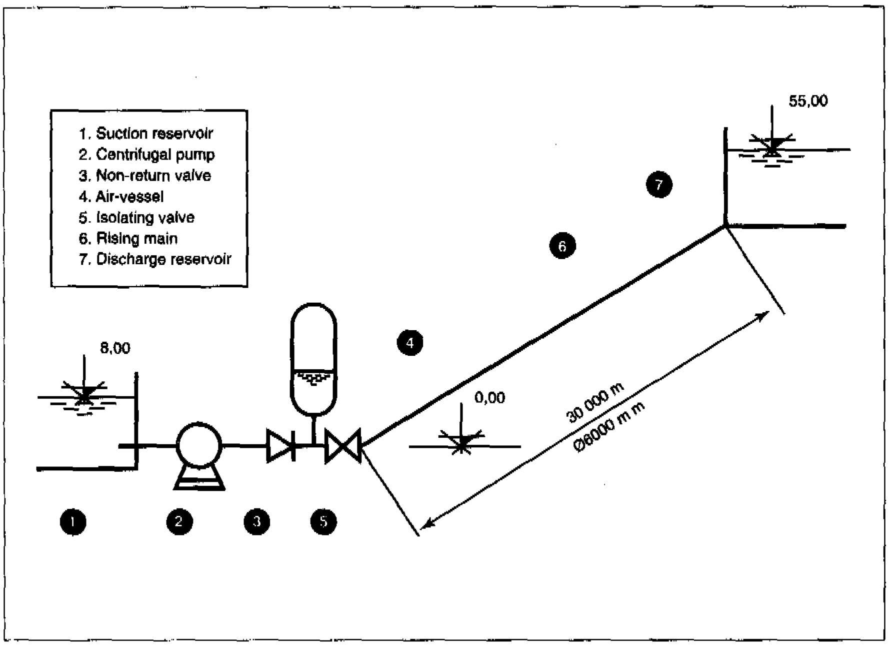


Figure 1. Hydraulic system.

overloading of the electric motor. But if the rising main is long or very long and the static head of the hydraulic system is 10 per cent or more of the total head (H_{man}) there is no risk involved.

Against the open IV and with air-vessel installation. The centrifugal pumping unit starts up against the open IV on pump discharge, and the air vessel installed as anti-hammer protection (AHP) is very soft from the water-hammer point of view. If the rising main is long or very long, the air vessel as an AHP must be large enough to protect all hydraulic systems. As the water column in the rising main is accelerated, the air vessel must be filling up in parallel. That is the reason why transient pressures during the pump's start increase very slowly during this period.

Standard pump stop

As for a standard pump start, pump manufacturers recommend closing the IV on the discharge site when stopping a centrifugal pump. The pump does not stop until the IV is closed. This procedure can be used only in the case when the rising main is short and some AHP is installed. As is shown in what follows, this method is very dangerous for long or very long rising mains because it immediately develops transient pressures that are higher or lower than the transient pressures developed by a power failure.

As shown in the foregoing, in the case of a long or a very long rising main, inequality[2] indicates that the time during which the discharge flow substantially changes is shorter than the time for reversing the pressure wave, so total water hammer follows. Furthermore, the closed IV does not allow any discharge flow into the rising main — as during the normal pump stop — because of power failure (the IV remains open). A case where the IV can be closed under a suitable programme or law is given diagrammatically. It shows a more favourable course of pressures in time-dependence. But the IV with a closing programme as already described is complicated and expensive.

Pump power failure without AHP. Should the centrifugal pumping unit experience power failure, the supply of electric energy for the pumping station suddenly stops. The pump stops within a few seconds, no AHP is installed, and the IV on discharge remains open. Therefore, because of GD2 of the pumping unit and the QH characteristics for MK = 0 (driving moment) or n = 0 (zero speed) and eventually positive suction head, a small amount of water can flow through the pump into the rising main. That is why transient pressures are less dangerous and more favourable for the rising main than in the previous standard pump stoppage (Figure 3).

Pump power failure with AHP. When a pumping station suddenly loses electric energy, anti-hammer protection starts to function. In a case when the rising main is not longer than 800–1000m, water supply can be prolonged into the rising main by a flywheel installed between the pump and the electric motor (extension of GD^2 — moment of inertia). If the rising main is longer than 1000m, the water volume in pipes dominates the moment of inertia of the pumping unit. However, for long or very long rising mains, even with several booster stations, the best anti-hammer protection is an air vessel (in the first pumping station) with suitable water and air volume, which replaces a failed pumping unit(s), and supplies water or other liquids into the rising main. The diagram in Figure 4 shows the time history of transient pressures (hydraulic system characteristic frequency) in a pumping station when AHP operates an air vessel. Pressures oscillate around the system's static head (H_{st}) as controlled damping. Correct the size of an air vessel so that the AHP has a characteristic frequency of its hydraulic system "pumping station with an air-vessel — rising main — reservoir" that cannot rise above the total head (H_{man}).

Conclusions

Enlarging the moment of inertia by means of a flywheel is not only very efficient but also very safe AHP. It is, however, limited by the length of the rising main (Maximum 800–1000m). It also depends on the rising main's diameter and capacity. As has already been shown, the best AHP of long and

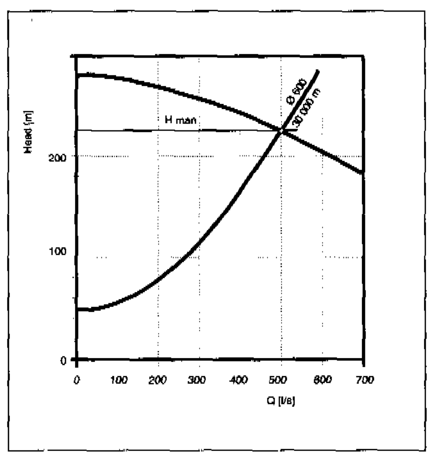


Figure 2. System characteristics: QH: pump and rising main curves. H: head in metres. Q: output in litres/s.

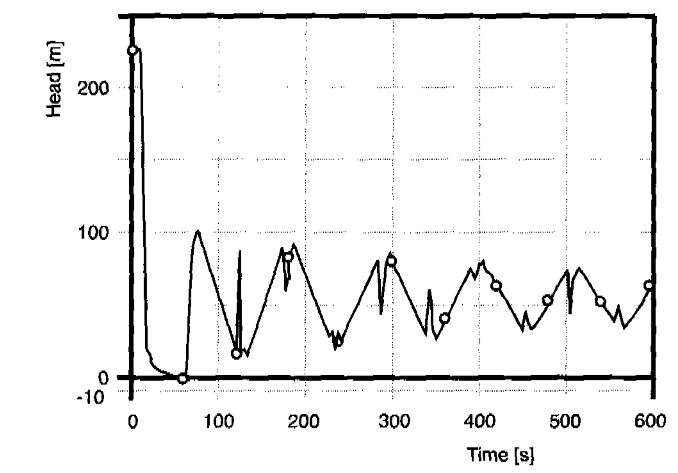


Figure 3. Time history of transient pressures when the pump stopped (power failure) and the IV remained open.

very long rising mains are air vessels with suitable air and water volume. Air and water volume can be lowered by a different system of connection pipes between the air vessel and the RM. There are several ways to do this.

One is direct connection between the air vessel and the rising main without higher friction losses in the connection pipe. This connection requires maximum volume.

A second way is asymmetrical throttling between the air vessel and the rising main — that is, outflow from the air vessel into the rising main with minimum friction losses (without throttling) and inflow into the air vessel from the rising main with a different-sized pipe that creates very high friction losses and throttled inflow into the air vessel. This connection creates conditions for the use of a smaller air vessel.

A third way is symmetrical throttling between the air vessel and the rising main — by Seidl[3]: suitable throttling of outflow and inflow. This method of pipe connection between the air vessel and the rising main allows the smallest possible air vessel for controlling water hammer.

In a case where there are few booster pumping stations installed on a very long rising main, we can build AHP in the form of a battery of air vessels in the main pumping station. However, each of the booster pumping stations must have a simple bypass with a non-return valve. The arrangement of AHP in this way is much more reliable for all hydraulic systems. It is not dependent on moving parts (corrosion) such as complicated valves, which are used for controlling transmitted pressures in the rising main but which transfer not only water but also crude oil or other such liquids.

The application of air vessels as AHP allows the startup and stopping of centrifugal pumps with open isolating valves at the discharge site of the pump, and protection of the rising main against transients is excellent, without any complicated and expensive maintenance. ■

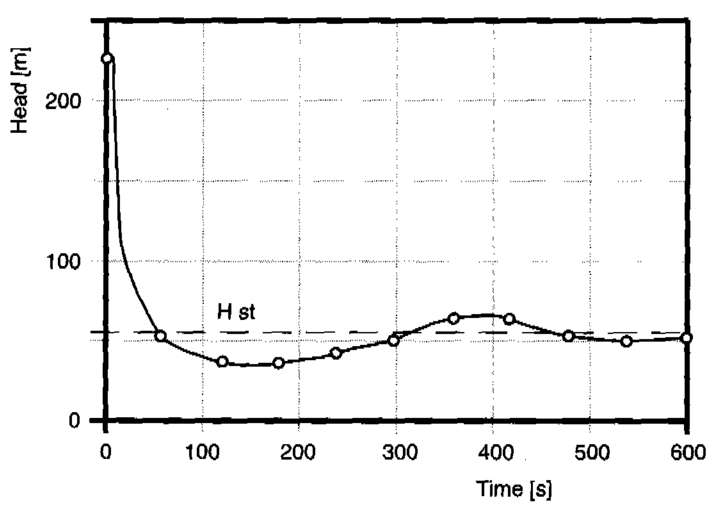


Figure 4. Time history of transient pressures when the pump stopped (power failure) and the air vessel operates as AHP.

References

1. Zhukovskij N E (1898) *Paper to Polytechnic Soc. Moscow* (English translation O Simin, proc AWWA, 1904).
2. Kafkova D (1963) *Fourier method for water-hammer solution in pipes*, NCSAV.
3. Seidl M (1966) *The air-vessel with symmetrical throttling of inflow/outflow as anti-hammer protection of the rm*, PhD thesis.
4. Chaudhry M H (1987) *Applied hydraulic transfer*, VNRCI.
5. Healzer J M, Vondra V M (1988) *Piping network transient analysis*. InterCept software adapted in co-operation with Prof Wheeler (SFSU).
6. Vondra V M (1993) *Contribution for mathematical simulating models of pumping systems*. PhD thesis.
7. Vondra V M (1993) *Contribution for solution of some problems of pumping systems*. Inaugural dissertation.
8. Paciga A (1967) *Pumping systems design*. SVTL.

Author

Dr Vladimir M Vondra is an associate professor in the design of pumping systems and hydro-power plants at the Slovak Technical University, Bratislava. He received his master's degree (1958) and PhD in mechanical engineering at that university, and worked for 17 years with one of Europe's largest pump manufacturers, Sigma, of Czechoslovakia, and elsewhere in Europe and the Middle East. In 1982 he became a director of Hydroconsult, a firm of consulting engineers, in Sydney, Australia.

RQflex:
The pocket laboratory

Now, using the Reflectoquant® System from Merck, the quantitative determination of completely different substances becomes a simple operation. This mobile system has been specially designed according to the requirements of everyday practice, providing onsite, quantitative storage data which accelerates the decision making process.

As "a complete pocket laboratory", it consists of the Reflectoquant® test strips, which are a further development of the successful Merckoquant® test strips in worldwide use, the reflectometer RQflex and a barcode contained in every package for calibration and instrument control.

The special features of the system

- High precision and batch adjusted calibration
- Mobility due to the small size
- No waste disposal problems
- Compensation of paper irregularities due to the extra large evaluation surface area
- Convincing price/performance/environmental safety ratio

RQflex –
The pocket laboratory

Merck KGaA
Frankfurter Straße 250
64271 Darmstadt • Germany
Telefon +61 51/723000
Fax +61 51/727714

MERCK

Up, up and away to the future of analysis

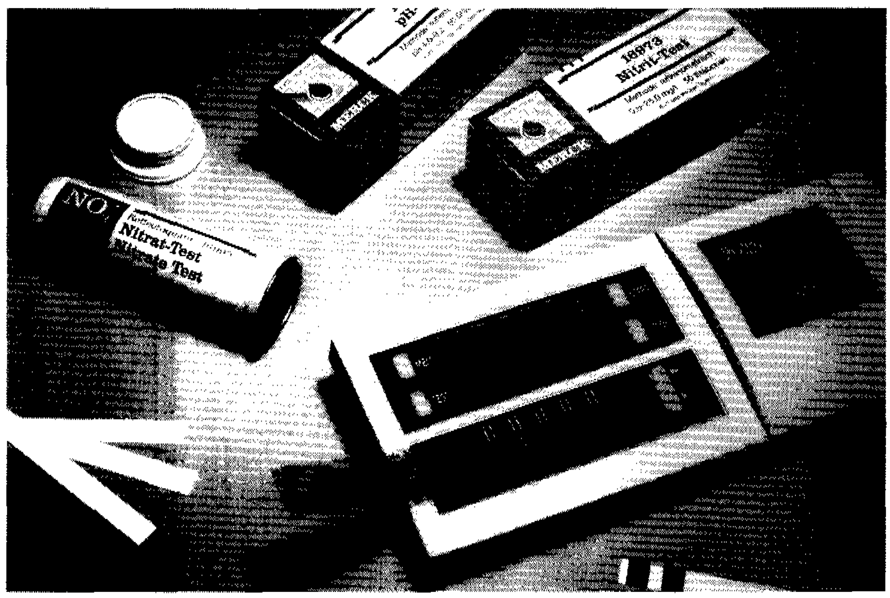
Joanna Sale and Klaus-Peter Riede *MERCK, GERMANY*

The necessity to preserve our quality of life forces us to monitor our environment carefully and critically. The numerous procedures and production processes that are having direct influences on our environment carry with them the risk of accidents and contamination which is steadily growing. To prevent this and to find the right solution is the most important task of the modern environmental analyst.

Today this kind of analysis is no longer restricted to the knowledge of a few specialists only. In every wastewater treatment unit, industrial or governmental, modern analysis units are present and used by everyone to ensure the efficiency and good quality of the water treatment.

In general, analysers are directly integrated into the plant to prevent any contamination. But other solutions are also often used as free-standing methods or additionally to augment analysers. For this task several methods and systems are today available. The range extends from specific national methods which involve sophisticated sample preparations to easy-to-use on-site methods, all of which are able to deliver the right results within a short time. Only the number of steps, and therefore the handling, is different. In general one has to decide between test methods with or without a meter.

Tests without meters use colour changes in the presence of the analyst. The result is found by comparing the sample with a colour chart. Despite their very simple construction, highly precise results are obtainable. However, these tests are all semi-quantitative or qualitative and the automatic documentation of results is not possible.



The "pocket laboratory".

Systems that require meters and reagents or mixtures of reagents either use wet chemicals in well prepared boxes and cuvettes (such as for Photometers) or test strips.

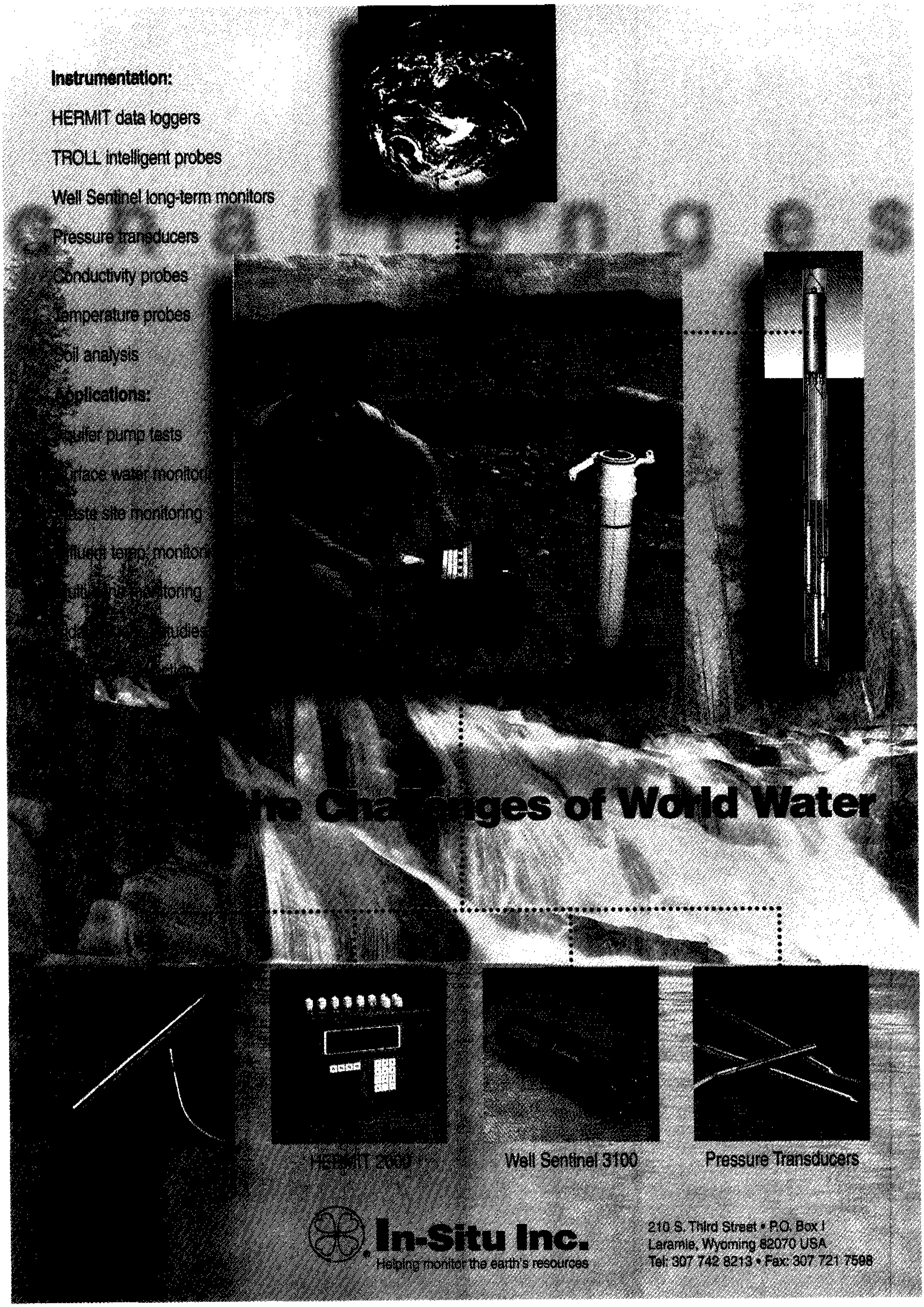
Using the recently developed Reflectoquant-System involving a well matched combination of meter and test strips, a new quality of results is reached while maintaining simplicity and easy handling. The analysis is possible not only of clear water samples but also coloured samples, like beer, wine, lemon juice and so on. The result is a system that provides accurate data and mobility.

The ability to carry the system in the pocket directly to the point of sampling gave it the name "Pocket Laboratory".

But the next generation of ready-to-use test kits is also on the market. All the test systems above are constructed for the analysis of inorganic parameters. Now it is also possible to find PCB, BTEX, PAH, TNT and RDX with test kits. The little cardboard boxes, with all the necessary chemicals and laboratory equipment, are easy to handle, can be taken anywhere and give quick, reliable answers to environmental questions without any complicated sample preparation.

These test systems are today's answer to the growing environmental pollution problems. Quick, precise and effective, these are the key words for modern analytical systems.

More information from Merck KGaA, Frankfurter Straße 250, 64271 Darmstadt, Germany. Tel: +49 161 51 72 0. Fax: +49 61 51 72 20 00. ■



Instrumentation:
HERMIT data loggers
TROLL intelligent probes
Well Sentinel long-term monitors
Pressure transducers
Conductivity probes
Temperature probes
Soil analysis
Applications:
Well Sentinel 3100
Pressure Transducers
In-Situ Inc.
Helping monitor the earth's resources
210 S. Third Street • P.O. Box I
Laramie, Wyoming 82070 USA
Tel: 307 742 8213 • Fax: 307 721 7598

Monitoring the earth's resources

The twenty-first century will provide many challenges affecting our planet's environment. As the need for consistent, high-quality water sources grows, so will the need for reliable and accurate instrumentation.

In-Situ

For more than a decade, In-Situ has tailored its instrumentation to meet the challenges of monitoring the earth's resources by providing world-class data logging systems and rugged water quality probes. We are dedicated to providing professionals with the best equipment and service possible.

In-Situ is widely known for its acclaimed Hermit line of data logging instrumentation. The loggers have been used extensively around the world. Even in the worst environmental conditions, the Hermit can be depended on to provide easy and accurate data logging for pH, conductivity, level, and temperature probes and flow meters. Its circuitry is built to provide efficient and long-term battery life for years of unattended data collection. The Hermit data logger is the choice of the water professional.

For pressure monitoring applications, In-Situ offers the PXD line of rugged and dependable pressure transducers in a variety of ranges that can be customised for unique applications. The slim profile and rugged stainless steel design of the newest PXD-261 is perfect for tight well applications. Another advantage of the PXD line is its serviceability to ensure that your investment in our high-quality probes is protected.

We can be assured that the challenges of the twenty-first century will be more complex than today's. At In-Situ, we approach challenges with innovative and efficient solutions. We will apply the best technology to solve your monitoring problems. Recently, we have introduced the TROLL. This revolutionary down-hole probe combines pressure and temperature sensors with data logging into a single unit. Using a personal computer, you can pre-program the instrument at the office and then simply lower it into the well and leave it. There are no surface cables to damage so the TROLL will operate completely hidden from the surface. Its small diameter is perfect for 5cm well applications and with its powerful software, you can view data as graphs or reports, fast.

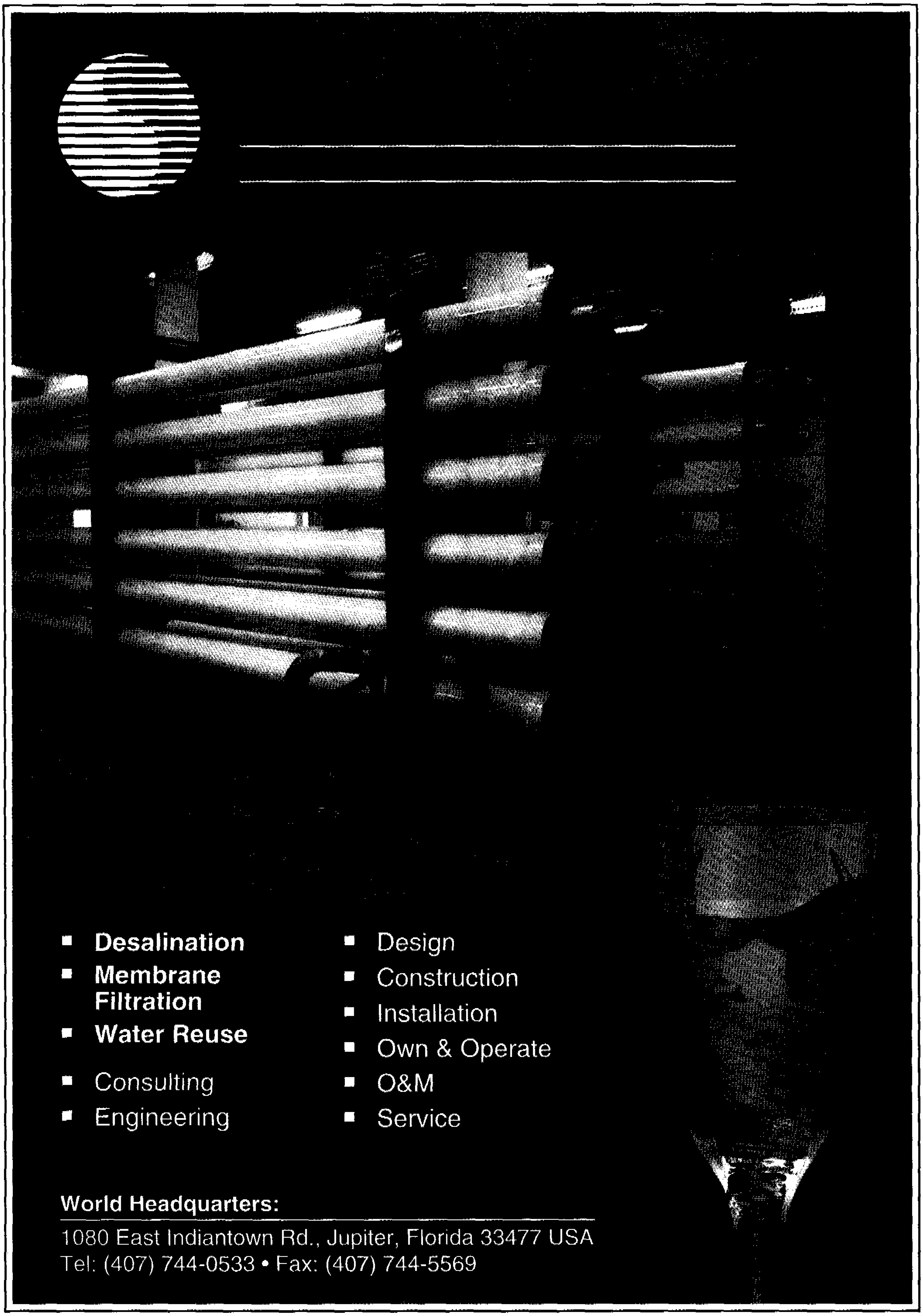
At In-Situ, we work to find ways to save you time and money. That is why the TROLLs will be available with networking and telemetry capabilities. With telemetry communications, not only can you program the TROLLs from the office, but you can easily retrieve data by modem.

All of our equipment is designed to provide the latest technology in solving your application problems. The rugged nature and dependability of our products is ideally suited for a variety of applications, including:

- Aquifer, lake and stream monitoring
- Pump test studies
- Multi-aquifer monitoring
- Tidal influence studies
- Well-cluster monitoring
- Soil vapour extraction
- Effluent temperature monitoring
- Waste site monitoring
- Storm water monitoring, and
- Agricultural run-off monitoring.

At In-Situ, we are dedicated to helping you monitor the earth's resources. Our instrumentation offers the quality, ease-of-use, and service that you would expect from a market leader. Whatever your application requirements are, our professional customer service representatives will be able to help you find a solution. We have worked hard to be the best, and we believe that you will find our service to be unrivalled in the industry. If you encounter any problems with your application while working in the field, call our experienced customer support professionals. We are dedicated to serving you.

In-Situ takes the problems of maintaining the earth's environment for future generations seriously. We are committed to helping you with your current and future environmental monitoring challenges. ■


■ Desalination
■ Membrane Filtration
■ Water Reuse
■ Consulting
■ Engineering
■ Design
■ Construction
■ Installation
■ Own & Operate
■ O&M
■ Service
World Headquarters:
1080 East Indiantown Rd., Jupiter, Florida 33477 USA
Tel: (407) 744-0533 • Fax: (407) 744-5569

Reverse osmosis, nanofiltration, electrodialysis

With tap-water consumption expected to be so high, in the early 1970s much interest was shown in producing fresh water by desalination of sea-water and brackish water.

W van Craenenbroeck, P Meeus
STUDIECENTRUM VOOR WATER AND TUSSENGEMEENTELIJKE MAATSCHAPPIJ DER VLAANDEREN VOOR WATERVOORZIENING, BELGIUM

Three pilot plants using distillation techniques were built in Belgium, two on the coast using sea-water and one near Antwerp (Kallo) using brackish water from the Scheldt estuary. Because the techniques cost so much and the need for tap-water was less than anticipated, none of these tests resulted in practical application.

A major drawback of the distillation approach is that volatile pollutants are not eliminated, and show up in the finished water. The problem was particularly acute with the highly polluted Scheldt water. Together with salts, most such substances can be removed by reverse osmosis.

In Belgium, the first use of membrane techniques for desalination dates from the early 1970s, when reverse osmosis was applied on laboratory scale to desalinate brackish water from the river Scheldt near Antwerp.[1]

As the quality of some conventional raw water sources deteriorated, the removal of specific ions by membrane techniques was also examined. The *Vlaamse Maatschappij voor Watervoorziening* built a pilot plant at the Blankaart reservoir production centre to compare the removal of nitrates by reverse osmosis with other techniques. Due to high energy consumption, non-specific rejection of nitrates and problems with brine evacuation, this technique was not retained.[2]

Recent developments

Within the framework of the *Studiecentrum voor Water* (Flemish Centre for Water Research, which groups the major water supply companies) an inquiry was held in 1985-86 with the aim of reorienting the research needs in the field of alternative water production to cover future demands for drinking water and industrial water. It was decided to look at the feasibility of desalination techniques for application in Flanders. The centre carried out a research project that compared the efficiency of reverse osmosis (RO) and electrodialysis reversal (EDR) for the desalination of different types of raw water. Two experimental sites were selected by the water supply companies involved:

- The Canal Dock near the Lillo Bridge, the Port of Antwerp, is of special interest to the Antwerp water supply company (AWW), given its central location in the highly industrialised northern part of the port, the water of which has high salinity to be removed, and
- The ground water production plant at Schoten, owned by the Provincial and Intermunicipal Drinking Water Company of the Province of Antwerp (PIDPA), and whose water quality has high sulphate levels to be lowered.

Experiments

Brackish water desalination experiments took place from January to October 1991 at the location of Lillo Bridge. The characteristics of the raw water quality are presented in Table 1. A mobile pilot plant was constructed in a 40ft sea container.[3] The plant consisted of a physico-chemical pretreatment unit (water flow 16 m^3/h) using flocculation-flotation-filtration and an RO module (1.2m^3/h) containing a spiral-wound polyamide membrane (DuPont A-15 ACM) and an EDR unit Ionics Aquamite III (1m^3/h).

The performance of a module with three membrane units (brine-in-series) was simulated with only one membrane. The product water reached an average TDS content of 1.7g/l and a conversion of 40 per cent out of the initial raw water TDS concentration of 13.5g/l.

Sulphate removal

At the second location, the PIDPA production centre at Schoten, the experiments aimed at the removal of sulphate from contaminated groundwater.

Parameter	Minimum	Maximum	Average
pH	7.71	7.89	7.77
Turbidity (FTU)	3.4	5.1	4.4
UV extinction (/m)	11.8	11.1	11.7
Filtrability (s)	46	73	60
Particle count (N/ml)	7315	8432	8101
Conductivity (mS/m)	560	513	589

Table 1. Quality of Antwerp dock water at Lillo Bridge (January–February 1989).

Parameter	Minimum	Maximum	Average
pH	7.35	8.00	7.59
Conductivity (μS/cm)	726	1103	984
H carbonate (mg/l)	246	287	265
Sulphate (mg/l)	205	444	337
Calcium (mg/l)	130	204	176
Magnesium (mg/l)	5.2	18.0	14.5
Total hardness (mmol/l)	3.5	5.9	5.0
Iron (mg/l)	2.5	3.6	3.2
Manganese (μg/l)	43	72	59
TDS, calculated (mg/1)	684	1026	888

Table 2. Quality of untreated groundwater at PIDPA production centre, Schoten, 1992.

The excessive sulphate concentration (up to 750mg/l) is due to the presence of pyrite in the Schoten subsoil, which is oxidized as a consequence of fluctuations of the groundwater table.[4] The raw water quality at this location is presented in Table 2.

The mobile pilot plant was adapted to the different pretreatment requirements on this location and to the smaller raw water flow (2m³/h). To protect the membrane against scaling and flux loss, the high total hardness had to be lowered. This was done by adding sodium hydroxide to increase the pH, followed by a pellet reactor.

After optimisation of the pretreatment, a series of RO experiments was carried out. Sulphate removal was excellent: more than 99 per cent out of a feedwater containing 400–2500mg/l sulphate in a simulation of a five-steps desalination (brine-in-series). Other ions such as calcium and sodium were also removed according to the rule that bivalent ions are more easily retained than monovalent ions. The TDS of the product water was only 20mg/l.

The EDR experiments showed a sulphate removal of 78 per cent from an artificial feedwater containing 400–700mg/l sulphate. The product water resembled a more typical drinking-water composition than in the case of RO, with a sulphate concentration of 80-140mg/l and a total salt concentration of 250mg/l.

Two ways of producing 10 000m³ drinking water per day with EDR on an industrial scale have been studied. One is the desalination of a 50 per cent split stream of filtered and softened groundwater, afterwards mixed with the same amount of filtered water. The other is practically identical, except that the pretreatment is without softening. Table 3 gives a summary of the characteristics of these two approaches.

Production characteristics	Reverse osmosis (softening)	Electrodialysis	
		Scenario a (no softening)	Scenario b (softening)
Pretreatment	softening (50% split flow) aeration filtration pH correction	— aeration filtration pH correction	softening (50% split flow) aeration pH correction
Desalination • Membrane type	(50% split flow) DuPont Permasep spiral wound polyamide	(50% split flow) Ionics aquamite 50	(50% split flow) Ionics aquamite 50
• Pressure	16 bar	—	—
Product recovery (per cent)			
• Desalination	80	80	85
• Total	90	90	92

Table 3. Desalination of groundwater at the location PIDPA Schoten: characteristics for the production of 10 000m³/d drinking water with RO and EDR.

Future developments

A major drawback of using both desalination techniques for removing sulphate is that monovalent ions are removed as well. The recently developed nanofilters are known to overcome this problem. Further research is planned to look more closely into their possibilities.

Other research is being planned by SVW (Flanders) together with four Flemish water supply companies, as well as by the *Société Walonne de Distribution d'Eau* (Wallony) to study practical problems involving the use of different membrane techniques. The water suppliers are interested in turbidity removal (microfilters), the removal of organics or bacteria (ultrafilters), bivalent ions or pesticides (nanofilters), nitrate ions (electrodialysis with specific membranes), and salinity (reverse osmosis). The latter case fits into a policy of rendering regional water supply less dependent on water imports. In coastal areas this may imply the use of brackish groundwater for drinking water. The other applications aim at refining present lines of water treatment. ■

References

1. Navewa-Anseau (1976). Annual meeting of the Belgian *Water Supply* Association, April 1975. Different contributions to the theme of Water desalination. *Information Bulletin Anseau-Navewa*, Brussels.
2. Germonpre R (1988). Etude des deverses procédés d'élimination des nitrates dans les eaux de surface. *Water Supply*, 6, pp 63–70.
3. Van Craenenbroeck W, Baee B And Claessens P (1992). Comparison of reverse osmosis and electrodialsis as techniques for the production of drinking water and industrial water. *Poster presentation on the annual meeting of the Belgian Water Supply Association*, Liége, pp 11–12.6.
4. Peeters P (1992) Limiting the aluminium concentration in groundwater treatment: a few realisation and their theoretical grounds. IWSA International Workshop on Aluminium in Drinking Water, 15–17/1, Hong Kong, pp 101–106.

Combined wastewater treatment in Poland

The city authorities in Oswiecim, southern Poland, decided to adapt an existing wastewater treatment plant for a local chemical works to treat the city's domestic waste as well. With design and equipment from a Swedish-based water processing company, the scheme has succeeded. For certain stages of the treatment process industrial and domestic flows are kept separate; in others they are combined.

Steve Minett *MINETT MEDIA, UK*

The original wastewater treatment plant at this site was built in 1983 to serve the discharge disposal needs of the chemical plant in the city of Oswiecim, near Bielsko-Biala. This chemical plant dates from the 1940s, when it was established by the German company IG Farben. During the war the plant employed forced labour from Auschwitz, the infamous Nazi concentration camp for which Oswiecim is the Polish name. The chemical plant was taken over in 1945 by the Polish state and remains one of the biggest such plants in eastern Europe. Its main products are synthetic rubber, polystyrene and carbides.

In 1991 it was decided, on the advice of the Swedish-based water processing company Purac Poland, to convert the treatment plant to a joint industrial and domestic wastewater plant. There were several reasons for this. The capacity of the treatment plant was too large for the needs of the chemical works, partly because the chemical plant was now recycling a lot of its process water systems; and the Oswiecim authorities wanted to establish a sewage treatment system for the city's domestic wastewater, which up to then was being discharged raw.

Purac first became involved in the contract by tendering for the design and supply of an aeration system while the plant was still handling only chemical wastewater. When the decision was made to incorporate domestic sewage treatment, Purac won the contract to design the joint-purpose plant.

Separate inflows

Looking at the process flow in the plant, there is a separate inflow for the industrial waste from the chemical plant. It flows in by gravity in a partly-covered channel. The domestic sewage is pumped in from the Kruki pump station, a few kilometers away. The pump station is equipped with four Sarlin pumps, each with a capacity of 600m^3 an hour. One of these pumps acts as a standby. The daily design flow from the Kruki pump station is 26 900m^3. The current flow, however, is only 12 000m^3 a day because the sewerage system in the city has not yet been completed. The head from the pumping station to the plant totals about 9–10m.

Neutralisation reduces pH

The industrial and domestic process flows are kept separate throughout the mechanical treatment phase in the plant. The industrial flow is screened with 20mm gaps. Screening debris is collected separately from domestic screenings and disposed of under different landfill conditions. For the industrial flow the next stage is neutralisation. When it arrives at the plant, the industrial flow has a pH of about 10. This is reduced to about 9.5 by adding sulphuric acid (H_2SO_4) in three neutralisation tanks. This lowering of the pH is necessary for the flocculation stage that follows. Iron sulphide ($FeSO_4$) is added, again in three separate tanks, to flocculate large organic molecules such as polymers. The flocculants are then settled out in two circular, primary sedimentation tanks, each 40m in diameter. The tanks are equipped with bridge-type bottom and surface scrapers, which remove the sludge for further treatment.

Dilution of concentrates

The industrial flow moves on to two equalisation basins that have a combined capacity of 90 000m^3. Czastaw Dabrowski, manager of the Oswiecim treatment plant, explains that the main function of these basins is to equalise the pH of the flow by allowing large volumes of flow, which can alternate between alkaline and acidic, to mix together. This also has a diluting effect on any concentrated chemical content in the flow. Additionally, the basins act as a flow buffer for the discharge from the chemical plant: they can accommodate three days' wastewater discharge from the plant in case of any problems with the treatment process.

Turning to the domestic inflow, this first passes through Zickert screens' 5mm gaps and then to a sand-trap and a fat removal process. It goes on to primary sedimentation in two tanks, each 40m in diameter. Only one tank is currently in use because of the low domestic sewage flow. The sludge is removed, with bridge scrapers, for further treatment, but is kept separate from the industrial sludge. At this stage of the treatment process the industrial and domestic flows are mixed together. This occurs in the inflow to the plant's pump station, which is equipped with three Polish-made submersible pumps.

Biological treatment

The joint flow then moves on to an anaerobic phosphorous removal zone in the plant's main treatment tanks. This zone is equipped with ITT Flygt submersible mixers, of the "banana" type. The phosphorous content of the flow is reduced to 0.5mg/litre. The next treatment stage is an aerobic zone, equipped with rubber pipe diffusers. These have micro holes in them to provide fine bubble aeration, and were manufactured by Purac in Sweden. Mr Jozef Bak, of Purac's Bielsko-Biala office, explains that they would have been made in Poland had the stainless steel pipes needed to feed the rubber diffuser hoses been available there.

At the end of the main treatment tanks there is an aerobic nitrification phase. No mixers are required here because, as is generally the case in the plant, the flow moves by gravity. The final phase in the process flow is secondary sedimentation, which takes place in three 40m-diameter, circular tanks, again equipped with bridge-type, surface and bottom sludge scrapers.

Divided sludge treatment

Sludge treatment at the plant is also separated into two parallel processes: one for industrial and one for domestic sludge. The domestic sludge goes first to two tanks, both having a capacity of 560m^3, for primary thickening. From these it goes into two digesters, each with a capacity of 2500m^3. Following fermentation in the digesters, the domestic sludge goes to another thickening tank, again of 560m^3, for a secondary thickening and homogenisation. After this it goes into a Noxon centrifuge for final dewatering.

The industrial sludge goes to one thickening and homogenisation tank, with a capacity of 140m^3, and then straight to a Noxon centrifuge. There are two Noxon DC 20 centrifuges in the plant, one used to dewater industrial sludge and other domestic sludge. At present both sludges are disposed of in landfill sites. However, analyses of the domestic sludge content are currently being carried out, and it is hoped that in the future this can be used for so-called "natural enhancement" purposes — for example, as a fertilizer in forest areas. It is unlikely, though, that it could ever be used in the cultivation of food crops. ■

Author

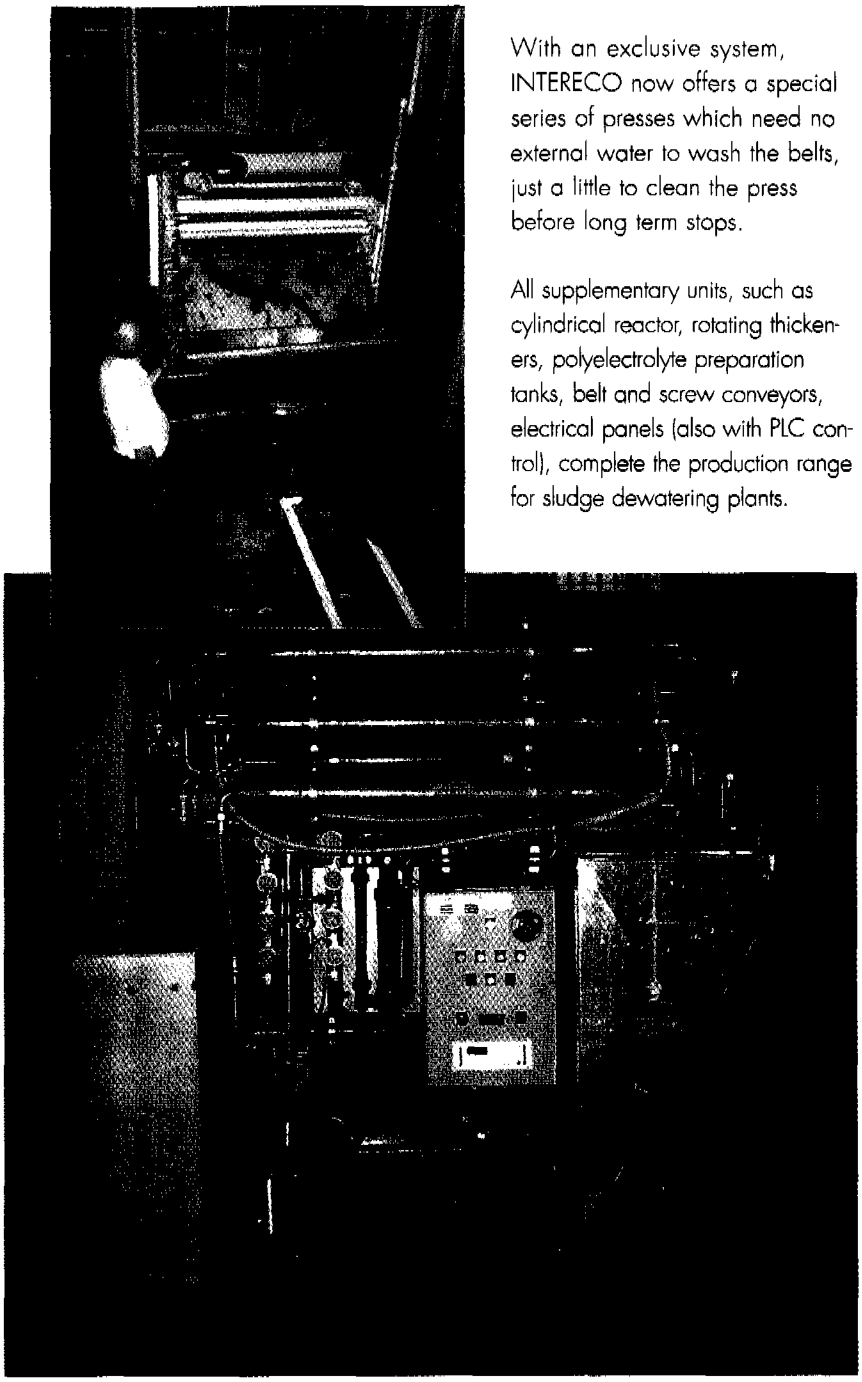
Dr Steve Minett BA (Sussex) MA, PhD (Stockholm) is owner and senior partner of Minett Media, Cambridge, UK.

Something new in belt presses

Intereco
I-10042 Nichelino (TO)
Via XI Febbraio 11, ITALY

Tel: [+39] 11 6054 297
Fax: [+39] 11 6054 244

One of the first manufacturers of very small filter belt presses (500, 800, 1000 and 1200 belt widths) since 1984. INTERECO is now offering a very new solution in belt presses.



With an exclusive system, INTERECO now offers a special series of presses which need no external water to wash the belts, just a little to clean the press before long term stops.

All supplementary units, such as cylindrical reactor, rotating thickeners, polyelectrolyte preparation tanks, belt and screw conveyors, electrical panels (also with PLC control), complete the production range for sludge dewatering plants.

Created from a specific request for a movable plant, then developed as complete plants ready to work to be sent anywhere, INTERECO also offers complete dewatering plants assembled on a very compact hot galvanized carbon steel frame "SKID".

With about 200 units working in Italy and 12 other countries (as far away as China), INTERECO's belt presses are used for biological as well as for industrial plants in many different applications. Special models (all in stainless steel) are also used as production units in the food industry.

Normal production is carried out in hot galvanized carbon steel frames. Tanks, rollers and other parts in contact with sludge are in AISI 304 stainless steel.

With studies and testing lasting many years, and after the installation of several operative plants, INTERECO now has enough experience to offer complete U.F. and R.O. plants for the most diverse uses.

Plants made by INTERECO are working on waste water coming from landfills (leach water), the textile industry, olive oil mills, in the food industry for milk or whey concentration, to produce drinkable water from brackish or sea water, or industrial water with required qualities.

Alkaline sludge hydrolysis

Disposal of sludge, because of both legal restrictions on methods and the increasing volumes of it, is a growing problem. A process developed in Sweden, combining alkaline hydrolysis with anaerobic treatment, offers a solution.

Steve Minett *MINETT MEDIA, UK*

The forthcoming implementation of new EU directives will impose further restrictions on the disposal of sludge from industrial and sewage plants. Dumping at sea and into water-courses will no longer be permitted. A certain amount of sludge can be used on the land as fertiliser, but the main alternative will be disposal at land-fill sites, and this is costly. In 1995, prices in the UK started at a minimum of about £5 per ton. In 1993, costs for wet sludge disposal in Sweden amounted to 100–200 kronor and in Germany to about 200 Deutschemarks per ton.

Moreover, many sites will not accept sludge with a pH value of more than 10.5 or 11. At the same time, more sludge is being produced because increasing amounts of wastewater are having to be treated. There is thus great pressure to find ways of reducing the volume of sludge produced and disposing of it more economically.
The Swedish-based company Purac Industry (part of the Anglian Water Processes Group) has developed a new process involving alkaline sludge hydrolysis, and it is is now available worldwide. The process can provide solutions to these problems; it both reduces sludge volume and generates useful by-products.

Field testing

The process has been thoroughly field-tested at a plant in Norway. Borregaard Industries Limited (a member of the Orkla Group) specialises in manufacturing pulps and wood-based chemicals, with a total annual production of about 160 000 tons. The process at Borregaard is used to treat wastewater streams of sulphite evaporation condensate (SEC) and caustic extraction liquor (CEL) as well as streams from the bleaching plant, where an aerobic process produces an excess sludge production of 14 tons of dry solids a day.
Field tests indicated that Purac's hydrolysis technique could reduce this to 2.5 tons a day.

How it works

The first step in the technique is to concentrate the sludge. This is done in two stages. First, the sludge is thickened in a sedimentation tank. Then it is dewatered in a centrifuge. The result is a sludge with a dry solids content of 5–7 per cent. The sludge is pumped to a hydrolysis tank. NaOH (sodium hydroxide) is added and the sludge is retained in the tank for five to six hours at a temperature of above 60°C. The high pH and the high temperature break down the cell walls of the bacteria in the sludge, making them more easily degradable by anaerobic methods.

After the alkaline hydrolysis treatment, the sludge is cooled to 38°C and mixed with sulphite evaporation condensate (SEC) until a pH suitable for further treatment is reached. The sludge is passed on to an anaerobic reactor (which uses the anaerobic stage of Purac's Anamet process). Here it is further broken down, and biogas is produced. On leaving the reactor the remaining sludge is separated in a lamella clarifier. The excess sludge is dewatered in a centrifuge, increasing its dry solids content to more than 10 per cent. It can then be taken out of the plant and burned — for example, in a boiler. The liquid from the lamella clarifier and the reject water from the centrifuge are returned to the biological treatment plant and their nutrients recycled.

Advantages

The alkaline hydrolysis process offers the following advantages:

- 70–80 per cent of suspended solids are transformed into a soluble form that can be easily biodegraded, so reducing (by approximately the same amount) the volume of sludge requiring disposal
- 70 per cent of nutrients in the sludge are released in the hydrolysing stage and returned to the treatment process, so reducing (by approximately the same amount) the volume of nutrients that need to be added to the process, and
- Gas produced from the anaerobic fermentation can be burned to provide hot water, steam or electric power. ■

Author

[illegible]

Non-profit-making advice for the world

There can be few consultancies in the water industry with so long a track record and so many overseas projects under their belt as the Delft Hydraulics foundation in The Netherlands.

Ron Thiemann *Delft Hydraulics, The Netherlands and*
David D Wilson *Horizontal Wells Environmental Consultants Incorporated*

Founded in 1927, when water engineering was at a peak in a country where dealing with water is a constant fact of life, Delft Hydraulics now employs 450 people. Most of them are academic graduates — necessary in a business worth $41 million a year, half of it generated in overseas projects.

As a foundation, the company ploughs back any operating profits into research, the 1996 budget for which is around $5 million. The company is as much concerned with the effects of its technology as it is with the technical aspects of its work.

The company covers five disciplines in its work:

- Hydrology
- Hydraulics
- Morphology
- Water quality, and
- Ecology.

Since operating profits are ploughed back into research we are in front on technical development. As a result, Delft can advise on, design, and construct projects that involve harbours, estuaries, rivers, canals or industry. They advise at policy and management levels and work with national and regional governments on issues like water quality.

With 50 per cent of turnover created outside The Netherlands, Delft Hydraulics is committed to sustainable solutions for tackling water issues. Currently being applied in locations as widespread as Italy, Pakistan, Bangladesh and Russia, an important company policy is to work with local people and employ principles of technology transfer.

Social structures

The company has procedures that require them to acquire an insight into the natural system and the social structures involved within it. Whether one is in Pakistan or Russia, an understanding of the place of the system in human life is necessary.

However complex a particular project may be physically, the aim of Delft Hydraulics is to help in a sustainable way. Each project, especially those overseas, is an educational experience for us. Technology is transfered in a way that is sustainable by the people whose lives it affects. Solutions cannot be applied without the involvement, knowledge and understanding of the local people. It is their future that will be involved.

The complexity of Bangladesh's river system is on a vast scale. Nobody knows that system better than the people who live in it. The best policy requires the involvement of the people who are already experts — the fishermen and the local environmentalists. For this, incoming personnel need to be active listeners. Different groups have different demands, and social as well as technical skills must be applied to provide several policy choices to decision-makers. The involvement is in complex cultural and social patterns as well as technical and structural issues.

The company started its life through research, with physical models for its

Solutions cannot be applied without the involvement, knowledge and understanding of the local people — it is their future

projects. Some 30 per cent of projects still depend on physical models, but the majority are now computer-modelled using numerical techniques, which the company has marketed, in the form of its own software, all over the world. As a non-profit distributing foundation, Delft Hydraulics has a mission to help the communities it advises.

Much of the company's work takes place against a background of effects that essentially help stabilise the local economy as well as the environment. In India we are helping the national hydraulic laboratory with our experience, and we are doing similar work in Indonesia.

But by no means is the company acting as some sort of technical missionary. If a project is going to be of permanent good it has to be practical and understandable to the people who will run it. The positive references the foundation receives arise from its belief that the social and cultural aspects of its work are as important as the technical. That is why active listening is the most important skill it can have.

Industry's origins

The environmental remediation industry was born of need and edict in the early 1970s. The new industry grew from components of the civil engineering and water resources industries, which provided methods and technologies for site characterisation and subsurface remediation. Techniques included excavation and removal of contaminated soil, and the use of vertical water resource wells to pump and treat groundwater. But these stopgap measures have often proved costly and ineffective.

New soil and groundwater remediation methods began to emerge in the 1980s. One company at the cutting edge of the new environmental technology was the Colorado-based Horizontal Wells and Environmental Consultants Incorporated. The company acts as a consultant for US federal, state and industrial clients who want to clean up contaminated groundwater using innovative technologies including horizontal environmental wells.

The environmental industry in the USA has enthusiastically adopted horizontal well technology as the answer to cleaning up ground water. The idea of horizontal wells has been around since the days of the Persian Empire, when they drilled into the sides of hills to capture spring water. The reasons it has been adopted by the environmental industry as its own technology are threefold.

First, it allows the recovery and remediation of water beneath existing structures with little or no effect on the foundations of facilities and buildings. Second, it allows the remediation system to be placed directly into the contaminated zone. The vertical extent of a contaminated zone is limited, and a horizontal well is more effective than a series of vertical wells for establishing contact with the contaminant. Third, drilling can be done and a remediation system placed without disrupting commerce.

For example, as often happens, where gasoline tanks at a filling station are leaking, you can drill from the edge of a site, place a horizontal well beneath the station or neighbouring property and recover the petroleum without closing any businesses to commercial activity.

The most common use for a horizontal well is to clean up contaminated groundwater, usually with pump-and-treat or air-sparging methods. However, examples of applications such as bio-remediation, soil flushing and barrier injection are growing in number. Most of the installation sites have been at some type of solvent spill. However, interest in installing horizontal wells to prevent groundwater contamination is growing. For instance, one company wants to install horizontal wells beneath a municipal landfill, pump in air and create a vapour barrier to prevent leachate from the landfill from reaching the ground water.

Educating environmentalists

In addition to cleaning up contaminated ground water, consultants work with leading companies in the horizontal well market to help educate the environmental industry on the benefits of such wells as a remediation technology. The company is retained by Charles Machine Works Incorporated, maker of Ditch Witch directional drilling equipment; Schumacher Filters America Incorporated, the North American distributor of Schumasoil filter pipes; and Baroid Drilling Fluids.

These industry leaders deserve much of the credit for advancing environmental horizontal well technology. Charles Machine Works has invested many research and development dollars determining the most cost-effective methods for drilling and installing horizontal wells. Schumacher Filters has developed a lightweight porous polyethylene pipe that meets the filtering needs of horizontal wells; and Baroid has developed the perfect environmentally friendly directional drilling fluid.

Most environmental horizontal wells have been installed in the USA, although Wilson sees a growth of demand in Europe and Asia. The US horizontal well market is expanding fast. Wilson has conducted two industrial surveys. The latest, in 1995, showed exponential growth in installations, with a projection of more than 400 horizontal well installations during 1996.

There is a range of applications for horizontal wells outside the USA. In Africa, horizontal water resource wells are used to capture water beneath dry river beds. In Europe, many environmental horizontal wells have been installed by FlowTex for groundwater remediation.

Europe, especially, will be a key area for market growth. In older urban areas it is important to use a remediation technology that does not undermine old building foundations.

Ultimately, market growth will depend on the regulatory framework, but in Asia and Europe there are tens of thousands of potential sites for horizontal well installations. ■

This article was written in collaboration with John Coops of the Press Bureau, UK.

Author

[illegible]

London's water supply

Sir William Halcrow & Partners Limited, consulting engineers, is playing a key role in developing London's stored water supply infrastructure.

Dr Richard Harpin *SIR WILLIAM HALCROW & PARTNERS LIMITED, UK*

The capital's main sources of stored water are the Rivers Lee and Thames, with the Thames Valley reservoirs and water treatment works supplying 70 per cent of the population. Stored water supply and treatment capacity to feed the new Thames Water Ring Main are being uprated to cope with increased demand. These include the Thames Valley stored water system and one of its main water treatment works at Ashford Common, where Halcrow's customised hydraulic models have been applied to optimise the configuration and assist in the design of major developments to the system.

The client, Thames Water Utilities Limited (TWUL), wants to concentrate water treatment on to four main works but needs to maintain flexibility when sourcing stored water from the eight Thames Valley reservoirs. Consequently, three new 2.5m-diameter tunnels have been constructed and the modified system was tested by Halcrow engineers using a computer model. "The Thames Valley model was developed initially to investigate capacities and constraints in the system using HYDRAN, from our HYDRA suite", said Dr Richard Harpin, Halcrow's chief engineer in charge of the studies. "The system is complex, with many combinations of routes: several reservoirs can be hydraulically connected to all four water treatment works at any one time. Safety is of prime consideration, particularly in such a large capacity system; maximum pressures caused by rapid surge transients need to be determined under routine and emergency conditions for a wide variety of system configurations. COUP, another member of the HYDRA suite, has the same data format as HYDRAN, and it was therefore possible to use the same model for the surge analyses. TWUL now has a general purpose analytical tool which can be quickly used to study the effect of design changes as they implement their strategy."

Halcrow has also been working on hydraulic model studies for Ashford Common water treatment works, looking at uprating the works from the peak output of 420Mld to 690Mld and checking the hydraulic performance of advanced primary and tertiary water treatment processes specified by TWUL, to meet changing EU water quality standards.

Besides optimising the hydraulics, Ashford's sophisticated new control system, specified by TWUL, has been modelled to ensure that the works stay within its designed operating bands. The effects of emergencies were investigated together with performance under routine operational changes. "To this end, we made the original Ashford model represent the control system more closely by including pump speed controllers, valve actuators, control algorithms and flow, level and pressure transmitters", said Harpin. "The control philosophy is unusual as it is demand-driven from the works outlet, whereas most works are traditionally supply-driven from the inlet. The effects of the control of the works on other components of the Thames Valley stored water system also had to be considered: operational changes at other works affect pressures at Ashford Common. It is fortunate that the Ashford model was developed using the same software; this meant we could easily combine parts of the two models — a good demonstration of the flexibility of our software. This also means Thames Water saves by optimising the hydraulic design and control systems associated with £100 million capital investments at Ashford."

In subsidiary studies, Halcrow has tested the mixing characteristics of the proposed design of chlorine injection in the chlorine contact tanks using three-dimensional modelling. This was to eliminate eddies which can cause water to move more quickly through the tank and have less contact time with the chlorine. In conjunction with TWUL and PWT Projects Limited, process engineers, Halcrow has also devised a new strategy for control of chlorine disinfection. This is notoriously difficult because of the transient nature of the disinfectant, hypochlorous acid, and new EU regulations which demand much tighter control on chlorine residuals.

Ashford Common is now at the commissioning stage and other water treatment works are being uprated in line with TWUL's overall investment strategy. With such large-scale engineering, optimisation of the hydraulics and control is crucial to provide a safe, cost-effective design. ■

Treatment processes at Ashford Common.

Filtration and water treatment: not new but better

Protecting public health against disease organisms was the prime consideration in water treatment technologies when they began at the end of the nineteenth century, and, given the pollution of today's water resources, it remains so in both industrialised and developing countries.

Pierre Schulhof *Compagnie Générale des Eaux, France*

"For a very long time people have dreamed of imitating nature to purify unclear or contaminated water. At first it was considered sufficient to clarify it by passing it through sand masses, or porous surfaces; then people became more demanding as scientific progress discovered new impurities, and every possible procedure for improvement was resorted to: physical, chemical, mechanical and biological, separately or jointly."

That text is taken from a conference in 1907. It referred to slow filtration technology, and the scientific progress to which it alluded was Pasteur's work on public hygiene.

We would probably write the same thing today, and it is still correct to say that technology progresses in successive leaps forward, each of them caused by a scientific or socio-economic event.

Slow filtration was thus the first of these water treatment technologies. It saw the light of day in England, Belgium, Germany and The Netherlands during the last years of the nineteenth century. It was introduced to France in 1896.

It is nevertheless remarkable that this technology has remained, with only a few improvements, practically the only one for half a century — if one disregards the introduction of chlorination, the second major event in the history of water treatment and a technological legacy from the First World War.

Indeed, it was only during the second half of the twentieth century that rapid filtration was introduced under the dual pressures of demographic development and eutrophic pollution that were just beginning to make themselves felt. Capacity to produce slow filtration at that time depended largely on increases in river levels and the presence of algae. This technology also needed too much space. After starting in large factories in Stockholm and Chicago, rapid filtration developed in France from 1960 onwards (Figure 1).

Ozonisation added

It was soon noticed that rapid filtration technology, however attractive, did not disinfect water as safely as slow filtration, and in many countries ozonisation was used to complement it. True ozonisation — virulicide with a 0.4mg/litre residue for four minutes — was started in France at that time on the initiative of Coin and Gomella. It was the first appearance of the modern concept of C x T to characterise the efficiency of a disinfection phase.

If we were to express in a single sentence the evolution of water treatment over the past 50 years or so, it would mention more than just the increase in pollution of resources, of which, because methods of analysis were lacking, people became aware only indirectly.

The slow increase in ammonia content first raised the rate of chlorination to virtually intolerable limits. This led to new treatment technologies of biological filtration and the elimination of chlorination in 1970.

But during the same decade a major event took place of which ramifications were not noticed immediately: the growing use of chromatography in laboratories. It became possible to detect organic pollution that had hitherto escaped notice. At the same time, thanks to Rook's work, there was growing awareness that part of the pollution derived from the effect of the treatment itself, and particularly of oxidants on natural organic material, that had previously not been considered as pollution.

Figure 1. Rapid filtration at Méry-sur-Oise.

This was the start of our present era. In 25 years considerably more treatment technologies would emerge than during the previous 75 years. There were many challenges: how to eliminate organic micro-pollution, and to what extent; how to disinfect water without creating by-products; what level of by-products should be accepted if the disinfection was not to be compromised? Distributors passed from an era of certainty to one of "balancing the risks".

First it was necessary to learn, in the light of the new constraints, how to use better the three technologies already available: coagulation, ozone, active carbon. It was known how to optimise coagulation to reduce the tenor of natural organic matter, and then how to reduce them further, before final chlorination, by frequently regenerated active carbon or by an ozone-active carbon coupling functioning in a biological reactor (BAC). The latter technique, which is highly efficient, was initiated in Germany and France in 1975.

The 1980s saw the emergence of several new technologies. The impetus was provided by the growing use of agricultural pollutants, nitrates and pesticides. Numerous denitrification procedures were developed, but none became really important because it was clear that the problem should be treated at source.

Technologies should not be categorised as "old" or "modern"; there are no fundamental differences in performance

On the other hand, radicular oxidation, which can be practised simply in thousands of treatment plants equipped with ozone by adding hydrogen peroxide, has proved an effective means of combating pesticides.

In the present decade, the 1990s, renewed priority is being given to the microbiological battle 100 years after the death of Pasteur. The reasons for this are an ageing population, an increase in the number of immuno-depressed individuals and awareness of new risks (giardia, crytosporidium). Added to these serious risks are the long-term ones. It is no longer accepted that water is the cause of one additional case of cancer in a hundred thousand or a million people over the course of an entire lifetime.

Disinfection, 100 years after Pasteur, is becoming a new science. The evolution of bacteria and parasites in the coagulation phase is being studied, and there is talk of advanced coagulation using new concepts of bacteria-killing logarithms for this traditional treatment; ozonisation vats or chlorine-contact tanks are worked hydraulically. This means that the classic disinfection treatments are optimised. The complex phenomena of reviviscence that occur in reservoirs and the distribution network are more and more understood.

But at the same time, the old slow filtration is being perfected. This is the most amazing factor of these 100 years of water treatment: no procedure has ever become obsolete or been abandoned. There is no "latest technology", and an old technology adapted to the new requirements remains forever new.

Value of membranes

If any single technology merited the term "latest technology", it would certainly be membranes. They have contributed to water treatment the concept of a total barrier. What is more, like other separating technologies they do not create by-products. During the past few years microfiltration and ultrafiltration have come into their own. They constitute an appealing means of fighting against the microbiological peril.

Distribution networks should nevertheless be protected by chlorination, and the elimination of natural organic matter is always vital to ensure both the stability of the chlorine and the absence of oxidisation by-products. In the case of water filled with organic matter, nanofiltration (the result of inverse osmosis but at a far more accessible price) would seem to be the best solution (Figure 2).

In many countries — the USA, Holland, Scandinavia, England, France — membrane technologies are used increasingly often.

Technology will never be efficient if the men who create, install, operate and control it are not trained for it

As regards matters of interest to developing countries, and more generally to long-term development, the following points are relevant:

- Microbiological risks are and will remain the main risks everywhere
- Scarcity of resources leads inevitably to re-use of water, voluntary or otherwise, and this can only increase the microbiological risk, which might be reduced but not eliminated by a policy of protecting the resource, and
- The dispersion of habitat leads to small treatment systems that are difficult to maintain and monitor.

Technologies capable of meeting these challenges exist.

We know how to re-use used water for irrigation effectively, whether through simple technologies that take up space, such as infiltration in the ground, or through compact technologies combining filtration and disinfection.

We also know how to produce clean drinking water from a resource polluted by used water, but technologies should not be categorised as "old" or "modern". There are no fundamental differences at the two ends of the scale between the performance of slow filtration and that of a microfiltration membrane.

While it is easy to maintain a slow filter without any special competence, it is just as easy, albeit requiring more energy, to obtain constant production capacity from a membrane.

Figure 2. Nanofiltration at Méry-sur-Oise.

Pros and cons of chlorine

Chlorination of treated water, especially in distribution networks, still seems indispensable, and should not be condemned for ideological or ecological reasons. On the other hand, we should not believe blindly in the virtues of chlorination and think it protects us in all cases. If we chlorinate water that is poorly prepared to receive chlorine, we run risks in the long-term with the by-products of chlorination, but above all we run short-term risks with pathogenic micro-organisms resistant to chlorine. These are increasingly numerous, and, paradoxically, populations are more and more vulnerable to them as hygiene and medicine progress.

If we were to settle for two simple measures to treat water before distribution, they should be those concerning turbidity and chlorine requirements, which need to be carefully watched to protect public health.

But we ought not to forget the sensors and means of analysis that have made such progress over the past 10 years. Here, too, at the two extremes of the scale can be found sensors in both sophisticated systems and terrain-analysing methods.

In the most important field of microbiology, reliable, simple and inexpensive means now exist for on-the-spot monitoring of the presence of test germs, especially *Escherichia coli.* Their use has become indispensable at the point of production for small companies and in distribution networks for large companies.

There are also methods that make it possible to choose sampling points in networks to ensure, by monitoring a limited number of points, as satisfactory an overall security as possible.

In 1996 we have a full range of technologies from which to choose, though they may have to be complemented over the next few years to meet new enemies such as algae toxins. The increasingly insidious pollution of resources and the resulting eutrophication will make this more and more necessary.

But technology will never be efficient if the men who create, install, operate and control it are not trained for it. Education and training can never be replaced by a new technology. ■

Author

Pierre Schulhof is the director of France's Compagnie Générale des Eaux and president of the water quality and treatment division of Association Internationale des Distributeurs d'Eau (International Association of Water Distributors).


New SCADA PLC Offers Big Savings!
SAFE
MICRO-16
We took the best features of a PLC
Ladder Logic programming, documentation, and remarks
On-line editing and monitoring
Remote programmability for ease of support
Modularity for ease of configuration and service
Low cost, heavy duty expansion I/O
Compact size
And added the features for SCADA
Superior transient protection
Optional radio and telephone modems, UPS battery backup, 24VDC analog loop power supply
Dial-up programming support
Modbus® protocol with store and forward, and dynamic master/slave modes
Sleep-mode for ultra low power requirements
The result: Big Savings!
TeleSAFE Micro-16 is a complete SCADA controller. No more bits and pieces from multiple vendors.
SAVES MONEY
With smaller enclosures, no heaters, and no extra transient protection required.
REDUCES MAINTENANCE
Designed for tough environments, the Micro-16 is warranted for 3 years.
The TeleSAFE Micro-16 is destined to revolutionize the SCADA industry.
To find out how you can use the Micro-16 in your systems, call or write today!
KENT PROTEK
Telephone: 44 (0) 1622 695 443
Lower Stone Street
Maidstone, Kent

Solving Kingston's water problems

When Columbus arrived in Jamaica in 1494, the island was described as "the land of wood and water". Today, many sections of it suffer from a shortage of water, but none more so than the capital, Kingston.

Earl D Wright *Underground Water Authority, Jamaica*

Jamaica, the third largest island in the Caribbean, has a population of 2.5 million people, of whom 650 000 are in the Kingston metropolitan area.

The island is 65 per cent limestone, which contains the major aquifers. Eighty-four per cent of its exploitable water resources occur as groundwater, 94 per cent of it in the limestone aquifers.

The island is divided into 10 hydrological basins. In the two most easterly ones the rock type is predominately volcanoclastic, and surface water predominates as an exploitable water resource. The remaining eight basins are mostly limestone, with groundwater predominating.

The Underground Water Authority, the agency responsible for regulating exploitation of the island's groundwater resources, in 1990 prepared a water resources development master plan for the island. A full inventory of water resources and demand was compiled.

Matching resources against demand for the island indicates that all demands can be met. The water used in 1990 was calculated as 22 per cent of exploitable resources. By 2015 the projected use will be 41 per cent of exploitable water resources. Although at national level available resources far exceed demand, there are some basins where the demand is higher than the available resource. The Kingston Basin is one of them.

	Unit	1995	2000	2005	2010
Demand	MIGD	46.2	47.1	48.9	49.1

Table 1. Water demand.

Demand and supply

The present and projected domestic water demand for the Kingston metropolitan area (KMA) is as in Table 1.

	Unit	1995	2000	2005	2010
Demand shortfall	MIGD	16.0	16.9	18.7	18.9

Table 2. Demand shortfall.

Water supply to the KMA is predominantly from inter-basin transfer. Groundwater is imported from the Rio Cobre Basin to the west, and surface water from the Wagwater River to the north and the Yallahs River to the east. Sources within the Kingston Basin are surface water from the Hope River and groundwater from the alluvium and limestone aquifers.

The total installed capacity from all these sources is 51 MIGD (millions of imperial gallons a day). The effective supply is, however, only 30.2 MIGD. The difference between installed capacity and effective supply is referred to as "unaccounted for water"

[illegible]

Table 3. Demand shortfall, adjusted.

[illegible]

Table 4. Demand and supply, adjusted.

and is due mainly to distribution losses, problems at source and other inefficiencies in the system. Considering the effective supply, the present and projected deficit or demand shortfall is as in Table 2.

The installed capacity of 51 MIGD is higher than present and projected demand, but not by so much as to avoid a demand shortfall, given that losses are inevitable in a water distribution system.

A major problem associated with the surface water sources is poor watershed management, resulting in high variability in the streamflow, and siltation. Siltation poses problems at intake, storage and treatment facilities.

In the case of groundwater sources there is significant contamination of the alluvium aquifer by nitrate from improper sewage disposal. An estimated 40 per cent of the groundwater in this aquifer is unsuitable as a potable source because of the high nitrate. The problem has caused a number of production wells tapping the alluvium aquifer to be abandoned. Over-production from wells in the limestone aquifers of the Kingston Basin has resulted in increased salinity (saline intrusion).

Solution options

If better management could reduce water loss from 41 per cent to 10 per cent, the demand shortfall would be as in Table 3.

It is clear that an effective water loss management programme would significantly reduce the demand shortfall. If a 10 per cent reduction were to be achieved, however, this in itself would not solve the water shortage problem.

The National Water Commission (NWC), the agency responsible for providing potable water to the public, has embarked on a water loss management programme estimated to cost $20.4 million over the three years 1994–97. Already significant water savings have been realised.

The programme involves metering all production sources, repairing all major visible surface leaks, and mains replacement. Many of these mains are more than 50 years old and badly corroded, resulting in leaks and frequent failures.

Demand management

Although demand management is not being aggressively pursued, it is recognised that such management would also significantly reduce the demand shortfall. A 10 per cent reduction in demand coupled with a 10 per cent distribution reduction would result in a surplus of 1.71 MIGD by 2010. The surplus that can be achieved by these two methods, though significant, will not solve the long-term problem, since average daily demand rather than maximum daily demand is used in the calculations (Table 4).

Developing new sources

Given the problems associated with existing sources, the high cost of constructing new ones and the inevitable problem of water shortage in future, it would be prudent to develop new sources soon. Three main options are being considered.

The first is to obtain 5 MIGD from the Rio Cobre and 8.5 MIGD from the alluvium and limestone aquifers in the Rio Cobre Basin at an estimated cost of $64.1 million. The second is to exchange high-nitrate groundwater from Kingston Basin with unpolluted water from the Rio Cobre Basin. High-nitrate water would be used for irrigation. The third is to divert streams in the Blue Mountain range at relatively high elevations of about 2000 feet above sea-level and transmit water by gravity through large-diameter pipelines and tunnels to the KMA. This is an elaborate option estimated to cost $300 million.

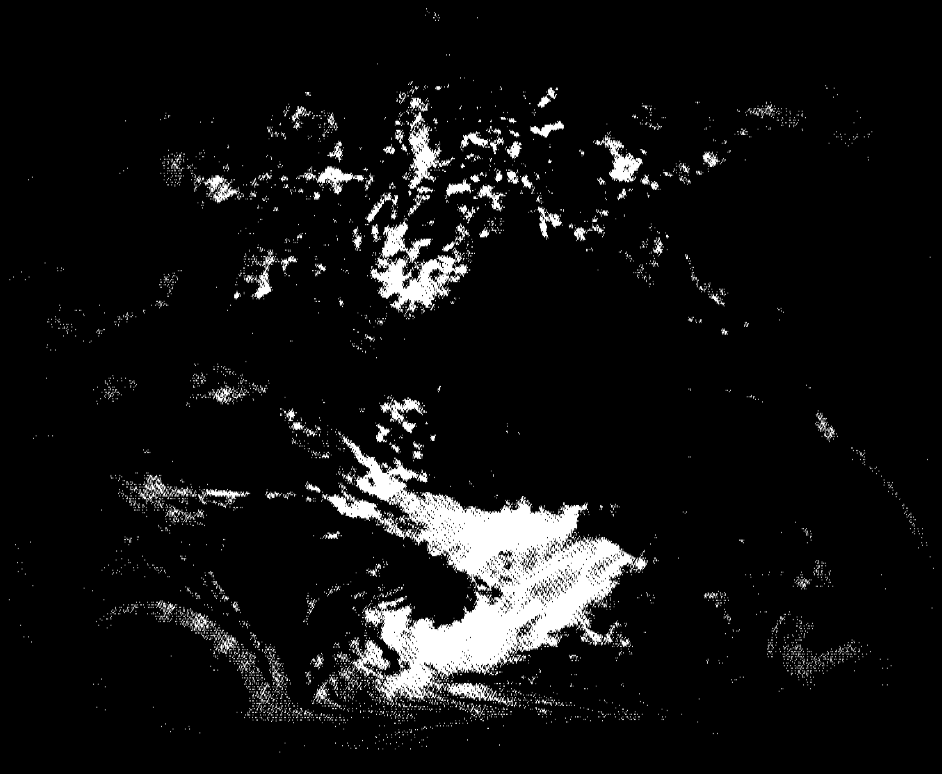
Other options or variations on those outlined are also being considered. What is clear, however, is the need for an inter-sectoral approach to the development, management and utilisation of water to satisfy competing users and the increasing demand for water.

In this regard the government recently passed The Water Resources Act, 1995. The Act is to "provide for the management, protection and controlled allocation and use of the water resources of Jamaica; to provide for water quality control and for the establishment and operation of a water resources authority".

Once the authority becomes functional, a more systematic approach to development of the island's water resources can be expected. Critical to the success of the new authority is institutional strengthening through international assistance. ■

Author

[illegible]



Monitoring strategies create opportunities and help the environment

Nestled within developing countries' hopes that their water-supply problems will one day be solved lie vast opportunities for those of us in the water industry.

Gregg Gustafson *INSTRUMENTATION NORTHWEST INCORPORATED, USA*

Whether it be the drilling of a single well or the creation of a municipal water system, it is this increased need for water quality services and technology that will lead to worldwide growth of the environmental market and, in turn, a quality living environment. Our success, however, will depend on increasing the co-operative partnership between government and private industry to develop and implement mutually beneficial monitoring strategies.

The following checklist provides a fundamental guideline of activities and considerations, not unlike those my company must adhere to when developing a new product, that should be addressed in order to establish an effective monitoring strategy:

Define, agree and conform to water quality criteria. What are acceptable water quality standards? Ideally, water affected by any sort of pollution should be prohibited; realistically, we must consider our neighbours' limitations. Those of us who are fortunate to have clean, potable water may not always understand the big picture. We cannot impose standards of prosperous nations on developing countries — they simply do not have the resources to support extensive environmental restrictions. The challenge, therefore, is to agree on what is acceptable and to conform to those standards in the most beneficial and cost-effective ways, given the limited resources.

Seek input from public and private sectors. The perspectives of those concerned with water quality — corporation managers, their major customers, government leaders and providers of environmental products and services — are essential because they are the ones guiding and supporting the implementation of these efforts. The collaborative process has already saved millions of dollars and will undoubtedly pave the way for more effective ways to answer questions on water conditions and applications.

Develop and test. Create a performance-based system that can produce comparable data. Are the collective standards being met?

Identify the need for new or improved techniques. In the past 20 years, environmental science has made significant advances from intermittent sampling and analysis equipment and techniques to dedicated equipment capable of continuous monitoring for a reasonable cost. Examine the current technology — is it meeting the needs? How does its construction effect our water resources?

Encourage and facilitate the sharing of information. Focus on developing comparable data so that it can be shared with and used by others. Develop workshops and on-site training sessions.

Measure the cost. Even though state-of-the-art equipment exists, some would prefer to avoid recognising the need for high-tech solutions. Instead, they expect individuals and companies to care for the environment and fail to think of the consequences their behaviour or products could produce. Determine the long-term economic and social costs related to such a belief system and publicise the results.

Water truly is our most precious and powerful natural resource, and as such must be used, apportioned and protected in the most judicious manner possible. Encouraging everyone — from the major players in the international community to the farmer tilling his field — to be active in establishing practical monitoring strategies will drive the demand for water-quality services, new technology and a quality environment for us all. ■

Author

Gregg Gustafson is president and co-founder of Instrumentation Northwest Incorporated (INW), located in Redmond, Washington, USA. Established in 1982, INW manufactures and distributes groundwater monitoring instrumentation and sampling equipment, including aquifer testing systems, submersible sensors and sampling pumps.

Product Showcase

Tapping water's secrets through oxygen

Measurement of dissolved oxygen is required for monitoring many different water systems, both natural and sewage and wastewater treatments.

Low oxygen in water may mean high contamination, either microbial or with inorganic ions or salts. Electrochemical sensors can measure such oxygen readily without complicated apparatus. The Umwelt-, Membran- und Sensortechnik Micro Oxygen Sensor 101 is compact, weighing only 250g. The electrode can be made in different lengths and waterproofed for use in any situation, especially outdoors.

In the UMS Micro Oxygen Sensor 101 the solution to be measured is separated from the measuring cell by a Teflon (PTFE) membrane coated with a fine protective layer of silicon rubber. A cellulose membrane can cover the tip of the silicon membrane, enabling the sensor to be used in non-water systems — perhaps for food products like beer and milk. Bubbles so not form on the sensor tip. The membrane is biocompatible and does not contaminate the silicon/steel sensor, which can be sterilised in steam to a temperature of 134°C.

The oxygen sensor causes oxygen molecules break up into ions and electrons, the latter migrate through an electrolyte toward a positive anode, causing a current proportional to oxygen content. In both pure oxygen and air, the sensor signal shows high linearity by the change in the oxygen partial pressure against the reading on the sensor. In air the error in linearity difference is a maximum of 0.4 per cent, in pure oxygen it is 1 per cent.

UMS Micro Oxygen Sensor operates with an analogue system containing an NTC resistor that measures solution temperature and compensates accordingly. ■

[illegible]

X-Pando — The Problem Solver

Wouldn't it be wonderful if one sealing compound could be used on all threaded pipes and fittings for almost any liquid, gas or liquid gas? Add to these demands a material that will correct problems resulting from using pipes and fittings that have damaged, mismatched or improperly cut threads or that use materials from different suppliers with slightly different threads. X-Pando Products Company manufactures such a product in its X-Pando Pipe Joint Compound.

X-Pando, with its offices and manufacturing facilities in Trenton, New Jersey, USA, has enjoyed its fine reputation as "THE PROBLEM SOLVER" for more than 55 years, solving pressure (up to 6000psig) and temperature (up to 1200°F) related leaks consistently where other products have failed.

X-Pando differs from other sealants in both formulation and performance. The material is an expanding cement product rather than a filling agent or epoxy. Because X-Pando expands as it sets, it will aggressively fill voids, gaps and pits, creating a leak-proof seal.

Add to these superior qualities the fact that X-Pando is manufactured for a safety conscious society with high environmental standards. X-Pando is non-toxic, containing no lead or asbestos and is made without ozone-depleting chemicals. X-Pando is UL classified and has been approved for the ANSI/NSF standard 61 for drinking water. X-Pando products also meet the very difficult standards and requirements of the FDA, USDA, API and NASA. Two of X-Pando's products have been tested and approved for medical oxygen.

Another quality product manufactured by X-Pando Products Company is X-Pando Special No.2. This particular material is made specifically to seal joints of cement lined pipes that will be welded. Special No.2 is already used extensively throughout the world for old and new construction projects and is mentioned by name in the American Petroleum Institute's procedures for installing cement-lined pipe. ■

For more information about any X-Pando products please contact X-Pando Products Company, PO BOX [illegible], Trenton, New Jersey [illegible], USA.
Tel: (609) [illegible]
Fax: (609) [illegible]

Trenchless chemical pipe cleaning process

Many municipalities face replacing water pipes more than 30 years old. Replacement costs about \$40–\$150 a foot, depending on location, population density, labour rates and so on. Replacement does not include traffic disruption, upset utility directors and politicians, and traders who lose business because of traffic detours.

Scale builds up inside pipes from years of bacterial deposits called tuberculation. The pipe maintains structural integrity but loses standard flow. In some areas flow is so poor as to jeopardise the municipality's fire-insurance rating.

But there is now an alternative to replacement: a trenchless process from Phoenix-based HERC Products Incorporated. HERC's patented PIPE-KLEAN® technology allows a small maintenance crew to remove scale from distribution lines, valves and hydrants with minimal disruption. PIPE-KLEAN® employs a ANSI/NSF Standard 60-certified formulation to dissolve iron, magnesium, calcium or manganese scale without damaging existing lines, valves, hydrants and suchlike.For this:

- A section of pipe is isolated from the main system
- The pipe is filled with PIPE-KLEAN® treating solution
- The solution circulates for a pre-determined time (usually 8–12 hours), and
- The solution is removed, neutralised, the system flushed and reconnected.

The process is usually less than 30 per cent of the replacement cost of the pipe. It has little impact on residents: minimal traffic disruption, no road replacement or excavation. It lowers the coefficient of friction in the pipe, thus lowering pumping costs. Hydrant flows return to near original, improving fire-fighting capabilities and reducing insurance premiums.

Several recent PIPE-KLEAN® projects in the USA so impressed officials that funds have been allocated for further such projects over periods of up to five years. ■

More information from: Dr Martin J Plishka, Technical Director, HERC Products Inc, 3622 N 34th Avenue, Phoenix, AZ 85017-4401, USA. Tel: +1 602 233 2212.

Pow Plastics Limited

Pow Plastics Limited are a long established company manufacturing high quality GRP products, primarily for the water services, industry including:

One-piece and sectional storage cisterns:

- Laminated, using Water Research Council-approved materials
- Insulation encapsulated during manufacture, although cisterns can be supplied uninsulated if required
- Flat pads for connections prepared during manufacture on pre-insulated cisterns
- Full Byelaw 30 packages available to maintain water quality
- Specially fabricated one-piece cisterns available for difficult locations
- GRP drip trays available for all cisterns
- Metric and imperial panels available for sectional cisterns
- Sectional cisterns available with internal or external flanges, or a combination of both, and
- A full range of accessories available including manways, ladders, connections, raised ballvalve boxes, partitions, and so on.

Equipment housings:

- Available in a wide range of sizes and colours
- All housings supplied insulated as standard, and
- Doors and louvres can be factory fitted.

Pump covers:

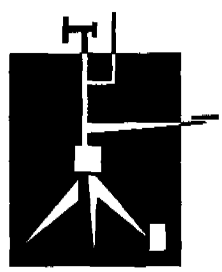
- Fabricated to suit pump
- Preinsulated as standard, and
- Split design to allow access without disconnecting pipework.

GRP special fabrications:

- Items can be specially fabricated to specific requirements, and
- A range of colours and surface finishes is available.

Pow Plastics Limited's products are specified by many consultants and local authorities. Our long list of clients includes: international hotel groups; health and local authorities; the MOD; major commercial, retail and financial institutions; and food and pharmaceutical manufacturers. ■

For further information please contact:
Pow Plastics Limited
Conitor House
Denbury Road
Newton Abbot
Devon TQ12 6AD
Tel+44 (0) 1626 333385
Fax+44 (0) 1626 333359



Datapod and EasyLogger brands of field data recording equipment

The Datapod models are small, stand-alone field units, dedicated to one or two specific data collection applications. The EasyLogger models can accommodate a variety of different sensors, all collecting data at different

intervals. These models have two RS-232C Communications ports. They can communicate directly with your desk or laptop PC, or with other terminals, by way of PC software and connecting cables. A variety of reports can be generated. The data is stored on Flash EPROM memory, which is non-volatile. On some models, these memory packs can be removed and sent from one location to another. The EasyLogger models accept multiple sensor input; they are available with up to 12 analogue channels. The EasyLogger models read both pulse and frequency inputs; they also accommodate digital input and output signals. Some models accept SDI-12 sensors; all models offer logarithmic scanning, two point calibration, and linear sensor input. Sensors and customized packages are also offered. ■

The Datapod and EasyLogger models are manufactured by and sold through:
DataLoggers Incorporated
A division of Omnidata International, Incorporated
PO Box 361, Logan, UT 84323-0361 USA
Tel: + 801-753-8311
Fax: + 801-753-8177

Intereco

One of the first manufacturers of small belt presses (500, 800, 1000, 1200 belt's width), Intereco is now offering a new solution in belt presses.

With an exclusive system, Intereco offers a special series of presses which need no external water to wash the belts, just a little to clean the press before long-term stops.

All supplementary units, such as the cylindrical reactor, rotating thickeners, polyelectrolite preparation tanks, belt and screw conveyors, electrical panels (also with PLC control), complete the production range for sludge dewatering plants.

Born from a specific request for movable plants, then developed as complete plants ready to work and to be sent anywhere, Intereco also offers complete dewatering plants assembled on a compact hot galvanised carbon steel frame "Skid".

With about 200 units working in Italy and in 12 other countries (as far as China), Intereco's belt presses are used for biological as well as for industrial plants in many different applications. Special models (all in stainless steel) are also used as production units in the food industry.

The normal production is in hot galvanised carbon steel frames. Tanks, rollers and other parts in contact with sludge are in AISI 304 stainless steel.

With studies and testing lasting many years, and after the installation of several operative plants, Intereco has now enough experience to offer complete UF and RO plants for the most different uses.

Plants realised by Intereco are working on waste water from land-fills (leach water), in the textile industry, olive oil mills, and in the food industry for milk or whey concentration, as well as producing drinkable water from brackish or sea water, or industrial water with required qualities. ■

Further information contact,
Intereco SNC
I-10042 Nichelino., Via XI
Febraio 8, Italy

Cytec Industries Incorporated

Applications for Cytec's flocculants cover every phase of liquid-solids separation in water and wastewater treatment including sludge dewatering, settling, coagulation, clarification, filtration, and flotation. Cytec's extensive product line includes a complete range of ionic charges, molecular weights, chemical types, and physical forms. This wide variety of products allows customers to benefit from customised chemical programmes which optimise their operations.

Increased throughput

In sludge dewatering, Cytec's polymers increase throughput and cake solids in belt and screw presses, centrifuges, and other mechanical dewatering systems. In gravity thickening, Cytec flocculants improve clarity, settling and sludge compaction. In dissolved air flotation, they produce clearer underflows and greater throughput.

Cytec polymers are used in raw water treatment to remove colour and suspended solids in order to meet potable water standards and to improve process water quality.

Technical support

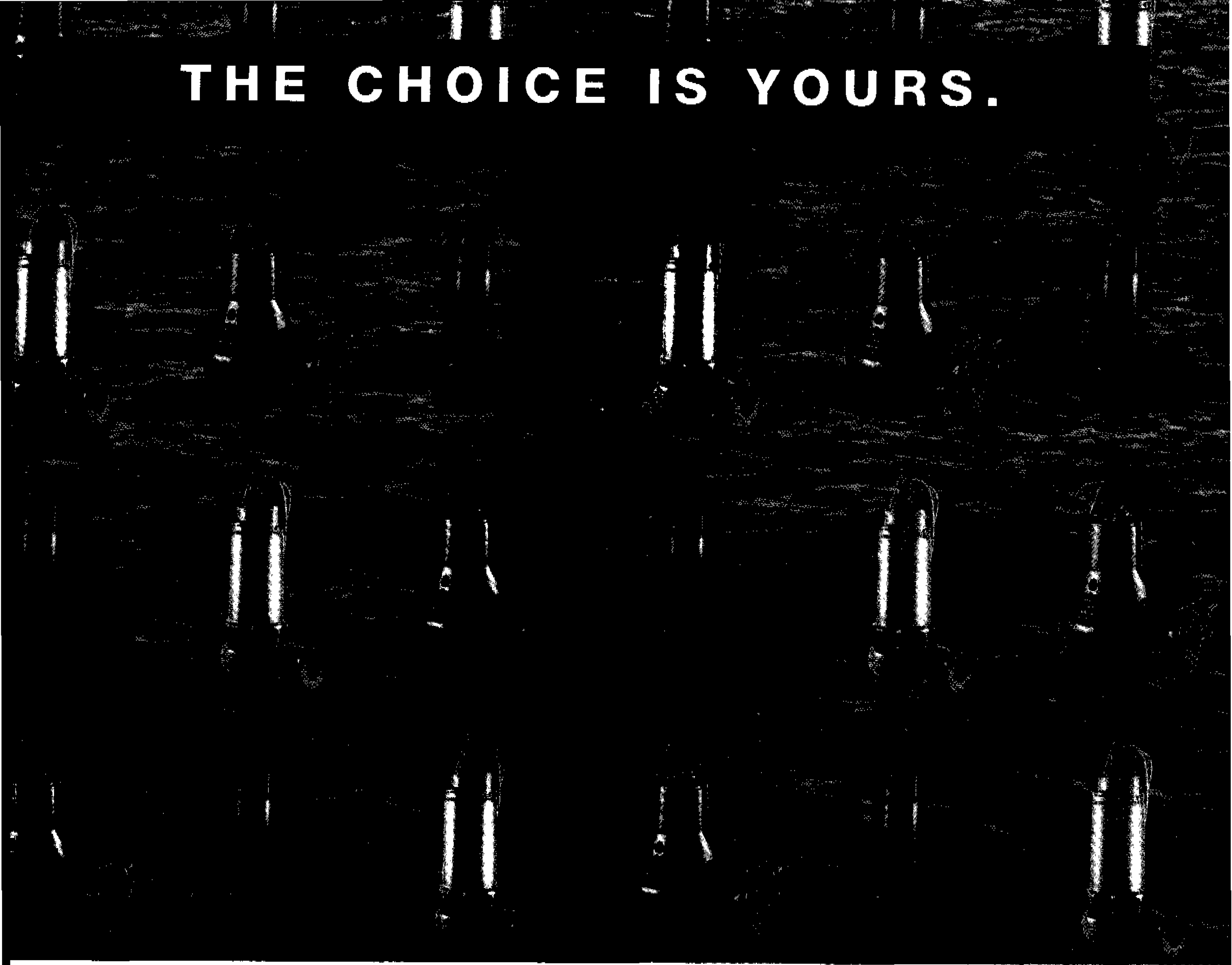
Technical support is provided to Cytec customers worldwide through a network of specialists experienced in specific market applications and products.

In addition to its wide line of flocculants, Cytec supports the international water and wastewater-treating community with a line of automated Cytec equipment (ACE) chemical metering and feeding equipment.

Cytec Industries Incorporated is an integrated, global, research-based company that develops and manufactures speciality chemicals and materials for the water treating, paper, coatings, plastics, mineral processing, oil production, textiles, rubber, aerospace, automotive, chemical processing, and drug and cosmetics markets. ■

Further information contact
Cytec Industries BV, Botlekweg 175, 3197 KA
Botlek Rotterdam, The Netherlands.
Tel: 31-181 29 54 00

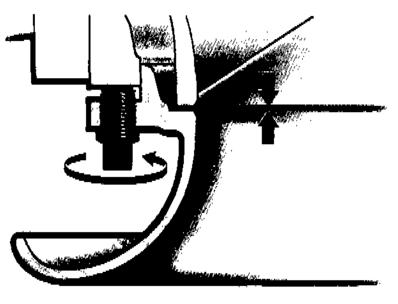
Products and Services Index



SARLIN. The smarter choice.

Not all pumps are created equal. And SARLIN pumps are built with a difference where that difference really counts. That translates, across the whole range of heavy duty submersible pumps, into enhanced dependability and efficiency.

Keeping it simple.
Whether you're pumping raw water, sewage, flood water or industrial effluent, keeping your pumps at optimal efficiency makes sound business sense. So a unique SARLIN feature allows simple, on-site impeller adjustment with just three screws. Even small increases in clearance can be quickly readjusted to factory settings for optimal performance at all times.



Comprehensive remote condition monitoring.
Knowing how your pumps are performing is also vital, and SARLIN's PM Plus system monitors all vital pump, motor, seal and performance parameters. Data can be accessed directly or via industry-standard telemetry, so you can schedule maintenance strictly on a 'need-to-service' basis. The result? Optimal performance and peace of mind.

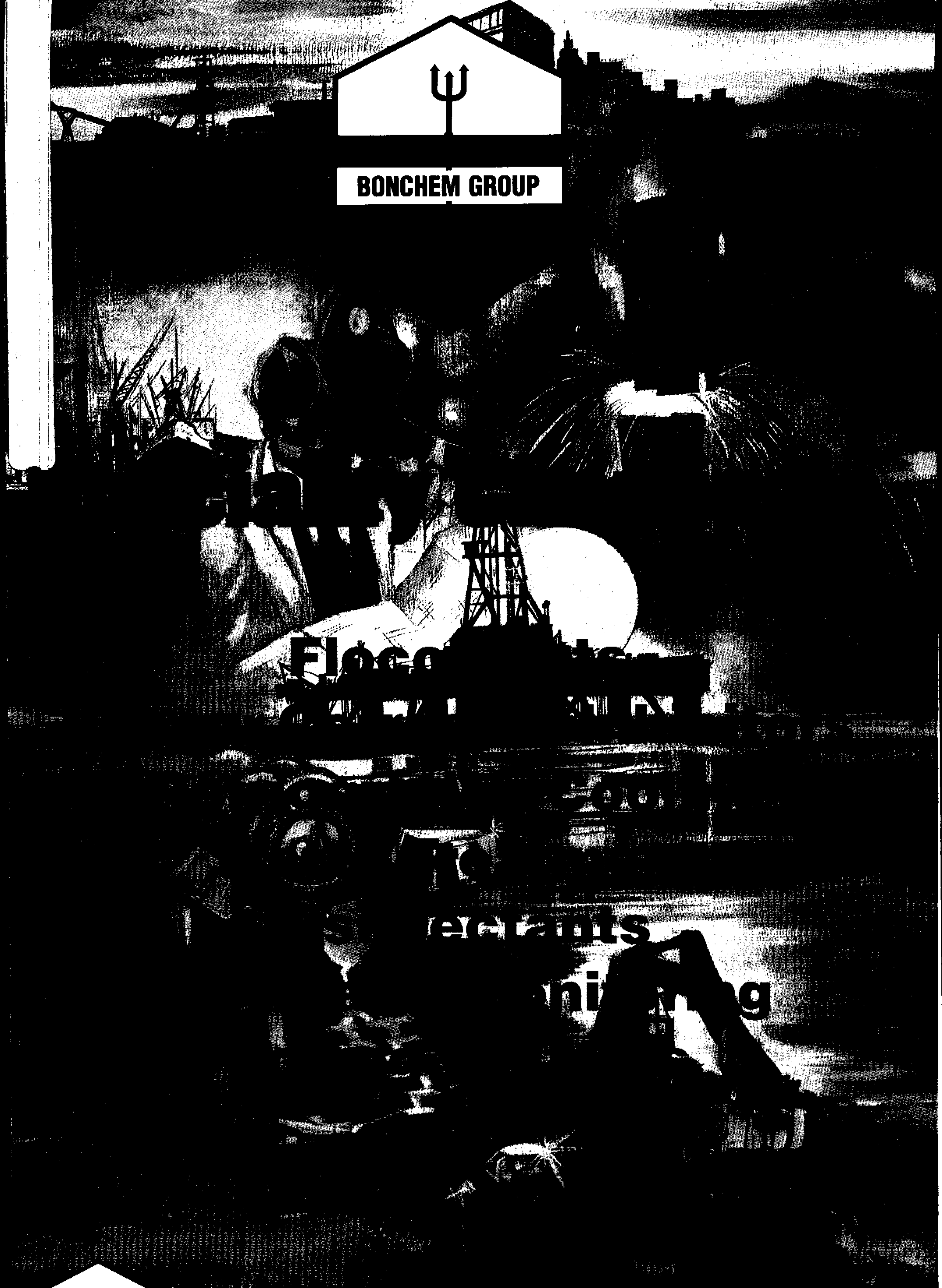
Packaged pumping stations.
No-one knows packaged pumping stations like us. SARLIN Pumps have been manufacturing such stations, in polyethylene or GRP, since 1976. These are delivered complete with pumps, internal pipework, level control systems and control panels, ready for connection with the sewerage system and power supply.

And if you still think all pump manufacturers are the same, give us a call and we'll convince you that SARLIN really is the smarter choice.

Oy E. Sarlin Ab, P.O. Box 750, FIN-00101 Finland, Tel. +358 0 504 441, Fax. +358 563 3989

SARLIN
Pumps

Alphabetical List of Advertisers


BONCHEM GROUP