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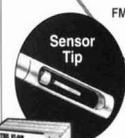
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  - 817  Dust Suppressants
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- 822  New Construction
  - 823  Plant Upgrade
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- 825  Over \$200,000
  - 826  \$100,001-\$200,000
  - 827  \$50,001-\$100,000
  - 828  \$10,001-\$50,000
4. How immediate is your need for the selected products/services? (select one)
- 831  0-3 months
  - 832  4-6 months
  - 833  7-9 months
  - 834  10-12 months
  - 835  Over 12 months
5. What is your reason for purchasing the selected products/services? (select one)
- 829  \$5,000-\$10,000
  - 830  Under \$5,000

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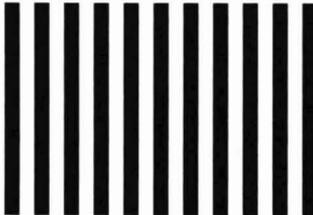
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- A. Function which best describes your activity in Pollution Control (check only one):
- A  Corporate responsibility for Pollution Control
  - B  Manage all Pollution Control Operations at this location
  - C  Supervise sub-group in Pollution Control Operations
  - D  Provide professional consulting service on Pollution Control
  - E  Provide staff environmental service on Pollution Control
  - Z  Other \_\_\_\_\_
- B. Type of Business (check only one):
- A  Manufacturing. If manufacturing, please check the appropriate SIC (check only one):
- (20) Food  (31) Leather
  - (21) Tobacco  (32) Stone/Clay/Glass
  - (22) Textile  (33) Primary Metal
  - (23) Apparel  (34) Fab. Metal
  - (24) Lumber & Wood  (35) Mach., except Elect.
  - (25) Furniture  (36) Elect & Electron
  - (26) Paper  Mach
  - (27) Print/Publish  (37) Trans. Equip.
  - (28) Chemicals  (38) Instr./meas./
  - (29) Petrol. & Coal  analyze/controling
  - (30) Rubber/Plastic  (39) Miscellaneous Mfg.
- C. Number employed at this location:
- A  1-19 B  20-49 C  50-99
  - D  100-249 E  250-499 F  500-999
  - G  1000-1499 H  1500-2499 I  2500 and up
- D. In your job function do you recommend, specify or purchase? (check all that apply)
- A  Pollution Control Equipment
  - B  Instrumentation
  - C  Chemicals
  - D  Parts & equipment for maintenance operation & control
  - E  Services/Consulting
  - F  None of the above
  - G  Other (please specify) \_\_\_\_\_
- E. What types of Pollution Control are you responsible for? (check all that apply)
- A  Air B  Water
  - C  Noise D  Solid Waste Disposal
  - E  Industrial Hygiene
  - F  Toxic & Hazardous Material
  - G  Energy Control/Energy Conservation
  - I  Recycling
  - J  Other (please specify) \_\_\_\_\_
  - H  None of the above
- F. Which of the following publications do you receive personally addressed to you? (check all that apply)
- A  Pollution Engineering
  - B  Environment Today
  - C  Environmental Solutions
  - D  Pollution Equipment News
  - E  The National Environmental Journal
  - F  Water Environment & Technology
  - G  None of the above



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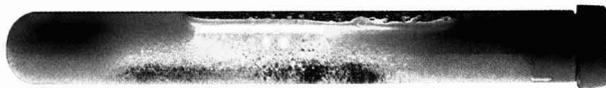
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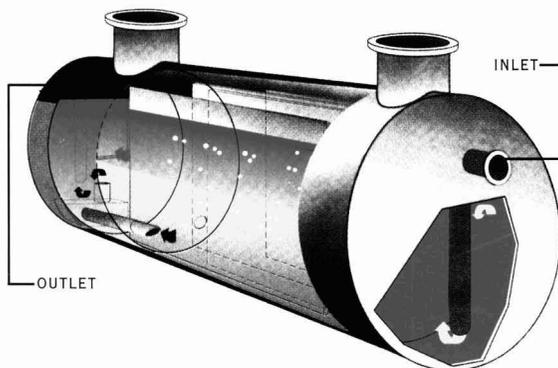


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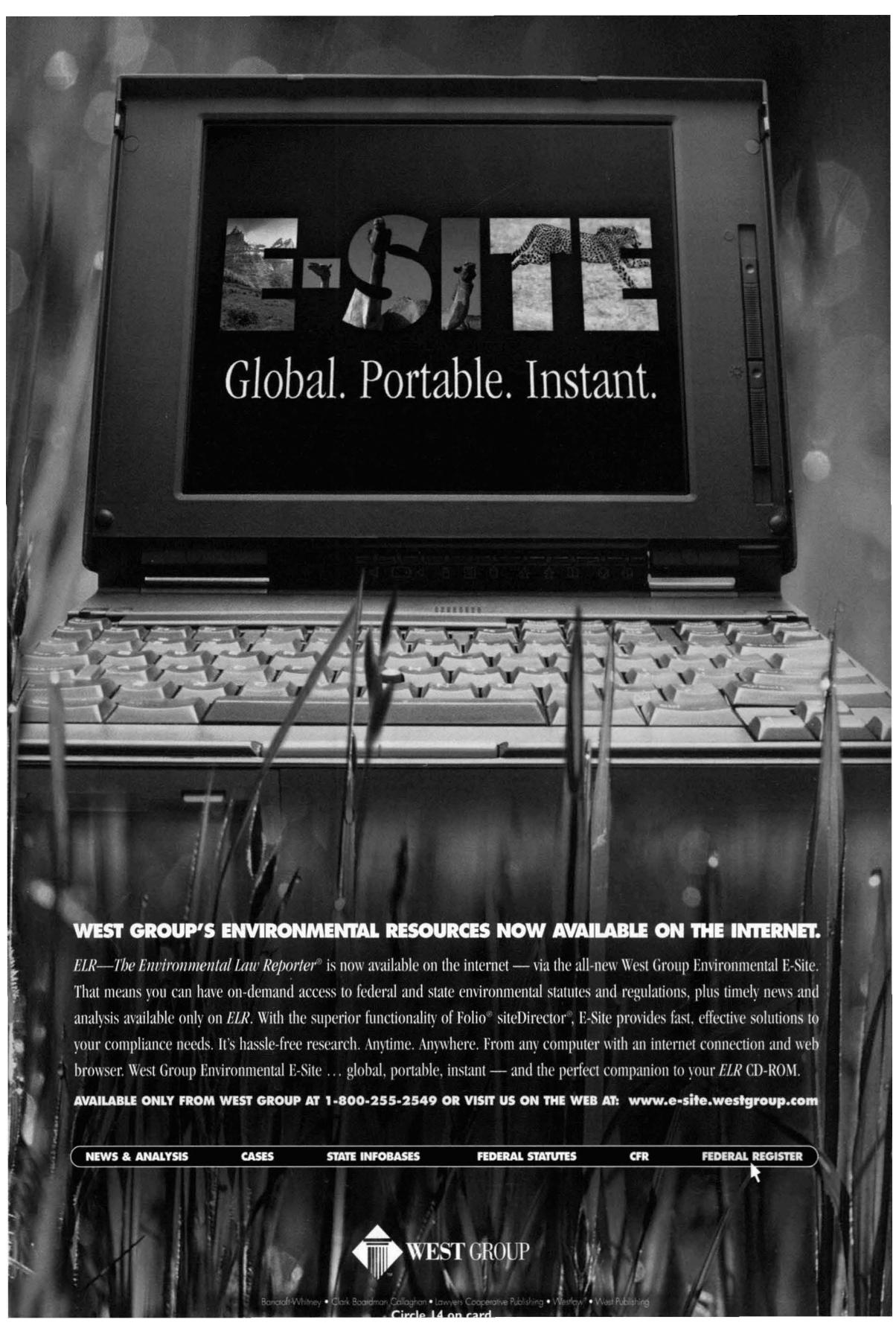
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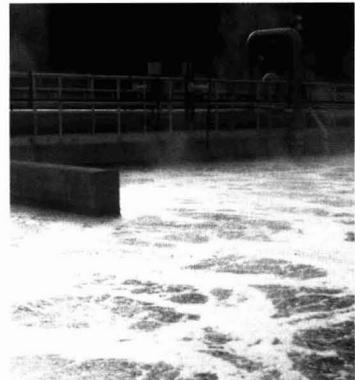
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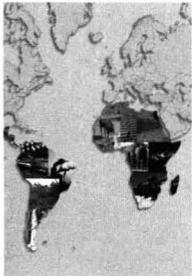
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## ABOUT THE COVER

With growing economies, Latin America and Africa are spending billions of dollars in the areas of industrial pollution control and environmental infrastructure development. These emerging foreign markets are creating lucrative business opportunities for U.S. environmental professionals.

COVER IMAGE BY KATHLEEN LOGAN.

# Have scrubber, will travel

Don't let today's somewhat slow U.S. market for environmental technology and services fool you. Look beyond our borders and you'll find the overall worldwide environmental market is booming. According to estimates compiled by Environmental Business International Inc. (EBI) in San Diego, the global market for this sector is expected to increase from approximately \$452 billion in 1996 to more than \$514 billion by the year 2000. The growing international market can be divided into two distinctly different segments: industrial markets with sophisticated pollution control demands and environmental infrastructure markets where the chief demand is for drinking water and wastewater treatment and solid waste disposal.

One leading example of locations with rapidly growing demand for environmental goods and services is Latin America, which EBI projects will increase its environmental market from \$8.8 billion to \$13.8 billion—a 12 percent increase—during the period of 1996 to 2000. As well, EBI estimates that during the same period the Asian environmental market (excluding Japan) will increase by 12 percent, the African market by 10 percent and the Middle East market by 8 percent. In contrast, the U.S. market for environmental goods and services appears to have reached a plateau. EBI estimates the growth for the United States in this sector will increase from \$171.8 billion to \$184.5 billion from 1996 through the end of the decade, which is a 1.8 percent increase.

Statistics compiled by EBI indicate that in the past, U.S. companies allowed foreign competitors such as Japan and Western Europe to dominate the lucrative global markets. EBI calculates that our nation's share of the non-U.S. environmental exports in 1996 was only 5.7 percent. Yet, recently U.S. companies have begun showing more interest in foreign markets.

If your company is contemplating doing business abroad, a number of governmental agencies can help you. In one of this issue's two cover stories on international business opportunities, "Latin America—an environmental hot spot," (page 18) assistant editor Kristie Guillotte mentions numerous agencies to consult regarding business ventures in Latin America. Likewise, our managing editor Ashley Blyth in her article, "The world of African opportunities," (page 14) lists contacts that are useful for U.S. companies interested in exporting products and services to Africa.

Another source of information for U.S. environmental firms is a free report jointly prepared by EBI and the U.S. Department of Commerce, *Meeting the Challenge: U.S. Industry Faces the 21st Century (the U.S. Environmental Industry)*, which was released in October. For more information about this publication, contact David Berg, the environmental policy analyst with the Office of Technology Policy at the U.S. Department of Commerce, at 202-482-8057.

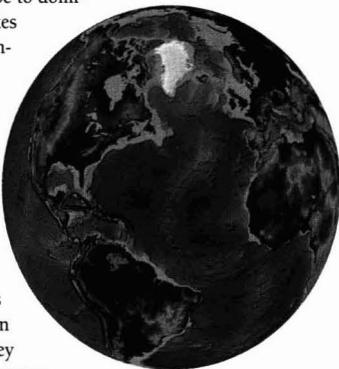
## Our 1998 Consultant's Guide: From assessors to zeolite exchange experts

The companies listed in our guide have expertise in nearly all imaginable areas of environmental consulting. Turn to page 40 for our handy annual directory that offers listings of more than 600 environmental consultants from all 50 states.



Angela Neville

Angela Neville, JD, REM  
Editor-in-Chief



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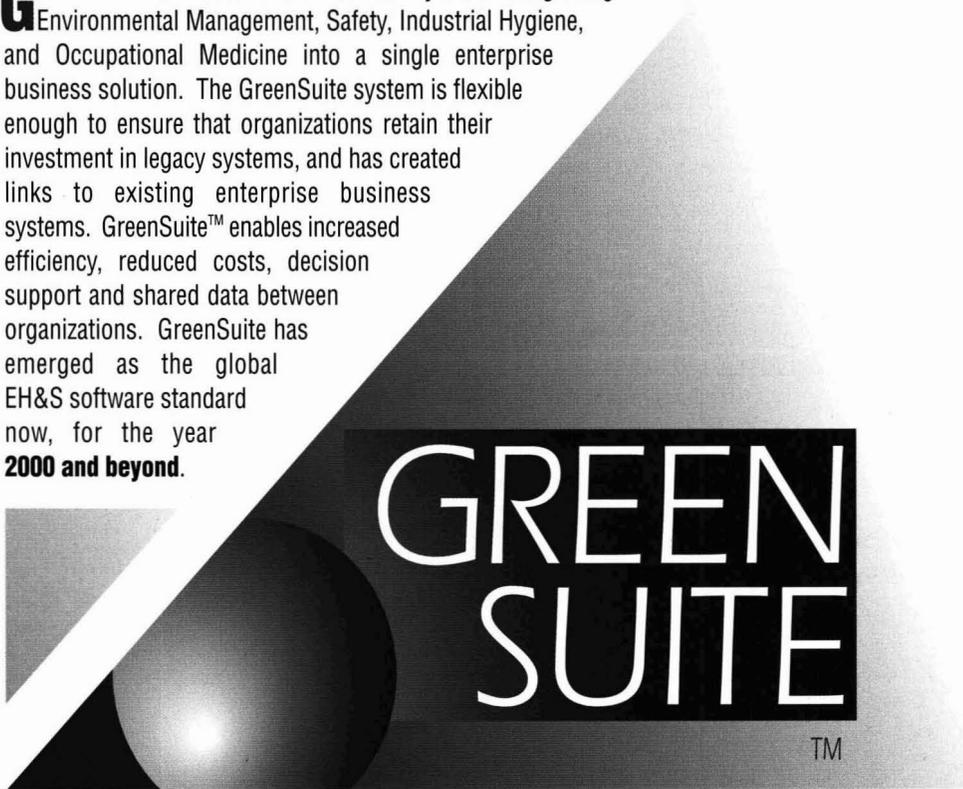
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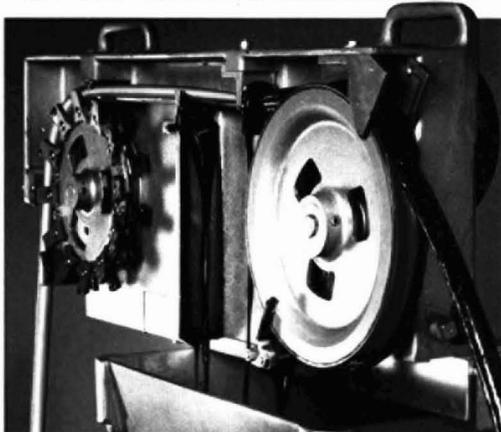
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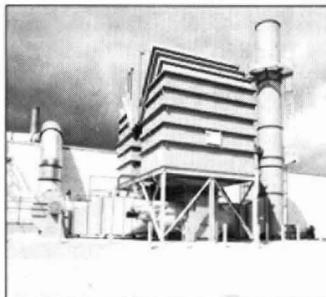
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# The SCOOP on skimmers

*Consider using skimming devices, especially belt skimmers, as an alternative to pump and treat for groundwater remediation*

By Bob Thibodeau

Sometimes, an important technological advance begins with a small step. In the case of remediation of petroleum hydrocarbons from groundwater utilizing existing recovery and monitoring wells, the breakthrough step was backwards.

For the past 2 to 3 years, state governments have based decisions on the amount of clean up that they require by the risk based to the environment. Risk Based Corrective Action (RBCA), commonly called "Rebecca," is a process that uses the principles of exposure assessment, toxicity and mobility to make cost-effective corrective action decisions on sites while still protecting human health and the environment. Many times all that is required is removal of the free-phase petroleum product, allowing any emulsified contaminant to degrade with time. RBCA has saved many millions of dollars for both taxpayers and businesses. With state regulatory agencies increasingly basing cleanup standards on RBCA, oil skimming devices have emerged as one of the most cost effective means of remediation.

Wastewater engineers in industrial settings have, for many years, understood the value of skimmers in the removal of hydrocarbons from water. Food processing plants, the metals industry, machining firms and utilities have all used skimmers with great success for wastewater treatment. Recently, skimmer manufacturers



**Belt skimmer in use in a 4-inch recovery well.**

well and water treatment equipment can be eliminated. Skimming allows the product to be salvaged for reuse, which eliminates the disposal costs.

## Picking a winner

The options for remediation through recovery wells are practically unlimited. Because these wells come in a variety of sizes, any of the available technologies, such as pump and treat or bioremediation, can be used in the correct size recovery well. Monitoring wells, however, are small, typically fewer than 4 inches in diameter. Initially installed for groundwater monitoring, they are cheaper to construct and just large enough to allow a bailing device or oil/water interface detector to pass through. As a cost savings measure, these small-diameter wells are increasingly being used for product removal. Many devices are now being used to remove product through monitoring wells.

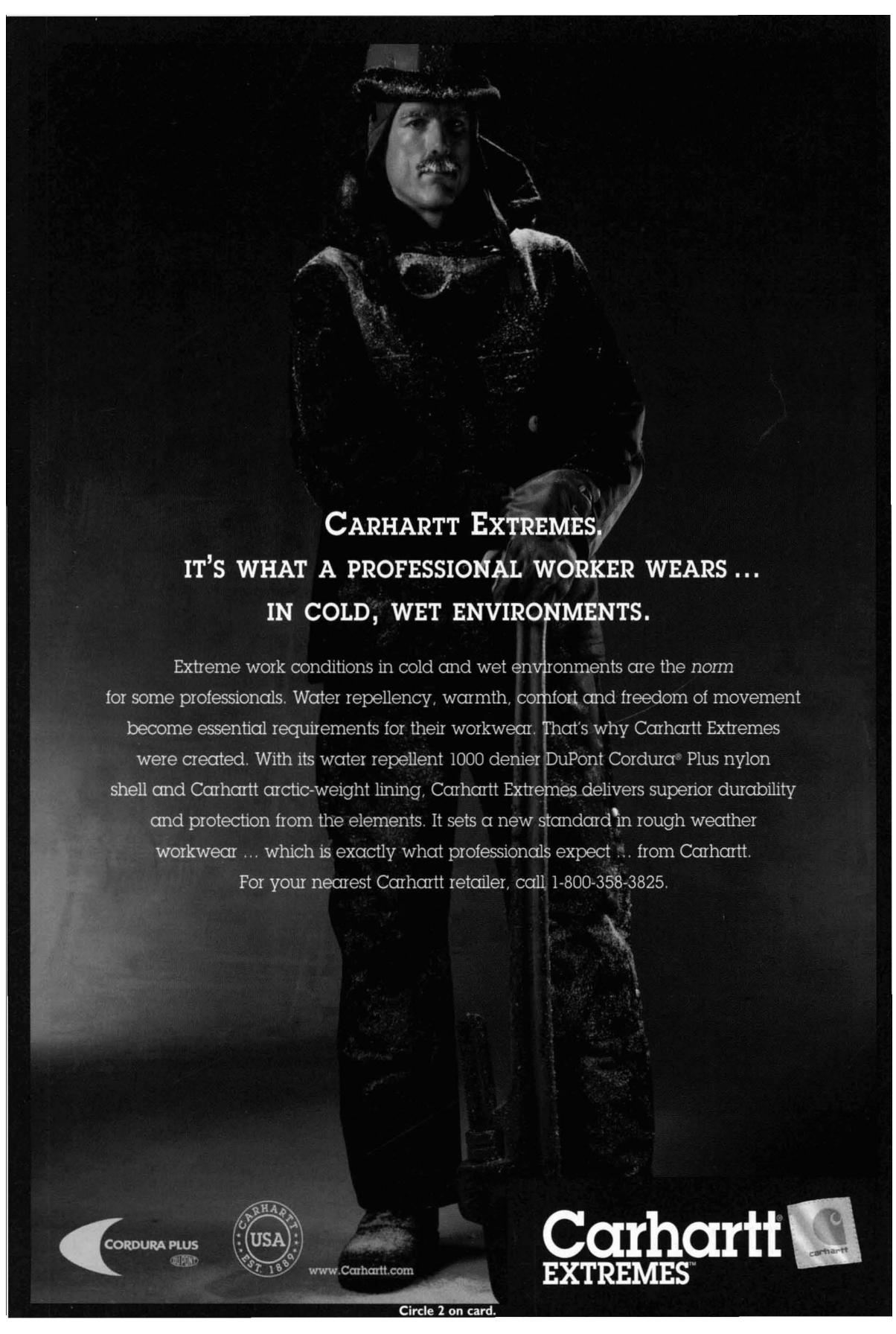
have modified their products for remediation of groundwater. The skimmer's ability to get into tight spaces and remove relatively large amounts of hydrocarbons lends itself perfectly to groundwater remediation.

Since most oils, fuels and other hydrocarbon liquids have the tendency to float on water, skimmers are designed to remove only the top, free-phase product layer. With only product being removed, the cost and maintenance of other down-

## Bailers

The typical bailer is a clear or semi-opaque plastic tube, open at the bottom, with a string or rope attached at the top to lower and retrieve the unit. The device is lowered through the oil/water interface and fills with liquid from the well. A low-pressure check valve allows liquid to enter as it is inserted, but closes as the bailer is removed to retain the collected liquid. Bailers were initially used to detect the presence and quantity of contamination in wells.

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## Slurpers

The best way to describe slurping devices is to compare them to a large drinking straw. A hose or tube is inserted into the well until it reaches the product and then a vacuum is applied to lift the liquid to the surface where it is collected.

## Passive bailers

A passive bailer is a tube that is normally filled with absorbent material. It is lowered into the well, secured with a rope or string and left to perform its function. Typically, a hydrophobic screen near the top of the unit allows the product to enter and be collected by the absorbent material but keeps the water out. Once installed at a set level, the passive bailer is able to collect product only within a set range.

## Electric pumps

Electric product pumps are an active means to remediate through monitoring wells. They are not sit and wait devices. Utilizing hydrophobic screens to keep water out, these units pump product to the surface where it is collected. Many styles are coupled with float sensors and some with buoyancy devices to assist them in keeping water out of the pump.

## Peristaltic pumps

Using external pressure as the drive mechanism, peristaltic pumps collect product in a pliable tube within a hard outer shell. Positive pressure, either hydraulic or pneumatic, within the outer shell collapses the flexible tube and pushes the product out of the tube. A series of check valves keeps the product flowing in one direction only.

## Belt skimmers

While not new to oil removal, continuous loop belt skimmers are relatively new to well remediation. The belt, which can have a vertical drop of 100 feet, is lowered into a well to a point below the water/product interface. The belt is driven by an aboveground motor and passes through a wiper mechanism that removes the product for collection. The cleaned belt is then returned back down the well to collect more of the free-phase oil.

## Advantages and disadvantages

Product recovery methods work in varying degrees. Find the one best suited to the site-specific problems, government requirements and the client's wishes. In your search, consider efficiency, initial cost and operating cost.

Bailing or slurping a well is a short term solution, but is probably not the

method of choice for long-term projects—those lasting several years. The initial cost of material is minimal, but the operating cost is very high due to the labor-intensive requirements of these methods. Operating cost is further compounded by the amount of water recovered that must then be treated or disposed of as hazardous waste.

Passive bailers are also relatively inexpensive initially, but maintenance can drive up the operating cost. Setting the unit at the proper depth can be tricky when the water table fluctuates; efficiency

product viscosity is relatively low and these units are properly set, they can be an efficient means of removing oil from a well.

Continuous loop belt skimmers have an initial cost lower than product pumping systems, but higher than bailers and slurpers. With all the system's equipment located at the wellhead, maintenance is relatively easy and inexpensive. Viscosity, however, has an inverse effect on belt skimmers. As the viscosity drops, the skimmer actually has a more difficult time collecting product. This effect is countered by the continuous nature of

**When skimming devices are used  
in conjunction with other equipment and  
technologies such as bioremediation,  
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is realized for a reasonable increase in cost.**

drops off dramatically as the viscosity increases and the product has a harder time passing through the hydrophobic screen. While not as labor intensive as some methods, frequent adjustment of the depth and purging the unit of collected product may be required.

Pumping systems designed for product-only recovery have a higher initial cost but are also considerably more efficient. The wide variety of sizes gives them the ability to fit many applications, including monitoring wells, but they can be difficult to position and keep at the correct depth. Floating units that ride the water table can make the problems associated with setting the depth easier, but caution should be taken to ensure that this does not also affect removal efficiency. Some units will leave a layer of free product as thick as 1 to 2 millimeters. Be aware that with any system that relies on hydrophobic screens to separate water and product, efficiency is decreased as viscosity is increased. Viscosity can also be a drawback when it comes to magnetically driven electric units. The high viscosity can cause the magnets to de-couple while pumping and decrease efficiency.

Peristaltic units must rely on proper operation of the check valves to perform at efficient levels. Any time pressure is lost due to one or more of the check valves sticking, the unit becomes inoperative. Should water enter the unit, most product pumps will emulsify the mixture and make recovery much more difficult. When the

unit. It may take two or three passes, but the belt will eventually get all of the oil out of the well. A properly sized unit will also remove product until a light sheen or less remains. By varying belt materials and speed, depending on the product being recovered. Efficiency can be maximized on a site-by-site basis. When skimming devices are used in conjunction with other equipment and technologies such as bioremediation, filters or oil/water separators, a much more efficient total remediation system is realized for a reasonable increase in cost.

## Changing requirements

With the requirements for site remediation becoming more reasonable, the use of skimming devices in lieu of pump and treat systems is increasing. The enormous expense involved with treating millions of gallons of water including the equipment, monitoring and related maintenance is being replaced with a much more common sense attitude. Skimmers, especially belt skimmers, offer a viable alternative remediation method. Pump and treat still has a place in this industry, but the small step backward to time-proven skimming, a more reasonable and cost effective method, cannot be overlooked. **ESP**

*Bob Thibodeau is a product manager at Abanaki Corp., Oil Skimmer Division, Chargin Falls, Ohio.*

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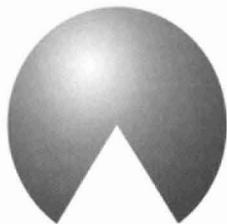
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# The world of African opportunities

*The improving economies in many African countries have created an emerging market for environmental firms seeking expansion*

By Ashley E. Blyth

**F**ollow the lead of U.S. Secretary of Commerce William M. Daley, who will lead a commercial development mission to Africa in December, and look to the continent of Africa to broaden your own economic base. Daley plans to stop in South Africa, Kenya and Côte d'Ivoire, and will be accompanied by U.S. business representatives "whose interests are compatible with the development aspirations of the host countries, and those for whom advocacy will assist their efforts to win contract awards." The business delegation will include U.S. companies in sectors recommended by the U.S. and Foreign Commercial Service and the U.S. State Department as having strong growth potential in Africa. These businesses include agribusiness, power generation, environmental technologies and general infrastructure.

Building on the momentum of President Clinton's March 1998 visit to Africa, Daley's mission is intended to strengthen commercial ties and expand the dialogue between the public and private sectors of Africa and the United States.

What do Clinton and Daley's trips to Africa mean to U.S. businesses? Plenty, said Donna Thiessen, professional staffer of the Congressional Committee on Ways and Means. Rep. Philip Crane (R-Il.), chairman of the Subcommittee on Trade within the Com-

mittee on Ways and Means, wrote the African Growth and Opportunity Act, which passed the House in March. The bill has also been reviewed by the Senate Finance Committee, and is expected to be voted on in the fall session. The African Growth and Opportunity Act, like Daley's trade mission, is part of a growing trend to promote exports, long-term economic relationships, free trade and stronger ties between the United States and African countries, said Thiessen.

## **Not just politics as usual**

The sudden interest in the economic growth in Africa is not just politically motivated. According to a U.S. Department of Commerce's International Trade Administration publication, "Big Emerging Markets: 1996 Outlook and Sourcebook," South Africa is the most advanced and productive economy in Africa, and is a relatively untapped market for many U.S. exporters and investors. Development in South Africa in agriculture, exports and infrastructure continues to generate employment and income. This growth is creating increased investment opportunities for foreign businesses.

South Africa is an ideal nation to consider for doing business on the African continent. The U.S. Department of Commerce's International Trade Administration calls the South African government's Reconstruction and Development Program (RDP) the "legislative blueprint for social development and economic growth" for post-apartheid South Africa. The policies of the RDP are

designed to meet basic needs, develop human resources and democratize the state and society. More specifically, the goals of the RDP are to provide the black majority with jobs, land, housing, water, electricity, telecommunications, transportation, a clean and healthy environment, nutrition, health care and social welfare.

Although the South African government has indicated to the International Trade Administration that it will redistribute land, build more than a million homes, provide clean water and sanitation, provide electricity to new homes and provide access to affordable health care and telecommunications over the next 5 years, no specific plans for financing the program are clear. Foreign investment from public and private sectors will probably be welcomed, especially if the investment furthers these goals.

Because the economy has diversified over the past 50 years, investment opportunities in South Africa are no longer limited to mining gold and diamonds. According to the International Trade Administration, mining constitutes 11 percent of the gross domestic product (GDP). Manufacturing represents the largest sector of the economy, contributing 26 percent of the GDP; finance services and commerce combined make up 29 percent; and agriculture constitutes 6 percent.

According to Afro-Caribbean Online, a Web-based African news bureau, a hurdle for potential investors is learning to trust the African countries' governments. South Africa's success in radically shifting government policies should encourage investors to look at other parts of Africa as well.

The World Bank anticipates that the economies of sub-Saharan Africa will grow at a rate of 3.9 percent a year from now until 2003. Population growth, universal use of the Internet and an emerging stock market are cited as reasons for the growth.

#### Meeting a need means adding value

Environmental professionals will find projects in Africa that deal with environmental problems related to mining, acid-mined drainage, agriculture, heavy erosion, desertification and lack of water, according to Bill Gorton, an adjunct professor who teaches environmental law at the University of Kentucky, partner at Stites & Harbison law firm and a 1996 delegate for the U.S. Information Service environmental and sustainable growth citizen exchange program. Water quality treatment also translates into work for U.S.-based companies that provide environmental goods and services.

"These countries are not without engineers. South Africa is the most advanced of all the countries in Africa, but nevertheless is 25 years behind us," said Gorton. "They're interested in the science, but more interested in the programs."

A concern in developing African countries is diversifying their economies and trying to create jobs. Gorton cited one Chinese government project as an example. The Chinese developed a dam on the Nile River near Lake Victoria to help create electrical power

generation, which in turn, developed industry in that country.

"People that are interested in doing business or providing value-added products are being sought or are being viewed very well by economic ministers or ministers of finance at very high levels of government," he said.

Alassane D. Ouattara, deputy managing director of the International Monetary Fund (IMF), stated that the following environmental issues need attention in Africa, especially in developing nations: forestry management, management of coastal fisheries, and air and water pollution.

The need to boost the economies of African nations often comes before environmental considerations. This mindset may be a challenge for U.S. firms looking for remediation projects. Projects that deal with infrastructure, such as developing water treatment systems or municipal waste, may be easier to obtain. One possibility would be to partner with local engineering firms to develop roadways for waste transportation. Part of the African Growth and Opportunity Act, the Equity and Infrastructure Fund Initiative, reaffirms the need for infrastructure—it authorizes a one-time appropriation of \$100 million for an equity fund and \$100 million for an infrastructure fund beginning once the bill passes the Senate and is approved by the president.

#### A wealth of sources

One possible source of funding and expertise stems from the Export-Import Bank Initiative, an effort on the part of the U.S. government to help U.S.-based companies do business with sub-Saharan African companies. The initiative requires that one member of the board of directors of the Export-Import Bank have extensive private-sector experience in sub-Saharan Africa. The board of directors must also establish a private-sector advisory committee composed of business people with experience in sub-Saharan Africa. The Export-Import Bank reports to Congress with recommendations to expand loans, guarantees and insurance to sub-Saharan countries.

"Non-governmental organizations, or NGOs, also are a large part of the economic base of a lot of these countries. If there is money to be had or incentives to be had ... it would probably be from NGOs," said Gorton.

A valuable source of funding and information is the World Bank Group, which is comprised of five organizations: the International Bank for Reconstruction and Development (IBRD), the International Development Association (IDA), the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIGA) and the International Center for the Settlement of Investment Disputes (ICSID).

For example, IFC is funding a feasibility study of a municipal waste incineration, or waste-to-energy, project in Durban, South Africa. The study was requested by municipal authorities in Durban, and IFC chose Camp Dresser & McKee Inc., headquartered

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in Cambridge, Mass., to conduct the study. The scope of the project includes the comprehensive evaluation of a waste-to-energy facility that would accommodate up to 1,000 tons per day and serve metropolitan Durban. According to Alicia Burke, a CDM representative, the project will evaluate Durban's existing landfills and analyze alternative solid waste management strategies.

"The project also involves an intensive field visit to Durban to review local waste management practices, the evaluation of waste characteristics and other relevant information, and meeting with representatives of key government, industrial and NGOs, followed by the preparation of a detailed report of technical, economic, environmental and financial analysis," said Burke. The city of Durban requested the funding, and IFC contracted the project to CDM.

Another source of funding for private sector environmental projects in Africa is the IMF. The organization has also publicly committed to funding private ventures into Africa. According to Ouattara, IMF is giving much consideration to preserving the environment and how that relates to boosting Africa's economy.

"IMF-supported programs often involve the adoption of 'win-win' policies that benefit both the economy and the environment. For example, curbing environmentally damaging subsidies and stabilizing farm prices," said Ouattara.

Ouattara pointed to IMF's sister organization, the World Bank, as another source of help to raise awareness and fund programs that integrate environmental concerns and natural resource issues. The World Bank and IMF "undertake studies to analyze the links between macroeconomics and the environment and assess the scope for improving environmental conditions through appropriate policy and institutional reform," said Ouattara.

### **Economics of African geography**

The continent of Africa is the world's second largest continent after Asia, including several surrounding islands. Within Africa's 54 independent countries—48 mainland and 6 island states—are bountiful business opportunities for environmental professionals. According to the U. S. Department of Commerce's Trade Information Center in Washington, D.C., South Africa is the economic powerhouse of Africa south of the Sahara Desert because of its well-developed infrastructure.

### **The pulse of the continent**

Although the U.S. Embassies in Nairobi,

Kenya and Dar es Salaam, Tanzania, were bombed in August, killing hundreds and injuring thousands, representatives on Capitol Hill claim to be committed to strengthening economic ties with African countries. The attacks are not indicative of the political climate throughout the entire continent.

Common sense advice to companies wanting to do business in African countries is to acquaint yourself with its political structure. Be aware of the possibility of political instability, such as resistance to environmental education and legislation, racial tension and changes in land ownership.

To prepare yourself for doing business in African countries, Gorton suggests

environmental protection in generic terms. [One official] said to us, 'We wouldn't really need the concept [of environmental protection] were it not for the white man,' said Gorton.

### **Get connected**

Another method of establishing crucial relationships in Africa is through the Lex Africa Law Firm Network. The purpose of the network, established by a South African law firm, is to provide legal advice; knowledge of local customs, practices and language; and contacts in key positions in government or quasi-government institutions.

According to the network, member lawyers and law firms operate on a non-

**The South African government has indicated to the International Trade Administration that it will redistribute land, build more than a million homes, provide clean water and sanitation, provide electricity to new homes and provide access to affordable health care and telecommunications over the next 5 years.**

making contact with someone in the locale and developing a business relationship. Such a contact is valuable for remediation firms, which will find business opportunities by being hired by a private African company and will not have as much interaction with area politics. Engineering firms specializing in infrastructure development, however, should partner with local companies to stay aware of the political climate, said Gorton.

Natural resource development, such as mining projects in Central Africa, can provide economic growth to the source country. Gorton explained that projects involving natural resource development—any project that uses soil, water or land—are doable and profitable, but U.S. firms need local assistance with the government and the political aspects.

Potential investors should also be aware that racial tension factors into the politics of the environmental movement. Traditional African cultures have always had respect for the environment, but can argue that environmental regulation and education would not be necessary if it were not for white settlers.

"For example, we met with some relatively high-level people in South Africa and we talked about the concept of envi-

exclusive basis so that members may use any other firm that has the necessary expertise or specialist skills to deal with particular transaction.

The Africa Chamber of Commerce also sponsors an annual Conference on Africa Investment, Trade and Infrastructure Development in the fall in Washington, D.C., for business to connect with African firms for possible partnerships.

### **What are you waiting for!**

Africa's economy is in a growth mode. U.S.-based companies offering environmental goods and services, especially those pertaining to natural resource development, agriculture and infrastructure development, should consider expanding business offerings to Africa. The U.S. federal government is making the exchange of goods and people with Africa easier than ever. With a little research, U.S.-based companies can quickly establish connections with local African firms and then secure funding. **EP**

*Ashley E. Blyth is group editor at Stevens Publishing Corp.*

**For more information, contact the author via e-mail at [ablyth@cmpu.net](mailto:ablyth@cmpu.net).**

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# Latin America— an environmental hot spot

*Opportunities abound for environmental  
companies willing to take a chance  
in Latin America*

*By Kristie L. Guillotte*

**W**ith Latin America estimated by the World Bank to sustain average financial growth rates in the 5 percent range by the year 2000 and the World Health Organization estimating at least 1 billion people in the world living without safe drinking water, opportunities for the environmental business community in Latin America are multiplying.

The Environmental Export Council (EEC) is working in a collaborative effort with the U. S. Agency for International Development (USAID) on a program called the Latin American Initiative for Environmental Technology (LA-IET). LA-IET acts as an umbrella program for activities in several different countries and regions of Latin America, including Brazil, Mexico, Central America and the Andean region. The primary objective of all programs falling under LA-IET is to increase the role of the private sector in environmentally sustainable development. Despite LA-IET's coordinated effort between the public and private sectors toward environmentally sustainable economic growth and development, many private sector companies have already begun working on their own in Latin America.

## **Don't drink the water**

Sixty years ago, John R. Snell, DS, PE, president of Worldwide Technologies, spent 2 years designing and building safe water supplies in a dozen towns in the Andes of Venezuela. The town of Merida, which had a population at that time of 10,000, suffered from an average of 10 cases of typhoid fever each week. Before gathering any data, Snell installed first a temporary chlorinator using bleach solution and then a full-fledged chlorine gas system. The cases of typhoid fever quickly dropped off to zero. Today, Merida still maintains its water treatment system, but other cities and even whole countries are not that lucky.

With a population of about 92 million, Mexico is in desperate need of clean water. The country represents the second largest environmental market in Latin America—Brazil has the largest—

and water-related projects constitute the majority of the market potential at this time. Mexico's water supply comes mainly from surface sources and must be transported to population centers.

Opportunities for both municipal wastewater and industrial wastewater treatment are abundant because most discharges are not treated and many existing plants are not functional. According to Edgar Berkey, PhD, vice president and chief science officer for Concurrent Technologies Corp., in the early 1990s, many water treatment projects were in the works, but the 1994 peso devaluation led to an economic crisis that postponed these projects. It took about 3 years but many are back on track, technically and financially. Berkey outlined the Mexican Water Resources Sectoral Program, devised

by the government, for 1995 to 2000. The program includes the following objectives:

- Setting Mexican government objectives and strategy;
- Extending access to potable water and municipal sewage treatment;
- Promoting investments that could possibly reach \$6 billion, most from non-Mexican government sources; and
- Helping Mexico City develop advanced primary treatment at wastewater treatment plants and a sewage collection system that is anticipated to cost \$1 billion.

Berkey suggested that U.S. firms take advantage of these opportunities in Mexico by partnering with Mexican firms, offering attractive finance packaging, targeting niche projects and focusing on multinational companies with complex wastewater problems.

The 55-year-old private company Grupo Fypasa specializes in water and wastewater treatment facilities and has completed over 100 wastewater treatment projects in Mexico. Berkey said, "Grupo Fypasa, like other Mexican water project companies, is seeking financial or strategic partners for projects—even those already on the books—equity partners for longer-term relationships, and companies that can strengthen all aspects of relevant business management."

#### Crossing Borders

BDM International Inc. reported in its publication *Insights* that despite what appears to be a thriving market, many factors inhibit the entry of outsiders into Mexico's environmental market. These factors also impede the country's ability to adapt proven environmental procedures. The intricately structured environmental system throughout Mexico is not receiving sufficient governmental funding. Because all branches of government are understaffed, especially in outlying offices, the level of difficulty increases for North American companies trying to work on environmental projects in Mexico.

The centralization of government agencies and decision bodies in Mexico City stifles the environmental opportunities that exist in the country. The majority of Mexican governmental agencies are located in Mexico City, resulting in the separation of regulators who establish norms and standards for environmental issues from the regulated individual states. The bureaucratic structure acts to further slow down the development, approval and implementation process of new regulations and standards. This, coupled with the physical size of the country of Mexico, further impacts environmental regulators' and professionals' abilities to monitor environmental progress.

Despite the obstacles, Weston International, a subsidiary of Roy F. Weston Inc., has taken advantage of the opportunities in Latin America. Currently the company is working with a Mexican company, EcologiaCalpin, SAdeCU (Ecocalpin), to clean up hazardous waste. Ecocalpin is an independent U.S.-Mexican venture that provides thermal treatment services for hazardous

waste in Mexico. Ecocalpin has purchased Weston's 5-ton-per-hour transportable incineration system (TIS-5) for which Weston is providing technical support services. Ecocalpin also owns two additional rotary kiln incineration systems ranging from 5 to 22 tons per hour. Each unit is capable of treating polychlorinated biphenyls (PCBs) and other hazardous organic, refinery, industrial and hospital wastes. The incineration facilities will be located near Toluca, 35 miles west of Mexico City, and in Coatzacoalcos, located along the Gulf of Mexico. One of the facilities may be licensed under the new CIMARI framework—Mexico's equivalent to a TSD facility—and include a landfill and chemical waste treatment facilities. Ecocalpin, with the support of its international engineering consultant, Praxis Environmental Inc., has completed engineering, permitting, geological, financial, environmental impact and feasibility studies for the three incineration systems. Two of the thermal treatment systems are expected to be in operation in Mexico by the first quarter of 1999.

Dennis Moran, Weston International president, has 20 years of experience dealing with Latin American environmental business opportunities. He said, "The best way to do business in Latin America is to work with a strong, reputable local organization. Your company's success is directly related to the local organization because if you establish a good relationship with them, they will do 90 percent of the work for you."

#### Clearing Brazil's water

The Environmental Export Council estimates the Brazilian water and wastewater treatment market's worth at about \$1.7 billion. Over the past 4 years, EEC has initiated programs in conjunction with USAID and the U.S. Department of Commerce targeted at increasing the level of U.S. private investment in municipal wastewater treatment in Brazil. Through trade missions, reverse trade missions and technical dialogue activities, EEC has brought U.S. and Brazilian public and private sector representatives together to expand export technology transfer opportunities and to examine issues related to overcoming barriers to financing, implementing and sustaining municipal wastewater treatment concessions and privatization in Brazil.

Norman F. Anderson, managing director of Consulting Group Latin America in Washington, D.C., said that the key components of a successful strategy in Brazil's water market are capital accumulation, regional integration, decentralization, the government's role and the export imperative. "Direct foreign investment is growing extremely fast," said Anderson. He defines direct foreign investment as new business or expansion of existing business through acquisitions or participation in privatizations. Anderson explained these privatizations as companies making long-term investments in Brazil's water market. It is estimated that \$5.2 billion—money that was poured into Brazil from other

### Useful resources

The following agencies are available to help you take advantage of business opportunities in Latin America:

- U.S. Department of Commerce, International Trade Administration Environmental Technologies Exports, can be found on the Web at [www.ita.doc.gov/envirotech](http://www.ita.doc.gov/envirotech).
- International Water Resources Association, 4535 Faner Hall, Southern Illinois University, Carbondale, IL 62901-4516; (618)453-5138; or [www.iwra.siu.edu](http://www.iwra.siu.edu).
- Inter-American Development Bank, 1300 New York Ave. N.W., Mail Stop E 0209, Washington, DC 20577; or (202) 623-3821.
- Center for Trade and Investment Services (CTIS)/U.S. Agency for International Development (USAID), [www.info.usaid.gov](http://www.info.usaid.gov).

countries—went into privatizations in 1997, double the 1996 figure.

### Remediation pays off

Remediation is in its early stages of development in Latin America, but it is proving to be a sector of the environmental field with much future growth. Frost & Sullivan, an international marketing consulting company, included in its report "Latin American Petroleum Industry Hazardous Waste Management and Remediation Markets" that the industry in Latin America has an annual growth rate of more than 7.1 percent. In 1996, the Venezuelan market alone generated almost \$200 million in revenue with an

anticipated growth rate of 13 percent. Brazil was not far behind with revenue at \$150 million. Frost & Sullivan's study concentrated on the oil industries of Argentina, Mexico, Brazil and Venezuela because they comprise most of the region's petroleum activity. The petroleum market is primarily regulatory and export driven. The market's future growth in all four countries will be motivated by their interest in export markets, which requires these countries to adhere to international environmental restrictions with enough authority to regulate domestic petroleum companies.

Because the petroleum market is still in the developmental stage, several chal-

lenges face U.S. environmental service providers in Latin America. Infrastructures are insufficient to adequately handle, treat and dispose of waste, and competition from self-supplied services is preventing the third-party service market from getting a firm grip on the Latin American market in the short run. However, today's market weaknesses create opportunities for the service providers positioned to enter the market by the end of the century.

Mirna Saab, Frost & Sullivan environmental analyst, said, "Because this mar-

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**“The best way to do business in Latin America is to have strong, reputable local partners. Your company's success is directly related to the local partners because if you establish a good relationship with them, they will do 90 percent of the work for you.”**

**Dennis Moran, Weston International president.**

ket is still in an embryonic stage of development, there is much room for development. These countries also have a lot of interest in getting acquainted with new technology.”

Living in countries without clean water, with air pollution and contaminated sites is what the citizens of Latin America face day to day. For U.S. companies willing to take a financial risk on projects to improve the conditions in these countries, the result will hopefully be a win-win situation—improved living conditions for Latin American citizens along with big profits for U.S. companies. **EP**

*Kristie L. Guillotte is an assistant editor of Environmental Protection magazine.*

**For more information contact the author at [kguillotte@cmfu.net](mailto:kguillotte@cmfu.net).**

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# The rise of air dispersion modeling

By Douglas J. Nolkemper, PE,  
and Gayle P. Van Durme, PE

*Computerized atmospheric transport models can determine the best and most cost-effective combinations of air pollution control measures*

Heightened public sensitivity and increased regulation of air quality have compelled many facilities to consider emissions control options. Whether it is criteria pollutants in non-attainment areas, regulated air toxics above minimum threshold quantities or any compound that might cause an odor, the determination of off-site impact is critical.

At complex facilities with multiple emission sources, it is often difficult to decide how much control is needed to satisfy regulations and meet public demands. Air dispersion modeling provides answers to these questions. Computer modeling shows the combined off-site impact of multiple sources and enables assessment of different control options to obtain the desired goals. One of the first steps in the modeling process is obtaining individual source emissions.

## **Source emissions**

The determination of emissions varies depending upon whether the source is existing or proposed, what the potential chemical compounds of interest might be, what the available test methods equipment are and what the costs are. Usually, determination of the compounds to be evaluated is a compromise of cost and ability to quantify.

Depending upon available equipment, pollutants can be quantified in the field or samples collected and forwarded to a laboratory for analysis. Pollutants can be quantified either individually or as a group, and each situation requires an evaluation of

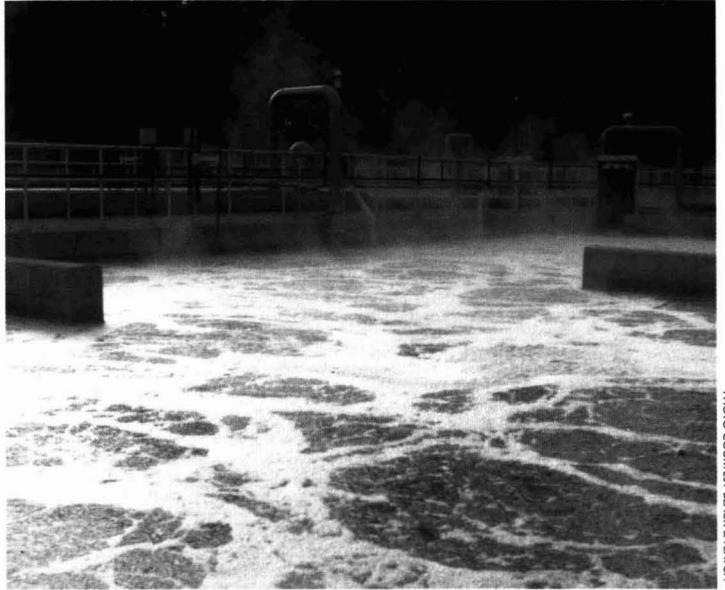


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**Air dispersion modeling can be used to model liquid surfaces such as wastewater in an aeration basin.**

applicable regulations, available test methods and consideration of cost and regulatory approval. Once the pollutants are quantified, the potential for off-site impact can be estimated with the use of an air dispersion model.

## **Air dispersion models**

A dispersion model is a mathematical representation of the transport and diffusion processes that occur in the atmosphere.

Numerous models exist and model selection requires an understanding of the underlying limitations and appropriate situations for each type of application. Some models are for release of dense toxic gases, others are proprietary for specific applications; however, the majority of situations require a Gaussian plume dispersion model, which is an approximation of the dispersion of a plume from a continuous point source. The basic assumption

underlying a Gaussian plume model is that the dispersion takes place in a stationary and homogeneous atmosphere, with sufficient wind speed—greater than or equal to 1 meter per second. The most widely used and accepted Gaussian plume model is the Industrial Source Complex (ISC) air dispersion model. The model is field tested and approved by the U.S. Environmental Protection Agency for use in most applications.

Because of its versatility and general acceptance by regulators, the ISC model is most often selected for a wide variety of modeling applications. The latest version of the Industrial Source Complex Short Term Model (ISCST3) takes into account several hundred point, area or volume sources, aerodynamic disturbances from nearby buildings, local meteorological conditions and surrounding terrain.

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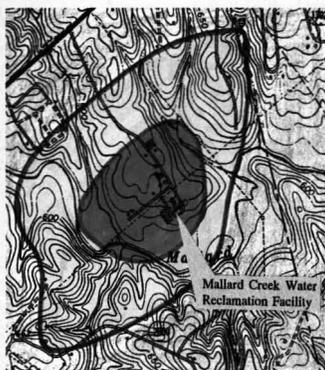
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- The quantification of the air emissions determined in the first step;
- Physical parameters of the source and surrounding structures;
- Electronic representation of the topography; and
- Processed nearby surface and upper air historical meteorological records.

Depending upon the emissions units, different adjustments will be required to the

**FIGURE 1**



0.5 ppb H<sub>2</sub>S      2.5 ppb H<sub>2</sub>S

**Dispersion model results with headworks odor control.**

data before it can be applied to the model. Some examples of emission units are pounds per hour, parts per million or odor units. Each one must be adjusted to an equivalent mass per time and air flow rate as required by the model. A supplemental program must also be run to determine if any of the surrounding structures will adversely impact dispersion. Besides buildings causing premature touchdown of plumes, nearby elevated terrain must also be considered as a factor leading to unanticipated high concentrations. Recent advances in geographical information systems (GIS) have improved the ease of including terrain in modeling runs. The model is customized to local conditions by including representative meteorological parameters. Typically, 5 years of historical meteorological data from EPA data bases or on-site recordings are processed into model ready format.

#### **Modeling reduces control costs**

The sources can be modeled individually or as a composite. Individual source modeling allows for assessment of the impact of single sources analysis, while composite analysis is more representative of real life field conditions. Whether the sources are modeled individually or as a group, the model is then run to determine baseline conditions. Modifications are then made to the mod-

eled emission sources to simulate proposed control measures. Each model run can be represented graphically to show impacts on surrounding receptors. A cost-benefit type analysis can then be used to determine which sources would reduce off-site air emissions impacts for the least dollars.

#### **Case histories**

Two recent applications of the ISCST3 model helped different municipal wastewater utilities determine the most effective and economical odor control approach.

**Charlotte-Mecklenburg, N.C.** For air dispersion modeling at Charlotte-Mecklenburg Utility Department's (CMUD) Mallard Creek Water Reclamation Facility (MCWRF), hydrogen sulfide (H<sub>2</sub>S) concentration was used in the model because it was the odor-causing compound at all site sources. Baseline modeling of existing sources was compared with known locations of odor complaints in the surrounding area and good correlation was established. At MCWRF, containment and scrubbing of the headworks area were considered as the first step in odor control because it had the highest H<sub>2</sub>S concentrations. The ISCST3 model was applied to examine the benefits of headworks odor control, and it was found that detectable concentrations of H<sub>2</sub>S would occur outside the plant property, but would not extend to the closest receptors to the south of the plant as shown in Figure 1.

A second model investigated the effect of odor control at preliminary treatment areas—grit basins and fine screens. The results showed that odor control at both

County Wastewater's (JCW) Nelson Complex, the ISCST3 model was used with odor input of dilutions to threshold because key process units had predominant odorous compounds other than H<sub>2</sub>S. Air bag samples were collected at major odor sources and sent to St. Croix Sensory Laboratory for odor panel analysis. Panelists sniffed samples diluted with fresh air as it is discharged from three ports and select the one that is different from the other two. The dilution ratio at which odor is first detected is called the detection threshold (D/T). In the initial planning, JCW engineers decided to provide odor control at the headworks due to the high source strength. Therefore, modeling focused on evaluating the need for odor control at primary clarifiers and trickling filters. Modeling of the individual sources showed that the primary clarifiers had a much greater off-site impact than the trickling filters. The modeling results established that odor control was needed at the primary clarifiers, but that as long as the trickling filter odor was less than 30 D/T, odor control was not required. Results from the first odor panel analysis showed that the trickling filters emitted 7-18 D/T. The modeling assured effective odor control, yet allowed JCW to avoid the high costs of covering and treating several large diameter trickling filters.

#### **Summary**

The ISCST3 dispersion model developed by EPA has been widely used for regulatory purposes. This model considers multiple sources and can be applied to assess the effectiveness of plant-wide emission con-

## **The Industrial Source Complex Short Term Model (ISCST3) takes into account several hundred point, area or volume sources, aerodynamic disturbances from nearby buildings, local meteorological conditions and surrounding terrain.**

the headworks and preliminary treatment areas further reduced the reach of H<sub>2</sub>S, but detectable concentrations would still occur outside the property line. Additional modeling showed that odor control at the primary clarifier launders and solids processing areas was also needed to limit detectable H<sub>2</sub>S to the plant site. The modeling results will allow CMUD to reduce capital and operating costs by targeting odor control to meet demand as the areas nearer to the site are developed.

**Johnson County, Kan.** At Johnson

County Wastewater's (JCW) Nelson Complex, the ISCST3 model was used with odor input of dilutions to threshold because key process units had predominant odorous compounds other than H<sub>2</sub>S. Air bag samples were collected at major odor sources and sent to St. Croix Sensory Laboratory for odor panel analysis. Panelists sniffed samples diluted with fresh air as it is discharged from three ports and select the one that is different from the other two. The dilution ratio at which odor is first detected is called the detection threshold (D/T). In the initial planning, JCW engineers decided to provide odor control at the headworks due to the high source strength. Therefore, modeling focused on evaluating the need for odor control at primary clarifiers and trickling filters. Modeling of the individual sources showed that the primary clarifiers had a much greater off-site impact than the trickling filters. The modeling results established that odor control was needed at the primary clarifiers, but that as long as the trickling filter odor was less than 30 D/T, odor control was not required. Results from the first odor panel analysis showed that the trickling filters emitted 7-18 D/T. The modeling assured effective odor control, yet allowed JCW to avoid the high costs of covering and treating several large diameter trickling filters. **EP**

*Douglas J. Nolkemper, PE, and Gayle P. Van Durme, PE, are environmental engineers with Black & Veatch in Kansas City, Mo.*

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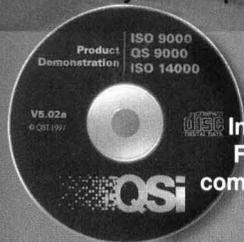
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By Dennis Abarca

**T**he ISO 9000 Standard for Quality Management System certification has increasingly become a requirement for organizations to maintain preferred supplier status among their customers. Following the success of ISO 9000, the ISO 14001 Standard for Environmental Management Systems has been issued and well received, especially in the international community. Like ISO 9000, it is becoming a requirement for domestic as well as international customers. This supply chain management situation has been furthered by the international community's fondness for the philosophy of "sustainable development"—the concept that organizations should leave behind sufficient resources for future generations to continue appropriate levels of industrial and societal output and growth.

Organizations have broad considerations when assessing the implications of pollution, ranging from regulatory to public image concerns. Increasingly, it is important for companies to position themselves as good corporate citizens. This not only has an effect on their image, but can even relate to their ability to attract quality employees.

#### **ISO 14000—a framework for an environmental management system**

ISO 14001 was adopted to provide a baseline management system to help ensure organiza-

tions' regulatory compliance through a proactive approach to management systems, and furnish a platform for continual improvement. In addition, some organizations see a financial opportunity in environmental management. Many businesses use ISO 14000 systems as a mechanism to reduce the cost of compliance, and to identify environmental management opportunities that contribute to financial performance.

Included in the standard's requirements are elements designed to provide consistency in operations and help achieve organizational goals. These elements include:

- Operational control;
- Verification of the implementation of the management system;
- Monitoring of performance,
- Identification of environmental aspects and legal requirements;
- Training of personnel whose work may have environmental impacts; and
- Establishing environmental objectives and targets for achieving the objectives.

Collectively, these elements provide a framework for a system that contributes to environmental performance and pollution prevention. Through the implementation of the ISO 14000 system, organizations create opportunities for the effective prevention of pollution that transcend the functions of these tangible mechanisms. Specifically, ISO 14000 implementation creates an opportunity for the organization to create a cultural shift towards environmental awareness that would have employees understanding how their activities may

affect the environment. By instilling an environmentally conscious culture into the organization, an environmental management system (EMS) becomes a means to prevent pollution.

#### **Laying the groundwork for pollution prevention**

Developing system documentation for ISO 14000 is a process in and of itself. This process requires time for the review of processes and activities, the identification of environmental aspects, the documentation of environmental management processes, the approval of the documents and the integration of that documentation into the EMS.

When assessing processes for their aspects and associated environmental management activities, interviews of operators should be performed to help ensure that nothing is missed. A common tool that is used to help facilitate this process is to have the operator map his or her activities on a flow chart. This helps identify infrequent activities that do not readily appear to be a direct part of the process or responsibilities of the operators involved. When interview subjects provide the information, the interviewer should review the environmental implications of the activities with the operator. This begins to lay the groundwork for a cultural change through which operators understand how aspects of their work may affect the environment. This will later be reinforced through EMS or ISO 14000 awareness training.

# A platform for pollution prevention

Through the medium of systems and cultural change, ISO 14000 can improve an organization's environmental performance

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This process of developing EMS documentation through the assessment of processes creates further opportunities. The examination of the implications of environmental aspects and issues is normally used in the development of training, but also provides input data for business decision making and strategic planning.

Once EMS processes are defined and documented for a department, training becomes an important implementation tool. As an ISO 14001 requirement, operators must be trained on the use of their systems, and on how their activities may affect the environment. Included in the training should be ISO 14000 awareness training including a review of the company's environmental policy and operating permits, and the function of important EMS mechanisms such as internal system audits.

Among the systems that need to be covered in the training are the specific environmental objectives and targets that apply to their relative departments. The standard requires that objectives and targets be held at each relevant level of the organization. In other words, the responsibility for achieving those targets lies heavily at the department level, rather than at the environmental compliance department level.

## ISO 14000 promotes cultural change

The end result of training should be a shift in thinking toward a higher level of environmental awareness. This would result from an understanding of why EMS processes are in place, and what impacts may result from operators' routine activities. Unlike cultural change that relates to other types organizational behavior, environmental awareness easily takes root because the personnel usually live in the area of their employment, and believe that they are contributing positively to something that affects their homes and families. This awareness becomes a significant factor in the prevention of pollution because it becomes part of their everyday thinking.

One company in Mexico that had gone through the ISO 14001 implementation process found that employees were not only operating with greater environmental awareness on the job, but were also taking their learning home and applying the EMS principles to their households. This is evidence of a cultural change that has the operators thinking "green" in everything they do.

## A means of tracking environmental performance

The ISO 14001 standard was designed to facilitate the prevention of pollution by

virtue of its required systems and mechanisms. By having documented EMS processes, greater control and continuity result from the increased level of discipline. Management is required to review the EMS for its appropriateness and effectiveness. Effectiveness can be measured against the EMS's ability to move towards achieving its objectives and targets, which typically include measures of increased environmental performance and a reduction of accidents and unintentional excesses.

Internal system audits help verify implementation, and also provide an opportunity to check the EMS's procedures against the real world activities of departments, and vice versa. If anything is missed during the initial process of developing the EMS, the system audits provide an opportunity to identify shortcomings and continually improve the EMS.

Companies that exhibit otherwise excellent environmental performance can face a challenge when on-site contractors have an effect on performance. ISO 14000 requires companies to have procedures for contractors to follow as well as appropriate training. Evaluating the environmental implications of contractors' activities would be the same process as evaluating the implications of any procured material or capital equipment from a supplier.

Corrective action systems are required to take a root cause approach to system and operating nonconformances. This approach not only directly improves the system, but also gives birth to new ideas that can improve control over environmental performance, and eliminate or reduce negative environmental aspects.

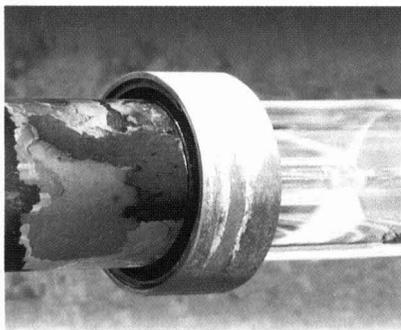
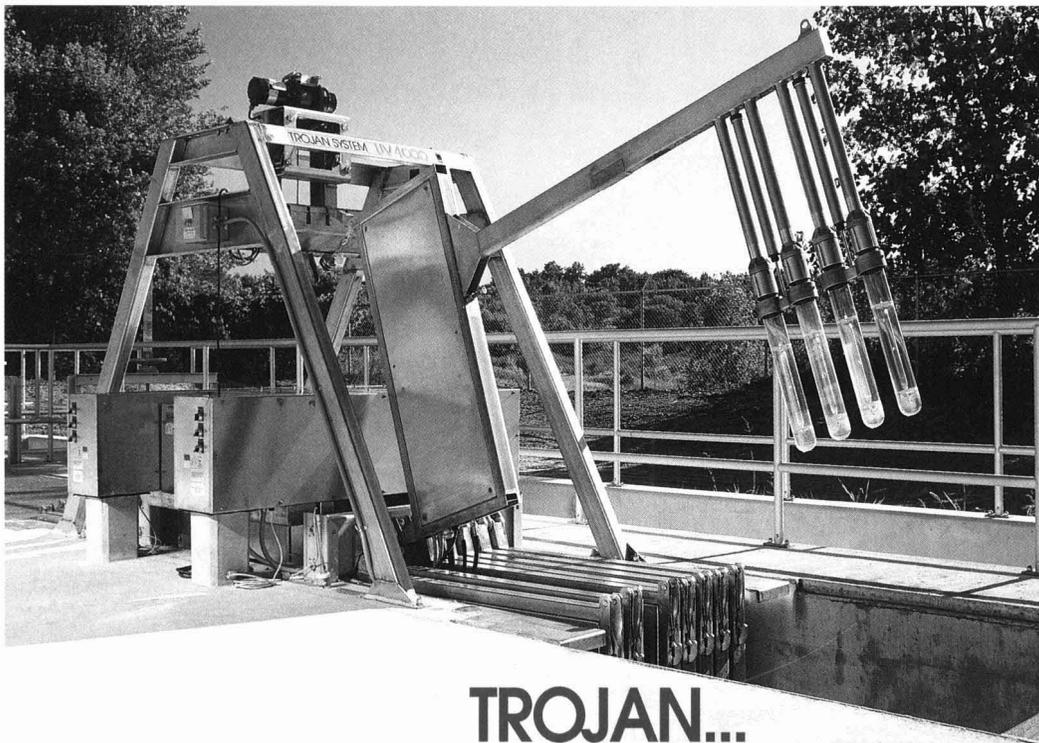
Perhaps the most important parts of ISO 14001 are the required environmental objectives and targets. These provide an organization with specific goals, and continual tracking of its performance against the goals. Importantly, because the objectives are set out at the department level, those who have a direct effect on attaining those goals are aware of how they are measuring up.

ISO 14000 provides organizations with the opportunity to bring environmental management across all functions of the organizations. Only the enthusiasm and imagination of its people limit the extent to which the ISO 14000 effort can benefit a company. 

*Dennis Abarca is the business development manager and ISO 14000 champion at ABS Quality Evaluations Inc., Cleveland.*

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# BEST bioremediation PICKS

By Brian L. Clark, PE

An overview of the biological treatment of industrial and hazardous waste for decision makers

**B**ioremediation is probably the most difficult remedial technology to evaluate and implement. It is by far the most elegant and pure clean-up solution—resulting in the transformation of toxic compounds to carbon dioxide and water—but the overall process can be unpredictable and unreliable due to a variety of physical, chemical and biological factors. Selection of a bioremediation technology requires an understanding of the biological processes involved and the physical application methods available.

## Biological processes

Bioremediation is the process of using bacteria to break down hazardous chemicals into non-hazardous compounds. Bioremediation results in the destruction of organic wastes, eliminating environmental risk and liability. Although it is often less costly than other technologies, bioremediation does require a high level of scientific knowledge to understand and optimize the environmental conditions under which hazardous compounds will degrade. Like many commercial uses of biological systems, including wastewater treatment, beer brewing, bread baking and cheese making, bioremediation of hazardous compounds is a complex process with many variables that must be controlled in order to achieve a successful outcome.

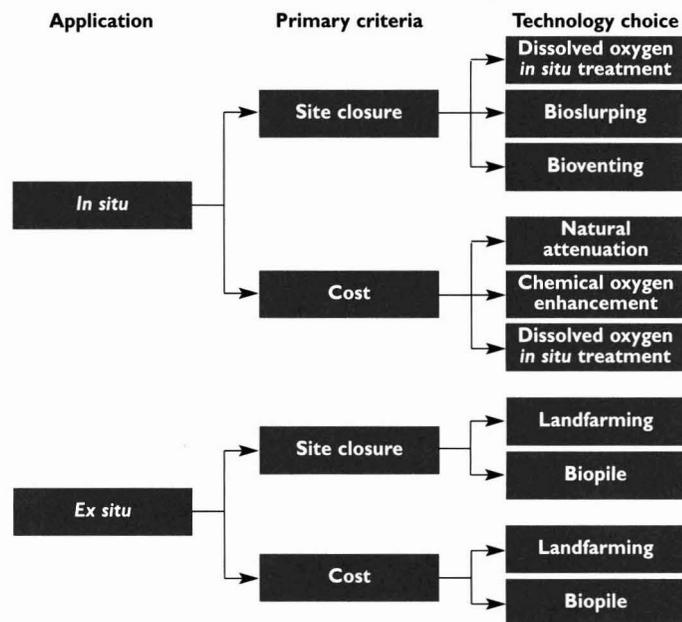
The key to any bioremediation process is the control of specific microorganisms under specific environmental conditions to achieve specific chemical transformations. Unlike commercial biological processes that are carried out in highly monitored reactor vessels, bioremediation requires that this control be performed in complex

hydrogeological settings to transform often complex mixtures of compounds to carbon dioxide and water in a process called mineralization. Bioremediation processes are catalyzed chemical processes in which the microorganisms provide the catalyst (enzyme) to transform a specific compound (contaminant) in an oxidation-reduction (redox) reaction. Enzyme production and the subsequent reaction will

not occur unless suitable environmental conditions are carefully maintained.

The primary components required to sustain a bioremediation process are: a bacteria species capable of producing target-specific enzymes to degrade the contaminant; an energy source, which is the targeted contaminant; and an electron acceptor, such as oxygen, for the redox reaction. Components of secondary

**FIGURE 1**  
**Technology selection flow diagram**



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importance are nutrients, moisture, pH and temperature. Absence, or even imbalance, of these components may limit the biological process and result in lack of contaminant transformation. For this article, we will refer to the primary and secondary components as "amendments."

### Selecting amendments

Regardless of the application process, most sites are limited by the availability of electron acceptors. Electron acceptors are generally of two classes: aerobic, the use of oxygen as an electron acceptor; and anaerobic, the use of an electron acceptor other than oxygen. Contaminants that degrade well under aerobic conditions include all types of petroleum fuels and polycyclic aromatic hydrocarbons (PAHs). Anaerobic conditions may be required for contaminants such as perchloroethene (PCE) and trichloroethylene (TCE). All of the technologies described below are aerobic technologies, and in most cases, the method for introduc-

ing oxygen is the focus of the technology.

Many bioremediation efforts fall short because they focus only on the addition of oxygen, and neglect the fact that bioremediation is a dynamic life process—increasing one amendment may trigger a need for another. Different sites require varying levels of amendments. For instance, some sites may already contain adequate populations of indigenous bacteria. These sites may respond well to the addition of nutrients or pH adjustment. Other sites may lack a good bacteria population and nutrients, and therefore require addition of both. The addition of nutrients alone is often referred to as biostimulation, and the addition of bacteria and nutrients is often referred to as bioaugmentation. Other amendments, including enzymes and surfactants, may also be used. Changing conditions during the course of a bioremediation project may require addition of a different amendment than originally called for—remember, this is a dynamic process.

### Selecting an application technology

Once an initial decision regarding amendments is made based on the physical and chemical data available, an application method for applying those amendments must be selected. Application methods fall into two large categories, *ex situ* and *in situ*. *Ex situ* methods require that the soil be excavated prior to treatment; *in situ* methods treat soil and/or groundwater beneath the ground surface without excavation. In general, *ex situ* methods are easier and less expensive to implement, but they do not address impacts to groundwater. The decision to use an *ex situ* or *in situ* method is usually made during an initial screening process with the site owner and is driven by the following factors:

1. Is groundwater impacted (on-site or off-site)?
2. Is excavation feasible? Site disruption during excavation allowable?
3. Is there space on site for soil treatment?

**TABLE I**  
**Common bioremediation technologies**

METHOD	PROS	CONS
<b>Approaches</b>		
Biostimulation	<ul style="list-style-type: none"> <li>• Inexpensive</li> </ul>	<ul style="list-style-type: none"> <li>• Effective at limited number of sites</li> <li>• Uncertain results</li> </ul>
Bioaugmentation	<ul style="list-style-type: none"> <li>• Increased rate of remediation</li> </ul>	<ul style="list-style-type: none"> <li>• Can be expensive</li> <li>• Some products not effective</li> </ul>
<b>Ex situ applications</b>		
Landfarming	<ul style="list-style-type: none"> <li>• Easy to implement</li> <li>• Rapid cleanup</li> </ul>	<ul style="list-style-type: none"> <li>• Requires large surface area</li> </ul>
Biopile	<ul style="list-style-type: none"> <li>• Can be implemented in small site area</li> </ul>	<ul style="list-style-type: none"> <li>• Difficult to control and monitor process</li> <li>• May be slow</li> </ul>
<b>In situ applications</b>		
Dissolved oxygen <i>in situ</i> treatment	<ul style="list-style-type: none"> <li>• Very rapid remediation</li> <li>• Works in both saturated and unsaturated zones</li> <li>• Can be retrofitted to existing pump-and-treat and air sparging/vapor extraction sites</li> <li>• Good process for introducing biological enhancements</li> <li>• Excellent operating flexibility</li> </ul>	<ul style="list-style-type: none"> <li>• May require more complicated design</li> </ul>
Bioslurping	<ul style="list-style-type: none"> <li>• Can be effective in both saturated and unsaturated zones</li> <li>• Removes contaminated groundwater in conjunction with biological enhancement</li> </ul>	<ul style="list-style-type: none"> <li>• Limited operating flexibility</li> <li>• Unpredictable results</li> <li>• May be high maintenance</li> <li>• Requires water treatment/disposal</li> </ul>
Chemical oxygen enhancement	<ul style="list-style-type: none"> <li>• Relatively easy to implement</li> <li>• May serve to temporarily appease regulators</li> </ul>	<ul style="list-style-type: none"> <li>• Not good for sites with moderate to high contamination</li> <li>• Expensive on unit cost basis</li> <li>• No operating flexibility</li> </ul>
Bioventing	<ul style="list-style-type: none"> <li>• Works in unsaturated soils</li> <li>• Relatively simple design</li> </ul>	<ul style="list-style-type: none"> <li>• Limited effectiveness in saturated soils</li> <li>• Difficult to deliver biological enhancements</li> </ul>
Natural attenuation	<ul style="list-style-type: none"> <li>• Inexpensive</li> <li>• Good for sites with proper chemical/physical and regulatory conditions</li> </ul>	<ul style="list-style-type: none"> <li>• Slow clean-up prolongs site closure</li> <li>• Usually requires long-term monitoring</li> <li>• Increased site characterization requirements</li> </ul>

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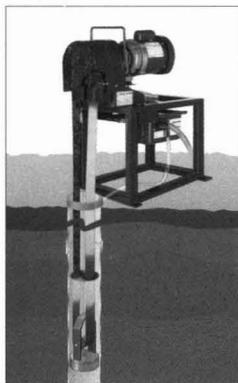
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4. How fast does the remediation need to be accomplished?

5. What is the soil type?

6. What is the contaminant?

7. Are there any specific regulatory constraints?

Following this determination, the next decision to make is which *ex situ* or *in situ* approach to use. Table 1 summarizes common *ex situ* and *in situ* methods in use today.

### Ex situ methods

Landfarming is the traditional method of choice for *ex situ* treatment. Landfarming involves the construction of a treatment cell; loading the soil into the cell at a depth between 8 and 24 inches, depending on the tilling equipment to be used; addition of the required amendments; tilling of the soil on a regular interval, usually every 1 to 2 weeks; and maintenance of the amendments and moisture levels. Landfarming is easy to implement, allows good contact of the amendments with the soil, and is easy to monitor. Space and weather conditions permitting, this is the *ex situ* method of choice.

Biopiles involve the mounding of contaminated soil in a lined and covered pile. Biopiles may be the option of choice for sites with limited space and cold or rainy weather. Air and amendments are circulated through the pile via piping that is installed within the pile during loading. These systems require a greater amount of engineering and maintenance than landfarms, and may be difficult to monitor because collecting soil samples from inside the pile can be a chore.

### In situ methods

*In situ* methods are generally characterized by their approach to providing oxygen to the subsurface environment. Most *in situ* methods use air, some use oxygen and others use dissolved oxygen. A top-level screening decision for *in situ* methods is where the technology will be used. If it will be used in the unsaturated soil zone, which is the zone above the groundwater, also called the vadose zone; the saturated soil zone, the zone in contact with the groundwater, often referred to as the smear zone; or used to treat the groundwater affect the screening results. Many methods do not effectively treat all three areas.

Dissolved oxygen *in situ* treatment (DO-IT) is the latest and most promising *in situ* bioremediation method. The DO-IT technology involves nearly continuous application of biological amendments along with extremely high levels of oxygen dissolved in water. The process works best at sites with contaminated groundwater, but can also be

used for treatment of the vadose zone.

Bioslurping, also known as dual-phase extraction, is the practice of extracting both vapor and liquid from the subsurface. The movement of air through the subsurface may enhance biological activity. In some cases, the extracted water is amended with biological enhancements, aerated and re-injected into the subsurface. This technology can be effective in the right soil conditions, but may require treatment of extracted vapors and the necessary vacuums to extract liquid can cause excessive dehydration of the aquifer, limiting biological activity.

Chemical oxygen enhancement is a popular method for speeding up natural attenuation. The chemical additive is typically a calcium or magnesium carbonate that releases oxygen molecules in the presence of water. This technology is only applicable for sites with very low levels of groundwater contamination.

Bioventing is a method used for unsaturated soil conditions. Air and sometimes nutrients are injected into the soil through a series of injection wells. Bioventing has limited application because it is not possible to inject other amendments that may be necessary. Also, injection of air can cause the volatile compounds to spread out across the site; if air is extracted instead of injected, treatment of the vapors may be necessary.

Natural attenuation is the practice of allowing naturally occurring processes of biological degradation, diffusion and dispersion to slowly reduce a contaminant plume. This option may be suitable at less contaminated sites, but requires a higher level of proof that it is a viable response, and may result in expensive long-term monitoring.

### Determine your needs

Often technical soundness is subjugated to the reality of limited budgets. Many cleanup decisions are made on the basis of capital preservation and not the effectiveness of the technology or its ability to achieve cleanup and closure. Figure 1 can help with the selection of an appropriate technology starting from a cost and effectiveness perspective. Regardless of the technology selected, make sure the biological amendments used at the site and the consultant or contractor performing the work have a proven track record with biological remediation. 

Brian L. Clark, PE, is executive vice president of Enzyme Technologies Inc., Portland, Ore.

For more information, circle 62 on card.

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### Drum accessories



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### Block calibrators



The CL700A series of block calibrators are housed in a rugged metal case for field use. It includes an RS-232 computer interface for data and program transfer or real time control. The calibrators have a fast settling time for rapid testing and fast heat up and cool down times. Omega. **Circle 65 on card.**

### Rings and saddles



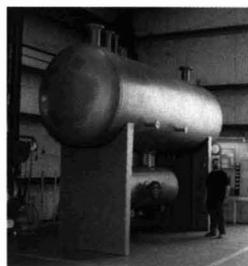
Jaeger Rings are slotted, cylindrical packing elements with standard Pall® ring type dimensions, free space, surface area and performance. Jaeger Saddles have a unique drip-point design that promotes high mass-transfer rates through effective wetted surface renewal. They are available in three sizes—1-inch, 2-inch and 3-inch. Jaeger Products Inc. **Circle 66 on card.**

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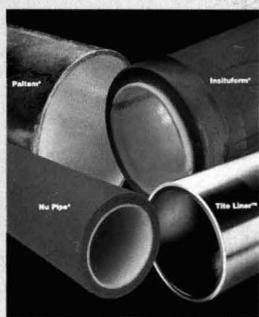


Tube No. 01LL is ideal for indoor air quality monitoring. It has a measuring range of 0.05 to 1.0 ppm by volume at five pump strokes. Direct reading results are obtained in less than 8 minutes by length of stain. The system includes a piston-type volumetric pump with lifetime guarantee. Sensidyne Inc. **Circle 70 on card.**

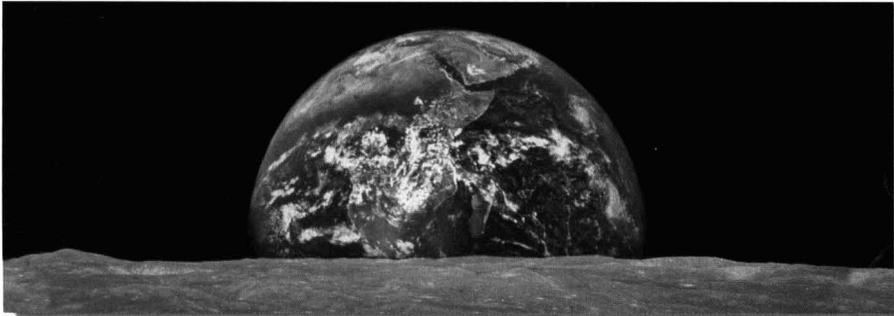
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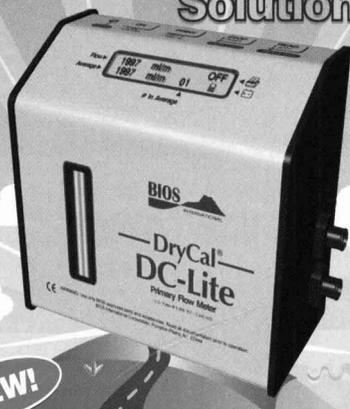


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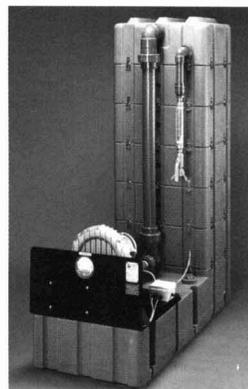


The Series 1200 oxygen analyzers provide monitoring of excess air and combustion effi-

ciency under any conditions. The instruments have three major components—the probe, the control/display unit and the optional gas flow calibration flow control unit. Land Combustion.

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## Filter



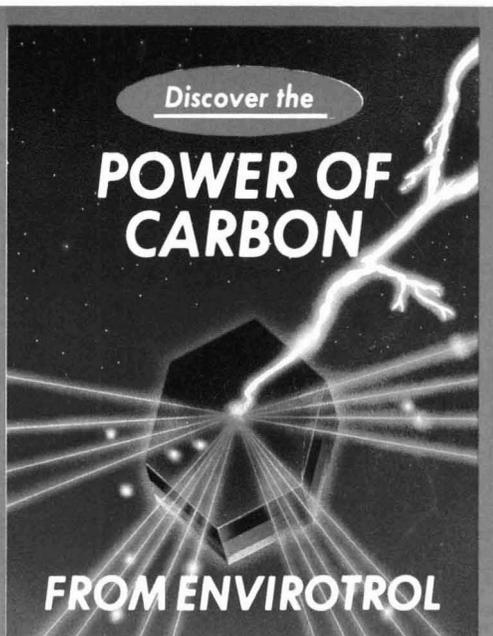
The P100 micro filter has the same breathing resistance and life span as traditional HEPA filters, but in a smaller size. Approved as  $\pm 2$  CFR in a complete line of combination cartridges, the P100 micro filter minimizes vision obstruction and fits easily under other protective gear. Survivair.

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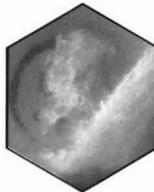


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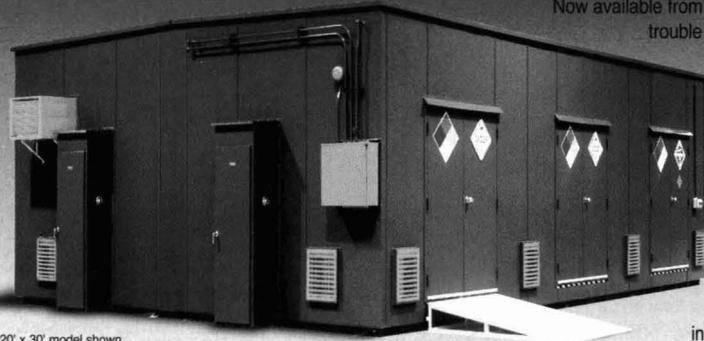
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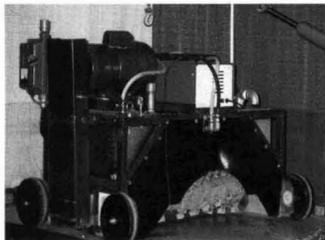
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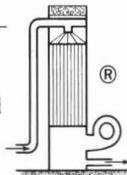
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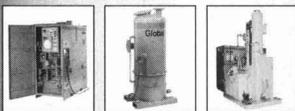
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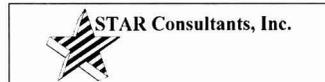
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**GLOBAL ENVIRONMENTAL MANAGEMENT INC;** 9299 Tonnerberger; Tecumseh, MI 49286; PHONE: 517-423-5174; FAX: 517-423-5175; Management Consulting on Environmental Issues; International Environmental Issues; ISO 14000

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**HANDS & ASSOCIATES INC;** 1150 Griswold Ave Ste 2800; Detroit, MI 48226; PHONE: 313-963-8870; FAX: 313-963-8876; Environmental Management Systems; Air Quality Compliance Assistance; Mentoring & Coaching

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**MACKINAC ENVIRONMENTAL TECHNOLOGY INC;** 300 Ferry Lane P O Box 485; St Ignace, MI 49781; PHONE: 906-643-9948; FAX: 906-643-9977; Site Redevelopment/Development ESAs Wetland; Site Remediation; Site Investigation

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**PROFESSIONAL SERVICE INDUSTRIES INC;** 24355 Capitol Ave; Detroit, MI 48239; PHONE: 313-255-4200; FAX: 313-255-7772; Brownfield Redevelopment; Underground Storage Tank Consulting; Due Diligence Assessments

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**SHIFRIN & ASSOCIATES INC;** 230 South Demitson Ave Ste 305; St Louis, MI 63105; PHONE: 314-721-2249; FAX: 314-862-0041; Environmental Site Assessments; Management of Underground Storage Tanks; Cleanup Remediation of Sites

**SUPERIOR PROPERTY SERVICES GROUP;** 230 East Grand River Avenue Ste 205; Detroit, MI 48226; PHONE: 313-961-8054; FAX: 313-961-8094; Brownfields Redevelopment; Wetlands Management; Environmental Site Assessments

**TEAM ENVIRONMENTAL CONSULTING INC;** 3398 North Dancer Rd; Dexter, MI 48130; PHONE: 734-426-0983; FAX: 734-486-0958; ISO 14000; Environmental Management Systems; Compliance Management

**TECHNICAL SERVICE ASSOCIATES INC;** 2600 Spring Arbor Rd; Jackson, MI 49203; PHONE: 517-787-3393; FAX: 517-787-4508; Permitting; Reporting Requirements; Environmental Audits

**THE BUSINESS ENVIRONMENTAL & SAFETY TECH CENTER;** 1105 North Front St Ste 29; Niles, MI 49120-1665; PHONE: 616-683-7373; FAX: 616-683-7515; ISO 14000 EMS Development; OSHA Written Programs & Employee Training; EPA Hazardous Waste Management Consulting

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**WG ELLERHOLZ ASSOCIATES INC;** P O Box 24512; Detroit, MI 48224-0512; PHONE: 810-771-6037; Air Pollution Control Equipment; Industrial Ventilation System; Energy Management Systems

**WILLCOX ASSOCIATES INC;** 1 Madison Ave; Cadillac, MI 49601; PHONE: 616-775-7755; FAX: 616-775-3135; Hydrogeological Investigations; Risk Assessments; Remediation

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**GME CONSULTANTS INC;** 14000 21 Ave North; Minneapolis, MN 55447; PHONE: 612-559-1859; FAX: 612-559-0720; Contamination Assessment; Phase I & II ESA; Brownfield Development Assistance

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**MATERIALS PRODUCTIVITY;** 1821 University Ave #5-219; St Paul, MN 55104; PHONE: 612-603-8282; FAX: 613-603-8286; Pollution Prevention; Cost Reduction; Process Improvement

**NOVA CONSULTING GROUP INC;** 1107 Hazeltine Blvd; Chaska, MN 55318; PHONE: 612-448-9393; FAX: 612-448-2579; Environmental Assessments; Asbestos & Lead Services; Air Quality Testing

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**SUPERIOR ENVIRONMENTAL CORP**; 14641 16 Ave P O Box 118; Marne, MN 49435-0118; PHONE: 616-677-5855; FAX: 616-677-3484; Brownfield Redevelopment; Soil & Groundwater Remediation; Regulatory Compliance

**WENCK ASSOCIATES INC**; 1800 Pioneer Creek Center P O Box 428; Maple Plain, MN 55359-0428; PHONE: 612-479-4200; FAX: 612-479-4242; Industrial Environmental Compliance/Mgt Operations; Solid Waste Planning, Design & Construction; Water Resources Planning, Management & Design

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**WIDSETH SMITH NOLTINS**; 2000 Industrial Park Rd; Baxter, MN 56425-2720; PHONE: 218-829-5117; FAX: 218-829-2517; Contamination Investigation; Remediation System Design & Operation; Hydrogeological Studies

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**CORPORATE SAFETY GROUP INC**; 14801 Elwood Lane; Ocean Springs, MS 39565-9400; PHONE: 228-396-9927; FAX: 228-396-9927; Occupational Safety & Health Training & Consultancy; Environmental Assessments; Fire Safety Training

**ENVIRONMENTAL MANAGEMENT SERVICES INC**; 600 North 26 Ave; Hattiesburg, MS 39401; PHONE: 601-544-3674; FAX: 601-544-0504; Phase I Assessments; Geoprobe & Other Field Services; Site Monitoring & Inspection

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**BURNS & MCDONNELL**; 9400 Ward Pkwy; Kansas City, MO 64114; PHONE: 816-333-9400; FAX: 816-333-3690; Comprehensive Environmental Engineering Services; Waste Management; Engineer Svc for Air Pollution/Water Suppl/Wastewater

**CONATECH CONSULTING GROUP INC**; 287 North Lindbergh Blvd Ste 208; Creve Coeur, MO 63141-7849; PHONE: 314-995-9767; FAX: 314-995-3766; Transportation of Hazardous Chemicals; Manufacturing & Packaging of Hazardous Chemicals; Expert Witness Litigation/Technical Consulting

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ronmental Assessments; Technical Labor; Underground Storage Tank Closures

**GARNER BASS ASSOCIATES IN ENVIRONMENTAL MANAGEMENT**; 3469 East Cinnamon Place; Springfield, MO 65809; PHONE: 417-887-8080; FAX: 417-887-8383; Environmental Management Systems; Regulatory Compliance; Due Diligence

**GEO ENVIRONMENTAL SERVICES INC**; 710 North 2 St Ste 400N; St Louis, MO 63102-2532; PHONE: 315-436-7102; FAX: 314-436-7103; Environmental Engineering Services; Civil Engineering; Geotechnical Engineering

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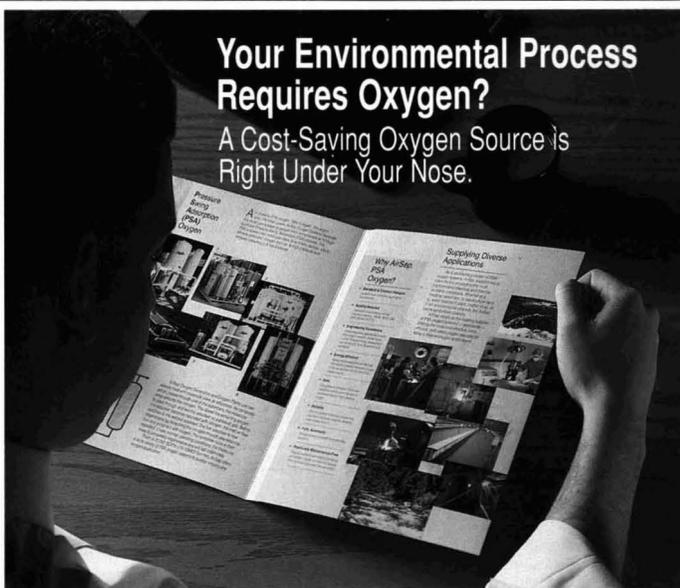


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## Montana

**EHS SERVICES**; 2020 Grand Ave; Billings, MT 59102-2679; PHONE: 406-656-3804; FAX: 406-656-3971; Environmental Consulting; Health & Safety Consulting; Regulatory Compliance Auditing

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**THE SCOTT LAWSON GROUP LTD**; 29 River Rd Ste 18 PO Box 3304; Concord, NH 03302-3304; PHONE: ; FAX: 603-228-3871; Environmental Health & Safety Consultants; ALHA & EPA Certified Laboratory; Industrial Hygiene Equipment Rental & Trading

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**X PERT DESIGN & DIAGNOSTICS LLC**; 199 Constitution Ave Building 1 Floor 2; Portsmouth, NH 03801; PHONE: 603-433-0191; FAX: 603-433-41920; In-situ Remediation; Radio Frequency Heating; Chemical Oxidation Remediation

## New Jersey

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**AMGIENT ENGINEERING INC**; 5 Crescent Ave; Rocky Hill, NJ 08553-0279; PHONE: 609-279-6888; FAX: 609-279-9444; Pollution Control Equipment; Regulatory Permits; Environmental Consulting

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FAX: 908-236-2232; Sanitary Engineering; Municipal Engineering; Residuals Management

**BROTHERM LLC**; 401 Towne Centre Dr; Somerville, NJ 08876; PHONE: 908-904-1606; FAX: 908-904-1561; Drying of Biosolids; Drying of Solids Oil/Water Mixtures; Solvent Extraction Process for Soil Remediation

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**ENVIROTECH CONSULTANTS INC**; 78 Clinton Rd; Fairfield, NJ 07004; PHONE: 973-882-1300; FAX: 973-882-4942; Soil & Groundwater Remediation; Geologic Studies; Brownfield Development

**ENVIROCOM**; 790 Carpenter Rd; North Brunswick, NJ 08902-2262; PHONE: 732-846-1568; FAX: 732-220-9582; Water/Wastewater Sampling/Analysis; Water/Wastewater Treatment; Hazardous Waste Disposal

**ENVIRONMENTAL LIABILITY MANAGEMENT INC**; 218 Wall St; Princeton, NJ 08540-1512; PHONE: 609-683-4848; FAX: 609-683-0129; Remediation; Risk Assessment; Brownfields

**ENVIRONMENTAL WASTE MANAGEMENT ASSOCIATES LLC**; P O Box 5430; Parsippany, NJ 07054; PHONE: 973-560-1400; FAX: 973-560-0400; Remedial Investigation & Cleanups; Phase I & II Site Assessment; Underground Storage Tank Services

## FIRST ENVIRONMENT

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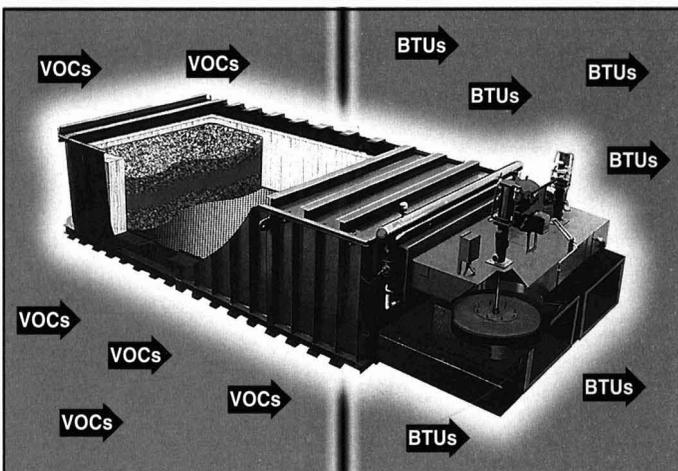
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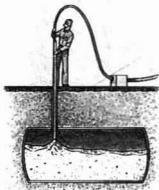
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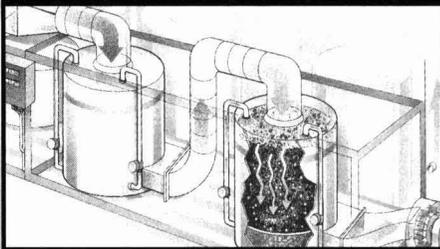
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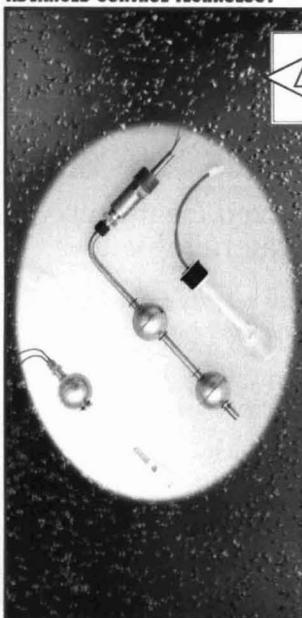
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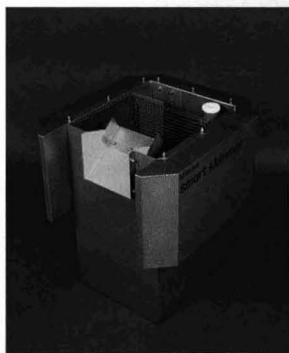
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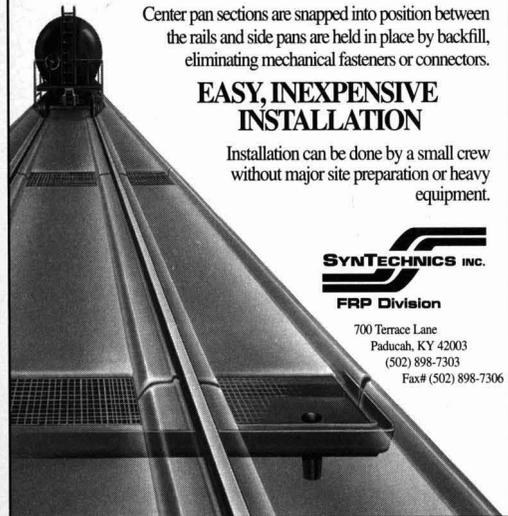
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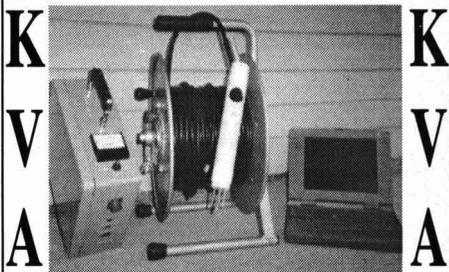
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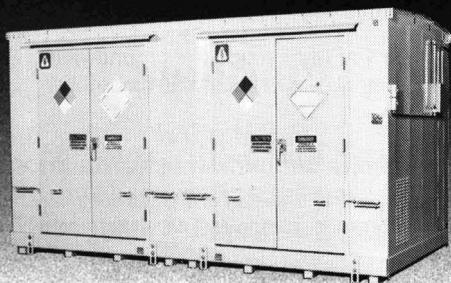
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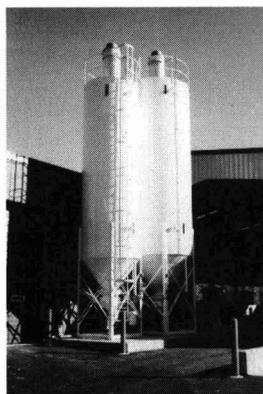
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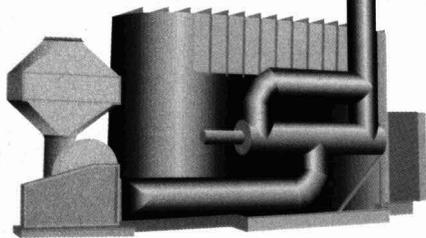
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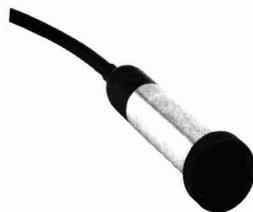
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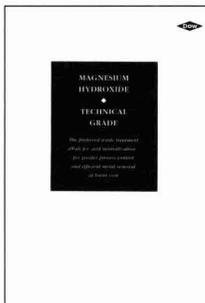


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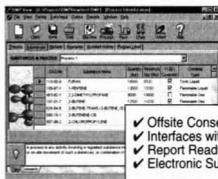
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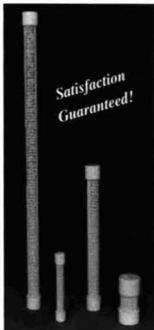
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- If the publication had second-class authorization as a general or requester publication, this Statement of Ownership, Management, and Circulation must be published; it must be printed in any issue in October or, if the publication is not published during October, the first issue printed after October.
- In item 16, indicate the date of the issue in which this Statement of Ownership will be published.
- Item 17 must be signed.

Failure to file or publish a statement of ownership may lead to suspension of second-class authorization.

PS Form 3526, September 1995 (Rev. 9/95)

# Protection perspectives

perspectives

Shenandoah National Park, located along the crest of the Blue Ridge Mountains in Virginia, encompasses over 195,000 acres. The park's famous roadway, Skyline Drive, winds through the peaks and meadows of the Blue Ridge and is a favorite destination for cross country travelers, explorers, hikers and naturalists. The park has 400 miles of hiking trails, sixteen waterfalls and several peaks over 4,000 feet in elevation.

During the early weeks of autumn, Shenandoah National Park is transformed into a fiery display of color. After the color has faded, dying leaves fall into the mountain streams, creating the foundation of a complex food chain. The leaf litter becomes food for insect larvae living in the rocky stream bed. The insect larvae, known as macro-invertebrates, are consumed by native brown trout, which then become the elusive prey of fly fishermen attempting to hook dinner.



PHOTO ©WESTFALL ECOIMAGES, MARK HOWARD, PHOTOGRAPHER, WOODBRIDGE, VA.

Contact Mark Howard via e-mail at [markwh727@aol.com](mailto:markwh727@aol.com)

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# FREE INFORMATION

# Environmental PROTECTION

November 1998  
Card expires January 1999  
Reader Service Card  
N9811F

## FREE INFORMATION

For FREE information on products advertised in this issue, circle the Reader Service Number on the card below. Please type or print clearly and answer all the questions on the card.

Follow these simple steps:

**1**

Answer all questions completely, sign and date your card.

**2**

Circle the number(s) on the attached card that correspond to the advertisement & items mentioned in this issue that you would like FREE information on.

**3**

Detach and mail your postage-paid card today! For faster service, fax your card to:

(312) 922-3165

IT'S THAT EASY!

### PLEASE SEND ME FREE INFORMATION ON THE FOLLOWING ITEMS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
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### 11/98 BUYING PLANS SURVEY WASTEWATER TREATMENT CHEMICAL PRODUCTS/SERVICES

1. Which of the following WASTEWATER TREATMENT CHEMICAL products/services do you plan to purchase in the next 12 months? (select all that apply)
- 800  Lime
  - 801  Activated Carbon
  - 802  Flocculants
  - 803  Odor Control Chemicals
  - 804  Chemical Feeders
  - 805  Antifoam/Defoamers
  - 806  Boiler Tube Descaling
  - 807  Chlorine
  - 808  Algaecides/Bactericides
  - 809  Chlorine Dioxide
  - 810  Fuel Additives
  - 811  Emulsion Breakers
  - 812  Dewatering Aids
  - 813  Corrosion Inhibitors
  - 814  Coagulants
  - 815  Magnesium Hydroxide
  - 816  Hydrogen Peroxide
  - 817  Dust Suppressants
  - 818  Potassium Permanganate
  - 819  Sodium Bicarbonate
  - 820  Standard Solutions
  - 821  Sludge Stabilization
2. What is your reason for purchasing the selected products/services? (select one)
- 822  New Construction
  - 823  Plant Upgrade
  - 824  Replacement/Maintenance
3. What is your projected budget for the selected products/services? (select one)
- 825  Over \$200,000
  - 826  \$100,001-\$200,000
  - 827  \$50,001-\$100,000
  - 828  \$10,001-\$50,000
4. How immediate is your need for the selected products/services? (select one)
- 831  0-3 months
  - 832  4-6 months
  - 833  7-9 months
  - 834  10-12 months
  - 835  Over 12 months
5. What is your budget for the selected products/services? (select one)
- 829  \$5,000-\$10,000
  - 830  Under \$5,000

### SUBSCRIPTION INFORMATION

YES, I would like to receive/continue to receive *Environmental Protection*.  No.

Signature \_\_\_\_\_ Date \_\_\_\_\_

Title \_\_\_\_\_

Business Phone (\_\_\_\_) \_\_\_\_\_ FAX No. (\_\_\_\_) \_\_\_\_\_

Please peel address label from cover and affix below. For faster service, photocopy this side only and send to our FAX # (312) 922-3165.

NAME \_\_\_\_\_

COMPANY \_\_\_\_\_

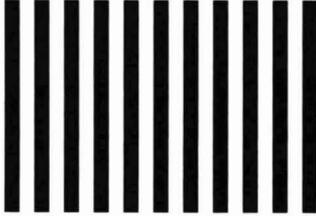
ADDRESS \_\_\_\_\_  Home  Bus.

CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_ ZIP+4 \_\_\_\_\_

- A. Function which best describes your activity in Pollution Control (check only one):
- A  Corporate responsibility for Pollution Control
  - B  Manage all Pollution Control Operations at this location
  - C  Supervise sub-group in Pollution Control Operations
  - D  Provide professional consulting service on Pollution Control
  - E  Provide staff environmental service on Pollution Control
  - Z  Other \_\_\_\_\_
- B. Type of Business (check only one):
- A  Manufacturing. If manufacturing, please check the appropriate SIC (check only one):
- (20) Food  (31) Leather
  - (21) Tobacco  (32) Stone/Clay/Glass
  - (22) Textile  (33) Primary Metal
  - (23) Apparel  (34) Fab. Metal
  - (24) Lumber & Wood  (35) Elect., except Elect.
  - (25) Furniture  (36) Elect. & Electron.
  - (26) Paper  (37) Trans. Equip.
  - (27) Print/Publish  (38) Instr./meas./
  - (28) Chemicals  (39) Misc. Mfg.
  - (29) Petrol. & Coal  analyze/controling
  - (30) Rubber/Plastic  (39) Miscellaneous Mfg.
- C. Number employed at this location:
- A  1-19 B  20-49 C  50-99
  - D  100-249 E  250-499 F  500-999
  - G  1000-1499 H  1500-2499 I  2500 and up
- D. In your job function do you recommend, specify or purchase? (check all that apply)
- A  Pollution Control Equipment
  - B  Instrumentation
  - C  Chemicals
  - D  Parts & equipment for maintenance operation & control
  - E  Mining
  - F  Engineering & Contracting
  - G  Agriculture
  - H  Consulting
  - I  Insurance
  - J  Utilities, public, private & cooperative
  - K  Govt. including municipal or district sanitary water or wastewater treatment sys. or plants
  - L  Transportation
  - M  Real Estate
  - N  Labs
  - O  Training
  - P  Misc. Services
  - Q  City
  - R  County
  - S  State
  - T  Federal
- E. What types of Pollution Control are you responsible for? (check all that apply)
- A  Air
  - B  Solid Waste Disposal
  - C  Noise
  - D  Water
  - E  Industrial Hygiene
  - F  Toxic & Hazardous Material
  - G  Energy Control/Energy Conservation
  - H  Recycling
  - I  Other (please specify) \_\_\_\_\_
  - J  None of the above
- F. Which of the following publications do you receive personally addressed to you? (check all that apply)
- A  Pollution Engineering
  - B  Environment Today
  - C  Environmental Solutions
  - D  Pollution Equipment News
  - E  The National Environmental Journal
  - F  Water Environment & Technology
  - G  None of the above



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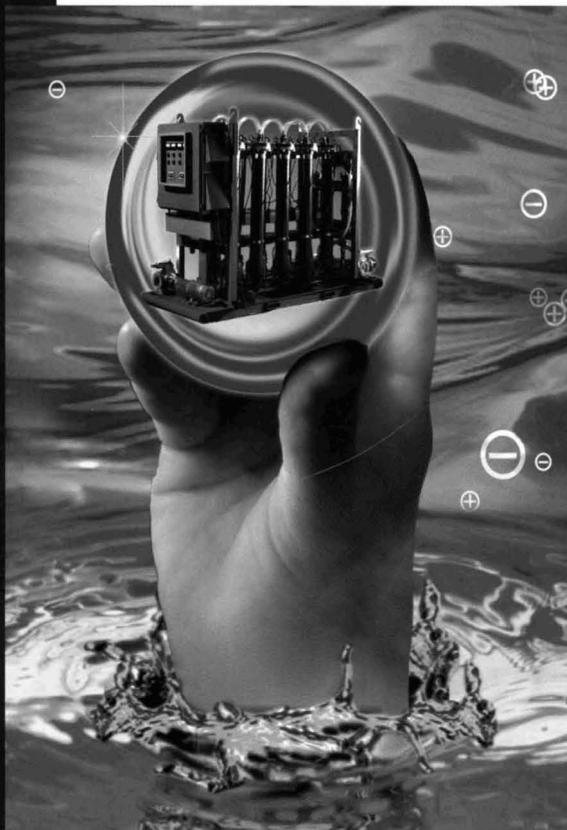


# Improve your BOTTOM LINE

with Ecoquip's JOULE™ EC System

If your current wastewater treatment technology is not meeting discharge limits, replace it with the Joule™ EC System from Ecoquip. This proven system removes most contaminants found in today's industrial waste water streams. Consider the installed cost, the operational cost and the quality of wastewater treated with the Joule™ EC System and you will discover it is something you can't afford to be without.

- Destroys organic compounds
- Eliminates pathogens
- Separates dissolved and suspended solids
- Reduces or eliminates odor
- Reduces chrome, nickel, zinc, cadmium and other metals
- Breaks oil emulsions
- Requires no chemicals
- Small footprint
- Less expensive to operate than traditional systems
- Simple to operate and maintain
- Buy or lease systems that exceed EPA standards through 2004
- 10, 25, 50 and 100 GPM units in stock



Call now for bottom line savings  
**(888) 568-5332**

1657 Oak Tree Drive ● Houston, TX 77080 ● Voice (713) 827-9355 ● Fax (713) 827-9396  
E-mail: [ecoloquip@ecoloquip.com](mailto:ecoloquip@ecoloquip.com) ● [www.ecoloquip.com](http://www.ecoloquip.com)

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## Unsure of which way to turn with environmental information systems?

Black & Veatch leads the industry with the technical resources and complete environmental services experience essential to a successful environmental management information system (EMIS) project.

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- Over 400 savvy IT professionals
- Alliances with major software vendors
- Off-the-shelf or custom solutions

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- ISO 14,001
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- 75% licensed Professional Engineers
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Black & Veatch can direct you  
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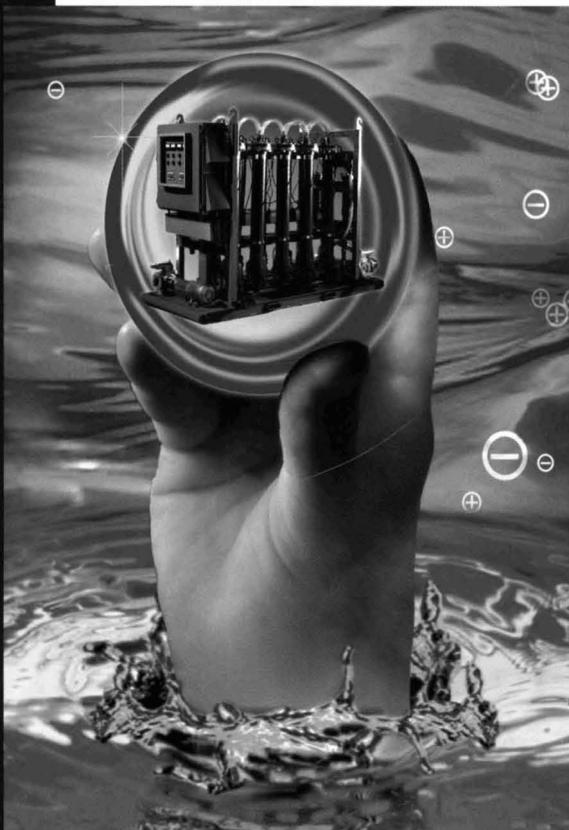
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call Patrick Pfeifer at 913-458-9079 or 1-800-856-5655.

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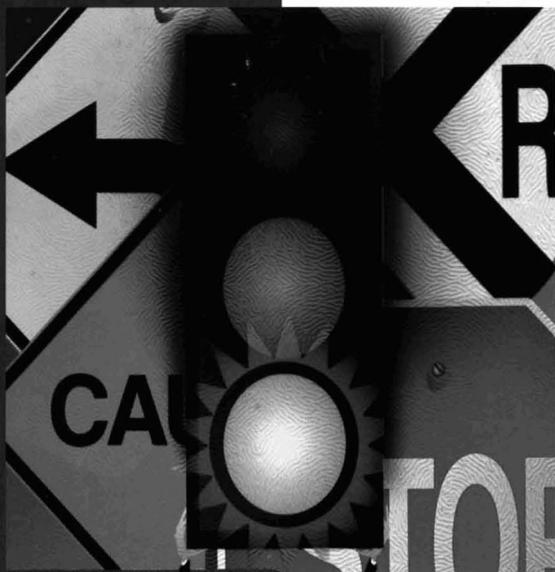
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- Eliminates pathogens
- Separates dissolved and suspended solids
- Reduces or eliminates odor
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