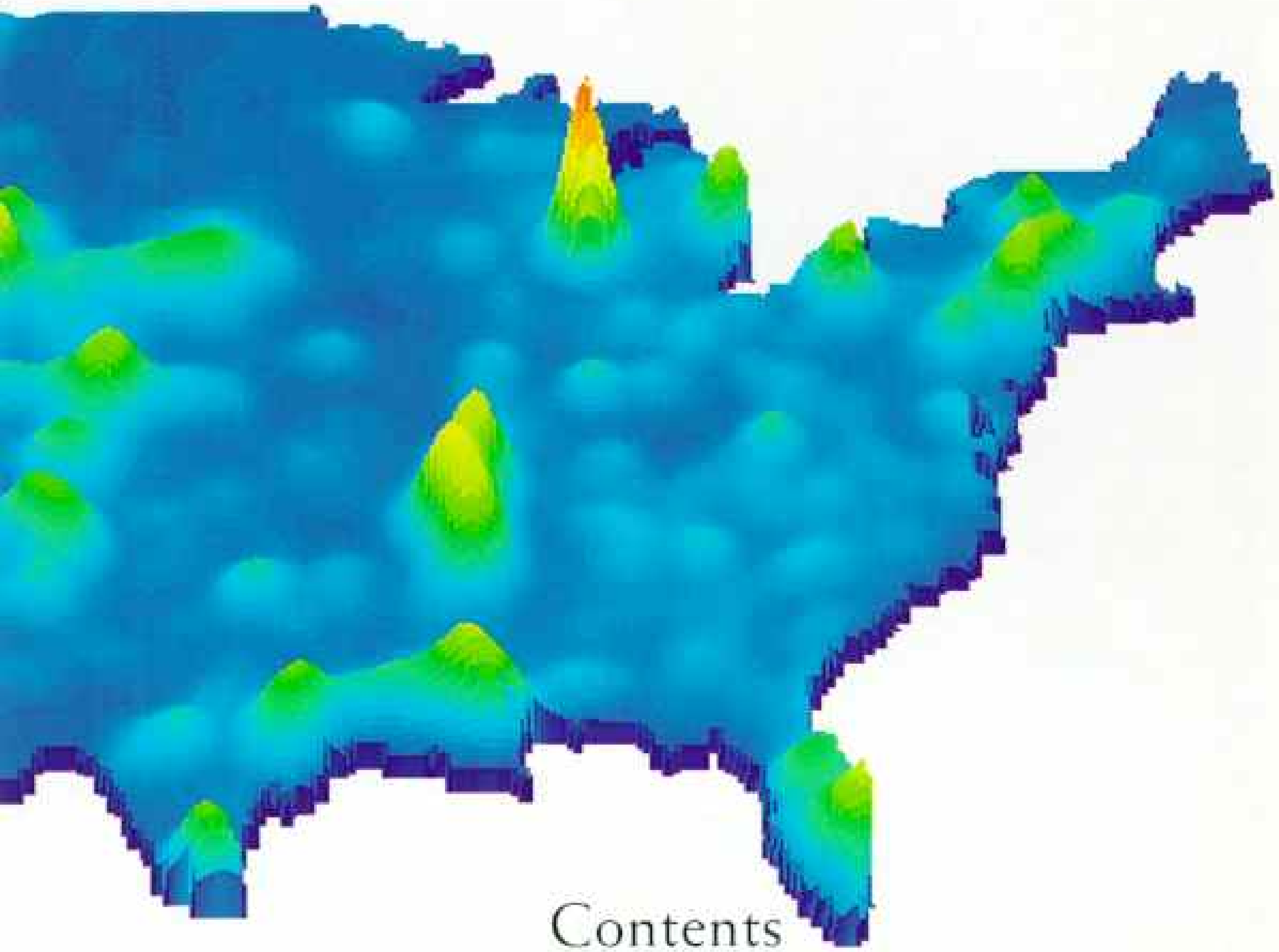
NATIONAL GEOGRAPHIC SPECIAL EDITION

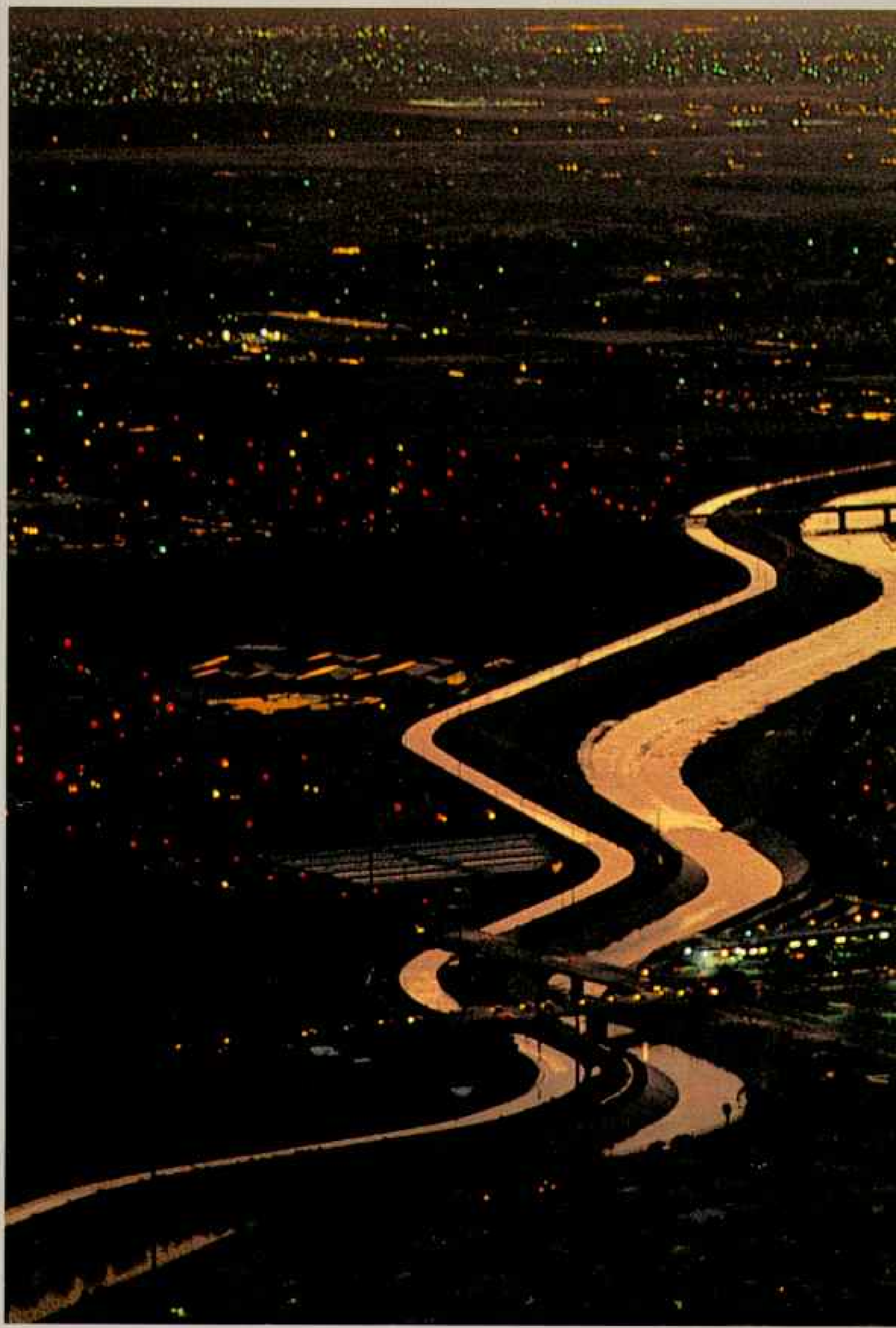
Water

THE POWER, PROMISE, AND TURMOIL OF NORTH AMERICA'S FRESH WATER



Contents

Cover ■ Thundering beauty and cheap electricity are Niagara Falls' twin blessings. The delicate balance challenges a society that thirsts after both. Photograph by Peter Essick.



Arteries of survival

Dammed and diverted, disputed and polluted, water is a commodity we can no longer take for granted. Few needs have inspired such heroic engineering feats as a reliable supply of fresh water. The Arizona Canal, winding through Phoenix and its suburbs side by side with a wider flood channel, is part of a vast network of man-made waterways in the southwestern U. S. that sustain life where it could not otherwise survive.

Water

BY MICHAEL PARFIT

Rain fell on the coast of British Columbia for four days, and water thundered through the valley of the Skeena River. It made the granite cliffs silver and the rivers bronze. It blocked Highway 37 from Kitimat to Terrace, and ran a foot deep across the road right beside a water-slide park. People stopped on bridges to watch trees tumble down the flood. I got out of the car by the river. Rain lashed my face. The ground trembled. The river roared. Water dominated life.

Except for floods and drought, we ignore water. For over a generation most North

Borrowed power

Overflow from four Great Lakes pelts thrill seekers at the foot of Niagara's American Falls, site of the continent's pioneer commercial hydroelectric plant. Buffalo's streetcars ran on Niagara current in 1896; now 20 percent of New York State's electricity is from hydropower. At night Niagara's torrents are turned down as the flow is diverted into reservoirs, which during high-demand daytime hours are emptied to feed hydroelectric plants downriver.

PETER ESSICK

Americans have seldom had to think about it. It comes to our taps when called. It drains away to somewhere else. Most of us have been able to swim when we want, bathe when we choose, water our lawns, and let our children drink from fountains at school. Like good health, we ignore water when we have it.

But, like health, when water is threatened, it's the only thing that matters. Fresh water is the blood of our land, the nourishment of our forests and crops, the blue and shining beauty at the heart of our landscape. Religions bathe their children and their saved with water. Greek philosophers described water as one of the four elements that made up the earth. To the Kogi Indians of Colombia the three things at the beginning of life are mother, night, and water. The Koyukon Indians of Alaska define cardinal directions not as north or south but as upstream or down. Where there is no water, there is no life. A healthy human being can live

BOTH BY RICK RICKMAN

Making every drop count

Buckets in the family shower help a home recycling program in Laguna Niguel, California. Collected soapy "graywater" was used on backyard plants during the drought of 1987-1993, which saw Shasta Lake (right) drop to one-third its capacity. Though rain has replenished the reservoir, water remains a constant concern for Californians.

A delta is dying

When these now vacant graves were newly dug, an arm of the Mississippi River ran past them. In 1903 the river was blocked upstream, and its old channel became Bayou Lafourche. Ever since the change in flow, invading seawater has killed marsh plants, land has sunk, and wakes from boats have gnawed deeper at the shoreline.

JIM RICHARDSON

for a month without food, but will die in less than a week without fresh water. We live by the grace of water.

During the past year, I flew my small Cessna 25,000 miles across North America, part of a team of NATIONAL GEOGRAPHIC writers and photographers who covered the continent to illustrate and document the state of our fresh water. And if health is the metaphor, then we—the far-flung members of this team that have swum the Mississippi, drunk the Yukon, rafted near Hudson Bay, and bought bottled water in Mexico City—have checked this continent's vital signs and heard every prognosis in the book.

Some of the people we talked with called fresh water the coming crisis of the 1990s. And though people have been crying crisis about water every time one new project or another needed money, the many examples of pollution, waste, scarcity, and

Foul waterways

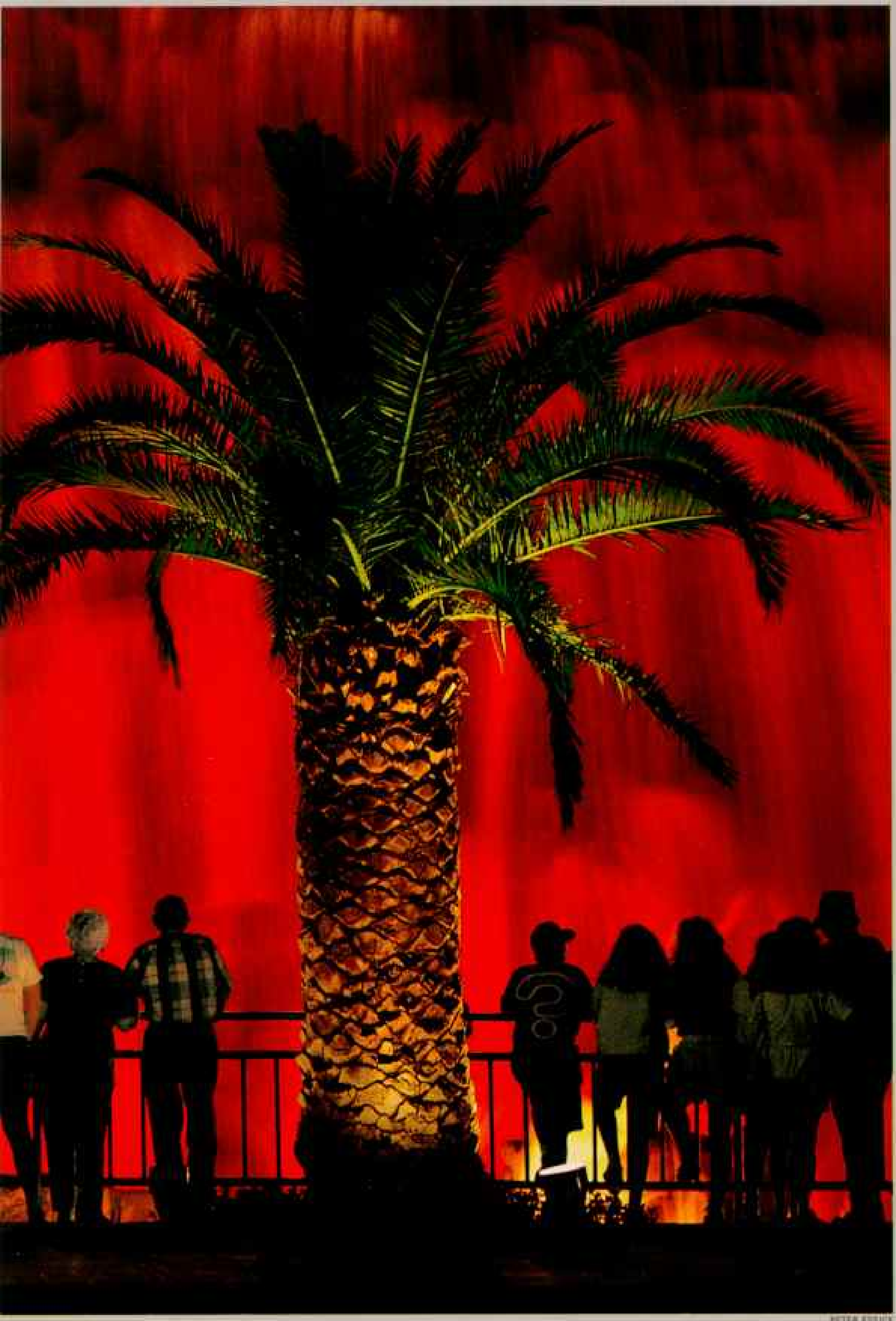
Offensive to the eye and alarming to health officials, a ditch carries sewage and toxic wastes to the Rio Grande near the home of eight-year-old Maria Guadalupe in Matamoros, Mexico. Pollution from the city's scores of ill-regulated factories is suspected of causing maladies and birth defects.

Mining for gold, silver, lead, and zinc near Ouray, Colorado, left a dismal muck. Metal precipitates from water seeping through the tailings have piled three feet deep, choking Joker Tunnel, the target of a cleanup program that includes diverting a creek around the polluted area.

PHOTO BY JIM RICHARDSON

All for show

A bubbling desert spring drew the first Spanish settlers to Las Vegas. Now casinos spurt with glorious excesses like the Mirage resort's Volcano. Though the fountain reuses water, groundwater removal for more practical purposes has caused parts of the Las Vegas Valley to subside as much as five feet, where annual rainfall amounts to four inches.



PETER ESSICK

mismanagement that we report on here are reasons for alarm.

But we cannot simply call the condition of this continent's fresh water a crisis. We are so familiar with proclamations of environmental despair that this would be just another shout in what has become an almost meaningless chorus. This is no tidy emergency that can be fixed overnight by an enlightened Congress. What we saw is more profound.

The story of water is complex. In our year on the water beat we covered a succession of disasters, curiosities, changes, conflicts, innovations, and unknowns. Each of those issues was, in the way of water, large. But though some spanned entire regions, and some were even international, all were specific to a place or a type of environment. While the concerns of Seattle, Toronto, and New York might be similar, they are not the same as those of Mexico City, or Alaska, or Baton Rouge. Nor was the picture uniformly bleak. There are reports of triumph here too.

These many scenes, as you add them up, begin to tell a single story. They tell us that a change is coming—a fundamental change in the way we use, see, and think about water. And though it may be profound, it is a change that all of us, through our own actions, will influence.

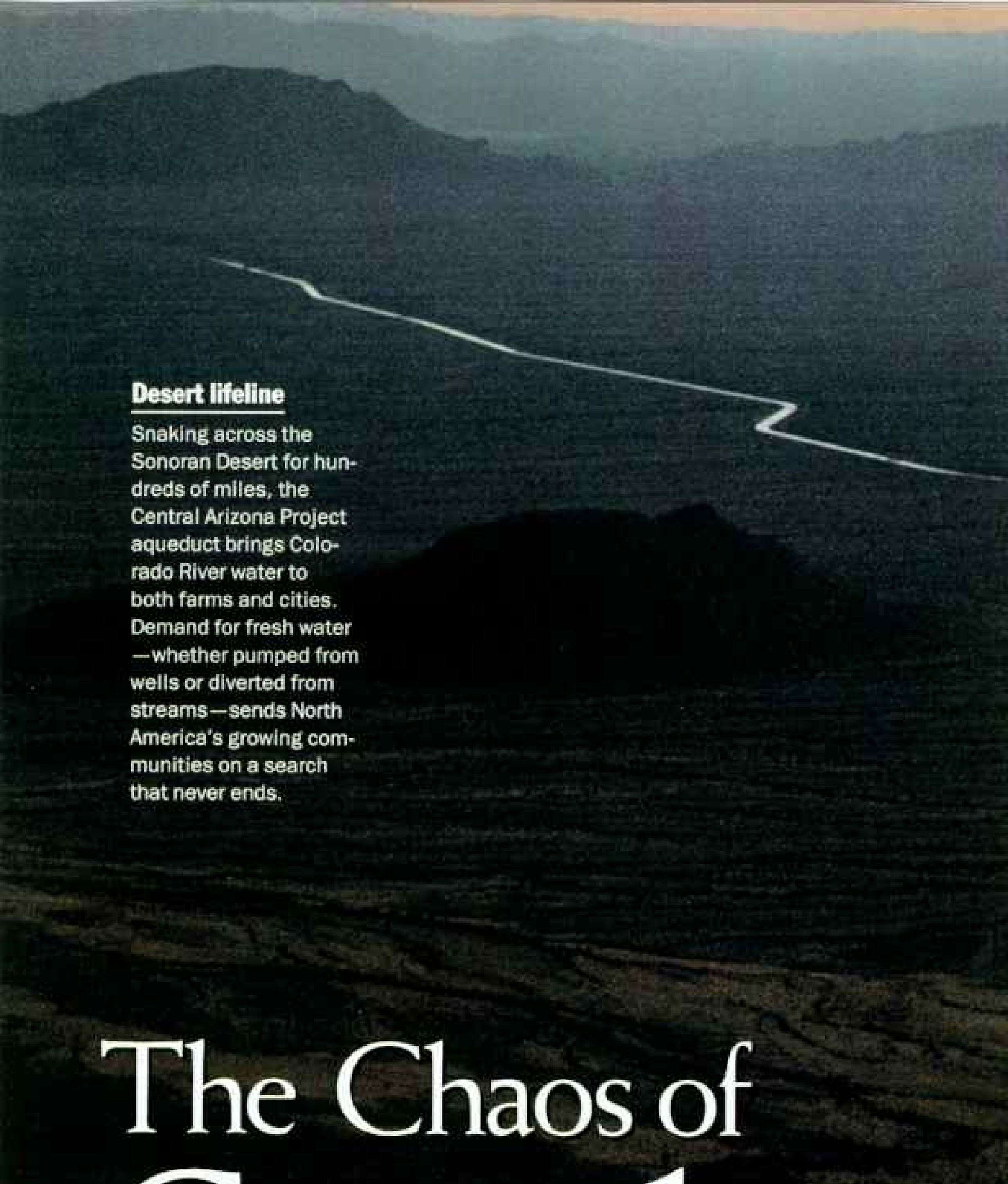
Whether we like it or not, it is already happening. As I stood by the Skeena River that day, chilled by the rain, watching the flood, I knew at least the first part of that change: It is no longer possible to ignore fresh water.

The story begins, as it must, in the clouds.

PETER ESSICK

The cycle of water

With the flash and boom of an Arizona storm, nature goes about its eternal recycling program. Rainwater eventually evaporates and rises to form clouds that release new rain. Humankind has yet to perfect its own management of this essential liquid asset.



Desert lifeline

Snaking across the Sonoran Desert for hundreds of miles, the Central Arizona Project aqueduct brings Colorado River water to both farms and cities. Demand for fresh water —whether pumped from wells or diverted from streams—sends North America's growing communities on a search that never ends.

The Chaos of Supply

Supply

Sharing the Wealth of Water

BY MICHAEL PARFIT
PHOTOGRAPHS BY PETER ESSICK

THE WORLD WAS BLANK, white and unformed. I was at the controls of my airplane, high over the Yukon River, inside a cloud, alone at the beginning of the system. Though I knew where this moisture had probably come from—transpired as vapor out of the forests far to the west or evaporated from the Gulf of Alaska—it was like being present at its birth. The clouds held me, blindfolded. I saw no water, but it was there. Slowly, magically, dangerously, it appeared on wing and windshield: a thin but growing film of ice.

In the system of water, clouds are a bucket brigade, not storage. The atmosphere around the planet carries only about a ten-day supply of fresh water—about one inch of rain. Each day on earth almost 250 cubic miles of water evaporates from the sea and the land. Its stay in the air is short; it is always seeking particles to stick to and fall with as rain or snow. I was a large particle, and the supercooled water stuck and came down with me.

As I descended into warmer air, the ice broke from the wings in chunks. Rain began, streaking across the window. The cloud was starting to unload its cargo, dropping it gently, like the quality of mercy, upon the earth beneath. The mask of moisture swirled from my face, and I emerged over a watery land. Lakes were splashed among spruce forests and bogs, and down the middle of a 15,000-square-mile plain called Yukon Flats ran the big river. It was broad, sinuous, flecked with pancake ice, and full of islands sleek as fish—long, forested salmon swimming upstream. With the rain I swept low in gusts of wind,

Diviner's touch ■ "Dowsing is like meditation. You clear your mind and center yourself," says Bill Burns, searching for water near Danville, Vermont. Dowsers claim coat hangers and tree branches can help locate sites for wells; hydrologists seek clues from geologic formations.

and for a moment it was like coming down over the unpeopled world.

Like a god, the power of the Yukon fascinates the people who live at its mercy. Earlier I'd visited Clarence Alexander, a Gwichin Indian chief at the town of Fort Yukon, where the river had recently ripped out the bank next to the Baptist school. Alexander talked cheerfully about the annual ice breakup, when the river smashes its winter chrysalis.

"Every spring we look for *action!*" he said with a grin. "It sounds like maybe 500 D8 Caterpillars all going at once."

The rain rattled on the windshield as I watched the churning water

Recycled rain ■ Clouds of tannin washed in from swamps upstream dye the crystal-clear water of Devil's Ear Spring in northern Florida. Percolating up through layers of limestone and dolomite, tens of millions of gallons a day discharge from the spring into

DAVID DOUBILET

the Santa Fe River. Fed by heavy rains, Florida's aquifers all told yield more than 4.5 billion gallons of fresh water each day. Nine out of ten Floridians look to groundwater for their drinking supply—nearly twice the national average.

below, struck by its urgency. This was action, all right. Human beings often feel calmed by water and seek views of it for solace, but the hydrologic cycle is anything but calm. All is movement, from the endless flex of freeze and thaw that breaks mountains down to sand, to enormous aquifers in which water oozes slowly but inexorably through the ground, to the great heave of fresh into salt at the river's mouth. Every day the Yukon River dumps an average of 145 billion gallons into the Bering Sea. The sun pumps vapor right back into the sky, and the cycle roars on.

This system is wildly uneven, just what you'd expect from something that moves so fast with such extravagant energy. From the air this inequitable distribution is striking; life is enslaved to the vicissitudes of water, and the shape and colors of the surface change in response to differences in rainfall. One day not long after returning from the Yukon, I took off eastbound in thick, wet air from Seattle, over dark, lush forests watered by some 40 inches of rain and snow a year. An hour later I crossed to the eastern side of the Cascade Range, where the land gets less than 15 inches a year and is covered by grass and sagebrush almost to Idaho. Over the dry land of eastern Montana I saw occasional spring pools emerge from hillsides, rimmed with green—like hallucinatory eyes in a parched face; the next day I flew across the rolling rock of the Precambrian shield in Canada, where every crease in the surface is filled to the brim by a deep-blue lake.

When I headed back west, I crossed the Appalachians after a rain, and even on the highest ridges pools of water glittered in the sun, as if the whole watershed were strewn with broken glass. But a few days later, crossing the Mojave Desert, I saw no shine in 500 square miles.

Yet even there the presence of water was indelible. On that bare ground every twisting thread of drainage was traced in sand. Even after years of drought the entire landscape was carved by past flow, as if water were a stampede and you could still hear the roar.

This is the system we're tapped into, a wild stallion of a system, the living structure that's in charge of the surface of the planet, as powerful in its cool, relentless way as the forces of magma that seethe beneath. No wonder one Romantic poet called water "sensitive chaos." When I flew over the northern Yukon and watched the current racing, this vast system looked invincible, indomitable.

"There ain't nothing holding back that river," Clarence Alexander had said. "No engineer's going to hold it back, not the Yukon River!"

Once Alexander's words would have applied to all the great waterways of the continent. No longer. The qualities that make water so extraordinary—its movement, its power, its uneven distribution, and above all its central necessity to life—have led us to change water as much as we have changed any other part of our planet.

This change has happened piecemeal, but from the air you can see it whole, like stepping far enough back from the picture to see the artist's intent. The picture is of a huge, intricate system in which the natural force of water has been met and changed by the force of human determination into a remarkably different structure. Except in a few remote places like the Yukon, the way water works in North America today

COMPUTER IMAGE BY CHUCK CARTER

The world's water supply

If all earth's water fit in a gallon jug, available fresh water would equal just over a tablespoon—less than half of one percent of the total. About 97 percent of the planet's water is seawater; another 2 percent is locked in icecaps and glaciers. Vast reserves of fresh water underlie earth's surface, but much of it is too deep to economically tap.

Filtered by forest ■ Before water shoots from a public fountain in downtown Portland, Oregon, it flows through the 102-square-mile Bull Run watershed, an old-growth forest in the western Cascades. Environmentalists complain that erosion caused by logging in the watershed, the main supply for 720,000 people, has harmed water quality.

has been shaped by human hand, for better or worse. It is a hand that reaches for water with demands that grow ever more persistent, with ever more uses, for a substance that becomes more precious every day.

The most urgent demand is for water in our homes, which is provided by everything from springs to vast convolutions of reservoirs, aqueducts, and pipes so big you can walk through them. Not far from the Yukon I found one of the most primitive of these sources.

"WE HAVE WASH DAY, we have bath day, we have mop-the-floor day," said Teresa Lord. This schedule did not seem particularly demanding, except for her. She and her family live without running water just outside Fairbanks, Alaska, and she hauls all the water for laundry, mop, and tub from a public spring ten miles from home.

"We're here almost every day," she said, filling a five-gallon bucket with water from an ice-covered pipe. "Been doing this since we moved here in '81." Her daughter, Amanda, ten, grabbed the bucket and began to drag it to the car while her mother filled another.

The place was called Fox Springs. Here about five gallons a minute of clean water was pumped from an old spring to a little shelter, where it came out of two stainless-steel valves. One of the valves bore a wag's sign: "Regular."

Millions of people on this continent still get water at places like Fox Springs. Nearly 2 percent of U. S. homes have no running water. In Canada it's less than half a percent, but in

Mexico, 15 percent of the population must haul or carry water. In Mississippi so many people still have no running water that a congressman made supplying it to them a major personal crusade.

Long after visiting Fairbanks, I landed at Greenville, Mississippi, and talked with Mard Webb, 86, whose home nearby was connected to a new water supply in 1992. Until then she had carried three buckets a day across the street from a house that had a well. Now, though her house has no indoor plumbing, she has a brand-new pipe and faucet on her porch. "I don't have to tote no more," she said. "Sure is good." A neighbor, Betty Taylor, who now has running water indoors, was more effusive. "It's like a miracle!"

The miracle is that so many people do get water in their homes without buckets. This miracle is not an acquired taste; you get used to it right away. And you use convenient water far more than you would if you carried it. Mard Webb toted about ten gallons a day, and Teresa Lord drove five buckets home in her Subaru. But a typical United States household uses about a hundred gallons a day—per person. Countrywide, that is 25 billion gallons of water a day roaring toward laundry, mop, and tub. It's toted for us, as if by magic, through hidden pipes in every town and city. The grandest of these is in New York.

"YOU'VE GOT TO SEE the Chamber at Site 2B," said Mike Krysko, an administrative engineer with the New York City Bureau of Water Supply. He spoke with delight, as if recommending a great horror movie: "Your jaw will hang open."

New York's structure of dams, aqueducts, and tunnels, most of it below the surface, supplies nine million people with 1.5 billion gallons of water a day. The city draws water from the Catskills over a hundred miles north into two major tunnels each twice the height of a basketball player and dug as deep as 800 feet under the city, from which it's distributed by 6,000 miles of pipe. A lot of water and a lot of pressure: When a 36-inch main broke adjacent to a park rest room in 1989, it looked like a bomb had hit. As we drove toward the Chamber, Krysko remembered the disaster with relish: "It just ate that building alive," he said.

The Chamber was 250 feet under the Bronx.

Spiritual bath ■ "He poureth water into a bason, and began to wash the disciples' feet." Jesus' humble act, described in the Bible, inspires Christians in Knoxville, Tennessee. In cultures worldwide, water is a source of spiritual nourishment. Frequently used in rituals, it is endowed with a range of mythic and symbolic properties.

Body bath ■ "They're magic; they just remove tensions," says Mana Arletta Behan, bobbing in the highly carbonated mineral waters of New York's Saratoga Spa State Park. Mohawk Indians introduced European settlers to the waters, which rise up through layers of limestone. Thousands flock to the spa each year for bath and massage treatments.

The elevator was small and slow. At last we stepped into a concrete room more than 200 yards long. It faded off into a misty distance like a hall of mirrors, with endlessly repeated images of enormous valves. I managed to control my jaw. In all there were 34 valves, each eight feet in diameter. They are connected to the first stage of New York's third deep tunnel, which is still under construction. When it is all hooked up, it will let the city drain its other two tunnels for the first time since they were completed in 1917 and 1936. People will go inside to inspect them for damage and debris.

When Krysko told me about this, we looked at each other and grinned, both wishing to be first into that historic grotto. I thought about piles of silt and fish bones. He had a different image. "You stuff all that water through those tunnels," he said as we crossed the placid Hudson going back to my plane, "and I don't think you're going to get much sedimentation. I think you're going to shine the walls."

Suddenly I could imagine what he was seeing—a high-pressure, seething roar far below. As usual, the surface of water looked gentle, but the reality was not.

THE USES MULTIPLY. From the air the whole landscape is busy with people getting water to do what they want. In the western plains the land is strewn with polka dots—fields watered by center-pivot irrigation systems that pump water from streams and from underground. The Rockies are sliced by what look like contour lines cut into the sides of mountains—ditches that take the abundant water concentrated in the high country and shepherd its determination to get lower, moving it along foothills to headgates at the fields. On summer flights I see fields flooded with strings of bright water, and it does not surprise me that in the U. S. irrigation takes one of the largest shares of water: 137 billion gallons a day.

MICHAEL PARFIT is the author of *Chasing the Glory*, a story of the people and places he encountered when flying his Cessna across the United States. His NATIONAL GEOGRAPHIC articles include "The Hard Ride of Route 93" (December 1992) and "Reclaiming a Lost Antarctic Base" (March 1993). The work of photographer PETER ESSICK has illustrated NATIONAL GEOGRAPHIC stories on topics ranging from model airplanes and corn to Botswana and the Bolshevik Revolution.

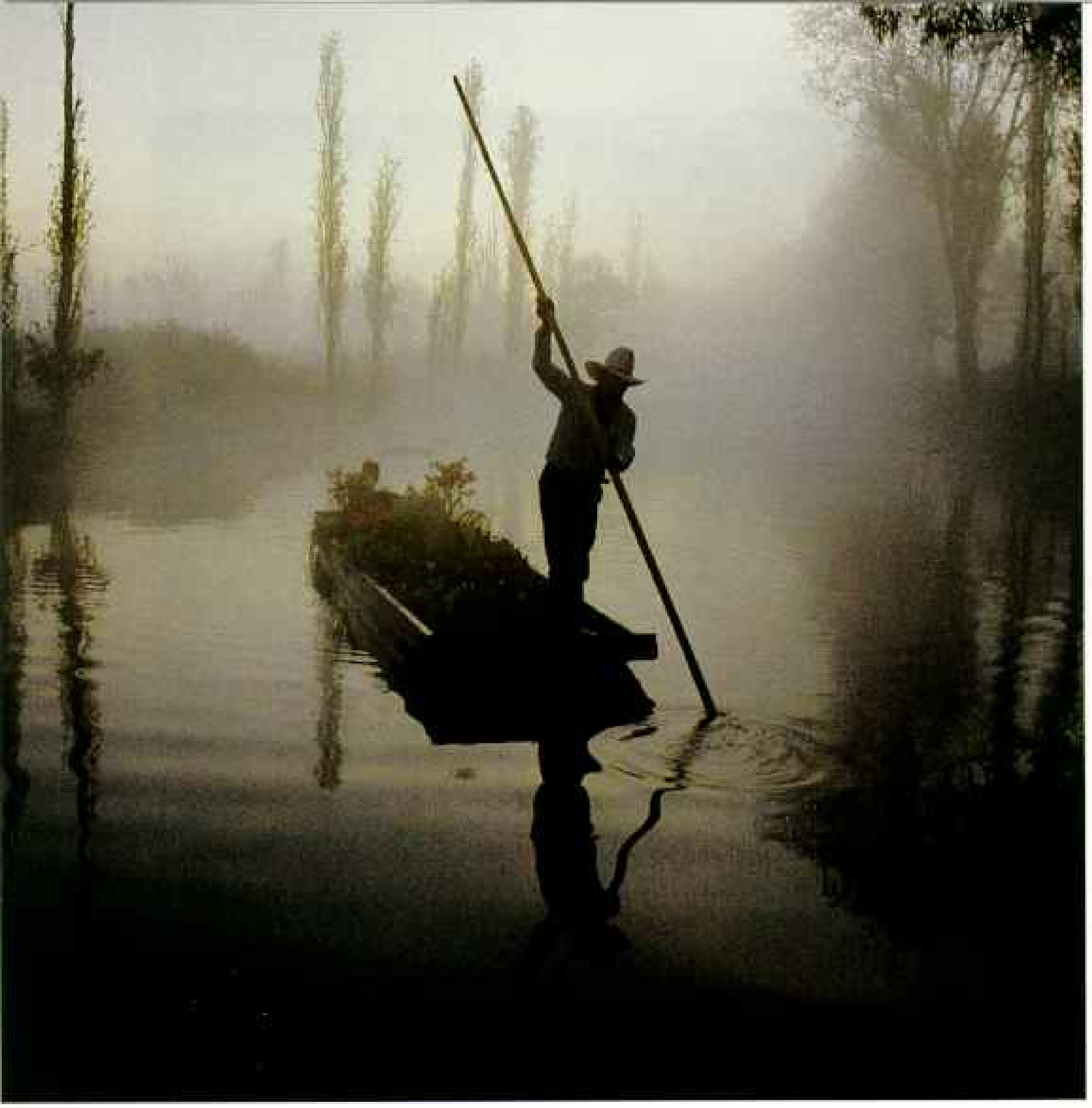
The land rumbles and steams with the uses of water. I cross dam after dam, pools pent up behind concrete that looks like eggshell, with a churn below each set of turbines—water, wrung out of power, heading downstream for the next stop. In the U. S. more than three trillion gallons of water—nearly eight times the average flow at the mouth of the Mississippi—goes through turbines every day to provide roughly 10 percent of the nation's electricity. But power plants that use coal, oil, natural gas, or uranium also need water for steam and cooling, and they take 131 billion gallons a day—more than five times as much fresh water as people use in their homes.

On bright fall days I can navigate by the many plumes of vapor from the power plants and from the factories that pump another 25 billion gallons a day from the system. Some days when the air is damp and the plumes lean together in the wind, it looks as if they're steam engines, thundering along side by side, driving the single rolling wheel of the earth.

ACTION! Water moves. If you have something you don't want, water will take it away. "The trouble with throwing your garbage on land is that it just stays there," a hydrologist told me wryly. So water receives a large dose of just about everything that floats, dissolves, or goes into suspension. But at the same time the movement of water, its beauty, its support of life—fish, for instance—also make it perhaps the single most significant recreational resource on earth. Most lakes I fly over are encrusted with vacation homes like something crystallized out of water, and when I cross almost any body of water on a weekend, I see a surface all stirred up by colliding wakes.

The whole system looks like that. Drinking water, power, agriculture, industry, waste, recreation: Inevitably, there's conflict. On the Columbia River, a proposal to provide enough water to help restore salmon runs may take it away from irrigation and turbines. In Kentucky, a new power project that will use water in order to control air pollution raised fears that it would reduce water for homes. In South Dakota, a project to move coal by water is challenged by downstream states and ends up expiring—guess where? In court. At this point water intersects with a different system, one even more complicated and far less natural: the law.

Water law differs from state to state and country to country. In the United States, laws tend to follow either riparian doctrine, which allows all those who own land along a natural stream to use water on that land, or the principle of prior appropriation, which lets you take water anywhere if you were first in line to get it. The latter is described by the phrase "first in time, first in right." Riparian law dominates east of the Mississippi, and prior appropriation is law to most of the West. These doctrines have been highly modified over the years, in some instances being almost entirely replaced by arrangements in which governments issue permits. The actual effect of these laws is hideously complicated by the fact that rivers run

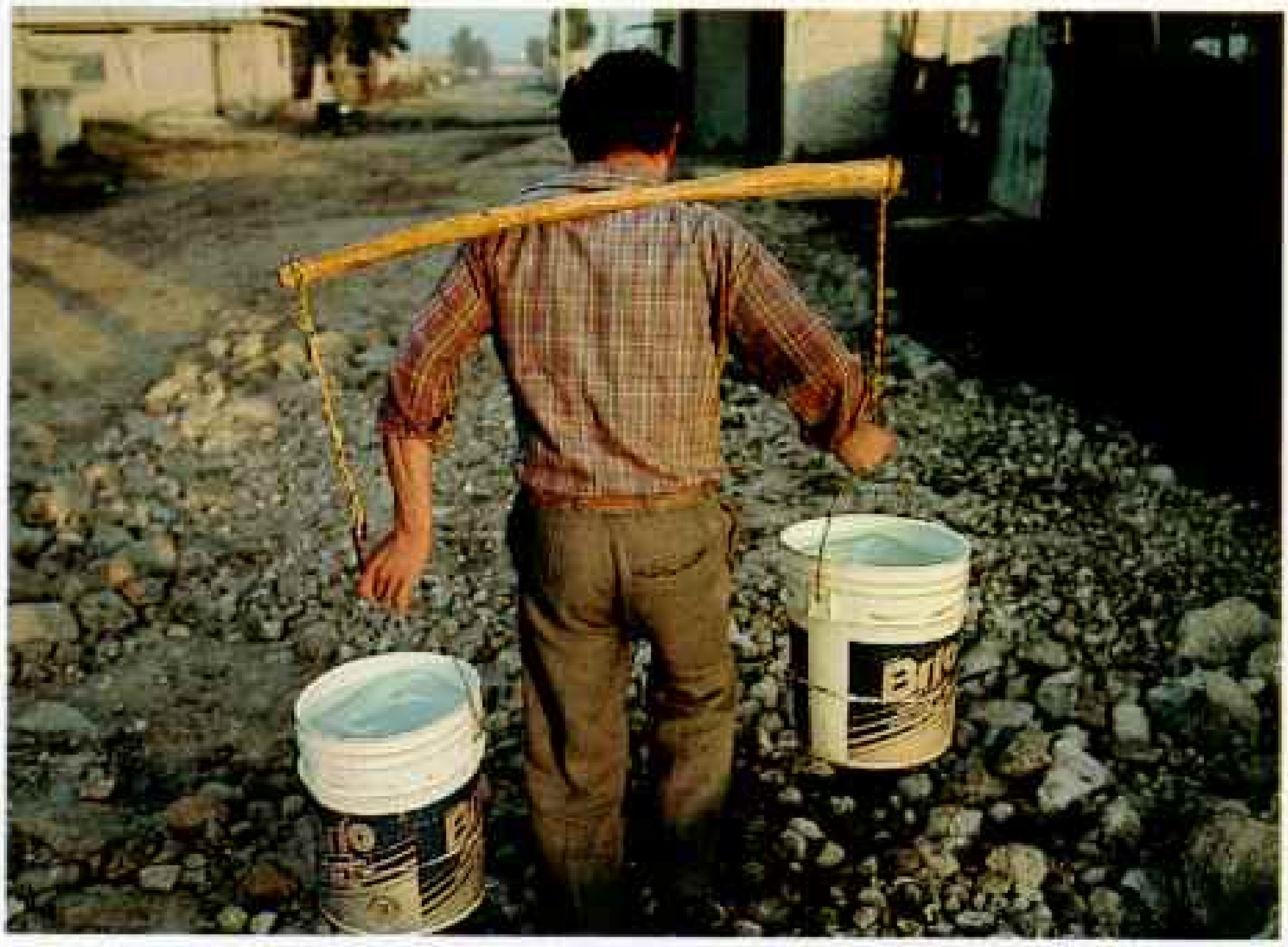


Threatened legacy ■ In a megalopolis of 15 million people, a Mexico City farmer poles a boatload of produce grown on the floating gardens of Xochimilco. Falling water levels threaten cultivation of the islands, or *chinampas*, which once sustained the Aztec. The cause: overpumping of groundwater, a problem throughout Mexico's capital.

from state to state and country to country, that laws relating to water quantity are often written and administered by different agencies from those that cover water quality, and that laws affecting surface water frequently differ from those that affect groundwater.

"Water laws in the United States are fractionalized," says William Goldfarb, professor of environmental law at Rutgers University and author of the book *Water Law*. "Fractionalized and disorganized, and anything but comprehensive."

These laws lead to some complicated allocation schemes—Las Vegas, for instance, has discussed buying water from a desalination plant in Santa Barbara, California, to trade to Los Angeles for rights to Colorado River water. And there are also legal questions about how to use water in place—such as how many rafts the National Park Service can allow a day in the Grand Canyon in order to prevent overcrowding. But nowhere is the almost unworkable complexity of water law more evident than in and around San Antonio, Texas.



Challenge of delivery ■ On the surface and below, two giant cities wrestle with distribution problems. New York City workers blast a shaft through bedrock for a five-billion-dollar tunnel built to increase capacity and relieve two older tunnels. Squatters outside Mexico City fill buckets at a public tap; the government is spending a billion dollars to modernize the capital's crumbling system, strained by 2,000 newcomers a week.

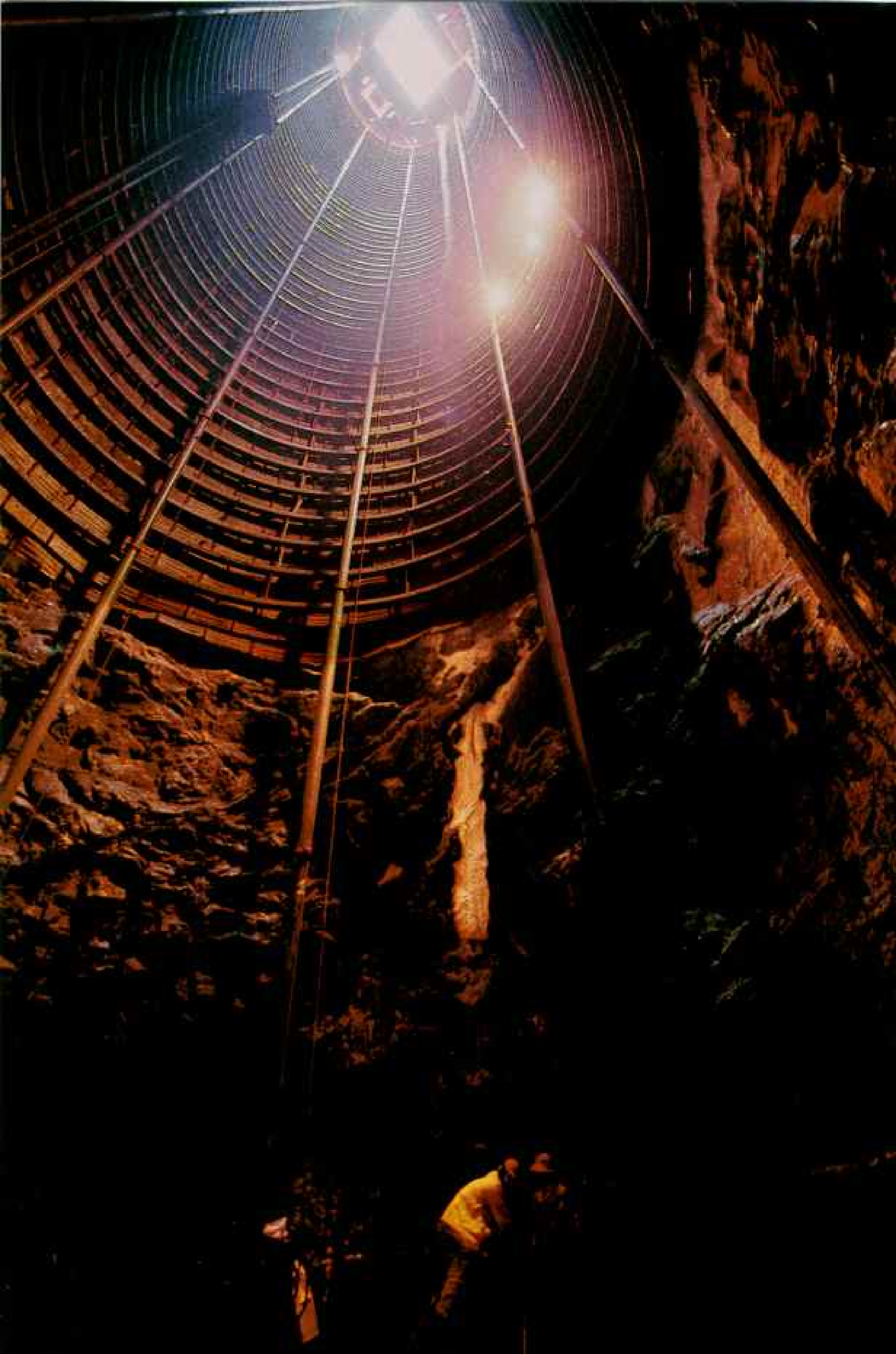
"YES YOU CAN HAVE MY WATER," says a sign on the wall of Maurice Rimkus's home 70 miles west of San Antonio. "Just like you can have my gun. . . . When you 'pry' it out of my dead hands." His house and farm stand on top of an unusual reservoir of groundwater, the Edwards aquifer, which is subject to enough legal disputes to flood Texas with depositions.

The Edwards is not like most aquifers, which are made of sand and gravel through which water moves slowly. It is a karst aquifer, which means the water flows through highly permeable limestone, sometimes in caverns as big as the Chamber at Site 2B. The aquifer is like a huge tilted Swiss cheese that fills from its northwestern side and spills water out of springs to the southeast. Because water moves through it so easily, how much you get depends mainly on the size of your pump.

The demands on the aquifer mirror the pressures on water everywhere. Rimkus and his fellow farmers want to irrigate with it. San Antonio wants it for industry, commerce, and domestic supply for its one million people. The springs drain into the Guadalupe River and provide water for both agriculture and industry downstream. And, as if this weren't complicated enough, several endangered plant and animal species depend on the springs and may die if they dry up.

The state of Texas controls surface waters with laws based on prior appropriation and permits. But, adhering to principles outlined by an Ohio judge who wrote in 1861 that groundwater movement was "secret" and "occult" and could not be administered, Texas law—with few restrictions—lets you take as much groundwater as you can use from below your land.

This suits Rimkus, who irrigates about 1,500 acres of corn and cotton with Edwards water. It also suits water entrepreneur Ron Pucek, who, thoroughly confounding the issue, recently drilled a hole in the aquifer in its southern edge, where it is under pressure, and



Scraped flat ■ A laser beam guides blades leveling a cotton field outside Phoenix, Arizona. Ordered by the state to reduce groundwater use, area farmers shed wasteful irrigation habits; by reducing runoff, laser leveling can cut water use by a third. Even so, growers find the high cost of the procedure difficult to bear in a time of low cotton prices.

hit a water gusher. Talk about *action!* When the well is uncapped, it shoots up a massive, 40-foot fountain—enough water to supply the entire city of Amarillo. Pucek used this flood to raise catfish—until he was taken to court.

If groundwater were really occult and came from the places people used to think it did, like the mysterious bottom of Crater Lake, nobody would mind if you raised catfish in it in Texas. But the hydrology of the Edwards aquifer is relatively well-known. An average of 640,000 acre-feet a year goes into it, and at present about the same amount leaves the aquifer from wells and at the springs. The problem is that San Antonio wants to ensure its future supplies, and the Endangered Species Act requires flowing springs, and neither may be possible if irrigators have the right to pump veins at will on one side of the aquifer and catfish farmers can open arteries on the other.

The whole thing wound up in court—in several courts. San Antonio water agencies sued Pucek, saying his gusher was irresponsible waste. The Sierra Club sued the Secretary of the Interior, demanding a plan to protect the endangered species. In the boldest move of all, the Texas Water Commission announced in April 1992 that the Edwards was not occult groundwater at all; it was a river that happened to flow underground and was thus subject to state regulation. But that idea was quickly thrown out by a state district court. Then, as one official put it, "using the Endangered Species Act as the hammer and the Texas Legislature as the anvil," a management plan was forged and passed into law this year. But it does not seem likely, when all the dust settles, that water law will be any less fractionalized or any more comprehensive—or comprehensible.

WHILE WATER USE in Mexico and Canada is still increasing, the total amount of water pumped out of rivers or the ground in the U. S. dropped about 10 percent between 1980 and 1985 and has only increased slightly since then. Irrigation has declined 13 billion gallons from an all-time peak of 150 billion gallons a day in 1980. This sounds as if it ought to mean more abundant water. It doesn't. It means that water is getting harder to come by. The lower irrigation use is caused in part by a decline in

agriculture and declining water levels in several major aquifers, like the Ogallala in the Midwest.* These trends have contributed to a secondary development—farmers selling their water rights to cities.

Laws and regulations have recently been passed to protect streams and the life in them. This legal right to instream flow—the right of water to stay in its own bed—is designed to support fisheries, endangered species, recreation, or, in some cases, even beauty.

Faced with such restrictions on new water supplies and increased costs, cities are turning to conservation, which is now considered one of the most economical ways of meeting increased demand. Even New York City and Seattle, both in notably wet parts of the continent, have become more aggressive lately in pushing conservation. But a model of what is to come is Tucson, Arizona.

"LOOK AT THIS!" said Richard Verduzco, sternly. "He's overwatering!"

I was shocked. Right next to a lawn, there was a small shine in the street. Twenty or thirty gallons had got away.

"See how saturated this is," Verduzco said, poking at the soggy lawn. "A little area like this does not need that much water."

Verduzco is a firm but cheerful man, kind to offenders but no soft touch. He is the Tucson water cop, and we had been out for several hours giving people warnings and tickets for water waste.

At first it had been hard for me even to see where sprinklers had leaked onto the sidewalk or where someone had hosed down a driveway, but now those things were like blood on the pavement: the stain of crime.

Tucson, faced with limited new supplies, has taken several steps to encourage conservation. Since 1989 it has required low-flow equipment and water-saving toilets in new construction; it sponsors educational programs; it runs a campaign to get people to cut back on summer water use—and hires a water cop to enforce water-waste regulations that provide for fines up to a thousand dollars.

All this action has paid off. Among major southwestern cities, Tucson has one of the lowest per capita domestic water-use figures—104 gallons per person per day. It has also produced

*See "Wellspring of the High Plains," by Erla Zwingle, NATIONAL GEOGRAPHIC, March 1993.

Liquid evidence ■ "They were watering their driveway and the sidewalk," says Tucson water cop Richard Verduzco, checking a misguided nozzle. Water wasters face fines as high as a thousand dollars in this desert city. Conservation campaigns, low-flow plumbing ordinances, and high water rates have helped turn most Tucsonans into avid savers.

From dishwater to lake water ■ Faced with shrinking groundwater supplies, a community in Glendale, Arizona, pumps treated wastewater into its artificial lakes. At Arrowhead Ranch and throughout this city, leaders look to effluent to help meet nondrinking

water needs, decreasing dependence on groundwater. Repugnant to some, the practice finds growing acceptance in central Arizona's arid cities: "Most people that move here don't even think about it," says Mayor Elaine Scruggs, an Arrowhead resident.

Water lessons ■ Groundwater overdrafts in Arizona cause hundreds of fissures like this one outside Tucson; in 1980 the state began to regulate groundwater withdrawals. Workers shut an artesian well tapped into the Edwards aquifer in south-central Texas, where a new plan manages competing demands for its waters. Learning to share existing sources—not simply searching for new ones—is crucial for ensuring future supplies.

people who give anonymous tips about their neighbors' wet and evil ways.

"We wouldn't have known about this if a concerned citizen hadn't called," Verduzco said as he wrote out a warning. "The next time, he'll get a fine." He grinned. "No more Mr. Nice Guy."

FROM TUCSON it is not far by water to Los Angeles. The future may be conservation, but the past and present are full of aqueducts—the western tradition is to get water somewhere else. I flew to California via the water freeway: up the Central Arizona Project aqueduct to Lake Havasu.* I turned west where three big pipes emerge from the lake and followed the narrow blue thread of the aqueduct across the desert. Where it ended, cities sprawled before me, far too big a crop of concrete to be watered by such a thin stream.

California is the epitome of both the craziness and the grandeur of water use and allocation. From Los Angeles I flew half the length of the state, as freeways and aqueducts multiplied below. I landed in the town of Willows, a hundred miles north of Sacramento, and met writer Richard Conniff at an airport café. In the café was a sign: "No water, no jobs." This was the place for us.

Dick Conniff was another member of the NATIONAL GEOGRAPHIC water team, a bearded, intense, persistent reporter and writer. He had just returned from a dawn vigil in a rice-field duck blind.

While I had been dashing around North America in a plane, he had been busy on the ground in California, going from desalination plants to wildlife refuges to aqueducts to corporate office buildings; wading through swamps, mud, and environmental-impact statements, learning how California has taken its dramatic water imbalance and tried to level it out. Clarence Alexander would be pleased. It's a story full of *action!* □

*See "The Colorado: A River Drained Dry," by Jim Carrier, GEOGRAPHIC, June 1991.

CASE STUDY

California: Desert in Disguise

BY RICHARD CONNIFF
PHOTOGRAPHS BY RICK RICKMAN

■ Oasis Green was the color of choice when landscaper Les Robin painted this parched lawn in Santa Barbara during the state's six-year drought. Using a biodegradable dye, he supplies a touch-up kit "for those embarrassing roots."

The drought ended in 1993. But the ordeal forced Californians to confront painful questions about water allocation—especially those two-thirds of the state's 31 million people who choose to live in the dry but booming south.

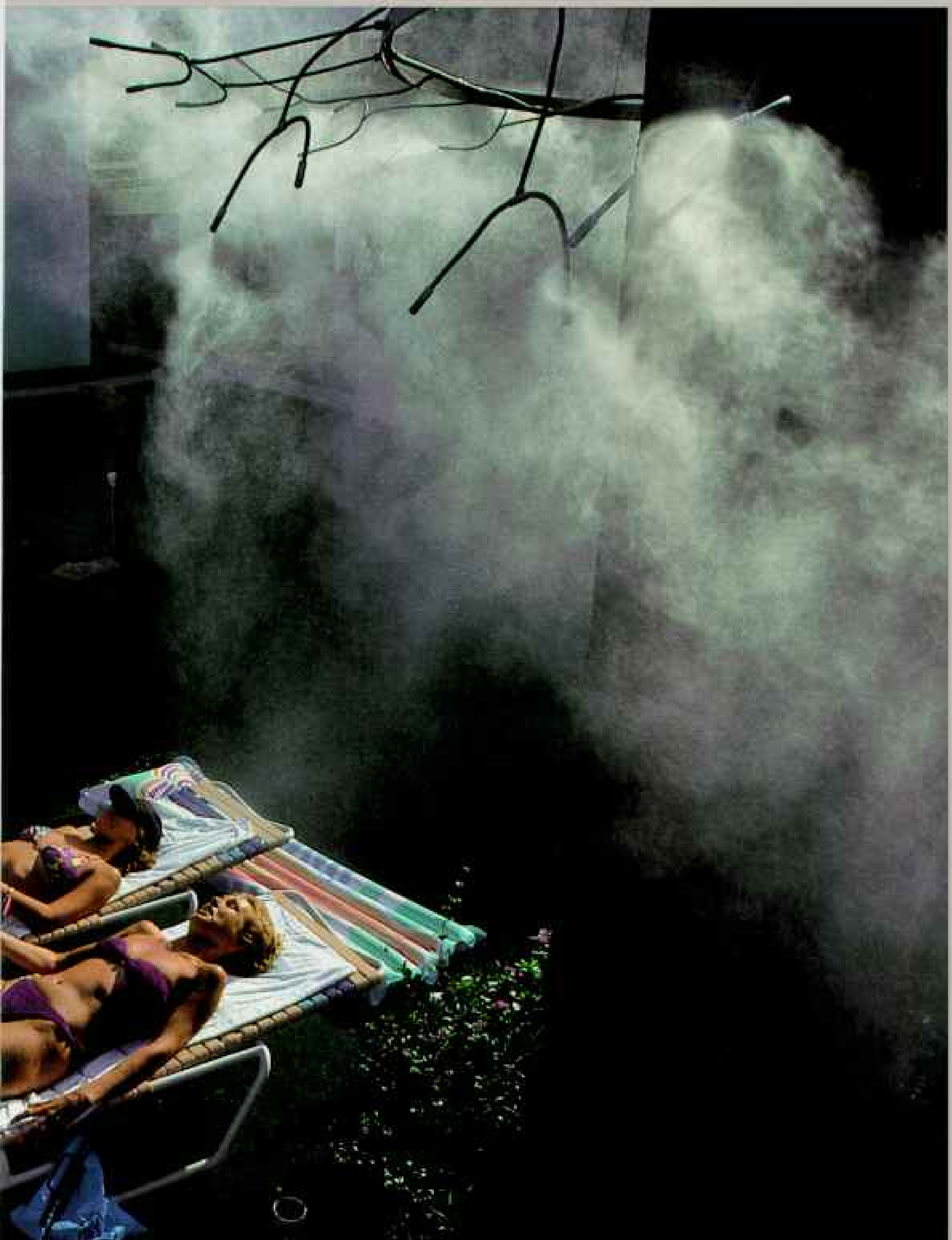
IT WAS AN AUTUMN MORNING before dawn, under a plum black sky, and I was out slogging shin deep through a flooded rice field, the popular symbol of everything wrong with the way California uses its water. The fields were unruly with the cheeping of pintail ducks and the *yack-yack-yacking* of mallards. As we passed, the birds seethed up off the water with a sound like waves breaking.

I was here in the Sacramento Valley to consider the Nature Conservancy's unorthodox proposition that growing rice in California might not be such a dumb idea after all. Once maligned by environmentalists as "a monsoon crop in a desert," the rice grows in a golf-course-green swath below the dry, golden foothills of the Sierra Nevada. Over the course of a season irrigators inundate as much as 700 square miles of this land to a cumulative depth of four to seven feet an acre.

That's enough water to make urbanites splutter about the monumental illogic of California water allocation, especially when the recent drought was reducing them to desperate measures like sprinkling houseplants with toothbrush rinse water. Agriculture takes 80 percent of the state's water deliveries, gets much of it far below cost, and often uses it for taxpayer-subsidized crops like rice. Critics say farmers are sending precious natural resources down the drain with the water. The field in which I was wading was supplied partly by an irrigation diversion with a defective fish screen known to kill up to a thousand threatened salmon a day. So why were the Nature Conservancy and other environmental groups joining rice farmers in a program that makes the cultivation of an aquatic crop here sound good?

RICHARD CONNIFF frequently covers natural history and environmental subjects and is a regular contributor to NATIONAL GEOGRAPHIC. RICK RICKMAN, a resident of California, won a Pulitzer Prize in 1985 when he worked for the *Orange County Register*.

■ Basting to perfection under a cooling spray from one of Palm Springs' ubiquitous misters, vacationers roast in the desert sun. Epitome of the contrary desires for nonstop sunshine and abundant water, Palm Springs occupies the heart of a sprawling man-made



oasis in the middle of a bone-dry desert. Billions of gallons of water from a local aquifer nurture this paradise of golf courses, parks, swimming pools, and artificial lakes. Even during drought, the Palm Springs experience suffers little wilt.

Supply

■ On average, California receives 193 million acre-feet (about 24 inches) of rain and snow a year. One of hundreds in the state, the great Central Valley aquifer holds 250 million acre-feet of accessible water.

PRECIPITATION

Three-fourths of California's rain and snow falls in the sparsely populated north. Snowpack depth in the High Sierra provides an accurate gauge of spring and summer water supplies.

Delivery

■ More than half the annual runoff, or 43 million acre-feet, is captured by 1,300 reservoirs—then delivered in a gargantuan network of canals, aqueducts, and pipelines.

Use

■ Agriculture takes 80 percent of captured runoff, leaving domestic, industrial, and environmental needs to vie for the remainder. For the Central Valley Project a new law mandates that environmental requirements be satisfied first.

The sun cut an opalescent wedge across the eastern horizon, and I had a momentary sensation that the credits were about to roll on another episode in the strange soap opera of California water politics: An unending saga in which bitter enemies pair off in unlikely alliances, ancient allies betray one another in public, and everyone is tied together not by sex but by the more primal force of plumbing.

The motive for the program was a law having nothing to do with water: The state had simply restricted the old practice of burning rice stubble off the fields after harvest. The farmers needed a new way to get rid of the stubble, and environmentalists wanted them to flood their fields each fall and let it rot, creating a huge new seasonal wetland for migrating waterfowl.

Even salmon fishermen from the coast, who were being put out of business in part by the faulty irrigation diversion, liked the idea. Fix the fish screen, they suggested, then time the release of the water to assist the out-migration of salmon in March and maybe rice could start saving fish instead of killing them.

With the sun up, I walked down a levee between a dry field and a flooded one, and on the wet side the birds swarmed thick as insects. Two fields away a huge flock of snow geese burst into the air, billowing like a white sheet against the clouds. It already looked like a win-win situation—possibly the only one in the I-win-you-eat-my-dust fight over California's limited supply of water.

Because of dramatic reforms in federal water law and the residual pressures of the longest drought in recent history—now officially ended after six years—California is sorting out who will get a bigger chunk of the state's water and who will scrape by with less. Agriculture, once the unquestioned king, is learning, in the rice fields and elsewhere, to accommodate its urban and environmental rivals for water. The change will affect the fate of the world's richest food-production area and determine whether California can continue its extraordinary population growth. (Already home to 31 million people, the state gains about 500,000 more, the equivalent of a new Denver, every year.) The politics of water will decide whose vision of the California dream—agricultural or urban or environmental—is going to prevail. Ultimately, water will determine whether the dream itself comes crashing down in dust.

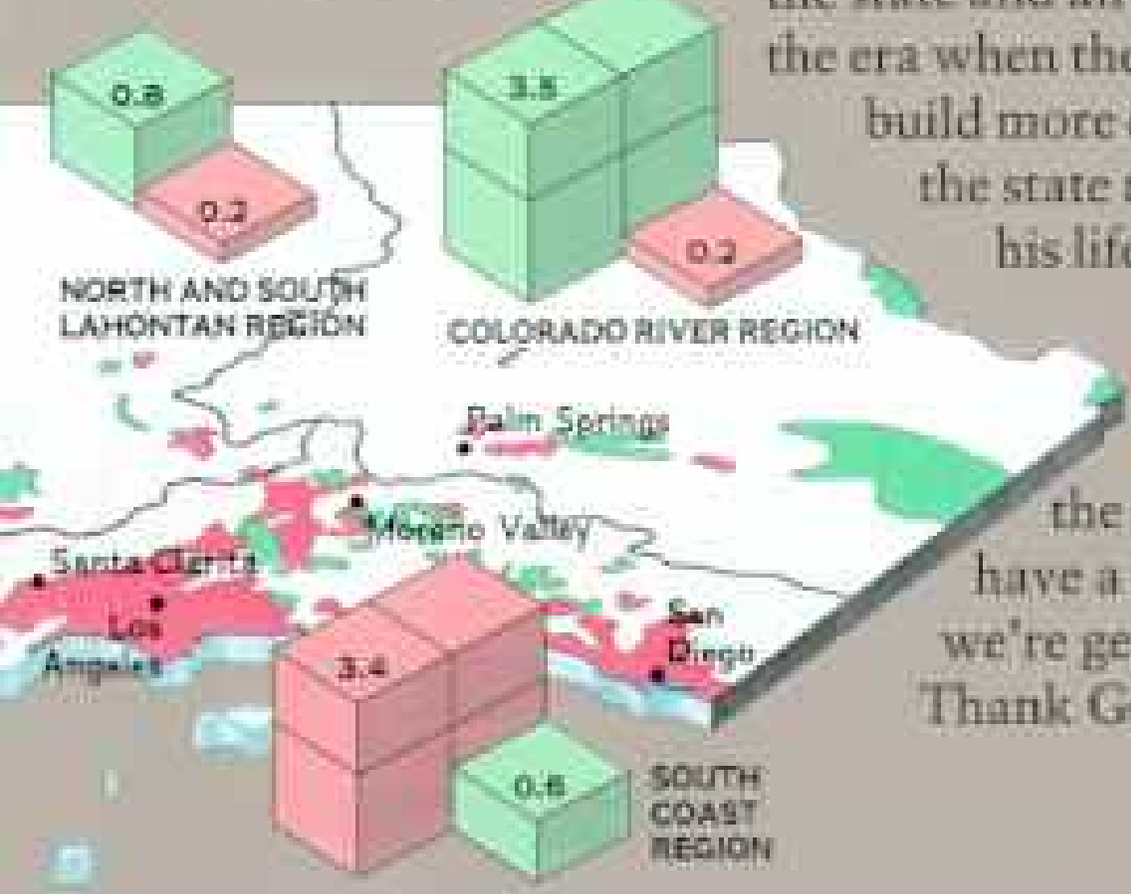
At the nation's tallest dam, near the northern California town of Oroville, I met with Chuck Von Berg, an engineering technician for the state and an unreconstructed "water buffalo"—a proud veteran of the era when the only solution to California's water problems was to build more dams. That was still Von Berg's answer; a few rivers in the state remain untapped. He had a peevish air of having seen his life's work, and all common sense, rejected by an ungrateful and environmentally oversensitive public.

"Ask the average person where their water comes from," he remarked, "and they will not have the faintest idea: 'It comes from the tap.' They think they have a water tooth fairy watching over them. Right now we're getting along because of facilities built decades ago. Thank God we had the people with vision to look forward."

NATURAL RUNOFF
After evaporation, aquifer replenishment, and vegetation usage, 70 million acre-feet runs off into streams and rivers.

WATER PROJECTS
Begun in the 1930s, the federally managed Central Valley Project is the nation's largest irrigation system. Southern California's 20 million people are supplied by the State Water Project, the Los Angeles Aqueduct, and out-of-state water from the Colorado River.

FARM VS. CITY
Only in the San Francisco Bay and south coastal areas does urban use exceed agricultural. In 1990, a year of drought, some 33 million acre-feet of water was used, with groundwater supplying 40 percent.



■ **Turned to pasture, Coyote Lake south of San Jose was one of many minor reservoirs that had run dry by 1991. Though the rains returned in 1992, officials waited for major reservoirs to refill before proclaiming the drought over.**

Built to help spawning salmon on the American River, the fish ladder at Nimbus Dam lofts a lonely sojourner in the once crowded fall run. During the drought streams often needed replenishing by reservoirs so that migrating fish could survive.

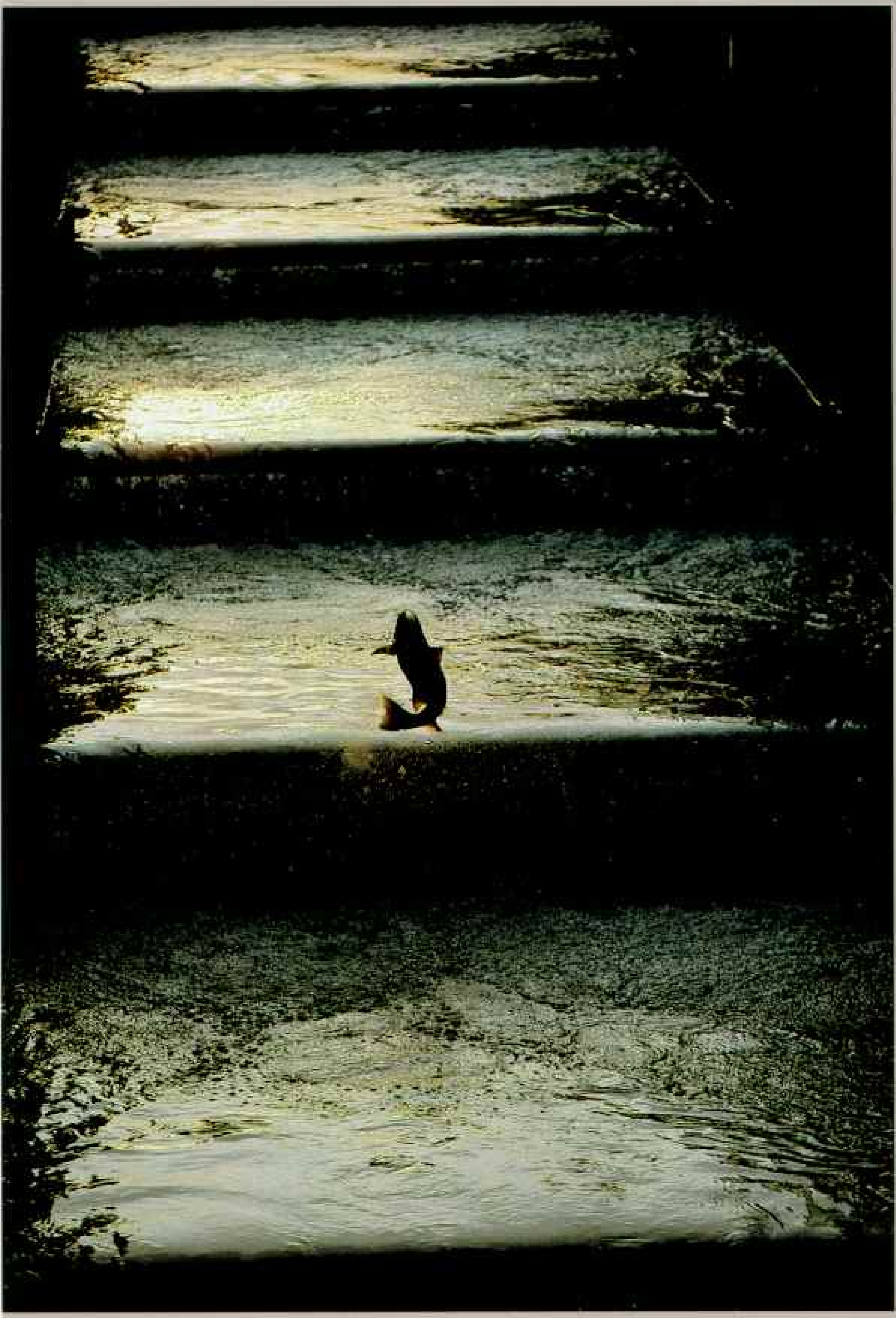
Even environmentalists admit to awe at what past water buffaloes wrought. Both the federal government's Central Valley Project, begun in the 1930s, and the State Water Project of the 1960s addressed the same key problem: Most of California's water comes from the mountains north of Sacramento, in winter and spring. But most of the urban and agricultural thirst is in the arid south, in summer and fall. This mismatch has traditionally set the thinly populated northern third of the state against the south, with the north typically yielding to the cardinal law of California water politics, which is "water flows uphill to money."

Boundless engineering genius and billions of tax dollars fixed the water mismatch—and did it with a speed and a mid-century American faith in technology that now seem almost foreign. Ambitious dams turned river canyons into reservoirs, million-gallon-a-minute ball valves opened, and water went zigzagging down trough-like concrete aqueducts—even *up* aqueducts and over mountains—to the south. The combined projects stand as the greatest system for controlling and transporting water the world has ever known. Their potential for causing havoc in the natural systems they supplanted became apparent only with time.

The two water projects occupy the Central Valley, a great tublike basin running more than half the length of the state. They parallel each other and often overlap. Green orchards and row crops fan out across the valley floor from side channels, regular as wallpaper.

The Sacramento Delta, at roughly mid-valley, is the heart of the system and also the weak point. It's a huge inland estuary where the Sacramento River from the north and the San Joaquin River from the south come together and then empty into San Francisco Bay. Pumps at the southern end of the delta suck up much of the water and send it south. It takes as much as two weeks to release the water from northern reservoirs into the Sacramento River, pull it down through the delta, and pump it to the customer hundreds of miles to the south. The reservoirs must also release water to meet quality and flow standards—at minimum, to maintain enough seaward flow through the delta to hold back the salt water, which might otherwise rush up as far as the pump intakes.

But it's more complicated than that. For instance, toxic wastes leaking from a derelict mine turn a stretch of the upper Sacramento River milky green. Diluting the flow to make it safe for fish and for downstream users took 95,000 acre-feet of reservoir water last year.



(An acre-foot is the amount of water needed to flood one acre one foot deep, or about 326,000 gallons.) The reservoirs also had to release cold water to keep the river at the optimal temperature for salmon. Whether you call such demands for water an environmental "taking" from agriculture or the aftereffects of an agricultural taking from the environment, the point is this: The rivalry starts at the reservoir itself.

Out in the delta one morning a University of California, Davis, fisheries biologist named Peter Moyle knelt on the rolling deck of a research boat, picking delta smelt from a net. For water interests, particularly farmers, Moyle is a nightmare. Early this year he won threatened species status for the smelt. Moyle has a salt-and-pepper mustache, thick bifocals with clunky two-tone frames, and an ironic academic manner. The smelts he was laying out on a plastic measuring tablet were translucent slivers, of no known economic value.

"Here's this tiny little fish, and it only occurs in the one place California gets half its water," Moyle said. "The way people should look at it is that the smelt is an indicator of the general health of the delta. There is literally not a species out here that's had an established population in the past that isn't in decline."

In truth, Moyle said, the problems go well beyond the delta. All over the state, farmers (and some cities) are pumping water out of the ground faster than the aquifers can replenish themselves. Groundwater withdrawals are still largely unmetered and unregulated in California. The common thinking among farmers is that everybody has his straw in the same can of soda—and if you don't sip it, somebody else will. But as they sip, the soda can is getting squished flatter: Emptied of water, the structures of the aquifer collapse, and the damaged aquifer can never again hold as much liquid as it used to.

The Central Valley alone has lost nearly 20 million acre-feet of natural underground storage because of aquifer compaction. "No wonder I can't get any damned water out of my well," one farmer told me. To put this number in perspective, the entire capacity created by all the man-made dams and reservoirs in the state is just 43 million acre-feet. In other words, California has permanently lost half the water storage that engineering genius and taxpayer dollars added. And it continues to pump water as if its aquifers will last forever.

Out on the research boat, the winch kicked to life with a *whudda-whudda-whudda*, and the trawling net cables came reeling in with about enough smelt to fill a teapot. "We stand a good chance of losing the delta smelt, and then losing the farmland anyway," Moyle said. "Why not just bite the bullet now?"

UNTIL RECENTLY the state leader in bullet biting was the Santa Barbara area, a rich slice of southern California coast sloping up to the green line of the mountains. Residents hewed to the antediluvian idea that they should live within the area's natural water resources, and, in effect, use the water supply to limit growth. It worked too, for a time, until local reservoirs nearly dried up in the drought, and conservation began to feel suspiciously like deprivation.

Up in the Santa Barbara hills one morning, a city water inspector named Lillia Espino bent over a hole in the ground and directed her flashlight at a water meter. Then she headed up to the house to shut

■ In the foothills of the Tehachapi Mountains workers inspect the penstocks in a great pumping ladder that carries northern water south across a 3,000-foot-high ridge. One of the engineering marvels of the century, the California Aqueduct will this year deliver some three million acre-feet of water

from one end of the state to the other. It is part of the 600-mile State Water Project, which is fed by a network of rivers and artificial lakes. Running south from the tributaries of Mono Lake, the older Los Angeles Aqueduct satisfies about 40 percent of the water needs for its namesake city.

off some water valves and bustled back, over and over, to see if the adjustments stopped a persistent flow of unknown origin.

The culprit in this case was a leaky toilet. The customer who had requested a water audit sat on her stoop with a baby on her shoulder and a sheaf of water bills in one hand. Espino told her that the toilet alone might be wasting 8,000 gallons a month and costing her $80. The conversation turned enthusiastically to California small talk of flapper valves and air-pressurized ultra-low-flow toilets.

The point of the audits, Espino said afterward, is to show people that they can save water and still lead normal lives—an idea that was often lost in Santa Barbara during the drought. Under mandatory water rationing, expensive plantings died, and tree roots seeking water blocked sewer lines. People had their lawns spray-painted to maintain the precious illusion of green. They turned in their gutter-flooding neighbors to water cops like Espino. Parents bathed the children en masse, then hauled the water out to the yard.

But bucket bravado eventually gave way to despair. Because usage dropped so dramatically in many places, each gallon had to bear a much larger share of fixed costs, and ardent conservationists often found that all their efforts earned them higher water bills. The

drought cracked local resistance to outside water supplies. Abandoning the use of water to control growth, area voters opted to build a seawater desalination plant and to hook into the State Water Project.

Santa Barbara and other California communities are now also banking heavily on reuse of what used to be called sewage. (New terms like "waste stream" and even "this vital resource" make the idea literally easier to swallow.) Municipal treatment plants have begun selling highly treated effluent to irrigate golf courses, grow tomatoes, and operate industrial cooling towers.

"San Francisco has wastewater we would kill for," William R. Mills remarked when I visited him at the Orange County Water District, where he is general manager. Mills is an unabashed advocate of the idea that sometime soon pioneering California communities will purify their wastewater and pump it right back out again for human consumption. He pointed out that the Santa Ana River, which used to run dry in summer, now flows year-round with the effluent from 18 upstream treatment plants. His water district captures the entire flow and filters it down through the sandy soil to replenish the aquifer.

"Every drop we put in the ground is extracted within three to five years by domestic wells and is drunk," said Mills, who takes a distinctly proprietary interest in his upstream suppliers. His district is projecting that upstream communities will continue to grow and send down even more effluent, thus providing the water to accommodate Orange County's own future growth. The county also reclaims its own effluent to meet drinking water standards. The main limitation on direct reuse is psychological, or as another reuse specialist put it: "It's going to take a lot of public education to get past the fear that what people put down the toilet is coming back through the tap."

■ Thirsty crystals, root-clinging polymers are being used by landscapers who seek to create drought-tolerant lawns and gardens. An organic compound, the water-retaining granules are tilled into topsoil to create a wet zone. Critics, however, doubt the efficacy of the polymers for water conservation and point to the need for costly lawn renovations.

THE GENERAL SCROUNGING for water in California produced one change even more unthinkable than water reuse: In 1992, after a decade of rancorous debate, business leaders, urban water agencies, and environmentalists ganged up and got Congress to break agriculture's monopoly on Central Valley Project water. The logic for CVP reform was inescapable: The population of California is growing rapidly toward 40 million people. All of them want to take showers as needed, and most would like to think there is also room in the state for ducks and fish. Since no one was prepared to build major new water projects, the only answer was to reallocate the old ones.

Under the reform law farmers lose about 20 percent of normal deliveries in order to correct environmental damage, mostly in the Sacramento Delta. They will pay tiered prices for what they get, to encourage conservation. The law also opens up the agricultural mother lode to urbanites through water marketing, an idea long advocated by some environmentalists as an alternative to building new dams: A tomato farmer in the San Joaquin Valley will be free to sell a share of his federal water to the highest bidder, simply leaving it in the pipeline to be taken up by the buyer when it gets to Bakersfield, say, or San Diego.

Soon after CVP reform became law, I visited the Central Valley Project's largest customer, the 600,000-acre Westlands Water District, near Fresno. Big three-wheeled John Deere 9900s were rumbling like elephants through fields of cotton, spinning it up into their

baskets. Boxcar-like bricks of cotton waited in lines along the edges of the endless flat fields to be transported to the gin. It was a bleak, dehumanized landscape, and also immensely productive.

Jerry Butchert, the water-district manager, was annoyed that Westlands always wears the bad hat in the water-politics soap opera. "Environmentalists have fostered the image that we're fat cats who get subsidized water to grow subsidized crops and feed at the public trough and put out selenium-tainted water and kill ducks." The truth, as farmers see it, is that agriculture's water helps feed urbanites: Growing one day's food for one adult takes about 1,700 gallons.

The cost of CVP reform will fall not just on huge, faceless agribusiness corporations, Butchert said, but also on people like Willie Rodrigues, a Westlands farmer. "You could call us corporate," said one of the four Rodrigues sons, who had gathered around the hood of a battered pickup truck. "We're having a board meeting right now."

Rodrigues was likable and gregarious, with a black Stetson and woolly gray sideburns. He and his sons farm 4,100 acres, having moved up in the mid-80s from a smaller farm. He'd run through his life's savings to keep it going, and he calculated that the reform bill would finish him off.

"We don't know if we're going to get *any* water next year," said Bruce, the eldest son. "We should be planting now." But putting in 400 acres of tomatoes was a $400,000 decision, and no banker would approve it without guaranteed water.

Rodrigues dismissed the idea that agricultural water conservation, for which the reform law provides federal funding, would be much help. Switching from the old practice of spilling water down long open furrows to new techniques like drip irrigation, targeted precisely to the plant roots, costs from $500 to $2,000 an acre. Rodrigues said it might cut water use by just 10 percent. Inevitably, reform means some farmland will be taken out of production.

I spoke with Carl Boronkay, then head of the Metropolitan Water District, which serves 15 million southern Californians. He has been

ROBB KENDRICK

■ Flooded for spring planting, rice fields north of Sacramento yield one of California's most water intensive crops. Though criticized by some for growing a "monsoon crop in a desert," rice farmers here have won praise by flooding their fields after harvest, turning them into winter wetlands for migrating waterfowl.

a leading advocate of water marketing, on the theory that the easiest way to get farmers to idle their fields is to let them profit by selling their federal water to the cities. Rodrigues, for example, pays about $50 for an acre-foot of federal water, for which Boronkay might gladly give him $125 or more in a dry year.

The market realities don't favor farmers. Boronkay dragged out a study showing that an acre-foot of water typically yields only about $400 on the farm versus $400,000 in manufacturing. The jobs are also in the cities, and Boronkay worried that without water marketing, shortages would drive major employers out of state.

"Cities throughout the state do not need all that much water," he said. But he also said it may ultimately make more sense to keep the manufacturers in California and let some crops go elsewhere.

ALL THIS LEADS Rodrigues to invoke the specter of Owens Valley, which has haunted the California water debate for much of this century. Around 1904 the city fathers of Los Angeles began buying up Owens Valley, a farm region east of the Sierra, and shipping its water by aqueduct 233 miles south. Farms dried up, and much of the water went to develop suburbs in the San Fernando Valley north of Los Angeles, where some of the city fathers also happened to own real estate.

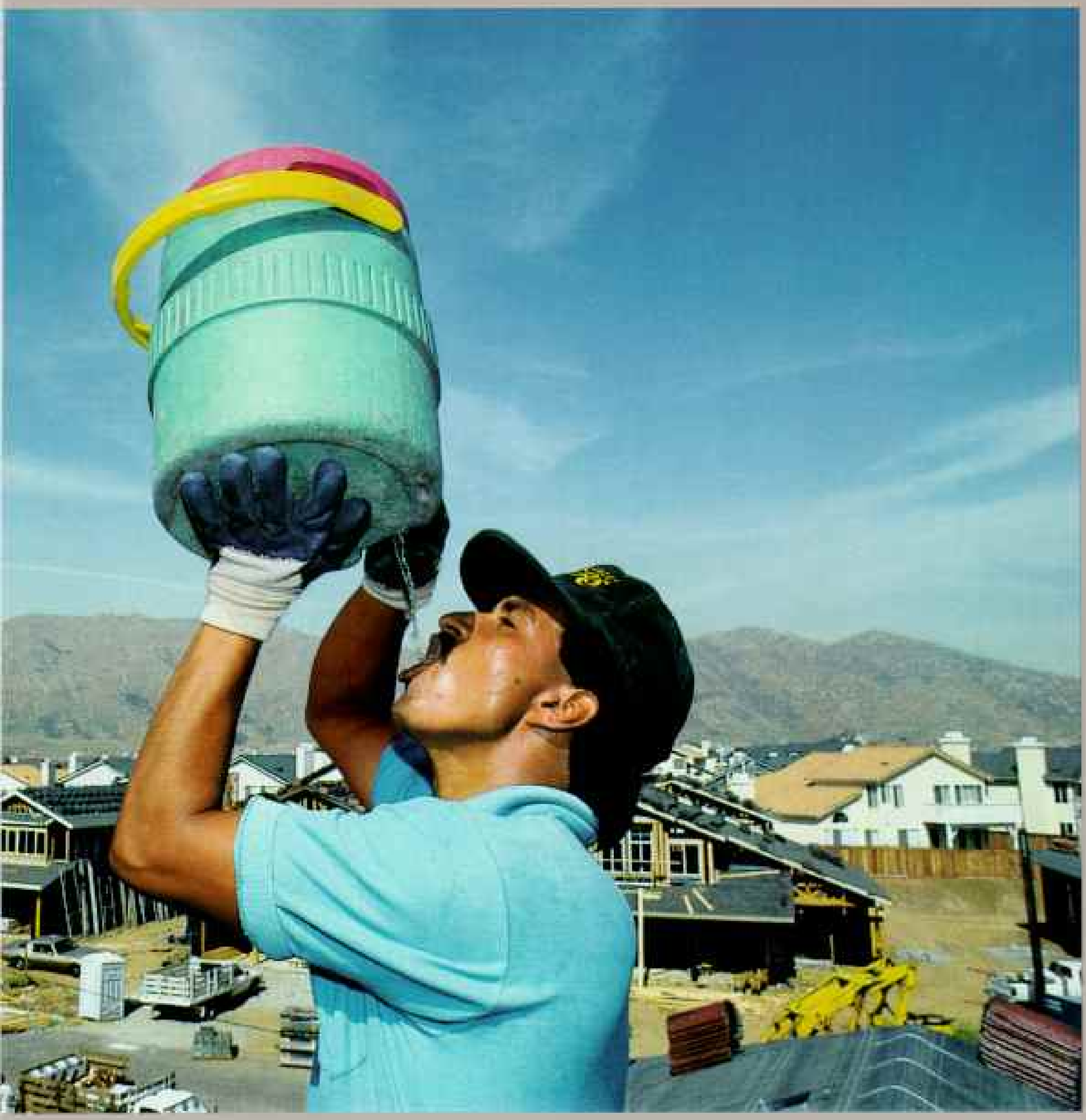
If this sounded like ancient history, Rodrigues suggested that I visit an area not far from his farm, near the western edge of Kern County. There the manager of a local water agency drove me out through dusty fields where abandoned grapevines had shriveled on their wires.

This area had been opened up to irrigation in the 1970s by the State Water Project. But local water costs during the drought soared to more than $300 an acre-foot. Because there was no groundwater to replace expensive project water, much of the land was simply going fallow. Tumbleweed rattled under the transmission. Up at a place called Point of Rocks we got out and looked all around at yellow fields where the almond trees had been cut down and stumped out. The desert, shedding its disguise, was reasserting its hold.

All that most owners wanted now, the water-agency man said, was a chance to sell their water to the cities and get out. A neighboring district called Devils Den had succeeded in selling out a few years back to the water agency for Santa Clarita, a Los Angeles suburb.

Santa Clarita, it turned out, was using the water to help make itself

■ Helping to quench the big thirst of a desert civilization for more homes, roofer Ignacio Zaragosa takes a break in the Riverside County community of Moreno Valley, which jumped from 28,100



people in 1980 to 132,000 in 1992. Southern California continues to absorb most of the state's immigrants, who contribute to a population increase of nearly half a million a year.

into the next San Fernando Valley. Clusters of pink-roofed new housing spilled over the ridgelines and huddled in the ravines. Heavy machinery was regrading the rumpled hillsides. Having doubled its population to 150,000 people, the valley was aiming to almost double it again. All it needed was water.

A city council member named Jill Klajic showed me around. She spoke passionately of water, politics, and real estate money still being tied together as closely as they ever were in Owens Valley or in *Chinatown*, the film noir about California water.

The major developer, Newhall Land and Farming Company, owns land long ranched by the Newhall family. It also owns the second largest private water company in the city. Klajic told me it uses its clout to influence the area's public water agency. The agency in turn makes sure that there will be water for Newhall's latest development.

For instance, Klajic said, Devils Den would help provide the water for a proposed 1,800-unit project with a golf course on a site designated as a "significant ecological area."

When I talked to the water-agency manager afterward, he replied that it was his job to provide water for *any* development authorized in the city or county plan. Like almost every other water manager in the state, he viewed regulation of growth as an issue for planning and zoning boards, not water agencies. But Klajic argued that the water

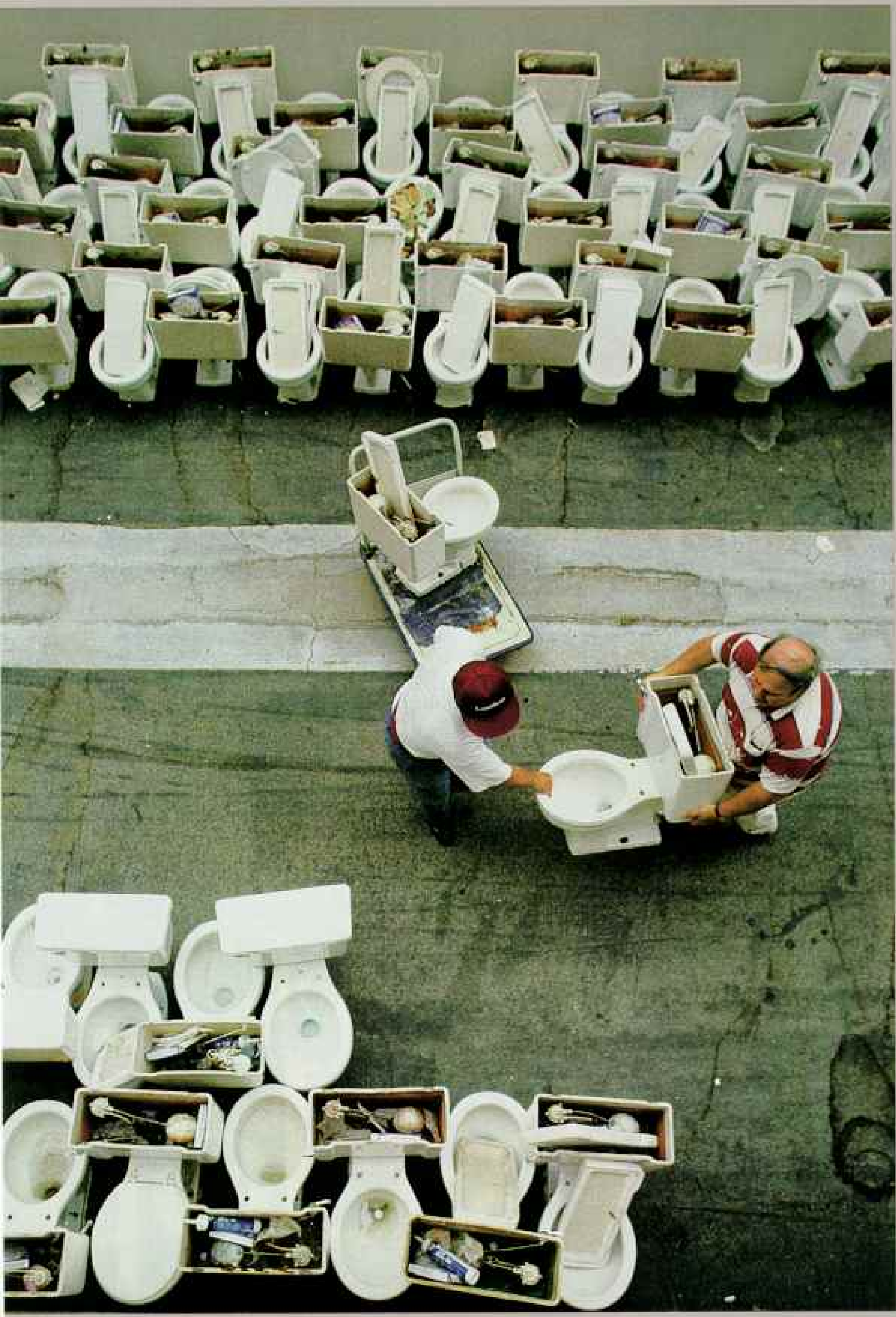
■ A new water ethic emerged during the long drought. In Santa Barbara a yard landscaped with carefully selected plants uses less than half the water of a neighboring lawn. Traditional toilets (opposite) each fetched owners in the L.A. area a hundred dollars under a widespread toilet rebate program. Using only 1.6 gallons a flush, new models will save the state millions of gallons of its most important resource.

agency had an unnatural zeal for growth, a zeal that water marketing would only encourage.

Our tour wound up at a place called Bouquet Creek, where another Newhall project was under construction. In the fall of 1990, lacking proper permits and thus flouting state and federal law, Newhall crews worked night and day to turn the creek bottom into a concrete channel, rendering a floodplain suitable for development.

Rain pelted down as we sat there, the area's first precipitation in six months. On roads all over southern California, cars skidded out of control, traffic backed up, police lights flashed. It was the beginning of a winter-long deluge that turned the entire state into a morass of snowdrifts and mud slides. Klajic stared through the windshield at the water rushing down the concrete bottom of the creek. "It doesn't have a chance to slow down here. That water is on its way to the ocean," she said, "not to the aquifer."

Others might hail water marketing and CVP reform as a great environmental victory. But it didn't seem to Klajic that she had much to celebrate. Water marketing would only stop new dams from being built, not new houses. The people of the state had faced up to agriculture. But unless they face up to the even more intractable problem of growth, California's problems with water may have only begun. □



The Power of Develop

Reservoir of strength

Its curving concrete dwarfing a maintenance man, Glen Canyon Dam plugs the Colorado River 67 miles above the Grand Canyon. Glen Canyon's completion in 1963 came near the end of four decades of feverish dam building —an epoch that helped swing the nation's population westward while providing massive targets for the modern environmental movement.

Development

When Humans Harness Nature's Forces

BY MICHAEL PARFIT
PHOTOGRAPHS BY PETER ESSICK

THE CHART WAS IN FRENCH, but I didn't need the language to tell me I was lost. I thought I'd kept track of my plane's course across northern Quebec, and the electronic wizards in the cockpit agreed with me. But the world outside said something different, and when in doubt I trust the world.

The chart, which I had just bought, showed a river—the Eastmain—zigzagging through an open landscape much like the world of scrub spruce trees, bogs, ponds, and granite hummocks I had been crossing all morning. But out the window there was no river. Instead there was a single sheet of water, dotted here and there with islands. The lake was calm, immense, seemingly ancient.

I looked around—forward, aft, to the sides. Again and again I checked the chart, the lake, the instruments. There was only one answer: For the first time in my experience, the world had changed.

I should have expected it. I was flying north toward Hudson Bay to meet another of NATIONAL GEOGRAPHIC's team of water reporters, John Mitchell, who was studying one of the most enormous water projects ever designed on this continent: Quebec's James Bay hydroelectric project. But I had not realized that part of the huge project had recently been completed. The chart had it wrong because this lake below me, which looked so ancient, had just moved in.

"Wow!" I said aloud. Whatever you think of dams, this was a mighty view. Where else can you see, so vividly, the power of a single decision?

When I fly west across America toward sunset, the shine of water

Water management before Columbus ■ The quest for water has always challenged desert dwellers like the Hohokam, who etched mysterious petroglyphs into volcanic andesite in present-day Saguaro National Monument outside Tucson. The Hohokam devised the first irrigation systems in what is now the United States, using stone and wood tools to dig canals from the Salt and Gila Rivers as early as A.D. 300. Mats woven of brush, strategically placed, helped direct the water flow to cornfields.

PAINTING BY PETER V. BIANCHI

leaps up at me: Bronze reflections blaze out of the darkening land. But the shape of this gleam has been vitally changed in less than a century. When the first pilots flew at the sun, most of the water ahead of them shone in moving strings of glitter: rivers and streams flowing unimpeded toward the sea. Today sunset is strewn with golden oak leaves: pools backed up into those drainage basins by dams. Much of our water, to use a common but curious term, has been *developed*. In one lifetime we have developed thousands of huge lakes, some more than a hundred miles long, flooding, in the U. S. alone, an area the size of Vermont and New Hampshire combined. We have made more than two and a half million smaller lakes and ponds. We have turned dangerous rivers into staircases for ships. And everywhere we have constrained the flood and transformed the ancient roar of rapids into the hum of electricity.

At 5,000 feet all that slack water shines in the sun, and everything looks simple and at peace.

Not so.

WATER ITSELF works in a tumultuous, eager system, powered by the sun, rushing from sea to cloud to river to sea and back. A major river system, say the Columbia, spends about as much energy every half hour falling from its mountain sources to sea level as was released by the explosion of the Hiroshima bomb. To use that force—to develop it—human beings have met it head-on with our own eagerness for change and power. The result is neither calm nor simple.

To understand why, I looked not just at the rambunctious nature of water but also at the similar human characteristics that marked what one writer has called the Age of Dams.

"And on up the river at Grand Coulee Dam," Woody Guthrie sang, "the mightiest thing ever built by a man, to run the great factories for old Uncle Sam; it's roll on, Columbia, roll on!" It was 1941, and Guthrie had been hired for $266.66 to spend a month writing songs for the fledgling Bonneville Power Administration in praise of the development of water. "Jackhammer Blues," "New Found Land," "Pastures of Plenty," "Eleckatricity and All," "Ballad of the Great Grand Coulee."

It was a time of almost mystical enthusiasm. The young engineers of the U. S. Bureau of Reclamation, the Army Corps of Engineers, and the Tennessee Valley Authority were going to wrestle the energy from rivers, cultivate the deserts, and put America to work. And after years of dustblown expectations, young Americans could suddenly be part of the mightiest thing. Concrete! Work! Adventure! Power!

"I just want to have worked on that dam," a young philosophy student told a friend at the University of Washington in 1935, before quitting school to get a job building Grand Coulee. The friend remembered it later as a credo of the time: "If our generation has anything good to offer history," the philosopher said, "it's that dam. Why, the thing is going to be completely useful. It's going to be a working pyramid."

That was an understatement. What human beings did in less than half a century was so extraordinary you can only compare it to a force of geology, except that it happened almost overnight. The Tennessee Valley Authority was created in 1933, and Hoover Dam was completed in 1935—the same year that that student decided to leave Plato and go pour concrete in the cause of perfect usefulness. From then on the juggernaut was almost unstoppable for 40 years.

There are now about 75,000 dams in the United States alone. Hundreds of locks, dams, power plants, levees, and pipes turned the temperamental Tennessee into a slave of electricity; smothered the rapids of the Columbia to make a series of lakes for both navigation and power; channeled and leveed the Mississippi and the Ohio into barge canals; harnessed the Missouri; watered millions of acres of dry land and desert; and blocked up the Colorado, turning its sand-struck waters blue.

And with those construction paychecks and all that power, economies blossomed. "The Northwest would still be territories," one water administrator told me, bending chronology a little, "if it weren't for hydropower." He didn't point out that the political system might be different worldwide without it too: The Allies' air superiority in World War II was built in part by new aluminum plants in the region, which were fired by Columbia River dams.

In those days environmental opposition was small and disorganized. Even Supreme Court Associate Justice William O. Douglas, who later became a leading environmentalist and opponent of new dams, was enthusiastic. After

LOS ANGELES DEPARTMENT OF WATER AND POWER

Slaking L.A.'s thirst ■ In 1905 Los Angeles gained rights to Owens Valley water and then used mule teams to build a 233-mile aqueduct. The system was later extended north to tributaries of Mono Lake (below), whose level has since fallen 42 feet. Calling the endangered Mono an "ecological and scenic treasure," a judge in 1991 ordered Los Angeles to stop taking fresh water from the streams that feed the ancient saline lake.

the war, he promoted TVA while riding horseback through remote villages in Asia. TVA, he wrote, "has caught the imagination of all the people across this broad belt of Asia." It was a "symbol of a new order, a new way of life." The usefulness was complete.

Things are different today.

ON AN OVERCAST AFTERNOON in Tennessee, I sat in a boat with a fisheries biologist and a motorized posthole digger beside a steep, red-earth shore that had been scoured of vegetation by the seasonal rise and fall of a reservoir. Dozens of small new benches, made of cedar stumps and lumber, stood in ragged rows on the shore above the water. They made the slope look like a bizarre kind of amphitheater, where cheering crowds might sit to watch the reservoir fill. In fact it was a spawning theater for smallmouth bass. When the lake is filled for summer, water will cover the benches, and bass will come. After a while each bench will be located by satellite navigation, and scuba divers will go down to peer into the little bass boudoirs to see how the fish are getting along.

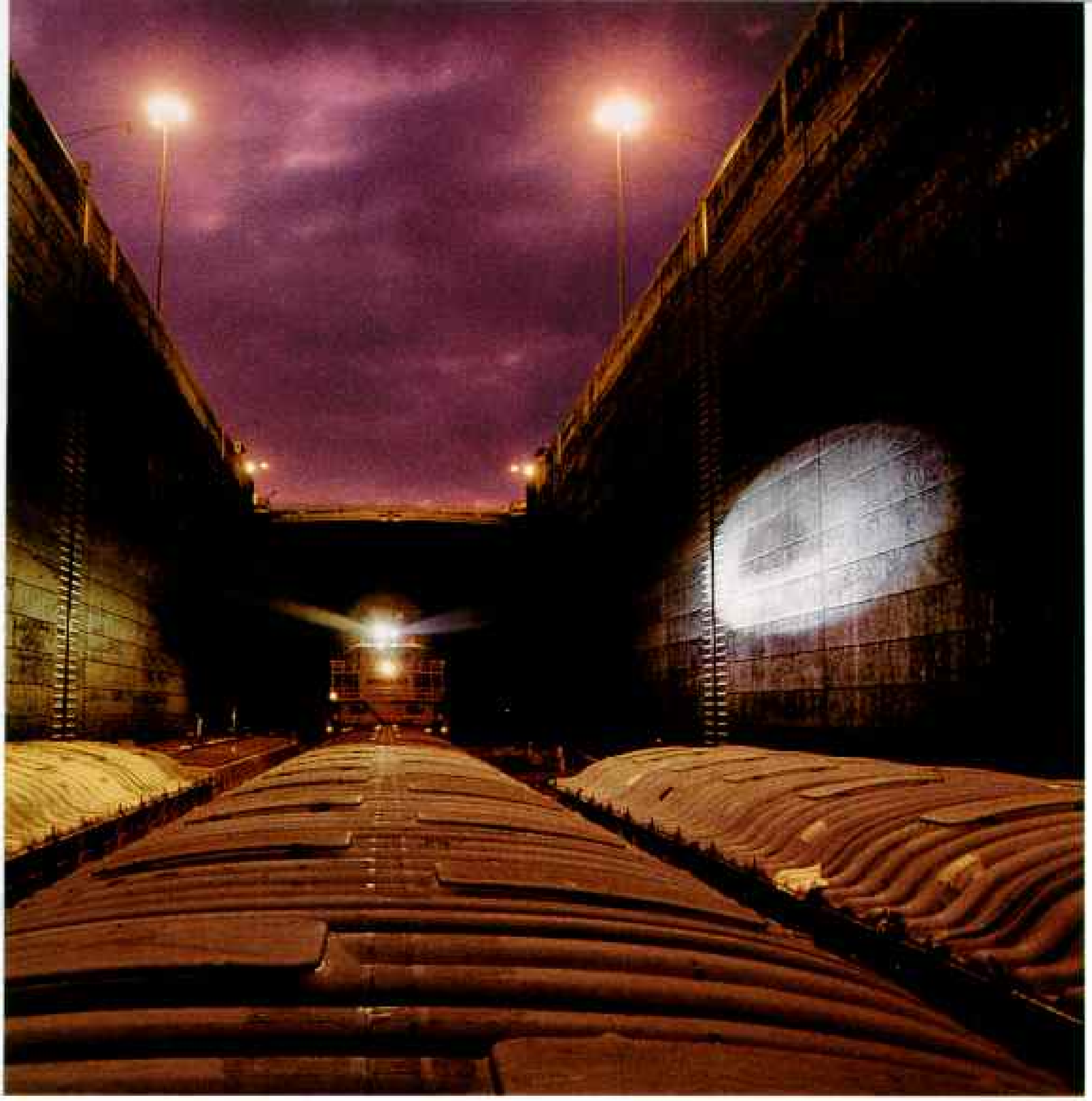
Our boat was behind Norris Dam, one of the first built by TVA. The bass beds are symbolic of the complexities of water development today, which has become far more complicated than it must have seemed in 1933.

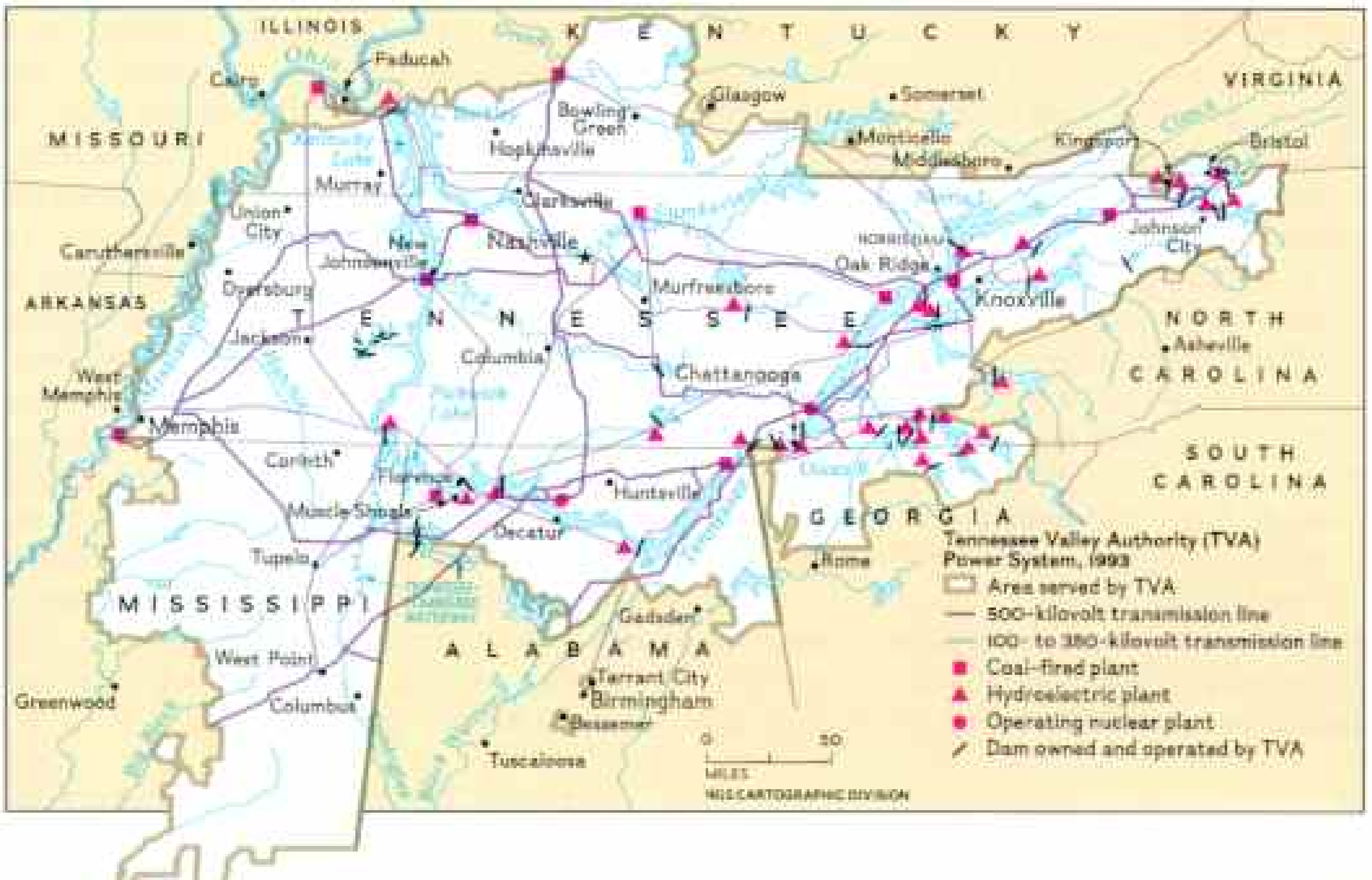
For TVA and water agencies everywhere, running dams is like rationing shower use in a house with 5,000 teenagers. In downtown Knoxville, I visited a small room where ten computer monitors and a weather radar screen provided information on rain and water levels. With the data, updated from all over the watershed, managers adjusted flow to make sure there was enough room in the system to absorb a flood. They didn't have much time.

"We get a lot of rainfall," said Arland Whitlock, manager of reservoir operations. "And when it falls, it's here."

Whitlock juggles a host of other needs. He must pour enough water through the turbines to keep cities and industries alight. He must save enough to provide abundant cooling water for the TVA's 11 coal-fired and two nuclear plants. Sportsmen expect him to keep reservoirs full most of the summer. Cities require their own supplies. Barge operators want deep channels. He attends to details that

Water's New Deal ■ A Depression-era project to tame the wild Tennessee River and its tributaries became perhaps the best known public works venture of Franklin Roosevelt's presidency: the Tennessee Valley Authority. The TVA's 47 dams, most built after a bruising battle over what Roosevelt's foes called his "socialism," generate power for a once underdeveloped region, help engineers stem flooding, and fill reservoirs for water sports. They also ease navigation along the river, sparking commerce and manufacturing. Barges now pass through locks in previously treacherous waters near Muscle Shoals, Alabama, where a towboat's spotlight illuminates the walls under twilight skies.

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Bowling Green
Hopkinsville
Glasgow
Somerset
Monticello
Middlesboro
Kingsport
Bristol
Murray
Clarksville
Union City
Nashville
New Johnsonville
Carrutheresville
Dyersburg
Murfreesboro
Oak Ridge
Knoxville
Johnson City
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Columbia
Chattanooga
Asheville
West Memphis
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MILES
TVA CARTOGRAPHIC DIVISION
Tennessee Valley Authority (TVA)
Power System, 1993
Area served by TVA
500-kilovolt transmission line
100- to 380-kilovolt transmission line
Coal-fired plant
Hydroelectric plant
Operating nuclear plant
Dam owned and operated by TVA

look minor but aren't—like lowering and raising reservoirs one foot weekly in summer and early fall to kill mosquito larvae on the banks.

Everyone who wants a piece of the Tennessee has a telephone, and it's easier to lobby TVA than the weather. "You're real close to your customer," Whitlock said, with only a trace of irony. "You get to see the result of your work almost immediately."

TVA, like many other water-control agencies, is even in the oxymoronic business of managing wildness. When you ride a wild raft on the Ocoee River, one of the more famous stretches of white water in the United States, it probably doesn't help the wilderness experience much to know you've got to get home before they turn off the river. In an accommodation between power and recreational demands worked out through Congress, the TVA runs the river full bore for 116 days each summer—during daylight hours only. "At night," Whitlock said, "it's basically just a wide, dry riverbed."

As more users line up to demand water and power, Whitlock juggles the conflicts, which tighten as demands grow. "It's a balancing act I enjoy," he said. "There's no more water now than 50 years ago, but we're operating closer to the edge." Lurking at this managed edge may be a flood: Keeping the reservoirs full in summer for recreation assumes typical dry summer weather; but weather isn't always typical. "Nineteen eighty-nine was a wet summer," Whitlock said. "It got real exciting."

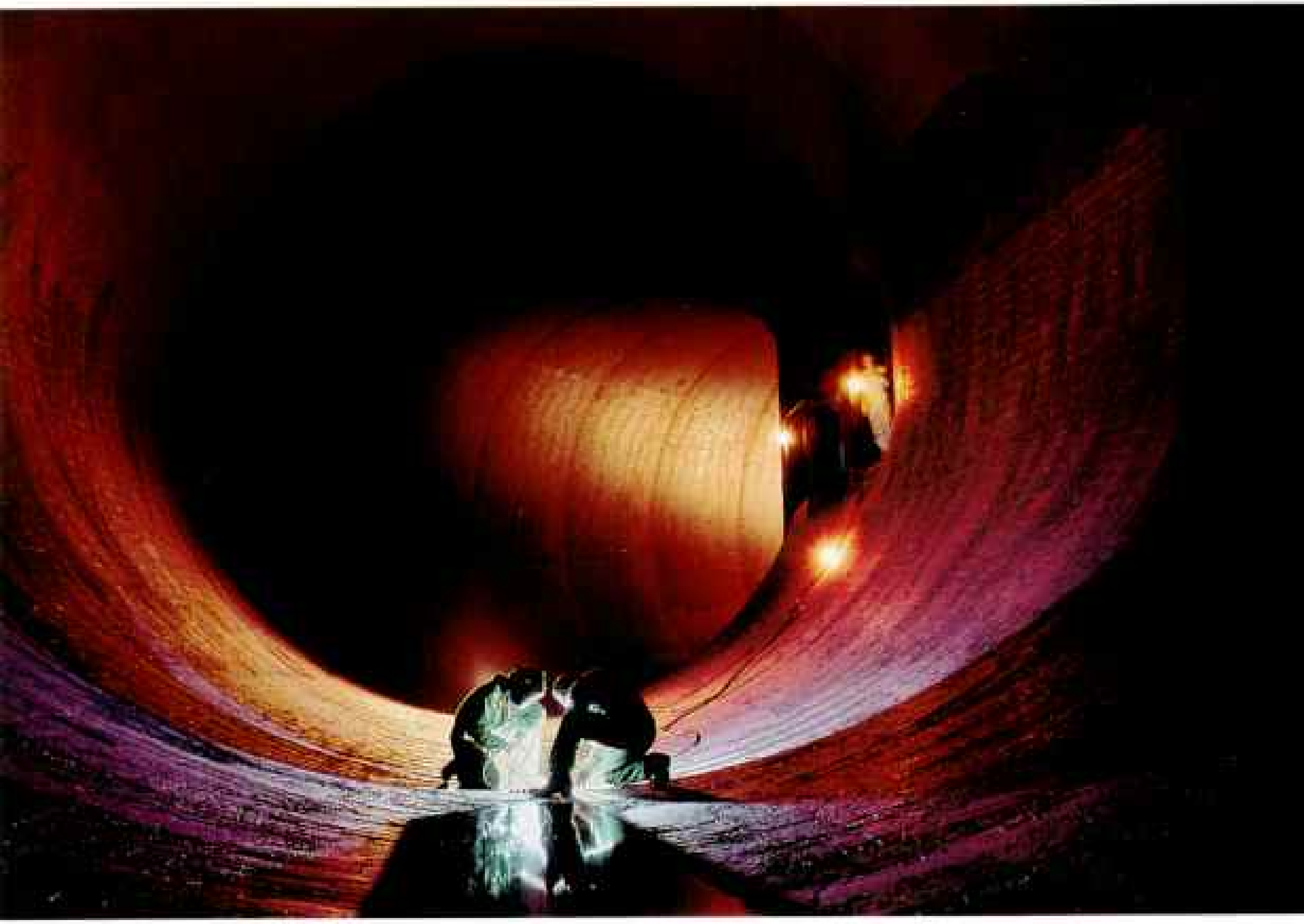
DEVELOPMENT is like powerful medicine—its side effects can be devastating. I see them everywhere. On the Columbia River, barges full of young salmon are shipped downstream among grain containers and windsurfers—an attempt to save salmon runs that have been almost fatally damaged by the river's new shape. On the Platte River in Nebraska, dams have controlled high water so well that the gravel bars that sandhill cranes need have been smothered by new brush. The flow of deep, cold water from the bottom of reservoirs is often so poor in oxygen that all aquatic life downstream is affected. Color can be a giveaway: I watch a brown stream submerge itself into a reservoir like a gritty personality giving up to blue domination, and I know that means the silt is settling out, slowly clogging the reservoir with material that would otherwise flow to the sea and replenish our coastal wetlands and beaches. Using water's power has given us light, jobs, transportation, and safety, but the price is still being reckoned.

"A river is essentially transmitting life," said Kevin J. Coyle, president of the conservation group American Rivers. "It's moving life from one place to another. These blockages stop that transmission. They shut down the systems, killing them off. It's a chain reaction of death."

Today the luster has gone off water development. Complications have become more aggravating. Many of the best sites are used up. Some multibillion-dollar projects—like the Tennessee-Tombigbee barge canal, which links the Tennessee River and Mobile, Alabama—have turned out to be far more expensive than the benefits warrant. As last summer's rampaging Mississippi River has shown, the safety of flood control is not perfect—it provides more years between floods but will not prevent the worst. The idea that big projects serve everyone has been tarnished by the image of rampant congressional pork barrel—the cynical use of patriotic fervor left over from the 1930s and '40s to win funding for home-state profit rather than projects of national interest. And many people have been grieved by the loss of places of great beauty, like the Colorado River's Glen Canyon.

The end of the Age of Dams is symbolized today by a short piece of concrete I see when I fly across southeastern Idaho. It's a spillway that hangs on a ridge beside a canyon, like a short road that once went somewhere but doesn't any more. It's all that's left intact of a huge earth-fill structure called Teton Dam, which blew out in 1976 when it was filling for the first time. The wall of water killed 11 people. When I see it, I remember standing in one of the hundreds of flooded homes a few weeks after the disaster, surrounded by dried mud that stank, talking to an elderly farmer who had helped push the dam's funding through Congress. His floors sloped: His house had been knocked from its foundations. "We're gonna save the house!" he said, though he moved slowly, as if still dazed by the water's roar. "We're gonna rebuild that dam!"

He died not long after. Eventually the house was torn down.



"Mightiest thing ever built by a man" ■ So sang Woody Guthrie of the Grand Coulee Dam, where welders work in the eerie emptiness of a turbine casing normally filled by 30,000 cubic feet of water roaring past every second. The dam, 175 miles east of Seattle, creates power for the Northwest—and, in summer, for the Southwest as well.

"Trying to keep up with the demand for more water or more power does not uplift people," a dam opponent said with considerable accuracy in the early 1980s. But to understand the state of water today, it's important to remember that once it did.

I SAW THE PRACTICAL SHAPE of this change at the professional playground of the U. S. Bureau of Reclamation, once one of the premier dam builders of the West. The playground is the bureau's research laboratory in Denver, Colorado. It's a vast room with grates in the floor, through which you can see a pool of water that surges and gurgles as if inhabited by river monsters from the Missouri. Above it, thousands of gallons of water rush up through pumps and pipes to cascade over scale models of water projects all around the world. For anyone who loves playing with water, it is more magical than Disneyland.

In the past these models were of new dams and irrigation systems; now they are of improved spillways, renovated facilities, safety improvements, artificial reefs, manufactured wetlands. "We're changing," said a bureau spokesman, "because we have to, and, I think, because we want to. We're going to be a resource manager, a protective organization, as opposed to a development organization."

Near the front of the bureau's research lab is a sign: "The Portland Cement Association is pleased to have been able to cooperate with the Bureau of Reclamation in the development of America's Natural Resources." The elegiac tone of the sign may reflect the end of the Age of

Dams, but more concrete will be poured. "The Four Horsemen of Destruction are still on the loose," Kevin Coyle said. "Dams, diversion, ditching, development." For almost every watershed on the continent there are, hidden somewhere, blueprints for more construction. Coyle claims that only 9 percent of river miles in the lower 48 states remain undeveloped, but many of those are marked by proposed dams, channels, or diversions.

That 9 percent is hard to find. One day I took off from southern Colorado and flew about 800 miles on an informal tour of water in the southwestern United States. Everywhere water was already developed. Among the many dams and vast blue reservoirs was one modest undeveloped drainage: the Virgin River, which rises in southern Utah near Zion National Park. It is a silty little river, running among mountains and through small towns and turning mostly to sand when it hits the desert. But in its small, 6,000-square-mile watershed, various agencies have identified 92 dam sites and made plans to build 16.

In the U. S., which has already developed about half of its entire hydropower potential, the Federal Energy Regulatory Commission has issued licenses for 192 new power dams that are not yet built. The omnibus water bill passed at the end of 1992 by Congress included more than a billion dollars for water development. In Canada and Mexico the potential, if not the money, is for far more construction. The relatively undeveloped rivers of Alaska too are the focus of development hopes.

"The Four Horsemen are driving a truck up the Alaska Highway," said Tom Cassidy, a lawyer for American Rivers. "It's an 18-wheeler, double-wide."

So the urge to develop is still with us, which was clear on that summer afternoon in northern Quebec as I flew over the altered landscape and eventually landed at the Cree village of Whapmagoostui, at the mouth of the Great Whale River. There, at the boat dock among many green canoes, was writer John Mitchell, looking tanned and fit—except for welts of blackfly bites all over his legs. He had just climbed out of a floatplane after rafting on the river, which may be the next one dammed as part of the James Bay hydroelectric project.

The impulse to manage water remains both a constructive and damaging force on the planet. As I left the Great Whale, I remembered how someone once adapted a poem by Robert Burns—the Scottish poet of lovely lasses and unspoiled beauty—to reflect that persistence:

"Flow gently, sweet Afton, among thy green braes,
We'll be damming thee up in a couple o' days." □

What price progress? ■ Water once tumbled over Celilo Falls, but the fishermen's haven on the Columbia River is now submerged behind The Dalles Dam. Not far away, windsurfers share the river with barges. The optimism of the era when dams spurred both the economy and recreation is now tempered by fears of damage to land and wildlife.

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James Bay: Where

Development

CASE STUDY

Two Worlds Collide

BY JOHN G. MITCHELL
PHOTOGRAPHS BY STUART FRANKLIN

DARKNESS IS ABOUT TO FALL across the valley of the Great Whale River. It is the end of a long August day in the north of Quebec, in a land of black spruce and tan granite, and we have come to see how this river runs while the water is free.

I am traveling with Matthew Mukash. He is a Cree Indian. His people have been living in this country for 5,000 years. Across the purling water one of their tepees stands pasted against the sky, a ghostly pyramid trailing a thin white plume of woodsmoke downriver. Mukash, who is chief of Whapmagoostui, a Cree village at the mouth of the river, on Hudson Bay, suddenly sweeps his hand in an arc. "All this will be flooded by the dam," he says. "The river has a sacred route to follow, but they will drown it. All of it."

The dam that troubles Mukash—if it is ever built—would be the linchpin of the Great Whale complex, just one part of the gigantic James Bay hydroelectric project. Sponsored by Hydro-Québec, a quasi-government utility, the project has been abuilding for 20 years. Its first power plant—the largest underground generating station in the world—was completed on the La Grande River in 1982; three others have since been commissioned, and work has begun on four more. Three great rivers—the Eastmain, Opinaca, and Caniapiscau—were diverted to feed the 500-mile-long La Grande, doubling its mean annual flow and increasing its winter flow by a factor of eight. In the resulting trade-off the Eastmain was parched to a trickle.

So far, Hydro-Québec has invested more than 21 billion dollars (16.3 billion dollars U. S.), built five wilderness airports, strung at least 5,000 miles of transmission lines through forest and wetlands, consumed more than 1.6 million tons of fuel, and blasted out and redistributed a volume of rock fill sufficient, in the words of the utility's literature, "to build the Great Pyramid of Cheops 80 times over."

And this is only for starters, because if and when all the elements of

■ **Shouldering a morning's haul of Canada geese, Leonard Masty, a Cree, heads back to his family's camp near Whapmagoostui. From native hunting grounds, Quebec's government plucks hydropower riches—inflaming tensions over land use as old as European settlement of North America.**

the James Bay project are ever in place, a territory the size of Montana will embrace no fewer than 30 major dams and 500 separate dikes, while impounding reservoirs that in aggregate surface area would equal Lake Erie. And there would be generating capacity to crank out a volume of megawatts exceeding that of all the major U. S. hydro dams in the Columbia and Colorado River basins combined.

In the view of Hydro-Québec and the provincial government, power of this magnitude provides jobs for the jobless, industrial growth, political stability. And it all flows out of a place so remote and sparsely settled that it hardly seemed necessary for Hydro-Québec to consult the indigenous population, the Cree and the Inuit, much less expect that many of these people would view the project not as a triumph of engineering but as a threat to their way of life.

■ LG1, the fifth Hydro-Québec powerhouse built on the La Grande River, rises from James Bay wetlands and forests—habitat of lynx, black bears, waterfowl, and one of North America's largest caribou herds. When completed in 1995, LG1 will churn out 1,368 megawatts of electricity for Quebec. Other La Grande installations help light up parts of the U. S. Northeast.

DRIFTING DOWN the Great Whale in the August twilight, I find it difficult to imagine this country bristling with development and easy to share the Cree's concern. I have seen enough of the river—tasting its spray in quieter rapids, walking around the rowdier ones, flying over the watershed's multitudinous lakes and streams—to know that this is wilderness as wild as any is ever likely to be.

The Great Whale complex would take this tumbling, 225-mile-long river and, with dams and dikes, convert much of its length into a series of artificial slack-water lakes. These reservoirs would submerge

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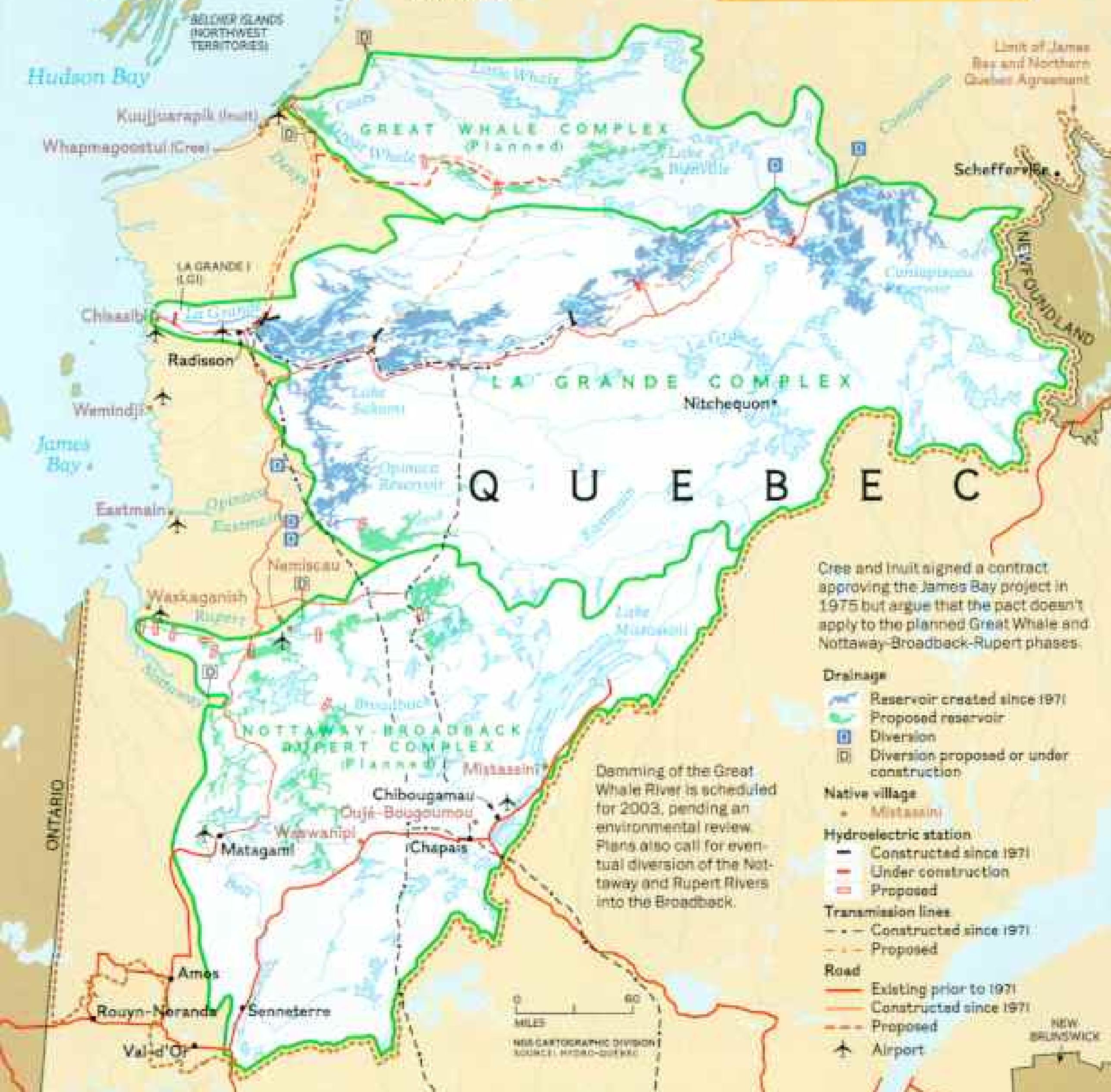
JOHN G. MITCHELL, a former field editor for *Audubon*, is author of *The Man Who Would Dam the Amazon*. He wrote "Our Disappearing Wetlands" in the October 1992 GEOGRAPHIC. London native STUART FRANKLIN has documented events from the fall of the shah of Iran to the student protests in Tiananmen Square. His most recent assignment for the magazine was "Pizarro, Conqueror of the Inca" in February 1992.

Power struggle in the great north

The Cree call electricity *nimis-chiiuskataau*—"fire that shakes the land." Proponents and critics of the James Bay project concur that the quest for electricity has indeed shaken the taiga stretching over an area the size of Montana. The project's initial phase, the La Grande complex begun in 1971, has flooded more than 6,000 square miles—diverting and damming six waterways into larger bodies of water to swell electric output. Quebec's political leaders see hydropower as a financial windfall, giving the Francophone province an economic bargaining chip in strained relations with English-speaking Canada. Native Americans say the project threatens their livelihood; environmentalists decry it as a disaster on a par with the devastation of the Amazon rain forest.



Cree and Inuit signed a contract approving the James Bay project in 1975 but argue that the pact doesn't apply to the planned Great Whale and Nottaway-Broadback-Rupert phases.

Damming of the Great Whale River is scheduled for 2003, pending an environmental review. Plans also call for eventual diversion of the Nottaway and Rupert Rivers into the Broadback.

Drainage
- Reservoir created since 1971
- Proposed reservoir
- Diversion
- Diversion proposed or under construction

Native village
- Mistassini

Hydroelectric station
- Constructed since 1971
- Under construction
- Proposed

Transmission lines
- Constructed since 1971
- Proposed

Road
- Existing prior to 1971
- Constructed since 1971
- Proposed
- Airport

more than a thousand square miles of riverine latids and untamed waters. There would be three big generating stations, an all-season road linking the Great Whale River and Whapmagoostui—now unreachable except by air or sea—with tamer precincts to the south, more work camps, more airports, more Cheopses.

True, there is an airport already at Whapmagoostui. The Cree possess snowmobiles and outboard motors, modern housing, telephones and television, plumbing, and—click!—electric lights. But a little comfort and convenience clustered at the snout of the Whale cannot alter the big wildness still intact in its belly or so quickly dull the racial memory of a time when all Cree lived in the bush. Only the James Bay project could do that.

In 1973 the Cree won an injunction to stop construction of La Grande projects, only to see that ruling overturned by the Quebec Court of Appeal. The court found that, since construction had already begun, a "balance of convenience" favored Hydro-Québec; that the nearly 10,000 Cree who occupy the area lacked clear rights in the territory, inasmuch as Charles II of England had granted exclusive rights to the Hudson's Bay Company in 1670; and that hydro development would not harm the environment but likely improve it. Stunned, the Cree sat down to negotiate.

From the bargaining table came a massive document, the James Bay and Northern Quebec Agreement, signed in 1975 by the Canadian government, the Province of Quebec, the Cree, and the Inuit (whose communities lie mostly to the north of the project area). In effect the agreement permitted completion of the La Grande power plants, compensated the Cree and Inuit with money packages totaling 225 million dollars, and promised them the right to govern, hunt, fish, and trap on their traditional lands. Hydro-Québec retained wide latitude in assessing and managing the impact of its projects.

But from the Cree perspective the social and environmental impact of the La Grande development would prove to be substantial. So when the project's next major installment surfaced in the Great Whale complex, the Cree argued that it was not explicitly authorized by the 1975 agreement and, in no uncertain terms, warned that they'd have no part of it.

■ Specks against a concrete face, two of 1,600 workers brought north to build LG1 put finishing touches on the colossus from a platform a hundred feet above the ground (opposite). Five hundred miles to the east, diverted water spilling over a concrete weir into the Laforge River (above) fulfills dreams of Quebec's political leaders—among them longtime premier Robert Bourassa, who called the wild waterways of predam days a "waste."

RADISSON IS A HYDRO-QUÉBEC company town. For nonnative Quebecers, it is the project area's capital city. Located only a few miles from the largest of the La Grande power plants, the community provides for hundreds of people who keep the company's north country infrastructure in working order.

Radisson derives its name from the 17th-century French explorer

Pierre Esprit Radisson, while the town's main street, des Groseilliers, honors his fur-trading partner. "We were Caesars," wrote Radisson, satisfied that in the wilderness there was "nobody to contradict us."

The venerable Radisson name is also attached to the project's principal substation nearby. When the wires started humming in 1979, Quebecers living in the province's towns and cities heated their homes mostly with oil or gas. But within a decade hydropower, delivered at favorable rates, had doubled the percentage of all-electric homes in the province—to 63 percent. Including industrial and commercial users, overall demand for electricity was up by 60 percent.

In fact, for a while in the 1980s it seemed as if Hydro-Québec's customers couldn't keep up with all the river water spinning those turbines along the La Grande. So, to avoid simply spilling that water over the dams, as well as to hurry along Quebec's coming of age as an

■ Oblivious to autumn snowfall, grandmother Mina George hangs strips of caribou to dry near the Little Whale River. Many Cree, who value the caribou for its meat and hide, still live as traditional hunter-gatherers for part of the year.

though their village homes boast TV sets and VCRs. The new roads that bring in modern conveniences bring in unwelcome visitors as well. City folk out for sport come to hunt on lands once the exclusive domain of native peoples.

industrial power, government and utility officials unrolled a welcome mat along the St. Lawrence River Valley for aluminum and magnesium smelters. Both require prodigious infusions of electricity. It now takes the energy equivalent of an entire Great Whale complex just to supply the half dozen metals manufacturers that responded to Quebec's invitation and the utility's contractual generosity with flexible rates.

One day in Montreal, I called on Pierre Bolduc, Hydro-Québec's executive vice president for marketing and international affairs. Bolduc said that the welcome mat was no longer out for more metal-smelting operations. But he predicted that once the economy began to improve, "aggressive industrial development" would resume in high-energy sectors other than metals—in the conversion of Quebec's older pulp and paper mills from chemical manufacturing processes to state-of-the-art electromechanical ones and in the supercharged environmental-control technologies of the 21st century. Hydro-Québec is figuring on a total growth of 525 to 600 megawatts a year.

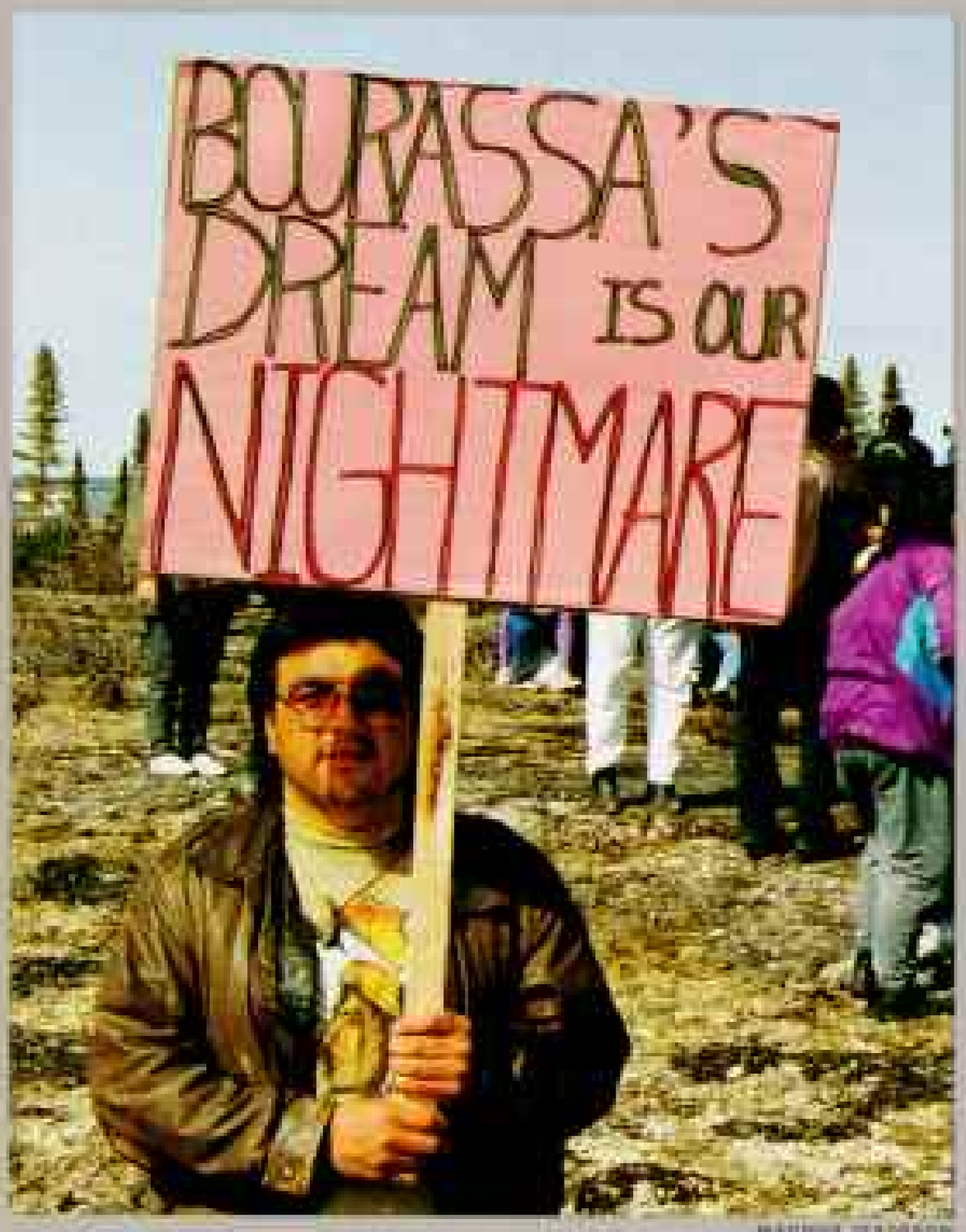
LAST YEAR New York State backed out of an agreement to import a thousand new megawatts from Hydro-Québec's grid, but other contracts are still in effect with northeastern U. S. customers, and these draw off 6 percent of Quebec's installed hydroelectric capacity. Bolduc explained why export contracts are essential to a growing Quebec:

"It is like having the need to house your family. Today the children are young and sleep in the same room. But you know that some day they will need more space. So you add a floor to the house, and it is just as easy to build five rooms as three. And until the children are older, you rent their rooms out to help pay off the mortgage."

In the Bolduc analogy then, the James Bay project is the house that Quebec built, the La Grande complex one of its floors, and the Great Whale complex another floor one flight up. And now a third floor is proposed for the 21st century. It is the NBR complex. It would divert the Nottaway and Rupert Rivers into the Broadback, increasing its mean annual flow sevenfold, and, with at least nine major dams, flood an area twice as large as that to be submerged by the Great Whale complex. But will Hydro-Québec ever build the NBR?

"I'm not too sure," Bolduc told me that day in Montreal. "There are more environmental variables in the NBR area than on the Great Whale. Still, it's an option."

Matthew Coon-Come, a wiry, impassioned young man from the village of Mistassini, is Grand Chief of the Grand Council of the Cree, and while he views the James Bay project as a "massive attack on Cree territory," he also knows that his people cannot freeze their ways forever in the past. But outsiders, he says, "are dictating the pace of change without giving us the opportunity to adapt. Other societies have had a hundred years or more to get ready for change. We are being forced to do it in 20."



MARNIE JACKSON

■ Cree opponents of the project championed by Robert Bourassa continue to press their case through demonstrations, even after tribal leaders signed a 1975 agreement bringing the Cree and Inuit 225 million dollars in compensation. Noting that the proposed Great Whale complex would submerge sacred burial sites, one Cree elder asked, "What would white people say if we started flooding their cemeteries?"

Of all the changes in the north country, the most threatening in the Cree's perspective are those affecting their sources of traditional foods. A kind of spiritualism is attached to their quest for wild foods; hunting, fishing, and trapping not only feed the stomach but also nourish the soul.

One can therefore appreciate the Cree's consternation when, in the early 1980s, the word went out that they should sharply restrict their voracious appetite for freshwater fish, such as pike and lake trout, because levels of methylmercury, a neurotoxin, had increased through the decay of vegetation flooded by the reservoirs of the La Grande complex.

Hydro-Québec officials concede that some species of fish in their reservoirs turned up with concentrations of methylmercury five times as high as those occurring in natural lakes in the region. While there have been no acute cases of mercury poisoning in any native community in the James Bay area, fears remain nonetheless.

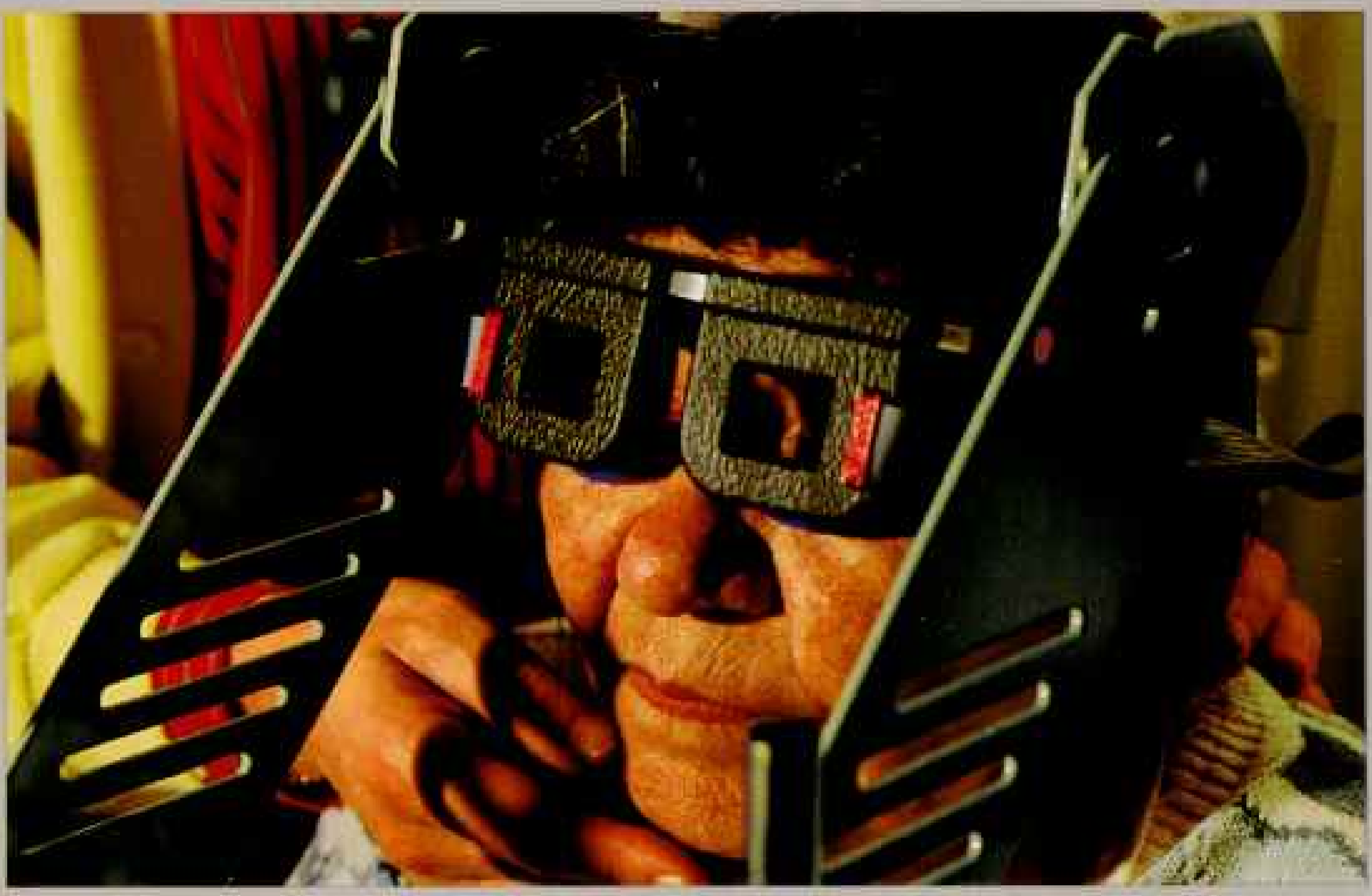
The Cree are likewise concerned about caribou. Cree say that the La Grande reservoirs have destroyed some of the best caribou feeding areas in the north country and that the Great Whale impoundments will destroy many more. Hydro-Québec officials claim that the reservoirs may actually be beneficial to migrating caribou in the wintertime—wide expanses of ice could make the migrating easier and keep the animals safer from predators.

IN 1991 THE CREE won a court judgment ordering Ottawa to initiate an environmental-impact assessment of the hydroelectric project proposed for the Great Whale River. The guidelines for that review, raising hundreds of separate issues that Hydro-Québec must address, were completed last year by joint panels of Cree, Inuit, provincial, and federal officials. A final environmental-impact statement is expected by the end of this year. While much of this assessment will surely focus on impacts most closely associated with the welfare of the Cree and Inuit, there are also issues of national, and possibly global, concern.

The marine ecology of James and Hudson Bays has only recently come under close scrutiny. Balances are finely tuned in the subarctic. Much of the marine food chain depends on spring blooms of ice algae

and phytoplankton, which in turn rely on a delicate blend of fresh and salt water. Shift the blending time or alter the mix, and you may well be disrupting an aquatic commissary supplying Cree or Inuit hunters who come from hundreds of miles away.

And finally there is concern about the cumulative impact of hydroelectric development on the entire Hudson Bay region and even beyond, off the Labrador and Newfoundland coasts. Manitoba has dams, diversions, and altered flows on the Churchill and Nelson



Rivers, and a palpable itch to develop the Gods, Hayes, and Seal as well. Ontario has plans to redevelop dams on one of its bay-bound rivers. If the La Grande complex is suspected of upsetting nutrient and salinity balances offshore, what happens when you throw Great Whale, NBR, and all the dammed rivers of Manitoba and Ontario into the bargain? How will this affect the ecological flux of the bays, the arctic char, the beluga whale, the bearded seal, the Canada goose, the Cree, the Inuit, even the fishermen of Newfoundland?

In Montreal, I put that question to Jean-François Rougerie, environmental project manager for the Great Whale complex.

"Yes, this is something we are concerned about," said Rougerie. "But so far, all the effects that we can measure remain local."

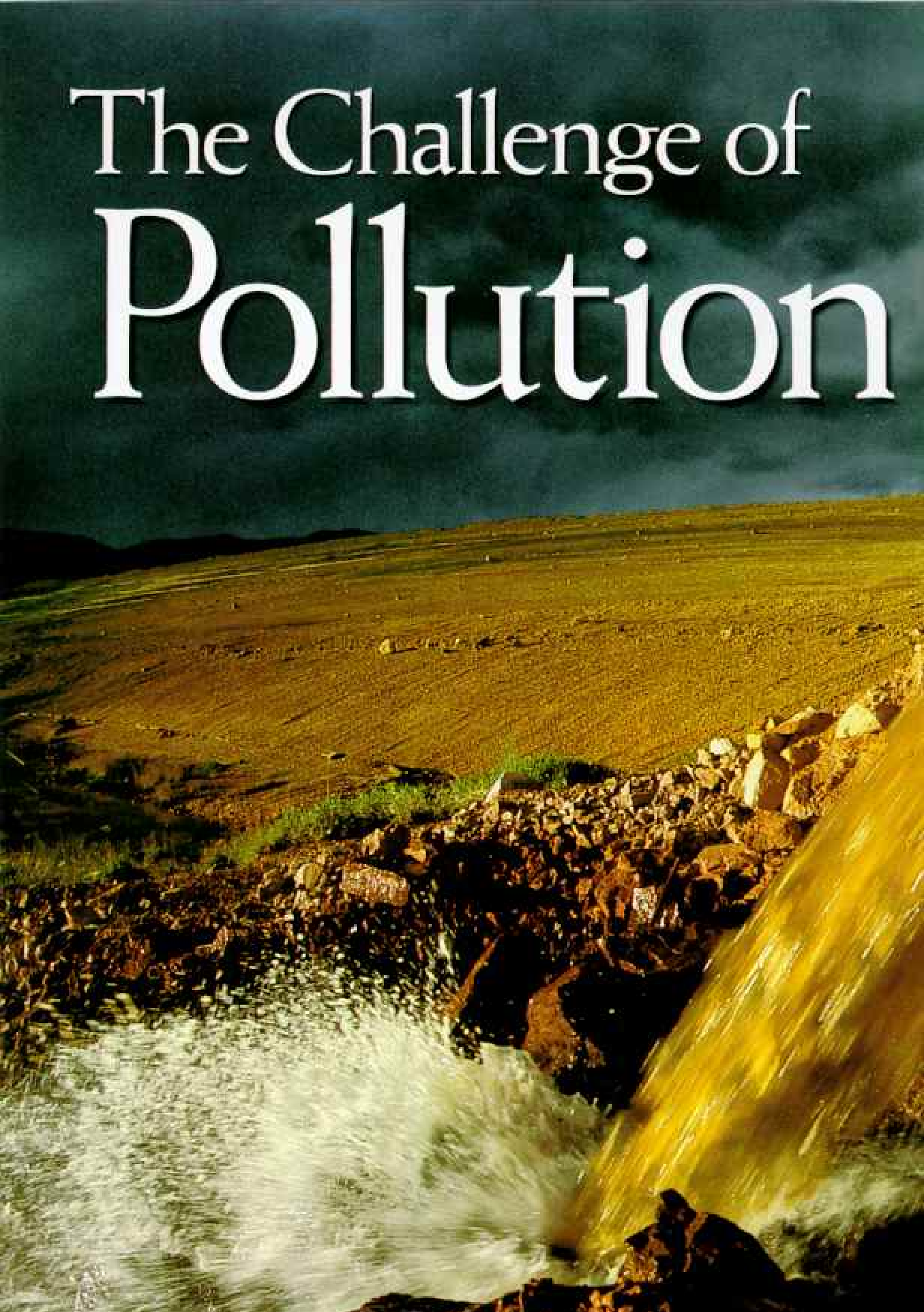
And I said, "Are you saying then, that if most of the rivers around James and Hudson Bays were developed the way the La Grande has been developed, there would be no major impact on the marine ecosystem of the two bays or on some place beyond them?"

"Based on the information we have now," said Rougerie, "that would be our conclusion. No major impact."

Hearing that, I thought suddenly of old Pierre Radisson, breaking the ice for a North American fur trade and confident as a Caesar because, in the wilderness, there was no one to contradict him. □

■ Infrared sensors at a Montreal lab check a Cree woman's eye movements for signs of methylmercury-induced brain damage. Naturally occurring mercury becomes methylmercury when land is flooded and vegetation decays. This toxin, which turns up in fish eaten by the Cree, is one marker of how development in the James Bay watershed has tainted native life.

The Challenge of Pollution



Soiled at the source

Heavy metal brew, partially treated effluent from the Climax Molybdenum Mine in Colorado gushes into the first of two cleanup ponds. Here iron oxide—which stains the discharge orange—and oxides of lead, zinc, copper, and manganese settle out.

When it comes to water pollution, the invisible can hurt most—including untreated heavy metal seepage from mines, many of them abandoned.

Pollution

Troubled Waters Run Deep

BY MICHAEL PARFIT
PHOTOGRAPHS BY JIM RICHARDSON

I GET MY WATER FROM A SPRING that comes out from under a mountain in Montana. I have always felt superior in this regard to most other people on the planet—their water might be threatened by carelessness upstream, but I'm here at the beginning of the flow, and mine is clean.

Not any more. One recent morning, having returned home from airborne wanderings over less fortunate people's watersheds, I found myself hiking through early snow to the cistern at the spring with a bottle of bleach and a humbled heart. A routine test of my water—which had never turned up problems before—had come back from the lab with the notation: "Too numerous to count—background bacteria."

What had happened? Something had seeped into my aquifer and clouded my peace of mind. I could only clean the cistern and try another test. Until then I would have to boil my water or risk disease. I had joined the ranks of too many people on this continent who aren't sure of the quality of what they drink.

Few things are as insidious as bad water. It's dangerous for you and your children, but you usually can't tell if you have it. And if you do, you may not be able to find out where the problems are coming from. Water can carry some of our most serious diseases—typhoid, dysentery, hepatitis—yet still look clear in the glass. We may do battle over how we get our water and develop it, but we fear for its quality.

This year Congress has been grappling with that very issue. The United States' first truly broad set of water-quality laws, known as the Clean

Risky fishing ■ A makeshift sign warns anglers away from the Fenholloway, Florida's only "industrial" stream. For decades waste from a pulp mill, fully owned by the Procter & Gamble Company until this year, overwhelmed the river. A treatment process has eliminated detectable dioxin output, but a state fishing advisory remains in effect.

Water Act, was passed in 1972, and now it's time to revise this act and the more recent Safe Drinking Water Act to reflect the current situation. This is tough, partly because the state of water is difficult to capture in the kind of unambiguous statistics lawmakers like and partly because it has become increasingly apparent that the sources of pollution are not just industrial and municipal institutions that can be controlled by specific laws. The burden of pollution belongs to us all.

Water's nature itself is a part of these complications. This simple structure of hydrogen and oxygen has even been called the universal

Groundwater gumshoe ■ Probing pollution's hidden migrations, U. S. Geological Survey researcher Denis LeBlanc (above right) uses an array of 10,000 test wells to sample groundwater beneath the Massachusetts Military Reservation on Cape Cod. Streamers of light mimic the path of bromide injected into the sand and gravel aquifer. Such tests help in understanding the spread of contaminants under the site, where jet fuel spilled years ago can be pumped out and burned in a cigarette lighter.

solvent. It takes into solution a vast number of substances, and what it can't dissolve, it simply pushes along or grinds up fine enough to carry in suspension.

Human beings have put this characteristic of water to work in thousands of ways. We wash with it; we flush with it; we mix it with chemicals to spray on our fields. It's in the processes that make paint, plastic, pork. We hose down the workshop, the garage, the factory. But this remarkable utility also means that it's very hard to put anything out of water's reach. Water is far more persistent than even the most determined rat or cockroach, so a lot of things we don't want in water get there anyway. If you pour poison on the ground, even in the starkest desert, water will pick it up, molecule by molecule, and because water is always going somewhere, it will take it away.

I once watched how we use this characteristic of water from a gravel bank on the upper reaches of the Yukon River. I was with Gerry Whitley, a pollution-control administrator who had just taken me on a tour of the city of Whitehorse's reservoir, power plant, and parks. Now we were at the end of the system. The water slid past silently, heading north into wilderness, but an unmistakable aroma rose from it. Whitley stood cheerfully on a manhole cover; beneath his feet sewage ran from settling ponds into the river.

JIM RICHARDSON's photographs have illustrated NATIONAL GEOGRAPHIC water stories on such subjects as the Ogallala aquifer in March 1993 and the Colorado River in June 1991. Before freelancing, Richardson worked for the *Denver Post*.

"Whitehorse is a microcosm of how we use water," he said. "Recreation, power, greenbelt, water supply; then below the city we dump sewage. This is how our society organizes stuff."

THE COST of this simple organization is enormous—not to water itself, which flows just as swiftly when poisoned with cyanide as it does fresh from a cloud, but to us. So the Environmental Protection Agency (EPA) determines water quality in terms of how pollution impairs the way we want to use it.

Impairment is a curious image—it makes you think of a creek hobbling along on a cane—but it's not a bad metaphor. Impaired water, in the EPA definition, is water we can't use as fully as we want to. Some is unhealthy to drink, some is unhealthy to swim in, and in some we shouldn't even fish. The agency, which compiles reports from each state, says in its most recent summary that only 22 percent of all the United States' stream miles and 67 percent of the lake acreage have been assessed. Of those totals, a third of the stream miles and almost half of the lake acreage are, in one way or another, impaired. And states set their own standards, so states that set more stringent standards can actually look more polluted on paper than lax ones. All that can be said with certainty is that based on the state reports, about 15 percent of our river miles and 38 percent of our lake acreage are *not* impaired.

"We've got a huge mass of data points," says Robert Adler of the Natural Resources Defense Council, a conservation organization, "but they can't be connected." Trends are even harder to gauge. Many rivers and lakes appear to have been dramatically improved since the infamous Cuyahoga caught fire in Cleveland in 1969 and since the passage of the Clean Water Act, which provided standards for pollution control and money to build treatment plants. But some think this is only a surface image.

"There are two very conflicting messages," says Kevin Coyle, president of American Rivers. "A lot of rivers are cleaned up—you can swim in them now. The Cuyahoga may never catch fire again. But when you look deeper, many of the nation's rivers are in worse shape than they have ever been. Though they may

look cleaner, they may be more deadly."

Recently, after following rumors of this deadliness, I sat at a picnic table on the outskirts of Brownsville, Texas, with Alma Alvear and her daughter, Thelma. Thelma was two years old. She looked normal. While her mother and I talked, she played with a plastic bow that was missing its arrow, occasionally looking up at me with calm, speculative eyes. Eventually Alma showed me Thelma's scars: a little knot of flesh on her belly and a line down her back. Thelma was born with a birth defect, spina bifida, and had a shunt inserted into her body to draw away fluid that collects in her brain. Some doctors suspect that pollution in the Rio Grande caused the defect.

Pediatrician Carmen Rocco, then medical director of the Brownsville Community Health Center, agrees. She had plotted an unexpectedly high rate of spina bifida and other related birth defects on a map of the Brownsville area. "These clusters are where people live near pollution," she says. Chronic, low-level exposure to polluted air and water, she suspects, may also either cause birth defects or trigger genetic susceptibility to them.

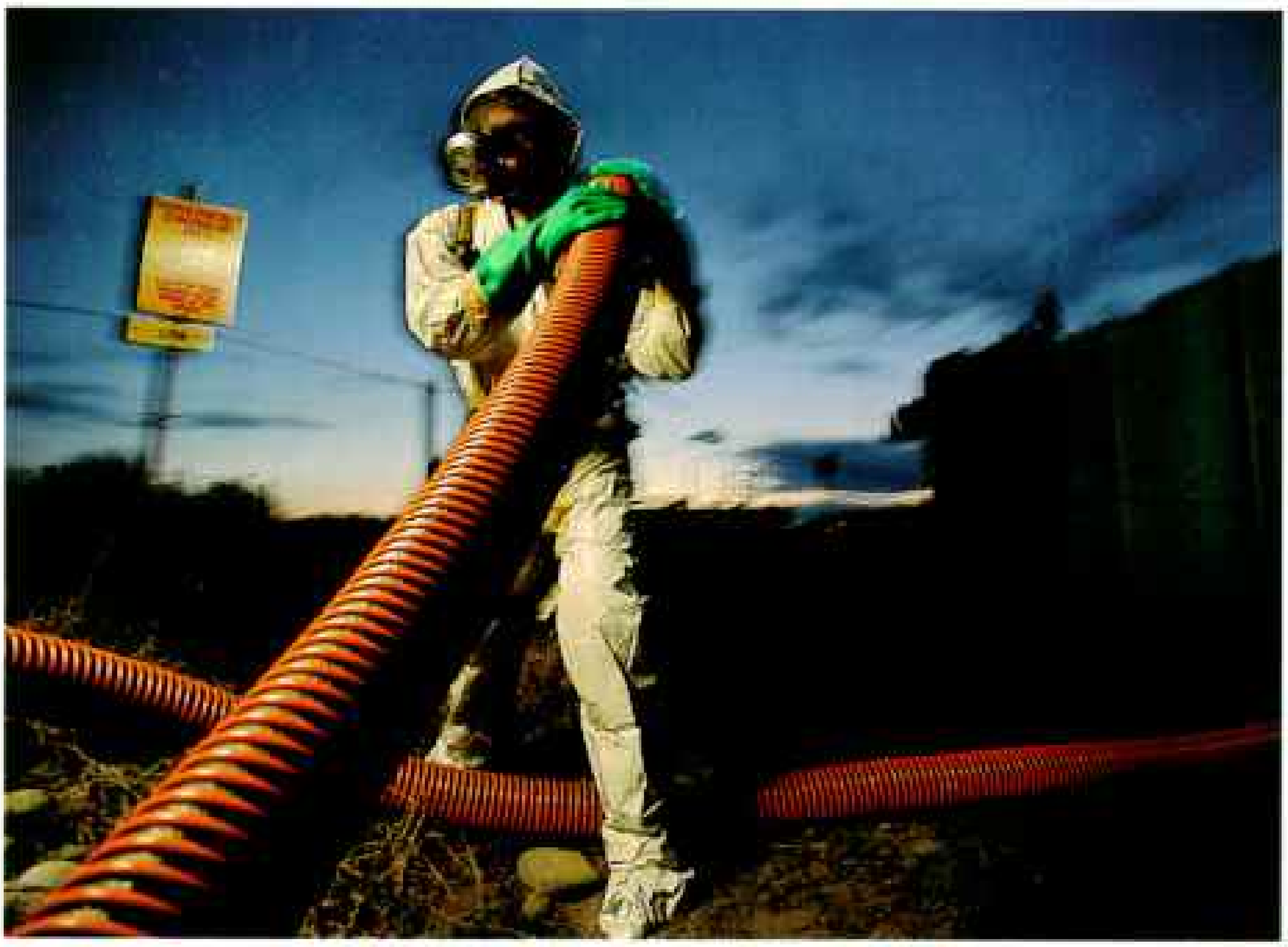
Like most medical problems attributed to pollution, the causes of the birth defects in Brownsville are almost impossible to document; there are too many factors to isolate. But it was not paperwork that convinced Rocco. It was her daily contact with grief.

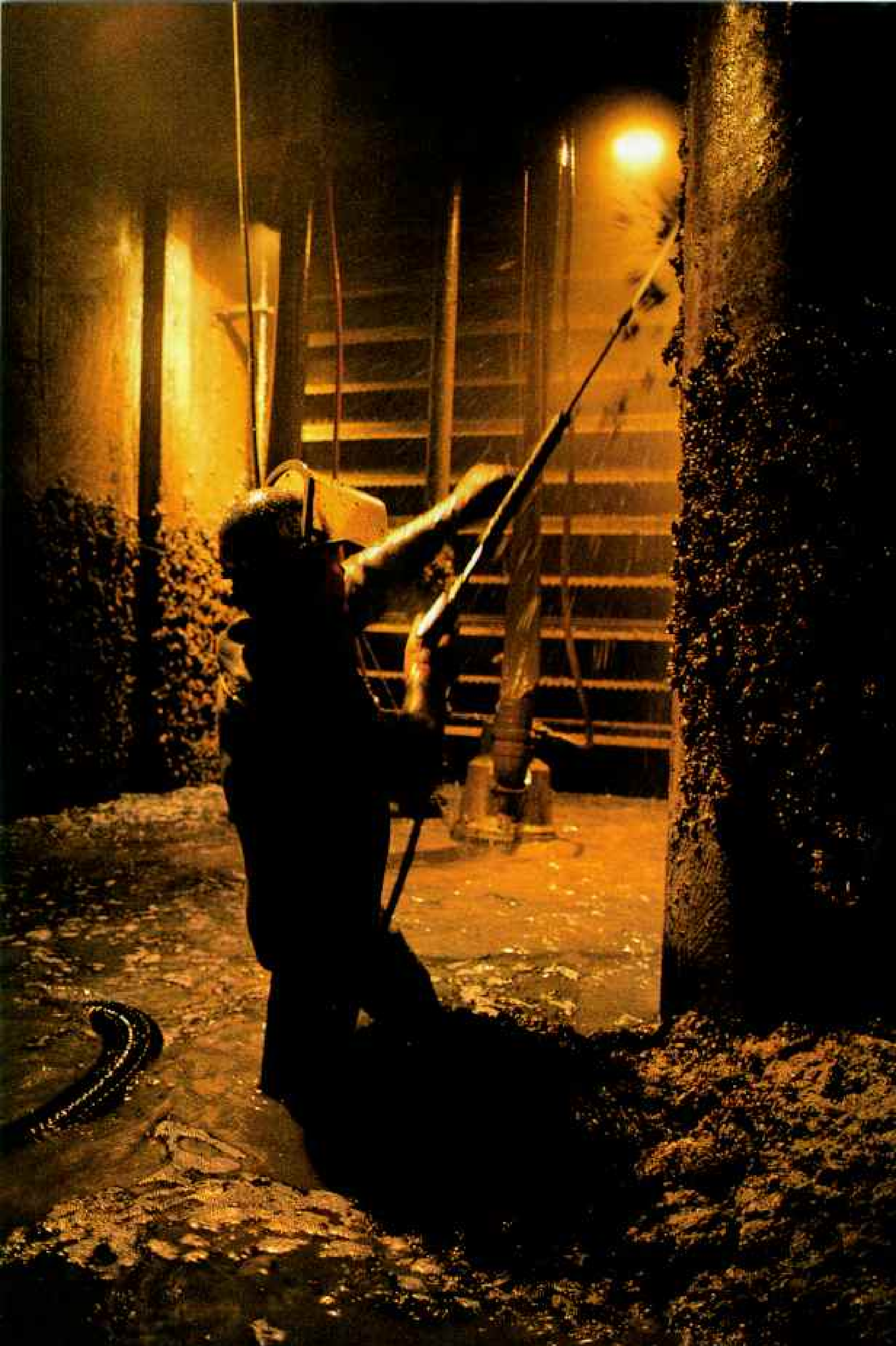
"I realized that every day I had been seeing babies with heart defects, blood disorders, limb anomalies, and other deformities," she said. "What was happening still is."

"It's been a hard time," Alma Alvear said, while Thelma regarded me thoughtfully. "She's had three operations on her head already. She's scared of doctors." Alma is only 22, but Thelma was her second baby with a similar defect. The first child died.

A breeze blew through pepper trees. Thelma climbed down, ran away, and brought her mother a doll to cuddle. I grinned at Thelma, but I didn't feel like smiling at all.

Cleanup hell ■ "One job can fill 12 dump trucks," says Stephen Clingenpeel (right), who uses water to blast away zebra mussels, prolific European invaders, from a power-plant intake on Lake Erie. A worker at the Hanford Site nuclear-waste storage facility in Washington State (below) struggles to contain a seven-square-mile plume of groundwater-contaminating carbon tetrachloride—a possible human carcinogen.





The Rio Grande was recently named the continent's most endangered river by American Rivers. The reasons for this unenviable award, and the possible sources for Alma's and Thelma's anguish, are multitudinous. Environmental groups say industrial plants on the Mexican side—many built by American companies to use cheaper labor—pour in toxic chemicals, and the burgeoning communities of families moving there for the work often have no sewage treatment. And on up the river on both sides of the border, intensively farmed and irrigated fields also drain downstream.

"This is what burns me out," said Luis Perez-Garcia, the environmental-quality engineer for the city of Laredo, Texas. He drove me around town, showing me gullies filled with old car engines, plastic bags, and trash. "It's easy to blame Mexico," he said, "but we're not taking any better care of the water. I'm just as concerned about what our industry and agriculture produce."

To Perez-Garcia the Rio Grande is an example of the growing concern water-quality experts have about polluted runoff. The river's distress may be caused as much by what drains off fields and pavement as what comes out of factory pipes.

Technically, water pollution can be divided into two types: point-source pollution—waste dumped by factories or sewage plants—and nonpoint-source pollution—otherwise called polluted runoff. In many ways the latter is the larger problem.

Polluted runoff is what happens when you spill oil on the driveway, then hose it down. It happens when a soybean field is treated with herbicide, and then it rains. It happens when someone throws a dead battery into a gully. It happens when a farmer's cows stroll through a stream. It happens when someone cleans a car part with solvent and dumps the liquid on the ground. It happens when a gardener sprays a lawn with fertilizer. Water picks it all up—oil, manure, lead, nitrogen, phosphorus—and adds it to the system.

Out of an EPA list of 18,770 impaired water sites, only 529 are polluted primarily by toxic point sources. Most of the rest are polluted by

Clear-cut disaster ■ Logging wounds bleed tons of sediment into the watershed of the Escalante River on Vancouver Island, British Columbia, where streams bear the dirty brunt of clear-cutting. Logging erosion has "paved" rivers with gravel, smothering prime salmon- and trout-spawning habitat.

runoff. Yet until recently most regulation and enforcement have been aimed at point sources.

"Water is in serious jeopardy," says the Natural Resources Defense Council's Robert Adler, "because we're not paying much attention to anything except pollution from a pipe."

In Cleveland I hiked with a few people under a highway overpass and down a railroad track to a beautiful little waterfall on a creek. The fall was like a piece of natural beauty crouching in the city's underbrush, hiding out from all that technology. But right at the top of the fall was a round door, like a manhole cover. It was part of a combined sewer system, one of the villains in the story of polluted runoff.

These systems have large underground pipes that carry sewage, industrial waste, and storm water to treatment plants. During heavy rains the storm water may be more than the plants can handle; overflow carries raw sewage and other pollutants straight into the streams.

We stood looking at the big door. Everything was dry, but in a storm it would open automatically and cough up a gush of polluted runoff and fecal coliform. Curses were spray-painted on the door. They seemed appropriate.

"People sitting around pointing fingers at industry don't realize that most water pollution is runoff," Jerry Schoen, an activist with the Massachusetts Water Watch Partnership, told me at a conference. "America's just waking up to a critical situation. The only way to make progress is to have everybody be part of it."

WHEN I FLY from west to east over the northern part of the United States, a curious thing happens. For hours I cross farmland irrigated by canals that move precious water from reservoirs to fields; then suddenly the canals are replaced by ditches with an opposite function: to get rid of water. These drainage ditches look like schematic drawings of natural watersheds—the same network of tributaries leading to a main channel but all straight lines and angles. To me they are symbolic of agricultural runoff, which, an EPA official said recently, contributes to "about two-thirds of the impairments in rivers, about half in lakes, and about one-quarter in estuaries."

Nutrients from fertilizers and livestock and silt from eroding fields are the leading pollutants, but others have been at least as deadly. Concentrations of the element selenium—a chemical naturally present in tiny quantities but as poisonous as arsenic in high concentrations—leached from soil by irrigation have killed thousands of birds in the West. And as William S. Ellis reports in his story on the Mississippi (following article), herbicides and pesticides that drain from fields fog even the clearest water with anxiety.

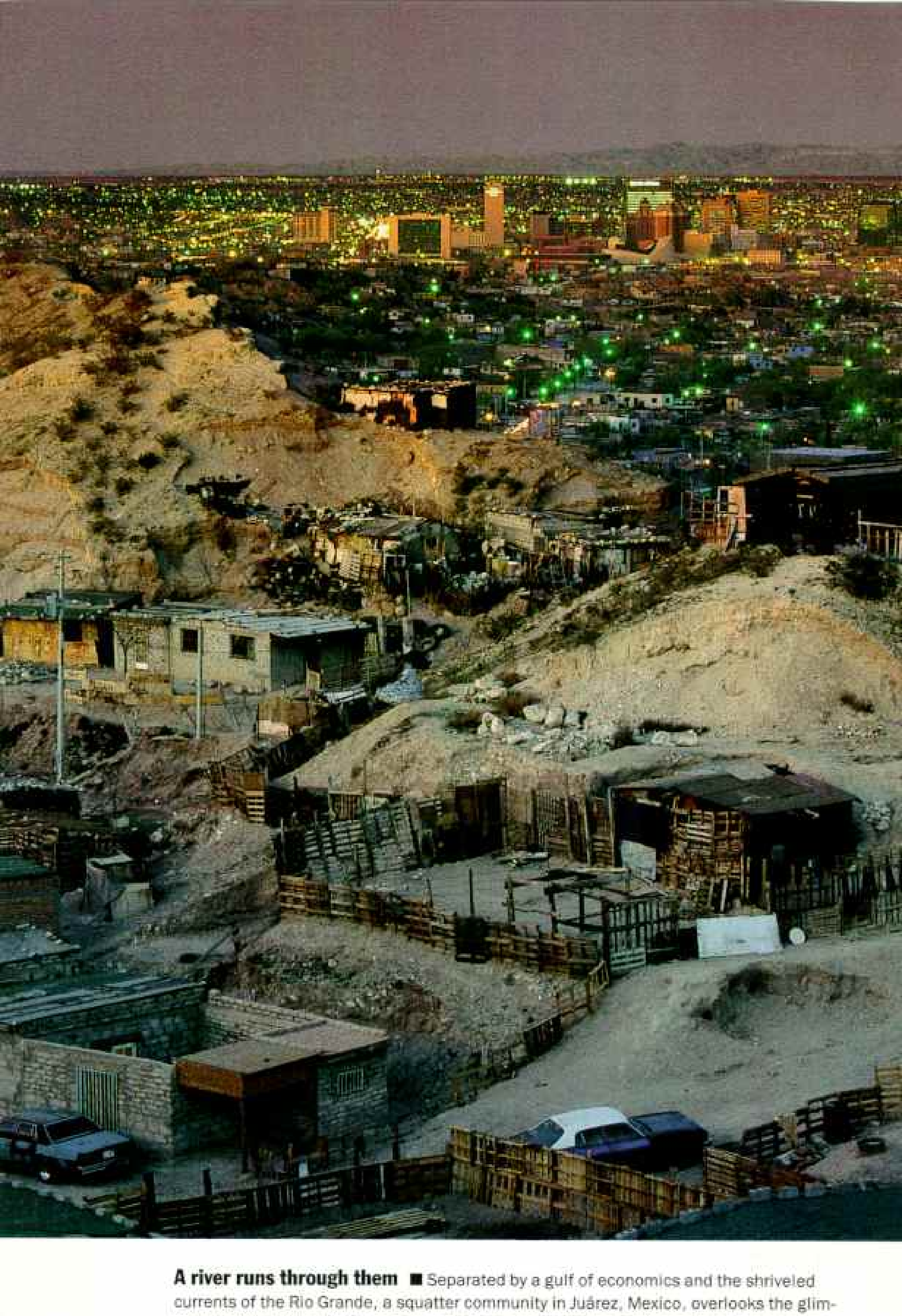
Most water looks clean from the air, but everywhere I can see human activities that lead to polluted runoff. Out West the vast clear-cuts in the forests of the U. S. and Canada allow silt to clog mountain streams, hurting both salmon and municipal water systems. In the East the bright emerald checkerboard of lawns means people may be using herbicides and fertilizers as intensively in the cities as on the farms. Even flying through rain, I'm in direct contact with water pollution. This is not just a matter of acid rain, which, though it's now getting less public attention, still kills lakes and trees. Odd pollutants have been blowing to places that should be pristine. At Lake Laberge, way up in the Yukon Territory, a study of fish flesh turned up a variety of chemicals, including the insecticide toxaphene, which has been widely used in Russia. It probably blew east, and rain raked it in.

"We thought we were living in a wilderness Shangri-la," a Canadian told me when I landed nearby and asked him about it. "Welcome to the world."

If places like Lake Laberge seem insidiously stained, that's nothing compared with the pollution of groundwater, which is out of sight and, possibly, out of reach.

One night I sat in a grade school auditorium on Cape Cod, Massachusetts, with a group of concerned citizens and a panel of experts, who were debating how to deal with plumes of sewage and toxic industrial chemicals that are seeping underground from the Massachusetts Military Reservation. The Department of Defense, responsible for cleanup, and the U. S. Geological Survey have each been studying groundwater pollution here for years, and Denis LeBlanc, a USGS hydrologist, was in an uncomfortable spot: The study goes on and on, and toxic chemicals keep moving toward the towns, despite cleanup efforts just begun.

"I've never come across a plume that didn't seem smarter than we are," LeBlanc said. "It's not a simple process."



A river runs through them ■ Separated by a gulf of economics and the shriveled currents of the Rio Grande, a squatter community in Juárez, Mexico, overlooks the glimmering downtown of El Paso, Texas. Explosive urbanization in the sister cities obscures

the international waterway itself, which American Rivers declared the continent's most endangered river in 1993. On its run to the Gulf of Mexico, the Rio Grande absorbs untreated sewage, pesticides, and industrial waste—the dregs of a bruising border boom.

Awash in waste ■ A sewage canal in Zaragoza, Mexico, swollen by warm water from a U. S.-owned auto-parts factory, supplies a bath for Erika Mendoza's infant son, Julio. Even tainted wastewater is a privilege on the border: Mendoza's neighbors divert effluent straight from the plant's drainage pipe to a communal tub.

"We've heard that for a very long time," another panel member said, not pleasantly. The moderator intervened.

"But it may be true," she said.

Laws have assumed that polluted groundwater must be cleaned up—the EPA's well-known Superfund program directs many of those attempts. But LeBlanc gingerly broached a topic that has recently been a subject of intense discussion among hydrologists.

"We need to recognize a difficulty the public is not aware of," he said. "It is possible that some of these plumes cannot be cleaned up in the foreseeable future."

LeBlanc quoted a much circulated editorial in the journal *Ground Water*. "A decade ago," LeBlanc read to the quiet room, "many of us thought it was feasible to clean up most groundwater. We now know that we did not understand the problem."

That lack of understanding can have a long and deadly legacy. Though new technologies, attitudes, laws, and community action hold the promise for a new era of hope and restoration, we've already lost some long-term battles. It's not clear how the pollution now stored in our groundwater and sediment may emerge to trouble our lives. So far we have only glimpses. I saw one in eastern Canada.

THE ESTUARY of the St. Lawrence is patrolled by about 475 beluga whales. These beautiful white animals live at the edge of the sea, where the taste of fresh water still lingers in the tide. The whales have been dying young.

In 1983 a group under Pierre Béland, a marine ecologist from Montreal, began to study the whales and their illnesses: lung disease, ulcers, cancer. They learned that the whales' flesh contained the dangerous chemicals called polychlorinated biphenyls, better known as PCBs. There was far more contamination in the whales, however, than the fish they ate in the St. Lawrence could account for. Béland also found an insecticide called Mirex in the whales' flesh. Mirex was once made on the shore of Lake Ontario, and though banned since the 1970s, it remains in the lake's sediment. But how did it get to the whales?

"It was like a detective story," Béland told me at his home in Montreal. He and colleagues finally solved it: Mirex was the gift of eels. Every year thousands of adult eels migrate from the Great Lakes through the St. Lawrence to the sea. Those from Lake Ontario come with Mirex, and belugas feast on them.

"When a whale eats an eel, he gets Mirex," Béland told me dryly. "And he gets as a bonus all the contamination from the Great Lakes."

As in most detective stories, the triumph was bittersweet: The crime had already happened.

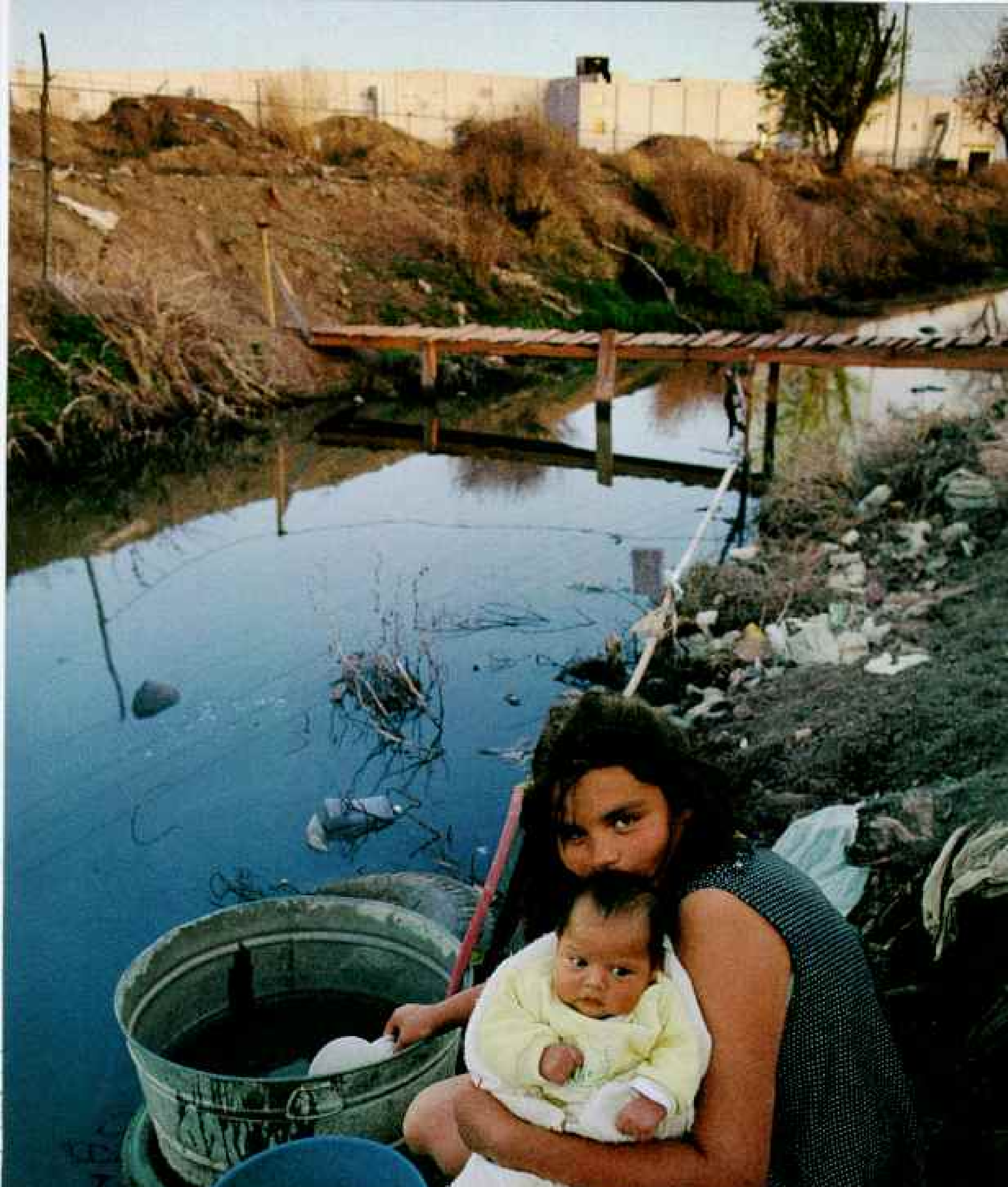
After I met Béland in Montreal, I flew north down the river to its mouth. There, from a thousand feet above, I saw the whales. They lay in scattered groups in the green water, as bright in their clusters as silver spoons nested in velvet. I made two turns over them, delighted. Then my plane's shadow slapped across a group, and all the belugas dived. They seemed to dissolve, silver to emerald to gone.

I circled again and looked, then again. The green water was bereft of whales, as if I had flown down time a generation, to when Mirex and associates had finished their work.

Struck by the sense of loss, I remembered a poem by Kathleen Raine:

Because I see these mountains
they are brought low,
Because I drink these waters
they are bitter,
Because I tread these black rocks
they are barren,
Because I have found these islands
they are lost;
Upon seal and seabird dreaming their
innocent world
My shadow has fallen.

But the shadow falls on us too, as Alma Alvear knows. We do not know what is coming from us to us in the springs of our world, what gifts the eels bring. Yet we cannot claim we are innocent. □



Pollution

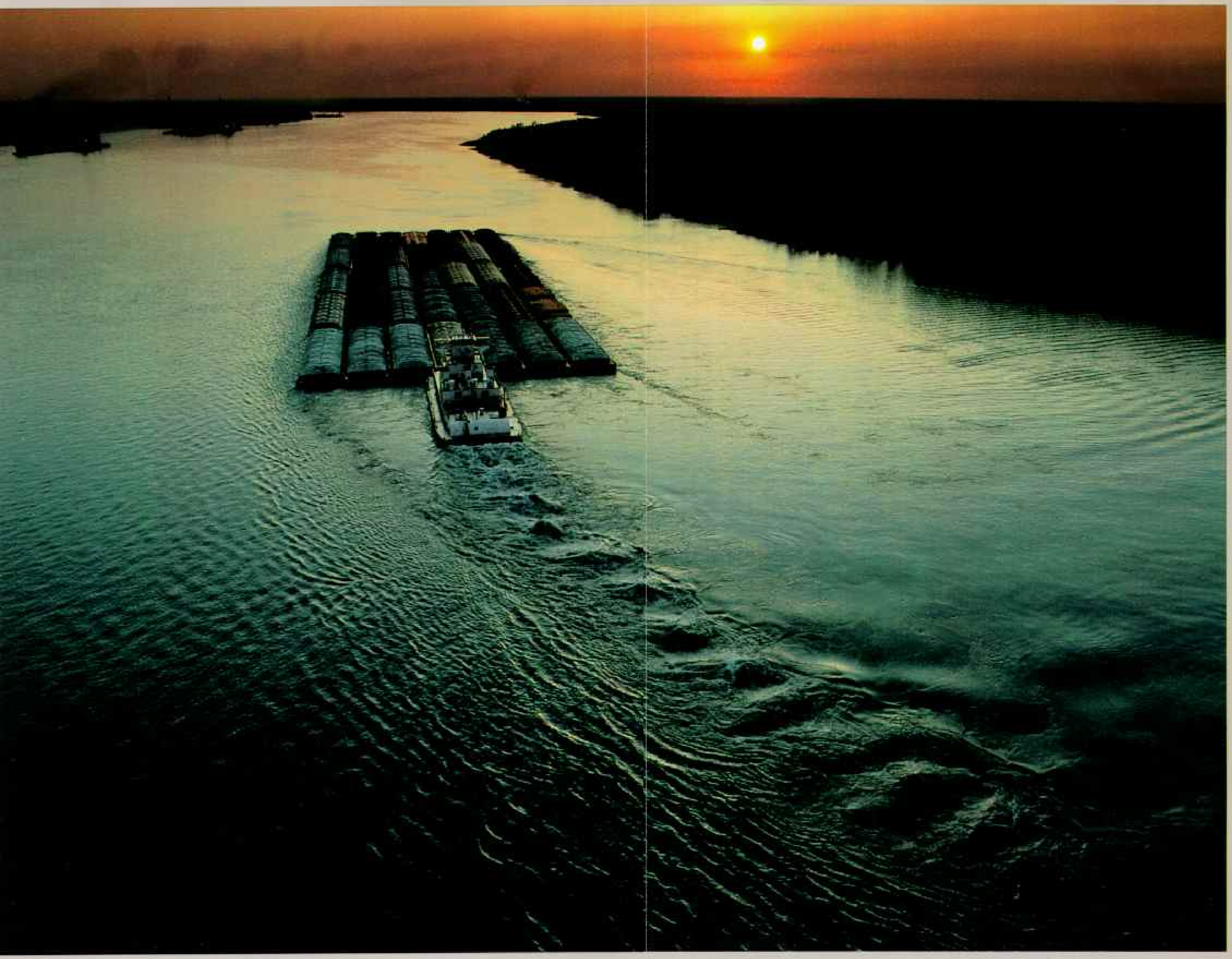
CASE STUDY

The Mississippi: River Under Siege

BY WILLIAM S. ELLIS
ASSISTANT EDITOR

PHOTOGRAPHS BY JIM RICHARDSON

■ Running fast and clear, Mississippi River headwaters rush from Minnesota's Lake Itasca, where nine-year-old Erin Brutlag is among those who seek to touch the shallows and witness the river's perpetual birth. As the Mississippi grows in strength, so do its problems: This mightiest of U. S. waterways, its flow altered by channels dredged to make way for towboats, is tainted downstream by agricultural and industrial runoff.



AS THE PLANET VENUS is something other than simply a star, so too the Mississippi is a river and much more. It is the sovereign of North American waterways, with a size and sweep to make it appear immune to the ills of pollution.

But such ills are there, borne by the great stream under the shadow of its might.

For many years it was widely believed that the river cleansed itself, that it was self-flushing as it raced on its nation-cleaving journey from northwestern Minnesota, where it rises as a cold, clear splash over rocks, to the Gulf of Mexico and a discharge of 600,000 cubic feet per second.

For all our efforts, the Mississippi has always maintained its pose of omnipotence; 29 locks and dams and miles and miles of levees were helpless last summer when the river rose up and swept our illusions of control away. Yet even in years of normal flow, the Mississippi is so wide and long and swift that we could also imagine that it would expurgate every milligram of contamination from its depths.

So it was that St. Louis did not build a sewage-treatment plant along the river until 1968. Up until that time all the city's raw wastes,

■ Mountain of trouble—yet in compliance with government standards—a 60-foot-high pile of gypsum (left) covers a square mile at an Agrico chemical plant south of Baton Rouge, Louisiana. A fast-accumulating by-product of fertilizer production, the refuse is contaminated with phosphoric and sulfuric acids. Heavy rains erode the hazardous material and wash it into the river, which carries a growing burden of chemicals as it drains its million-square-mile watershed (above).

averaging some 300 million gallons a day, vanished downstream.

The hurts, if not the smells, of such insults to the Mississippi were mostly hidden, for the 2,350-mile-long river's capacity for natural assimilation is indeed vast. Besides, there was no effective monitoring of water quality then. The Clean Water Act was four years away.

In those years of the late 1960s one species of mayfly hadn't been seen around parts of the upper Mississippi for at least a decade, but little concern was raised over that playlet of nature whereby the insects, which burrow in the river bottom, abandon the site if the water is severely polluted. What was more apparent was the changing (for the worse) taste of the fish, especially the bottom feeders such as catfish.

Even now, with health advisories against consumption of fish because of pollutants in them, there are men and women for whom the sizzle of grease for a river catfish fry is music more sweet than that of a thousand strings.

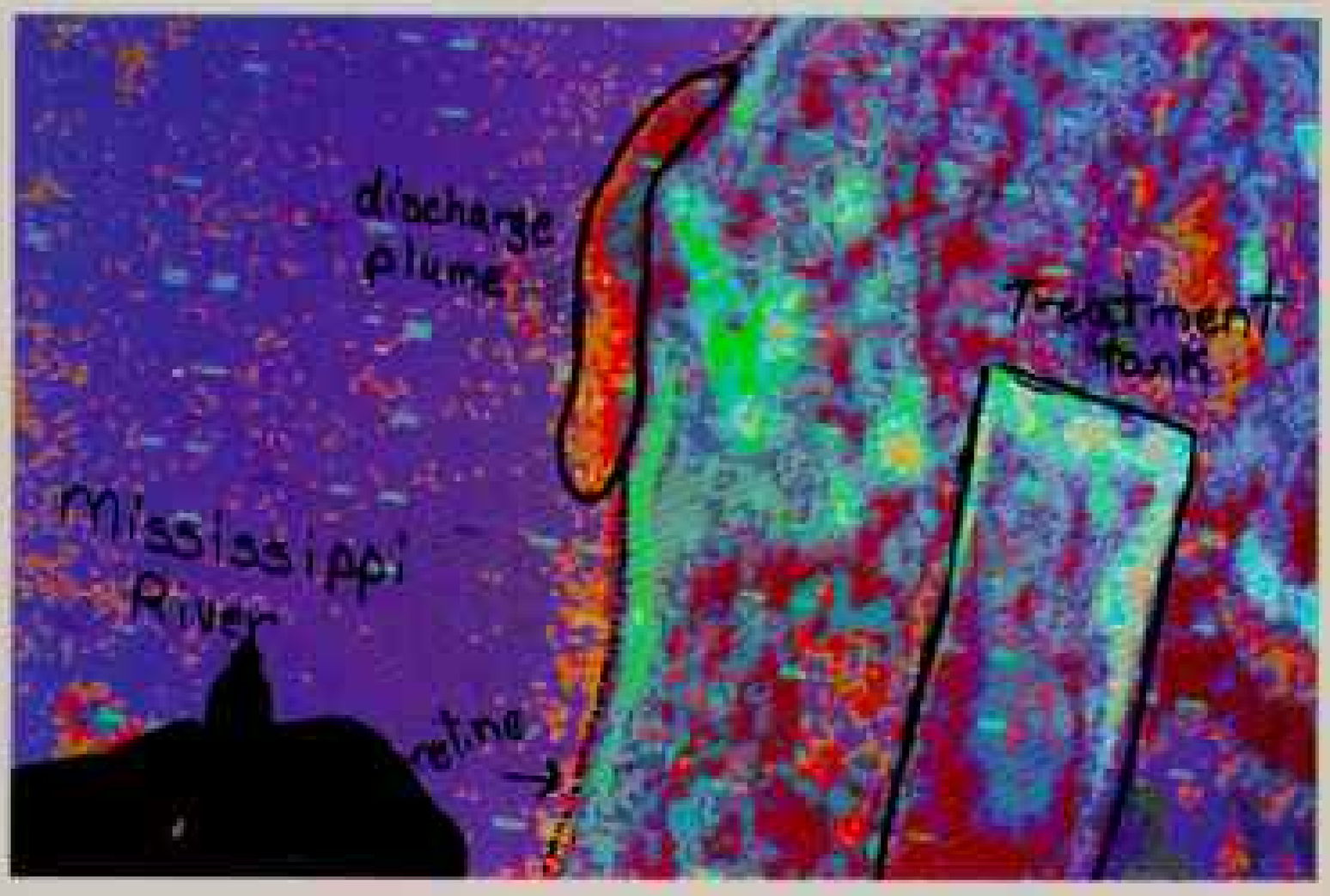
See:

An aged man sits on a fishing pier at Bonaventure's Landing, not far from Port Allen, a river town in Louisiana. There are three ugly, oily catfish in the lard tin he is using for a holding tank. He is asked if he intends to eat the fish.

"Say what?"

"They say there's pollution in the river. You going to eat the fish?"

He stares at me with frozen disbelief, and then he smiles until his old face becomes a delta of wrinkles. He speaks the final words on the matter: "Do the preacher read the Bible?"



■ Pollution monitor and pilot Al Cibuzar trains wing-mounted sensors on a discharge plume from a paper mill in Brainerd, Minnesota. To assess its impact on the river, he measures chlorophyll *a*, an indicator of phosphorus. Computer imaging (above) shows effluent that is rich in phosphorus but within antipollution standards.

THE SEWAGE IS MOSTLY GONE from the river now, and the general health of the water today is better than it was, say, half a century ago. However, there are other, different poisons in the Mississippi. Unlike the raw wastes once consigned to the river with a flush, these contaminants are chemical, originating with industry and agriculture. They can be found hidden in the mud, and sometimes in the flesh of fish. Some cause cancer in laboratory animals and are suspected of killing humans.

"Many things about the river have greatly improved in the past 50 years, but at the same time many other things have advanced into a greater state of contamination," said Robert H. Meade, a research hydrologist with the U. S. Geological Survey. "You don't see raw sewage in the water any more because of controls by the Clean Water Act. You rarely see oil slicks in the river any more because the Coast Guard has really been tough, and you see almost no phosphate detergents any more because states have been banning them."

Meade reckons that, off and on, he has spent a full year on a research boat on the river since 1986, the year the National Water Quality Assessment Program began and Meade drew the Mississippi as his assignment. The study has been completed now, and the findings are being prepared for Congress.

So he is sitting at his desk in Denver, in a government office not much larger than a Dumpster, as knowledgeable a counselor on potability to be found anywhere, and he repeats that, yes, there have been improvements, but. . . .

"The agricultural thing, the herbicides and insecticides, that's the big surprise," Meade said. He was speaking, of course, of the chemicals farmers use to control weeds and parasites. Such runoff, especially in the central Midwest, is a major source of pollution of the Mississippi and its tributaries. Some of the poisons, having become attached to sediment particles, have astonishing staying power. For example, the insecticide dichlorodiphenyltrichloroethane, or DDT, continues to be found in the Mississippi although it has been banned in the U. S. for more than 20 years.

One billion pounds of weed and bug killers are used throughout the United States each year. In the Mississippi two of these pesticides are of particular concern to the Environmental Protection Agency for their effects on the water taken out of the river for drinking purposes.

One is alachlor, used extensively for weed control in corn, cotton, and soybean fields, and the other is the even more heavily used atrazine, also applied to corn as well as sorghum and sugarcane. The

■ **Shedding light on sediment, water-quality specialist John Sullivan of Wisconsin's Department of Natural Resources uses a strobe to illustrate good light penetration in a river sample taken near La Crosse. Poor clarity would mean high levels of silt, which blocks sunlight from aquatic plants that provide food and habitat for wildlife.**

former chemical is classified as a "probable human carcinogen," meaning that it will likely cause cancer; atrazine is a "possible human carcinogen." EPA standards set a maximum of three parts atrazine per billion parts water, and, generally, levels are within that range. But in the spring, after application to fields, and following heavy rains, the levels in tributaries sometimes soar to as much as a hundred parts per billion.

An even more demanding burden on the waters is the amassing of sediment. At some places along the upper reaches it is filling in the river and backwaters, and especially the already shallow impoundments. As a result of the displaced water seeking outlets, new channels are being sculptured, and the shape of the river is changing. The great aquatic habitat of the northern backwaters of the Mississippi seems to be on an irreversible course to becoming terrestrial habitat. Much of the appeal of the upper river would be lost then, for the glimmering pools would vanish. And missing too would be the shameless burping of frogs and all the other music and dance of the creatures borne in the backwaters.

"There is no question—sediment is the real threat to the upper Mississippi today," said John F. Sullivan, water-quality specialist for the state of Wisconsin's Department of Natural Resources. "In addition to the material washing into the river because of erosion, there is added material as a result of the river cutting new channels. Then too the sediment that entered the tributary floodplains decades ago is still there, and with heavy rains some of that comes in."

Sullivan has been working on studies of the upper Mississippi since 1986, and during that time he has concluded that the overall quality of the water is better now than it was at the opening of World War II. "It may not be that we are up to level one, but there are indications that the river has improved and continues to do so," he said. He cited the lowering of levels of ammonia and an increase in the population of mink along the banks.

The number of mink taken by trappers in the 1960s was low, apparently because the animals were taking in PCBs—or polychlorinated biphenyls, synthetic industrial chemicals once used in making paint and electrical transformers. The chemicals seemed to affect the mink's reproduction, but now, with PCBs no longer manufactured in the U. S., their numbers have risen.

■ **Desperate measures failed last July as record floods devastated the Midwest, including East Dubuque, Illinois.**

While some debate the benefits of levees in major floods, such defenses in Louisiana keep the Mississippi from cutting a new course and stranding cities that depend on its flow. Engineers buttress banks of the Atchafalaya River, the big river's natural pathway to the sea.

OF ALL THE CHEMICALS introduced into the river, few, if any, are more insidious—more persistent—than PCBs. Almost completely banned in 1979, they continue to appear in the flesh of fish, although levels are falling.

PCBs are drawn to sediment, to which they attach and can remain for a hundred years. But traffic on the Mississippi—recreational boats as well as commercial barges—is constantly stirring the silt and resuspending the chemicals into the path of vacuum-mouth sweeps by fish. In the spring of 1975, 60,000 pounds of carp caught in and near Lake Pepin on the upper Mississippi had to be destroyed because of the presence of PCBs in their flesh.

By that time the petrochemical industry had been a fixture along the river in Louisiana, between New Orleans and Baton Rouge, for about 25 years. In this 150-mile-long corridor, where sugar and

DAVID GURALNICK, DUBUQUE TELEGRAPH HERALD

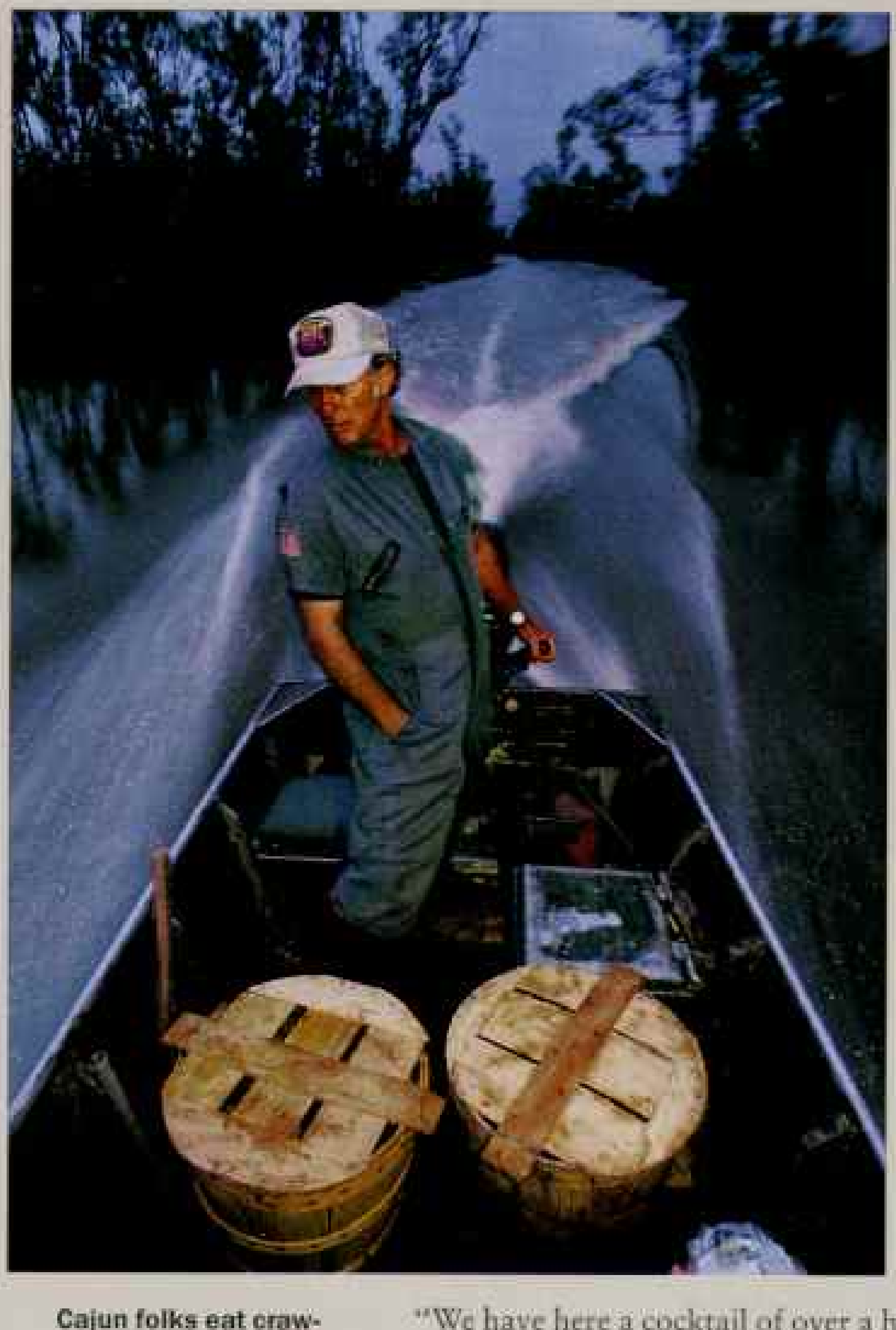
cotton plantations once claimed most of the land, thickets of stacks rise along the riverbanks, wafting putrid yellow emissions.

There is a spot with a fine art deco front in La Place, Louisiana, called the Airline Motors Restaurant Bar, and the paper place mats the waitresses slap down in front of customers identify industries in the river corridor between the state's two most important cities. They can be counted in the time it takes to get an egg and a biscuit. There are 130, but what isn't shown are the hundreds of industrial-waste sites. Nor is it revealed that Louisiana in 1991, as in the previous year, led all states in the release of chemicals into surface water, including 130 million pounds of toxic runoff into the Mississippi from just two fertilizer plants, both branches of Agrico Chemical Co., a subsidiary of Freeport-McMoRan Inc. of New Orleans.

There are oil refineries along the river here, and plants for the manufacture of many synthetic materials, such as the dry-cleaning bags that we are all cautioned not to put over our heads. Also, great quantities of fertilizers are produced, and a by-product of that process is a waste called gypsum. But unlike the wallboard material used in construction, this gypsum is contaminated with sulfuric and phosphoric acids as well as radium. In places collections of it are in mounds a mile square and 60 feet high. When it rains, eroded material washes into the Mississippi, although companies are now taking steps to shrink the flow.

"We have here a cocktail of over a hundred toxic chemicals in the water, interacting with one another to make other, new chemicals," Oliver Houck, a professor of law at Tulane University, said. How, he wonders, can treatment of such adulterated water possibly guarantee its safety? "This river is our drinking water here in New Orleans. We are sucking up these discharges. It's just as if you put your child's mouth up against the tailpipe of a car."

The 21-year-old Clean Water Act mandates permits for the discharge of industrial toxic wastes. But enforcement has been slack. "To this time, the federal government has been slow to bring action



■ Bayou boatman Norbert LeBlanc hauls bait to his crawfish traps in Louisiana's Atchafalaya swamp, then delivers them to locals for supper. "A lot of Cajun folks eat crawfish regular," he says. The hardy crustaceans thrive in the muddy waters cursed by fishermen upriver; statewide, 100 million pounds were harvested last year.

in this regard in the state of Louisiana," said Houck. "So we have started a program to bring legal action to clean up this mess." The demands for change are so strong now that industry, as well as the government, has started to pay heed.

Certainly, Dan Borné, president of the Louisiana Chemical Association, is taking it all seriously. "The pressure is on us to reduce these emissions," he said. "That's what the public wants. They're telling us to clean up our act, and, you know, our guys are getting the

message. It's going to take us years to build trust, because it took us years to lose it."

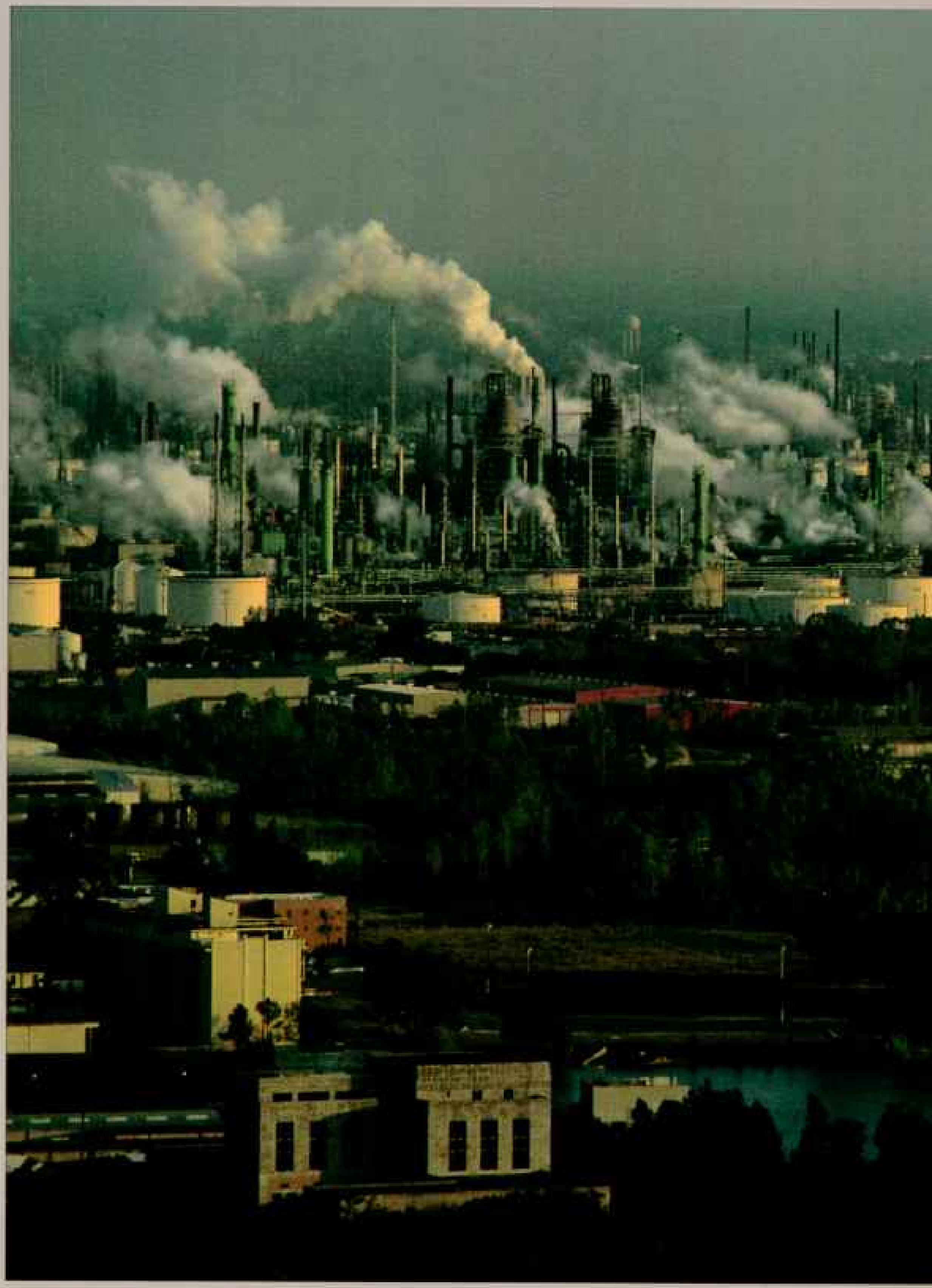
WILLIE FONTENOT wants to believe that, but he is too immersed in the wrongs of the past to entertain the pleas of industry for redemption. As the environmental advocate for the public in the Louisiana Department of Justice, he tracks toxic discharges with the tenacity of a bloodhound. He knows where foam-mouthed pipes drop the pollutants, and he knows the sites where the Mississippi, when high, washes in and over, and then falls back, heavy with contaminants.

It is of little wonder to him that the population of Louisiana's state bird, the brown pelican, was wiped out over a decade, starting in the mid-1950s, because fish in waters around the mouth of the Mississippi were laced with a pesticide called endrin. The stock of pelicans was reestablished with birds imported from Florida.

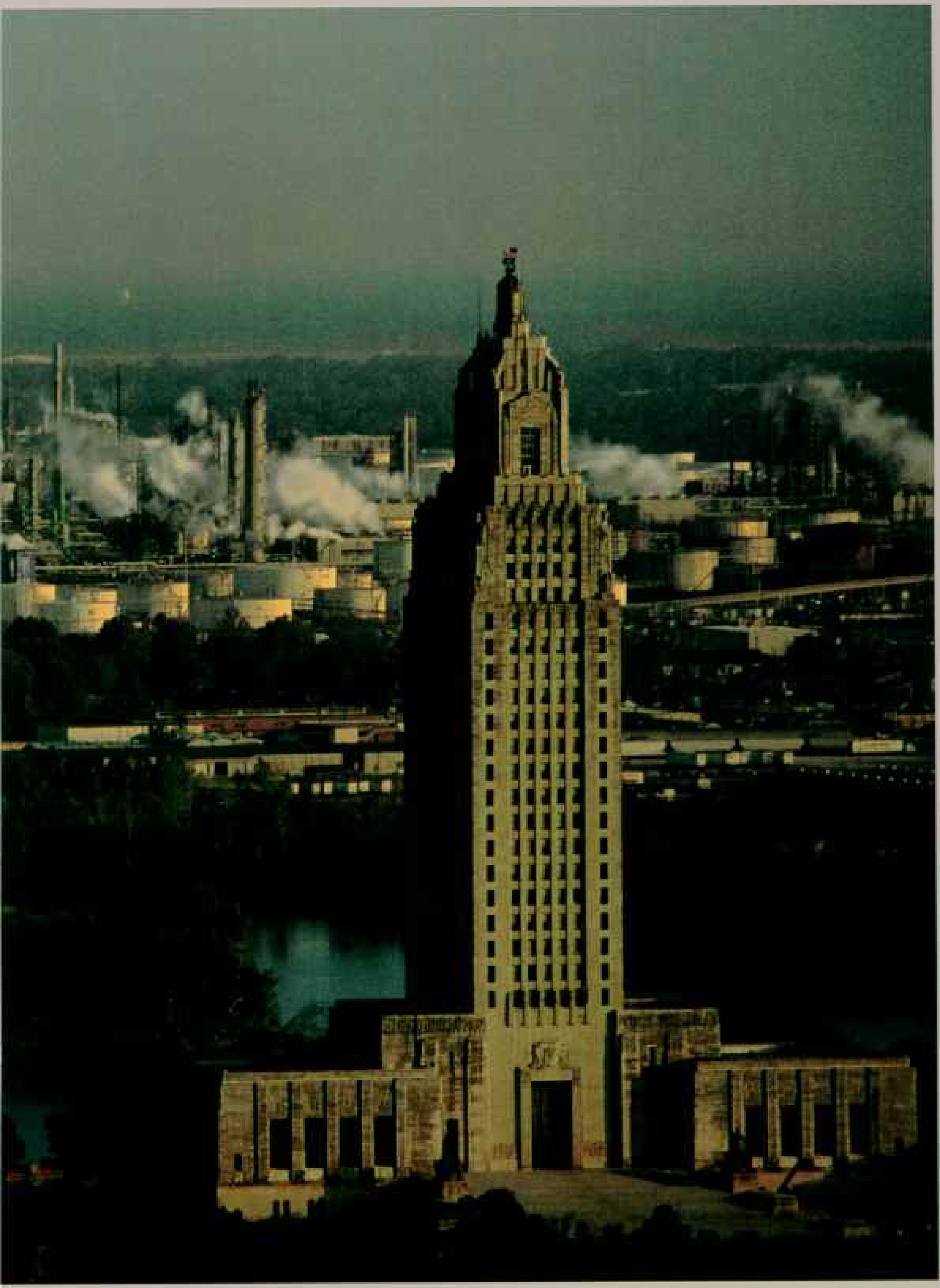
"I personally think the river is cleaner now than it was ten years ago," Fontenot told me, "but there's still a tremendous amount of materials being dumped in the water." He cited the release of fish-destroying dioxin into the river by three paper mills, and when I asked if that was legal, he replied, "That's a good question."

■ **"Just pinch off the tail and eat the meat—then suck the yellow fat out of the head," advises Nick Stipelcovich, Jr., who ate 32 pounds of crawfish in 45 minutes to place second in Louisiana's Breaux Bridge Crawfish Eating Contest.**

Crawfish are prolific in these parts, and recent floods have stretched out the season. Says a fisheries expert, "We've got so many crawfish we can't give 'em away."



■ Industry threw up a smoke screen in Louisiana in the 1920s, when oilmen moved in to tap petroleum fields on the lower Mississippi. Though railed against by Governor Huey P. Long, the petroleum industry crowds the riverbanks behind the State Capitol in Baton



Rouge (above), where Long is buried. Industrial chemicals, whose long-term effects are unknown, are most dense in the river from here southward—a region dubbed Cancer Alley by skeptical residents fearful of pollutants in the air and water.

State and federal monitoring agencies lack the money and manpower to do the job they'd like, and the degree of enforcement has often turned on political trends. But if the regulations are nebulous, they are at least in place, and that has been in large measure responsible for improvements in the quality of the water in the past decade.

Moreover, there is anger upon this riverfront land. Voices are being raised in the small churches where cardboard fans stir the steamy air of summer, and what was once so easy for a company desiring to locate along the lower Mississippi has become a challenge, even for a giant like Formosa Plastics Corporation.

There is a man named Wilfred Greene who lives in a single-story house behind a chain-link fence in the hardscrabble settlement of Wallace, halfway or so between New Orleans and Baton Rouge on the west bank of the Mississippi. It is one of those places in the Deep South where many of the houses appear to be abandoned, and the tragedy is that they're not.

Formosa Plastics planned to build the world's largest rayon-making plant on 1,800 acres of land in the Wallace area. It would have been a 700-million-dollar project, and jobs would become available. But there were those in the community with this concern for the health of

■ Clashing with relatively clear water in the Gulf of Mexico, the Mississippi bears a heavy load of sediment, diverted from delta marshes by man-made levees and channels and deposited in the sea. "The Gulf will be lapping at the levees of New Orleans in 50 years if we don't act now," warns Dugan Sabins of Louisiana's Department of Environmental Quality.

Yet there is hope: Encouraged by the river's improved health since raw wastes and phosphate detergents have been reduced, Louisiana aims to redirect the river's flow to sustain marshes.

And as researchers, environmentalists, and citizens themselves push for stricter chemical-effluent standards, optimists dream that the big river will mend.

people and the environment, and one of them was Wilfred Greene. He formed the RAP group, for River Area Planning, which challenged Formosa at every turn until the company abandoned its plans.

"We certainly believe there can be something done to help the community economically," Greene said, "but we don't want the chemical plants coming in here to destroy our lives."

Greene has lived in Wallace almost all his life. He is 71, and when he talks, he has to stop to squeeze some spray into his mouth to regain his breath. "There are people here who wanted the plant, and some of them don't speak to me to this day. But they'll come around to seeing that I was right."

A dirt road runs in front of his house, and on the other side of that is the levee, and then the Mississippi. He swam in the river here when he was a child, and I asked him if he would swim there now with industry so heavy in the area. "Not less I was fixin' to die," he said.

Of course, the sprawling, smoking, heavy-duty petrochemical plants are not solely responsible for damage to the lower Mississippi. The coastal marshes of the delta are disappearing at a rate of 25 to 30 square miles a year as they become open water, and that is something removed from the presence of toxic wastes.

"In the upper Mississippi the sediment is filling in the backwaters. Down here we want the sediment, but most of it goes into the Gulf. It seems we're from different worlds, the upper and lower rivers." Suzanne Hawes of the Army Corps of Engineers in New Orleans went on to explain that marshes remain stable as long as the soil is wet. But when they are drained for building projects, the organic matter dries out and compacts. Because of that, New Orleans is sinking. Some areas of the city are as much as 12 feet below sea level.

Hawes carries the title of project manager for the environment, and she can remember back to the mid-1960s when, she told me, there was little or no information on the quality of the waters of the Mississippi. "The chemical companies would not let scientists on their property to take samples," she said. "But that's over. They don't chase people off with guns any more. The river is being cleaned up."

THE NATION'S RIVER, like a patient long on a gurney in the emergency room, is being admitted for care. That can only please Lloyd Spriggle, a man I came to know one summer in Bay City, Wisconsin, where he was born 81 years ago and would retire as a rural mail carrier. He spoke of the joy of his early life on the Mississippi—the trapping of mink and muskrat, the fishing and clamming, the ice-skating by Thanksgiving at the latest. "The river was always good to me, and so I wanted to be good to it," he said.

Starting in 1963, he was a driving force behind a write-in campaign to institute quality controls for the river, and indeed, in time, the hundreds of postcards he had people send to officeholders resulted in the setting of early federal guidelines for swimming and fishing. And now he says the work must continue, for the river deserves that.

We walked out to the water's edge where a soft, marbled light of late day fell, and he started telling me about something that had happened the evening before. "There were so many of them around the light pole, I could almost hear them laugh," he said.

Mayflies. He was talking about the mayflies. They were back. □

The Promise of Restora

tion

Rebirth of a river

Rank and lifeless by the 1960s, the Nashua River in Massachusetts was a toxic stew of untreated sewage, running red with dye from paper mills. Today it's a haven for anglers and canoeists and a model for communities striving to clean the waters they have fouled.

COURTESY NASHUA RIVER WATERSHED ASSOCIATION (LEFT); GEORGE STEINMETZ

Restoration

New Ideas, New Understanding, New Hope

BY MICHAEL PARFIT

PHOTOGRAPHS BY
PETER ESSICK AND GEORGE STEINMETZ

THE GILA RIVER seemed to smoke with the dust of dissolving hills. Beside it a cliff made a hissing sound, its foundations torn by the water, its walls tumbling in cascades of sand. Rain had fallen in Arizona for weeks, and the Gila had climbed right out of a flood-control dam that was supposed to stop it. It drowned lettuce fields. It cut all the north-south roads. It broke irrigation canals. It grew and spread and carried photographer Peter Essick and me down the flood in a little rubber raft.

National Guard helicopters flew back and forth over the river. Bulldozers worked all day at the edges of fields, building walls later washed away in the night. It was a crisis: straightforward to fight, soon over.

Most of our water troubles are less obvious but more widespread: Across the continent a toll of pollution, diversion, and waste degrades water. But it's not like the Gila flood. We can't send in Guard helicopters; we can't just suspend life for a few weeks to get out of the jam.

People have long been convinced that with bulldozers and concrete we can control water and adapt it to our ways. We have changed water to our benefit in many cases, but we have also messed it up. The changes have often been drastic. We've turned rivers into lakes, deserts into alfalfa fields, aquifers into waste dumps. We've even changed the chemistry of rain. It's not just a crisis; we've undermined the foundation of life.

Yet the hydrologic cycle is, ultimately, a system of rebirth—the sun blazes, thunder roars, and water comes around again. Human beings, too, come around, to new ideas, new understanding, new hope.

GEORGE STEINMETZ

Mud brigade ■ Knee-high with muck, a Boys Club member totes trash pulled from a New Hampshire section of the Nashua River. Such volunteers have removed hundreds of tons of metals, plastics, and other rubbish. Yet they can't get a grip on more serious freshwater threats: fertilizers, pesticides, and oily pavement runoff swept in by rain.

In the past year of flying around North America, I found that hope in many places. There was hope in Washington State, where federal agencies are putting unemployed loggers to work restoring streams damaged by logging. There was hope in Richmond, California, where Peter Duda, an engineer at the Chevron oil refinery, volunteered to create a wetland on company grounds; the wetland now helps clean more than half the refinery's wastewater. There was hope in British Columbia, where a mild-mannered man named Roy Argue helps schoolchildren

BOTH BY PETER ESSICK

River rodeo ■ Riding a dozer, hydrologist Dave Rosgen herds boulders, trees, and soil to restore the natural meanders, floodplains, and fisheries of rivers clogged by erosion. After repair by Rosgen, the sinuous top leg of the San Juan's East Fork in Colorado teems with trout; the unrestored lower section remains silt braided and dying (right).

raise salmon fry in aquariums. There was hope in Colorado, where hydrologist Dave Rosgen (above) came riding out of the West in a cowboy hat and jeans, with a holster on his hip and hard words on his lips for those who would ignore the needs of a river:

"What a gunsel!" he says. "What a pinheaded snarf!"

Rosgen teaches technical courses in stream classification, protection, and restoration, but he ends many of them with philosophy from, of all people, Hermann Hesse:

> *'Love this river, stay by it, learn from it.' Yes, he wanted to learn from it, he wanted to listen to it. It seemed to him that whoever understood this river and its secrets, would understand much more, many secrets, all secrets.*

To Rosgen, learning the secrets of a river is a way to save it. "We do the damnedest things to the river without a basic understanding of what it's doing," he said one afternoon, during one of his courses. He was splashing around in a stream, a tape measure and pens in his holster, while students—hydrologists, biologists, and engineers from several government agencies—worked behind him.

Shouts echoed up and down the stream: "Seven!" "Fifteen!" "Thirty!" The students were measuring rocks in millimeters, which was part of Rosgen's system of learning about the natural state of individual rivers. If you can get that basic understanding, Rosgen said, you can show how human activities—logging or grazing, for instance—affect each waterway. And, as he and colleagues have shown from California to Maryland, if a river is damaged, you can restore it to a shape it will maintain on its own. "Here's a major rule," Rosgen said. "The river must take care of itself."

Four students came splashing up the stream, counting bends and riffles. Rosgen said: "Is this exciting or what?"

It is. In Florida I boated down a long ditch—all that was left of the Kissimmee River after the U. S. Army Corps of Engineers straightened it in the 1960s. Two biologists, an engineer from

the South Florida Water Management District, and I went roaring down the ditch between humps of spoil, then slowed, turned a corner, and slipped into an intimate, sinuous world of overhanging red maple trees and flocks of white ibis. This was what the river once looked like, and what some of it will look like again. It was a demonstration section of a new, 372-million-dollar Corps of Engineers project to turn 22 miles of canal back into 43 miles of Kissimmee curves.

I asked the young engineer whether she had ever anticipated working on this kind of restoration project.

"No," she said. "I always wanted to build a dam." She laughed. She liked what she was doing, which reminded me of Rosgen's students. Once—in the era when Grand Coulee Dam and the Tennessee Valley Authority were new—building dams was a focus of human drama and achievement, on the leading edge of change. But now that focus may be restoration. The dam days brought the hope of work, expansion, power; these days, though darkened by the shadow of self-inflicted catastrophe, bring hope for renewal.

IN THE WINTER I found hope way out East, on a 56-mile-long stream in Massachusetts and New Hampshire called the Nashua.

The story of the Nashua begins back in the 1960s—at what seemed a hopeless point in the history of North American water. Lake Erie was said to be on its deathbed. In Cleveland, Ohio, the Cuyahoga River caught fire. In many rivers sewage and industrial waste flowed untreated. One of the most blighted was the Nashua, where I flew to see a remarkable change.

"The river was small, but a tremendous number of people depended on it," said Erla Zwingle, another member of the Geographic's team of water reporters. I visited while she did research on the Nashua, which was once so polluted its fumes blackened paint on nearby buildings. We stood on a bridge over clear water. "Generations of families and industries survived because of this stream," Erla said. "So the cleanup depended on large numbers of people making large numbers of decisions."

The Nashua's pollution grew up with America: For more than a century wood, wool, shoe, cotton, and paper mills had dumped waste into its quiet flow. By the mid-1960s the river was classed as unfit even to receive sewage. Because of dumped dyes, people used to bet on whether it was going to be red, orange, blue, green, or white the next day. Then a woman named Marion Stoddart (page 117) started a campaign to restore the Nashua and its tributaries. It's been called a one-woman crusade, but in many ways it worked because it wasn't.

"Marion Stoddart didn't go out there as a lone person in the wilderness," Erla said. "She did it by making key allies."

"What we were working to do," Stoddart said, "was to get everyone on every level working together."

Stoddart built coalitions with businessmen, labor leadership, and paper companies—the worst polluters. She focused on economic as well as environmental issues. She gave bottles of dirty river water to key officials. At a hearing before the state water-pollution-control board to reclassify the river's quality rating, which would force the cleanup, she demanded a goal many thought unthinkable: water safe for swimming. "Come on, be realistic," she was told. She didn't back down.

Within a few years people cleaned up their businesses, changed state law, and testified before Congress. And with federal help eight treatment plants have been built or upgraded, and a broad conservation buffer zone called a greenway has been created along about half of the Nashua and two major tributaries. Today most of the industry is still there—and many parts of the river are safe for swimming.

"Marion Stoddart qualifies as a hero," Erla said, "but the Nashua shows that heroes don't accomplish things on their own. Everything worked because everybody worked."

Hope germinates and spreads. The same thing happened on a number of rivers. The federal Clean Water Act of 1972 attacked point-source pollution—the kind that comes directly from industries and treatment plants. That and efforts by citizens restored many notoriously damaged rivers. From the air I have watched water-skiers cutting arcs in the Ohio just downstream from Pittsburgh and have marveled at the beautiful blue waters of Oregon's

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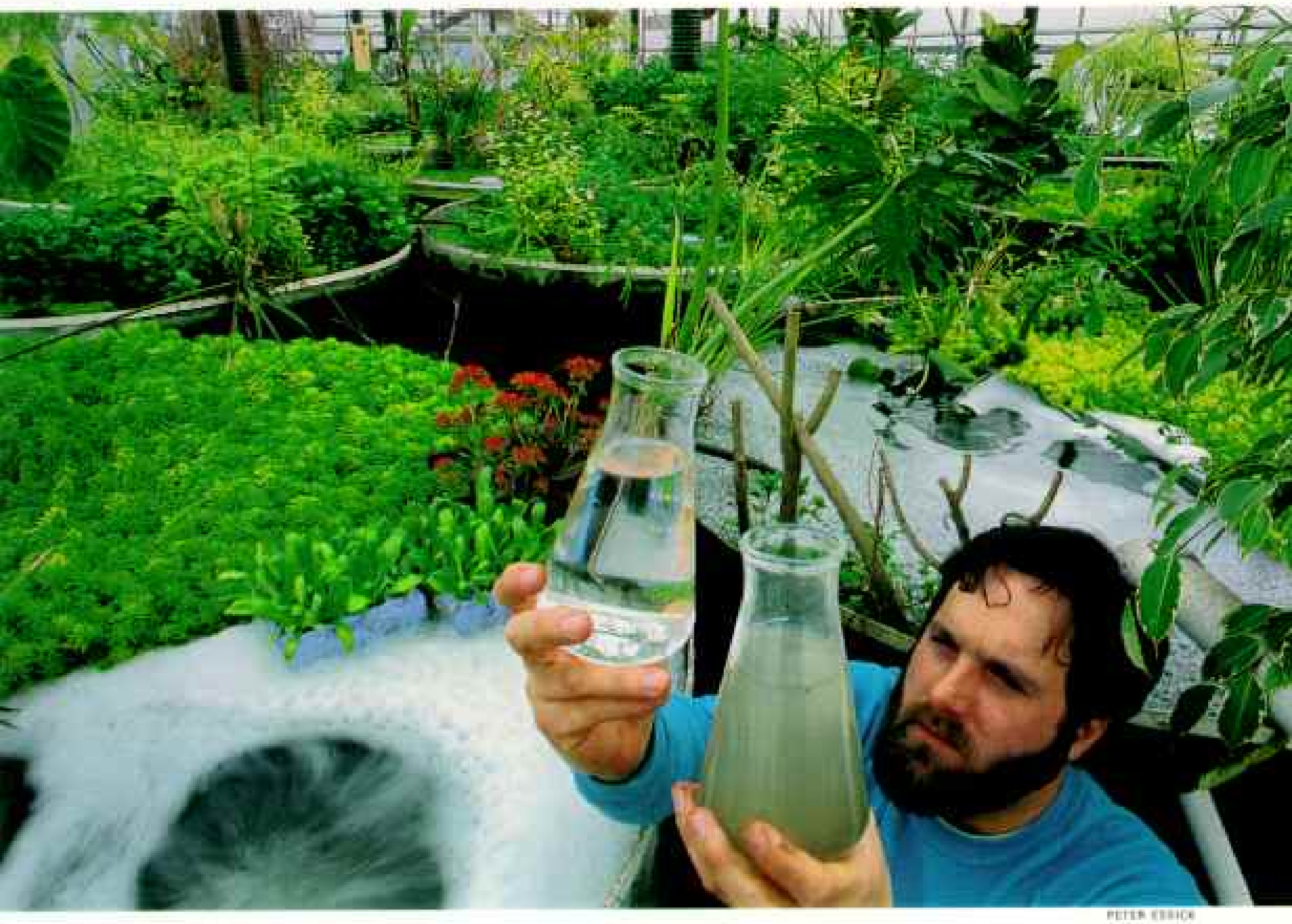
California photographer GEORGE STEINMETZ took his camera around the world for NATIONAL GEOGRAPHIC articles on oil and alcohol. Recently, he covered the Italian city of Milan.



PETER JESSICA

Sludge busters ■ Plants, bacteria, snails, and fish with an appetite for filth naturally break down sewage piped into vats at an experimental greenhouse in Providence, Rhode Island. After about five days the brew is safe to discharge, nearly drinkable, and even smells good, says manager Scott Sargert, eyeing before-and-after samples.

Willamette, once an industrial ruin. Now that phosphate detergent use has been cut back, even Lake Erie is sitting up in bed. I've flown down Maine's Penobscot River, where salmon have come home in numbers not seen for decades. And I've watched ducks feeding at the mouth of the Cuyahoga itself.

YET THESE STORIES are just a beginning. Much of our water is still a mess. The Clean Water Act did lower some point-source pollution, but nonpoint sources, also called polluted runoff, remain rampant. The natural system of lakes, streams, and water movement is so complex that attempting to clean up without taking care of the whole process is like trying to keep a loved one's heart beating in a glass case. For instance, to help stop polluted runoff, you must protect the natural landscape along the bank of the river—the riparian zone. Or, as we've learned from the Cape Cod aquifer in Massachusetts and the Edwards aquifer in Texas, to get clean and abundant supplies of groundwater, you have to pay attention to what's going into the huge stone sponge of the aquifer and how much is going out.

"What initially appears complex," Rosgen once told me, "upon further examination turns out to be more so." Yet we don't have the political structure to cope with this complexity. So people like Marion Stoddart and Dave Rosgen, the river keepers, and sometimes even the Corps of Engineers all have one thing in common: They're trying to figure out better ways to adapt politics to water.

The most useful political forms have a structure similar to the broad, interwoven nature of watersheds themselves.

Water draws boundaries between empires of flow. The most familiar to North Americans is the Continental Divide, which stands between the Pacific and Mississippi drainages. Inside the boundaries—within the watershed—every stream shares its final destination with all others. The Mississippi's watershed is the largest: 1,245,000 square miles—41 percent of the surface of the lower 48. There are some two dozen major watersheds in the U.S. alone—vast drainage systems that end up in the Columbia, the Rio Grande, the Hudson, the Colorado.

WATERSHEDS COME in families: nested levels of intimacy. On the grandest scale the hydrologic web is like all humanity—Serbs, Russians, Koyukon Indians, Amish, the billion lives in the People's Republic of China—it's broadly troubled, but it's hard to know how to help. As you work upstream toward home, you're more closely related. The big river is like your nation, a little out of hand. The lake is your cousin. The creek is your sister. The pond is her child. And, for better or worse, in sickness and in health, you're married to your sink.

The intimacy of the smallest watersheds may be a key to their restoration: At that level every individual can have an effect. "It's almost impossible to address water quality on the main stem of a river," says James Fisher of the National Watershed Coalition. "If you do it one small watershed at a time, you still have public support. Small size is the advantage."

This replaces Big Brother with Joe down the creek. Stopping polluted runoff with laws, enforcement, and fines alone would require an army of water cops, but your neighbor's peer pressure has almost as much clout. "We know when someone has done something bad," said a California farmer. This process cleaned up a creek in Alabama damaged by polluted runoff from local farms. Farmers who were reluctant to protect the creek were persuaded more by their neighbors than by the law. And the rewards are immediate: If you fence livestock out of a creek, bacteria levels will decrease and new vegetation will grow in by the next year.

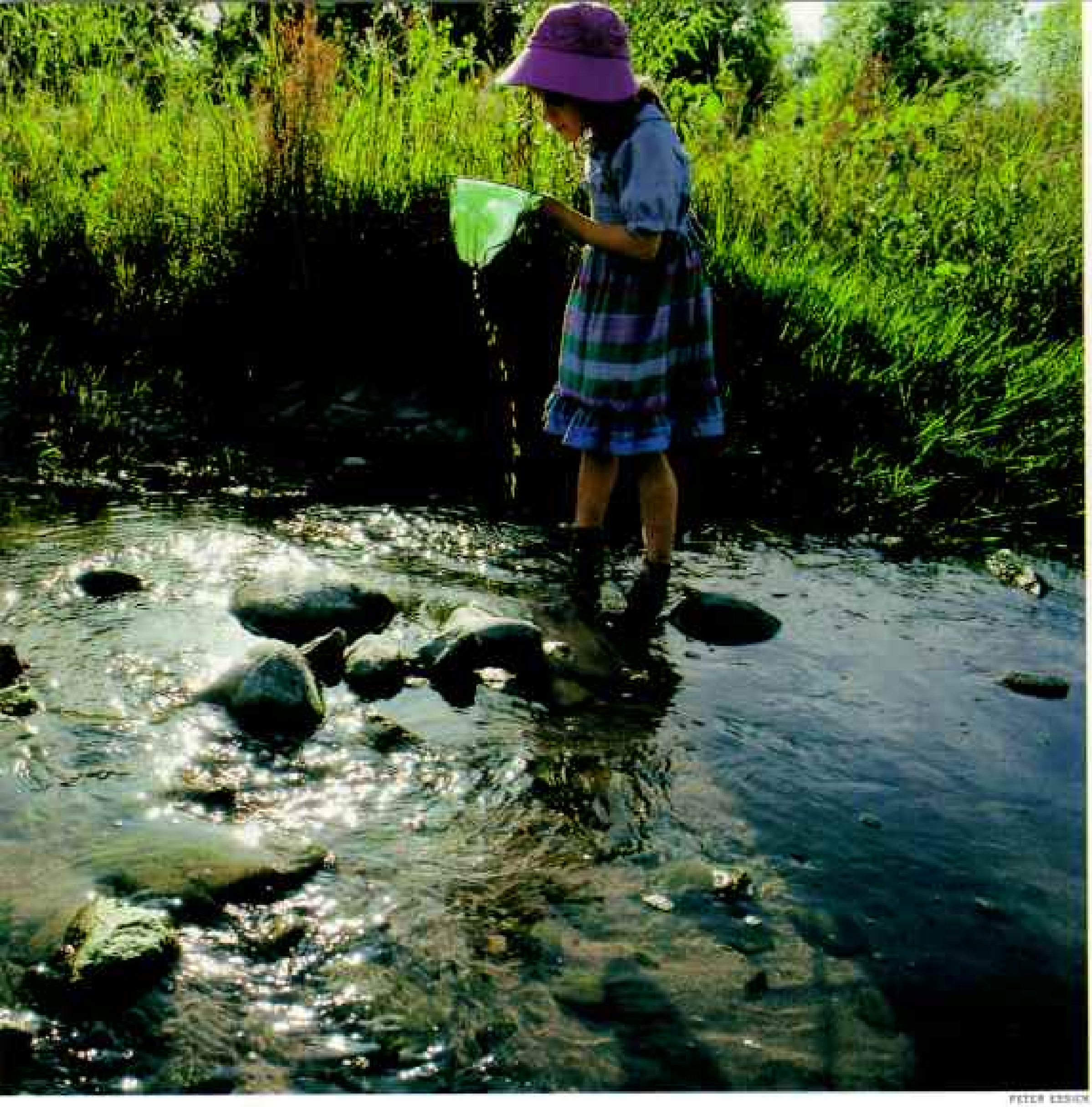
Hoping to tap this power, the Tennessee Valley Authority has begun organizing its

cleanup efforts into 12 separate watershed groups called River Action Teams. This may be part of what one environmentalist called the ideal world of water politics. In that world an umbrella organization covering a major watershed provides consistency, planning, and support for the many tributaries of local energy.

These are exciting times. Some of this ideal world may actually come true. In the spring I even found hope near Washington, D. C.

It was a national conference called Watershed '93 held in Alexandria, Virginia. The organizers had expected 800 people, but more than a thousand showed up from all over the U. S.—a fire marshal's nightmare, each room jammed, doorways blocked by people.

I roamed from crowded room to crowded room, learning about manure control in one,



PETER ESSICK

River redux ■ Long ago pumped dry by farms and towns, the Santa Cruz River in Tubac, Arizona, is again a toe-cooling oasis, where Justine Baker, five, nets minnows. The river's salvation: 13 million gallons a day of sanitized effluent from the Nogales wastewater-treatment plant. Such effluent streams create riparian refuge for wildlife.

discharge permits in the next, and pollution enforcement in a third—"When in doubt, fine 'em. Gets their attention."

A familiar voice floated from another room. " . . . pinheaded snarf!" it said. I got closer and heard it quoting Hermann Hesse: "Love this river, stay by it, learn from it. . . ." I couldn't see the speaker through the crowded doorway, but I had an idea the voice wore a big hat. Finally I saw him. Yup. Dave Rosgen. "If we have to get to restoration," he said later, "we've lost the battle."

This was not what I expected Rosgen to say. He was, after all, the restoration cowboy. But it made sense. Even Rosgen's meticulously restored streams have a look of plastic surgery; you know they cover a lot of injury. The larger challenge is to prevent such damage from happening in the first place.

Though many of our lakes and rivers are not healthy, water still flows over some areas of this continent almost as freely as it did centuries ago. Those regions are vital to the watershed. It's not just a matter of scenery or

PETER ESSICK

Gooey lesson ■ Pond algae make a point for teacher Nancy Crook with second graders Juliane Sanders and Tara Nguyen (standing), whose Marietta, Georgia, elementary school uses an Adopt-A-Stream program to work water issues into the curriculum. "We need water, and animals do too. So we have to keep it clean," says Juliane.

recreation. Every bit of the system that still runs without interference is like a piece of ancient but critical machinery we no longer know how to build. It's of inestimable value. Ironically, some of North America's largest cities are the most rigorous protectors: To meet quality regulations, both New York and Boston are developing tough watershed provisions to protect their supplies—buying land, limiting development, controlling farming, repairing old sewage-treatment facilities. Programs like Adopt-A-Stream and Save Our Streams get volunteers to both preserve small watersheds and educate adults and children about their value. Just as Western medicine is learning it's as important to prevent illness as to treat it, we're also learning from water how vital it is to protect the health that's still there.

Some environmentalists push for new laws or additions to programs like the National Wild and Scenic Rivers System. Others, like Rosgen, seek ways to protect water from damage while still using it and its watersheds. "We have to produce beef," Rosgen said. "We have to manage timber stands. Water-resource management is not necessarily preservation."

This kind of management involves simple but controversial things, such as setting houses and farm fields a certain distance back from stream banks or changing bridge, highway, or culvert designs to make room for a stream's natural meanderings. And it involves complex and costly things like separating storm drains from sewer lines to prevent combined sewer overflow (CSO) discharges. But most of all it involves political and economic will.

"I'm optimistic about what we can do," said John Cairns, Jr., chairman of a national committee on restoration of aquatic ecosystems. "I'm pessimistic about what we will do." The price of change is high. In the watersheds where New York City gets its water, for instance, controls on development may hurt the economies of towns already less affluent than the New York boroughs that consume the water. How much will today's taxpayer spend to restore water hurt by yesterday's sins? Will Louisiana yield authority over the Mississippi to a committee in Wisconsin, or the other way around? "That's the big question, isn't it?" a water specialist said at Watershed '93. "How do you get people to give up power in order to survive?"

AS I RODE the Gila River's rampage, I wondered if we will ever give up the illusion that we can control water. There is hope. "We represent the river," Rosgen said once, and I met a lot of people who think of themselves as advocates for water. Theirs is an attitude that treats water as if it were a life-form, in need of friends, and that recognizes it the way we'd recognize an allied nation that's beyond our control. Such an attitude acknowledges the freedom of water, its mystery, its strength, its sovereignty, and honors what it may freely give.

"All of us believe we are working for the

Making waves ■ When Marion Stoddart explored the Nashua basin in the 1960s, "the highest form of life in the North Nashua was sludge worms." Outraged, she has spent 30 years getting industries to treat waste, citizens to monitor water quality, and builders to limit riverbank development. Today the activist canoes the waters she helped revive.

river," said Cynthia Poten, a keeper of the Delaware River. "We're working for current and future generations, and for all living things."

In British Columbia, Roy Argue said, "In Prince George almost nobody makes money off salmon. But people work just for the sake of having salmon in the stream. I think that's wonderful."

"Water is a living thing," said Clarence Alexander, the Gwichin Indian chief I met in Alaska long ago. "You have to treat it as such. We don't cuss out the river. We treat it like it's got a soul of its own. This might be our superstition here, but our superstitions are pretty much like real."

The Gila ran exuberantly out of control, and Peter Essick and I rode the brown waves, carried away by water. The skeletal branch of a mesquite tree rose from the river, thrashed the surface, then sank. A trailer held its aluminum hem high but got wet anyway. Refugee rabbits paced its deck. A whirlpool opened, sucked itself tight, and disappeared. The river was swift but casual, tearing up farmland and costing millions with little apparent effort, like someone who crunches your knuckles just shaking hands. It didn't seem like a place to be hopeful, but I was. Change happens.

We swept around a bend and there, on a cliff above the water, was a line of pickup trucks, parked with doors open. The people of the valley had come to watch. They stood beside their pickups, little silhouettes of human beings with light behind them, standing there without moving, as if transfixed by what they might learn from the river.

Pulling together ■ On the leaf-flecked Nashua River, boys from Groton School in Massachusetts are too young to recall the days when capsized boaters raced to a clinic for tetanus shots. Threats to the river remain: Roughly a sixth of the basin's waters still

GEORGE STEINMETZ

fail to meet quality standards, largely because of polluted runoff curling through tributaries. Since rivers ignore the boundaries of town and state, clean-water advocates promote the regulation of entire basins to protect the waters that ultimately link us all. □

Resources

Further information on freshwater issues can be obtained from the following selected sources.

Water Information Lines

American Ground Water Trust:
1-800-423-7748

U. S. Environmental Protection Agency: 202-260-2090

U. S. Department of Agriculture Soil Conservation Service: 1-800-THE-SOIL

Organizations

Adopt-A-Stream
P.O. Box 435
Pittsford, NY 14534-0435

- Organizes volunteer programs to clean up and monitor water quality.

American Rivers
801 Pennsylvania Avenue S.E.
Suite 400G
Washington, DC 20003-2167

- Seeks to preserve and restore America's river systems.

American Water Resources Association
5410 Grosvenor Lane, Suite 220
Bethesda, MD 20814-2192

- Provides posters ($5) and booklets ($1) on water use.

American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235-3098

- Operates Blue Thumb campaign to preserve water resources.

America's Clean Water Foundation
750 First Street N.E., Suite 911
Washington, DC 20002-4241

- Develops and distributes educational materials.

Freshwater Foundation
725 County Road 6
Wayzata, MN 55391-9611

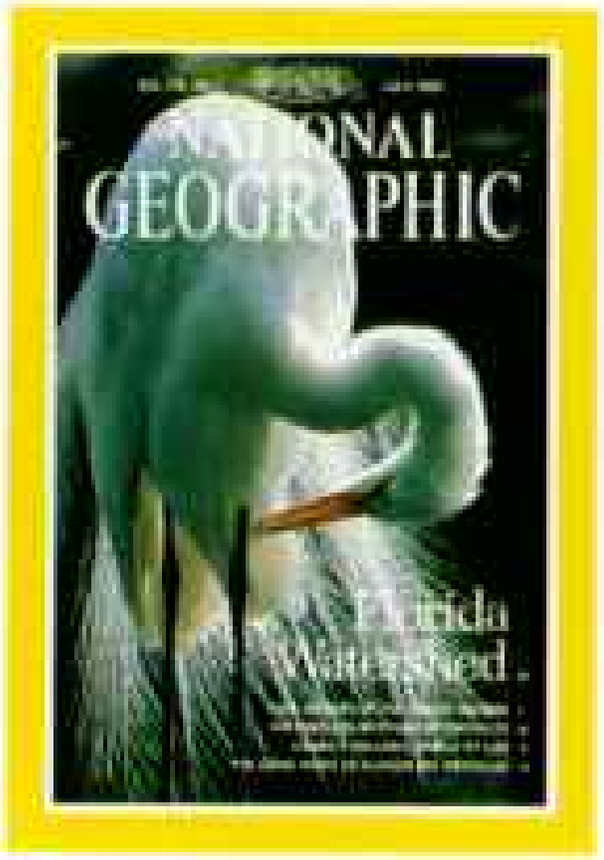
- Provides educational programs and freshwater research.

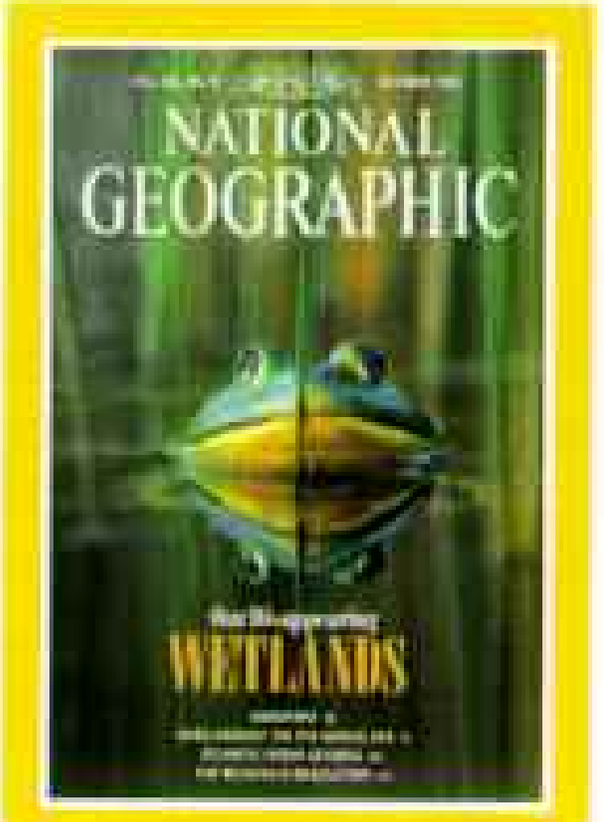
Izaak Walton League of America
1401 Wilson Boulevard, Level B
Arlington, VA 22209-2318

- Operates Save Our Streams program and provides publications.

National Water Information Clearinghouse
U. S. Geological Survey
423 National Center
Reston, VA 22092-0001

- Supplies federal water data.





Nebraska Groundwater Foundation
P.O. Box 22558
Lincoln, NE 68542-2558

- Clearinghouse for general groundwater information. Produces Children's Groundwater Festival.

Water Education Foundation
717 K Street, Suite 517
Sacramento, CA 95814-3408

- Focuses on water use in western states. Provides information to teachers and others.

Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994

- Presents materials on water-quality issues.

National Geographic Programs and Products

Television Special
"The Power of Water" will air on PBS at 8 p.m. ET, November 10.

Videos
"Fresh Water: Resource at Risk," grades 4-9, 25 min., 1993.

"Great Lakes, Fragile Seas," general, 59 min., 1991.

"Water: A Precious Resource," general, 23 min., 1980.

Wonders of Learning Kit
"Captain Conservation: All About Water," grades K-2, 1993.

Computer Courseware
Kids Network: "What's in Our Water?" and "Acid Rain," grades 4-6.

GTV interactive videodiscs: "Planetary Manager," grades 5-12/adult.

National Geographic Articles

"Chesapeake Bay: Hanging in the Balance," June 1993.

"Ogallala Aquifer: Wellspring of the High Plains," March 1993.

"Our Disappearing Wetlands," October 1992.

"Lake Tahoe—Playing for High Stakes," March 1992.

"The Colorado: A River Drained Dry," June 1991.

"South Florida Water: Paying the Price," July 1990.

"The Great Lakes' Troubled Waters," July 1987.

"Our Most Precious Resource: Water," August 1980.

Other Publications

America's Renewable Resources: Historical Trends and Current Challenges, edited by Kenneth D. Frederick and Roger A. Sedjo, Resources for the Future, Washington, DC, 1991.

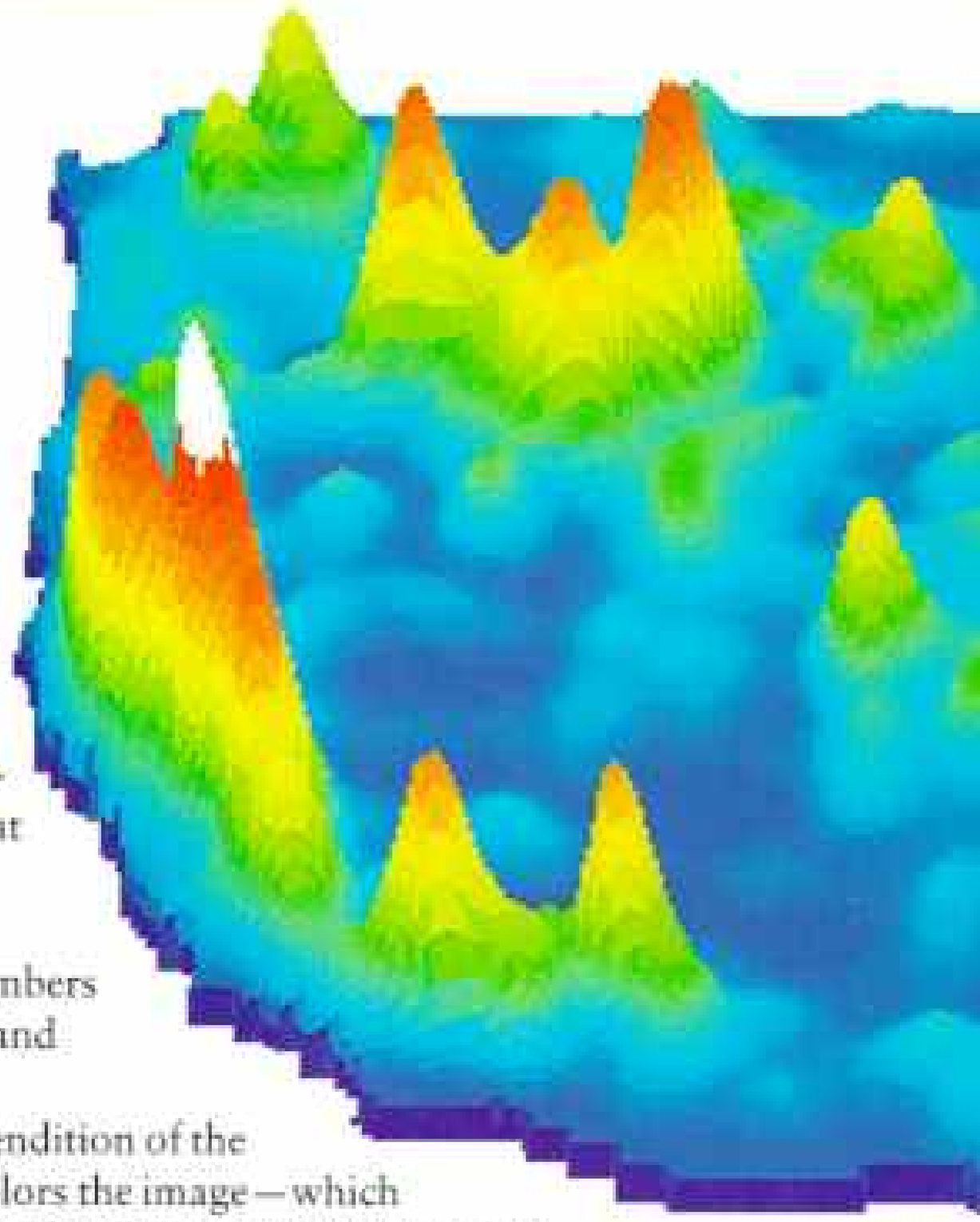
Cadillac Desert: The American West and Its Disappearing Water, by Marc Reisner, Viking Penguin, New York, 1987.

Overtapped Oasis: Reform or Revolution for Western Water, by Marc Reisner and Sarah Bates, Island Press, Washington, DC, 1990.

The 1993 Information Please Environmental Almanac, compiled by World Resources Institute, Houghton Miffiin Company, Boston, 1993.

Introduction

"When the well's dry, we know the worth of water."



BENJAMIN FRANKLIN quoted those prophetic words nearly two and a half centuries ago, when America's wells—both literally and figuratively—overflowed with water.

Today those same wells are in danger of running dry, and along with the rest of the world we face a critical shortage of clean, fresh water.

The problem is not the *supply* of water; earth has virtually the same amount today as it did when dinosaurs roamed the planet. Ninety-seven percent of that supply is in the form of salt water. Only 3 percent is fresh, and two-thirds of that is ice.

The problem is simply people—our increasing numbers and our flagrant abuse of one of our most precious, and limited, resources.

The bizarre image at right, a computer-graphics rendition of the United States, dramatizes the problem. In varying colors the image—which was created by the U. S. Geological Survey—indicates the volume of withdrawal of surface and ground water throughout the country for most uses. White represents the highest level, ranging down through red, yellow, green, and, finally, blue for the lowest level. California and Idaho show the areas of highest use, thanks largely to crop irrigation. In California, for example, 78 percent of the water used goes to agriculture and only 22 percent for urban needs.

Altogether the United States withdraws 339 billion gallons of ground and surface water a day. Although four *trillion* gallons of water falls on us daily in the form of precipitation, much of that disappears in evaporation and runoff, and our rivers and aquifers are being dangerously fouled and depleted. Occasionally, as with the catastrophic flooding of the upper Mississippi Valley last summer, we seem cursed with an overabundance of water, but such events are mercifully rare.

This special 13th edition of the NATIONAL GEOGRAPHIC is devoted exclusively to the subject of fresh water—our use and abuse of it, our potential supply, and our prospects for the future. The edition is only the second of its kind in the Society's 105-year history; in February 1981 we published a special edition on the subject of energy.

That report focused on major sources of energy—oil, coal, natural gas—as well as various substitute sources. But there is, of course, no substitute for water; it has already begun to replace oil as a major cause of confrontation in the Middle East. The confrontations can only grow and widen.

This special edition on water has been more than two years in the making. A team of top photographers, writers, and editors crisscrossed North America, exploring people's attitudes, habits, and perceptions of water. The team found historic mismanagement of water, blatant cases of waste and pollution, and widespread ignorance of water problems. Yet they also found a growing awareness of the challenges water presents and an encouraging readiness to face them.

One thing is certain: We must mend our ways. The United States uses three times as much water a day—1,300 gallons per person—as the average European country, and astronomically more water than most developing nations. When we realize that it can take a thousand gallons of fresh water merely to produce one eight-ounce steak, then—as Ben Franklin put it—we know the worth of water.

The question is how we will use that knowledge.

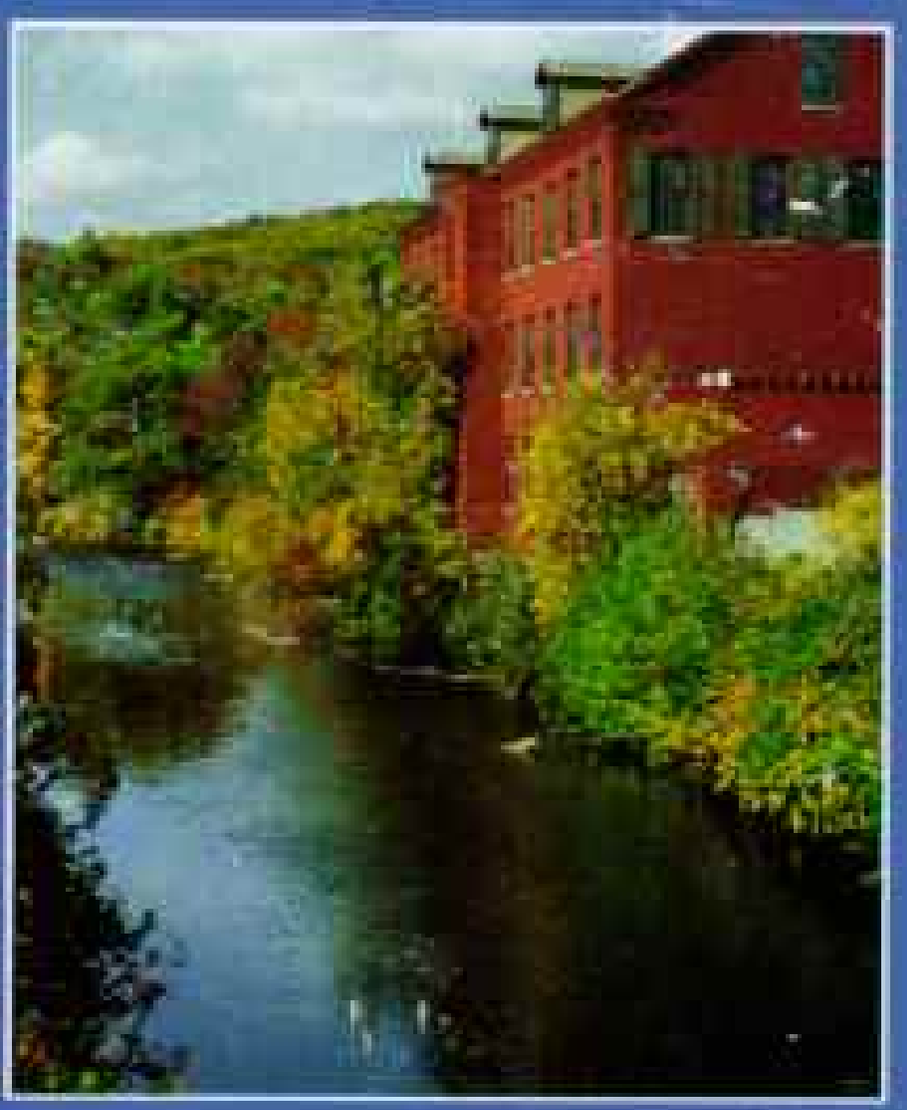
—WILLIAM GRAVES, EDITOR

Double Map Supplement: U.S./Water

Supply
Sharing the Wealth of Water

Development
When Humans Harness Nature's Forces

Pollution
Troubled Waters Run Deep



Restoration
New Ideas, New Understanding, New Hope

NATIONAL GEOGRAPHIC MAGAZINE

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