quality and quantity. Pumping rate and volume shall be monitored continuously and periodic reporting shall be required. Weirs, or other stream gauging methods, shall be installed in the upper tributary of Big Spring Creek and in the stream channels immediately downstream of the outfall structures at Big Spring and the Buckley property. Stream flow shall be monitored during groundwater pumping, at a frequency to be determined by DNR, to demonstrate compliance with any established minimum flows. Water levels in the ponds shall also be monitored periodically, at a frequency to be determined by DNR, by recording levels from staff gauges in the ponds. Pumping shall be reduced or stopped if flows or pond water levels fall below established minimum values. An annual fisheries survey shall be conducted in Big Spring Creek and below the unnamed tributary from the Buckley property ponds, in consultation with DNR, to characterize species composition and abundance once groundwater pumping begins. An annual macroinvertebrate survey shall also be conducted, in consultation with DNR, to characterize community composition and assess water quality and quantity once groundwater pumping commences. Continuous water quality and quantity monitoring shall be conducted annually in July or August once groundwater pumping begins, in consultation with DNR. Results of the annual fisheries, macroinvertebrate and water quality and quantity monitoring shall be summarized in a report and submitted to DNR shortly after data collection. It is anticipated that stream flows and pond water level measurements shall be submitted to DNR on a more frequent basis (e.g., monthly). Periods when pumping ceased or was reduced due to low flows and/or water levels shall be indicated in the reporting. The monitoring program for the existing Big Spring Creek channel will likely be revised if, while not required by this Agreement, the stream channel is restored. While the main elements of the program may remain similar, monitoring locations may vary. A modified monitoring work plan shall be submitted if and when stream channel design is complete.

c. **future long-term monitoring of wetland resources** shall be completed to supplement wetland reconnaissance surveys completed by GSWA in March and April 2000 and to provide data that will be used to assess and protect the ecological health and diversity of wetland resources in the vicinity of the proposed high capacity wells.

The scope of work for the study shall consist of three primary phases taking place over a period of four years: pre-operational field studies (2000); operational monitoring (2001 – 2003); and adaptive management (2000 – 2003).

The objectives of the pre-operational field studies phase are to refine the baseline characterization of wetland resources in the project area; refine the analysis of potential impacts of proposed project elements on wetland resources; and establish the baseline parameters and framework for long-term monitoring activities.

Work elements of the pre-operational field studies phase shall include wetland boundary delineation; plant community characterization; endangered/threatened species surveys; soil and water analyses; water level monitoring; and establishment of permanent vegetation quadrats to facilitate species identification and percent cover estimates. GSWA shall submit a comprehensive report to DNR by September 30, 2000 that describes the methods, relationship to ongoing monitoring activities, findings, and conclusions of the work elements completed during the 2000 summer months.

The objectives of the operational monitoring phase are to evaluate the significance of observed hydrologic or vegetative community alterations in wetlands during groundwater collection system operation, and the relationship of these alterations to system operation; and establish the limits of influence of the groundwater collection system with regard to wetlands in the project area.

Work elements of the operational monitoring phase shall include vegetation monitoring; endangered/threatened species surveys; water analyses; water level monitoring; and an impact analysis.

GSWA shall submit to DNR a comprehensive report by mid-October in each year of monitoring (2001 – 2003) describing the methods, findings and conclusions of the work elements. Species lists, interim findings and final reports shall also be submitted to DNR.

The adaptive management phase provides opportunity for changes in operational limits based on monitoring results in wetlands. The objectives are to evaluate the need for operational adjustments of the groundwater collection system based on wetland health; develop recommendations regarding on-going wetland monitoring needs beyond the initial period; and, while not required by this Agreement, establish wetland resource restoration and enhancement goals if appropriate.

Work elements of the adaptive management phase shall include operation plan review to assess the need for operational adaptations to avoid impacts on wetland systems due to natural, temporal events (e.g., above- or below-normal precipitation) or groundwater extraction rates; monitoring program review; and development of a wetland restoration plan.

All data gathered in the future under the additional groundwater, surface water and habitat monitoring described in this numbered paragraph shall be submitted to DNR for its review and evaluation. The data shall be used as the basis for modifying conditions in any approval of (a) high capacity well system(s) to ensure the continued protection of the groundwater and nearby surface waters and wetlands and associated biological communities.

3. The commitments made by GSWA in the documents it has submitted to DNR as part of the application for (a) high capacity well system(s) **(the groundwater study; the aquatic resources study; and the wetland resources study - see numbered paragraph 1)** are all incorporated by reference into this Agreement.

4. The commitments made by GSWA in the work plans it has submitted to DNR (to do **a future groundwater study; a future aquatic resources study; and future long-term monitoring of wetland resources** – see numbered paragraph 2) are all incorporated by reference into this Agreement. The descriptions of future work activities provided in the final work plans prepared by URS – Dames & Moore and submitted to DNR on behalf of GSWA shall, once approved by DNR, take precedence over the studies summarized in numbered paragraph 2 of this Agreement. This Agreement does not require any stream habitat restoration activities, stream channel restoration, or wetland resource restoration or enhancement.

5. This Agreement shall be incorporated by reference into any subsequent conditional approval of (a) high capacity well system(s). Any violation of a commitment documented herein shall become a violation of that conditional approval and will be enforceable as such.

6. Following receipt of the application for (a) high capacity well system(s) in Adams County and GSWA's related environmental information, DNR assessed the potential environmental impacts of the proposed project and prepared an Environmental Assessment (EA). DNR issued a news release announcing that the draft EA was available for public review and comment. While the law did not require it, DNR held a public informational meeting at the start of the public review period to describe the draft EA findings and to invite public comments. After the review period closes DNR shall review and evaluate all comments received (both oral and written statements submitted at the public informational meeting and written comments received within the public review period). DNR shall subsequently determine whether any additional environmental review, such as an Environmental Impact Statement (EIS) is needed. Following completion of the environmental analysis and review procedure, DNR shall render a final decision on the application for (a) high capacity well system(s).

7. DNR shall use its authority under section 281.17, Stats., and chapter NR 812, Wis. Adm. Code, to ensure that the proposed withdrawal will not adversely affect or reduce the availability of water to any public utility furnishing water to the public.

8. The Applicants have consented to DNR using its broad authority under sections 31.02, 227.44(5), 281.11 and 281.12, Stats., to protect the groundwater and nearby surface waters and wetlands.

9. Wisconsin has a "reasonable use standard" relating to the withdrawal, use and sale of groundwater. In State v. Michels Pipeline Construction, Inc., 63 Wis. 2d 278 (1974), the Wisconsin Supreme Court gives unrestricted freedom to a landowner to withdraw, use and sell groundwater in any amount, provided that such withdrawal does not cause unreasonable harm to others.

10. The operation of any high capacity well system shall have, under all climatic conditions but especially during drought conditions, no significant adverse impact on any nearby groundwater, surface waters or wetlands. When determining whether any significant adverse impact is occurring, DNR staff shall examine the physical environment and evaluate all relevant groundwater modeling information and other data. A significant adverse impact would occur when the quantity or quality (e.g., temperature, dissolved oxygen, suspended solids, etc.) of the waters available to any affected surface water or wetland is reduced or affected such that its physical, biological, social, economic or any other public interest value cannot be maintained.

11. The Applicants agree to be bound by the terms and conditions of any approval of (a) high capacity well system(s) and recognize that any such approval may include minimum stream flows or pond water levels below which the Applicants shall be limited in their extraction rate or shall stop extraction. The Applicants may not raise the issues of jurisdiction or authority in any future proceedings that might arise regarding a) the reasonableness of that initial approval or b) compliance with it. Under the provisions of section NR 812.09(4)intro., Wis. Adm. Code, failure to comply with any condition of that approval shall void the approval.

12. If following approval of any high capacity well system DNR reviews future data gathered under numbered paragraphs 1 and 2 or elsewhere and determines that additional environmental studies and/or monitoring might be helpful to further assess impacts and/or protect resources, it may unilaterally amend its approval to require such additional studies/monitoring. Any such future amendment is subject only to a limited appeal by the Applicants on the reasonableness of the modified portions of the approval. The appeal may not raise the issues of jurisdiction or authority.

13. If following approval of any high capacity well system DNR determines that the operation of the system is causing a significant adverse impact on any nearby groundwater, surface waters or wetlands, DNR may unilaterally amend its approval to impose conditions to eliminate that impact, including lowering the extraction rate. Any such future amendment is subject only to a limited appeal by the Applicants on the reasonableness of the modified portions of the approval. The appeal may not raise the issues of jurisdiction or authority.

14. The Parties recognize that approval of any high capacity well system in this instance shall be a phased data-driven interactive process, allowing for modification efforts by any of the Parties. If data generated after any approval reflects that a higher extraction rate would under all climatic conditions have no significant adverse impact on any nearby groundwater, surface waters or wetlands, the Applicants may seek an amended approval for that higher extraction rate. Under those circumstances, DNR may not raise the doctrine of collateral estoppel to seek to prevent such a modification effort.

15. In addition to any decision on the application for (a) high capacity well system(s), the Parties recognize that GSWA's potential pipeline, bottling plant and any stream/wetland restoration activities may require many other permits. Such permits may include, but would not necessarily be limited to:

a) **water regulation and wetlands permits** (water quality certification – chapters NR 103 and NR 299, Wis. Adm. Code; structures – section 30.12, Stats.; pipelines – sections 30.12 and 30.20, Stats.; culverts over navigable streams – section 30.123, Stats.; dredging – section 30.20, Stats.; grading – section 30.19, Stats.);

b) **air permits** (direct stationary sources – boiler, emergency electric generator and process lines; indirect sources – parking areas and road access; and operation); and

c) **wastewater permits** (sanitary wastes, noncontact cooling water and boiler blowdown, contact cooling water and process wastewater, and stormwater).

16. All reports, studies and other data submitted to DNR under this Agreement are subject to Wisconsin's public records provisions found in subchapter II of chapter 19, Stats., except as provided in section NR 2.19, Wis. Adm. Code.

17. This Agreement consists of eleven (11) pages, counting the signature pages, and contains the entire understanding between the Parties with respect to the June 20, 2000 application for (a) high capacity well system(s),

and supersedes all prior and contemporaneous discussions or negotiations. This Agreement cannot be amended except in writing signed by duly authorized representatives of the Parties.

18. The obligations of each Party in this Agreement shall be binding upon, and its rights and benefits shall inure to the benefit of, the successors and assigns of that Party.

19. This Agreement is made and delivered in Wisconsin, and shall be governed by Wisconsin law applicable to contracts executed and performed therein. Any disputes shall be resolved in an appropriate court in Wisconsin.

20. This Agreement may be executed in separate counterparts, each of which shall be deemed an original. Each party to this Agreement shall execute eight (8) duplicate original counterparts and shall circulate the same to all other parties identified in this Agreement.

GREAT SPRING WATERS OF AMERICA, INC.
A Delaware corporation
777 West Putnam Avenue
Greenwich, CT 06830

By: ______________________________ 8-28-00
Mark Evans, Vice President
& General Counsel

Date of signature

20. This Agreement may be executed in separate counterparts, each of which shall be deemed an original. Each party to this Agreement shall execute eight (8) duplicate original counterparts and shall circulate the same to all other parties identified in this Agreement.

BUCKLEY SPRINGS TRUST
c/o Brian T. Buckley
704 Evergreen Circle
Las Vegas, NV 89107

By: ______________________________
Brian T. Buckley, Trustee

8/28/00
____
Date of signature

20. This Agreement may be executed in separate counterparts, each of which shall be deemed an original. Each party to this Agreement shall execute eight (8) duplicate original counterparts and shall circulate the same to all other parties identified in this Agreement.

ROLAND C. AND SANDRA L. JENSEN
398 Golden Avenue
Wisconsin Dells, WI 53965-8629

Roland Jensen
Roland C. Jensen

8-28-2000
Date of signature

Sandra L. Jensen
Sandra L. Jensen

8-28-2000
Date of signature

20. This Agreement may be executed in separate counterparts, each of which shall be deemed an original. Each Party to this Agreement shall execute eight (8) duplicate original counterparts and shall circulate the same to all other Parties identified in this Agreement.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

By: George E. Meyer
George E. Meyer, Secretary

9/20/2000
Date of signature

RUNNING DRY

What happens when the world no longer has enough freshwater?

BY JACQUES LESLIE

In the world there is nothing more submissive
and weak than water. Yet for attacking that
which is hard and strong nothing can surpass it.
—Lao-tzu (sixth century B.C.)

When I was a war correspondent twenty-five years ago, I paid more attention to blood than to water. Carnage transfixed and terrified me; water seemed to flow inconsequentially through the embattled landscape before me. The Mekong River, in its multifingered brownness, and the reverse-flowing, hugely contracting and expanding great Cambodian lung-lake, the Tonle Sap, barely registered on my psyche, except as obstacles: my thoughts on water consisted chiefly of military observations, such as that the onset of the rainy season slowed down Khmer Rouge advances more effectively than the regime's hapless human enemies did. I can't say when the pendulum began to swing—probably about the time I stopped thinking about the war, a decade or two later. More recently, I started to notice how many news stories involved water. The subjects weren't just hurricanes, droughts, and floods but less predictable phenomena, such as the accelerating destruction of U.S. watersheds caused by urban sprawl, violent protests in Bolivia prompted by a water-utility-rate increase, and a death sentence handed down to a Chinese administrator who embezzled nearly $2 million set aside for the resettlement of people displaced by Three Gorges Dam. I began reading every water text I could find, and in March I attended an international water conference in The Hague at which water ministers from 115 countries declined to agree on how to address the problem of water scarcity. Now when I envision the globe, I try to see beyond political boundaries to the world as it really is: a collection of watersheds, lakes, rivers, and aquifers that together maintain the earth's biota—which is to say, us. Now the world's quotidian skirmishes and conflagrations are mere background noise. Now it is water that scares me.

We face an unassailable fact: we are running out of freshwater. In the last century we humans have so vastly expanded our use of water to meet the needs of industry, agriculture, and a burgeoning population that now, after thousands of years in which water has been plentiful and virtually free, its scarcity threatens the supply of food, human health, and global ecosystems. With global population hurtling toward roughly 9 billion people by 2050, projections suggest that if we continue consuming water with our habitual disregard all those needs cannot be met at once.

The world's supply of freshwater remains roughly constant, at about 2½ percent of all water, and of that, almost two thirds is stored in ice caps and glaciers, inaccessible to humans; what must change is how we use the available supply. Humans have grown so numerous that the usual response to anticipated water scarcity—to increase supply with dams, aqueducts, canals, and wells—is beginning to push against an absolute limit.

In the developed world widespread water shortages are projected but not yet broadly experi-

Jacques Leslie is the author of The Mark: A War Correspondent's Memoir of Vietnam & Cambodia, *published in 1995. He is working on a book about water.*

enced. In the developing world the crisis has already arrived. As many as 1.2 billion people—one out of five on the globe—lack access to clean drinking water. Nearly 3 billion live without sanitation: no underground sewage, toilets, or even latrines. More than 5 million people a year die of easily preventable waterborne diseases such as diarrhea, dysentery, and cholera; in fact, most disease in the developing world is water-related. As Peter Gleick writes in *The World's Water 1998–1999*, "For nearly three billion people, access to a sanitation system comparable to that of ancient Rome would be a significant improvement in their quality of life."

To be sure, the water shortages that give rise to these conditions so far are regional, not global, and often involve inequality of distribution and high pollution levels as much as absolute scarcity. Thus one water basin experiences a shortage while neighboring basins enjoy ample supplies. Water doesn't ship well, except in unusual circumstances, such as the provisioning of some Greek and Caribbean islands by tanker or barge: water is far too cheap and unwieldy to justify long-distance transport. This tends to keep shortages confined to specific areas, but it also means that they can't easily be alleviated with water from another region.

In one way, however, the impact of water shortages has already registered globally, thanks to water's role in agricultural production. Indeed, water experts refer to grain as "virtual water," since many countries facing water shortages respond by importing grain. It takes roughly a thousand tons of water to produce a ton of grain, so importing grain has an obvious shipping advantage. As a result, stockpiling grain is one way to counter water shortages. The billion-dollar question among water and agriculture experts, in fact, is whether, owing in part to water scarcity, the human race in the twenty-first century will lose the capacity to feed itself. For now, the answer is unknowable, since predictions inevitably rest on highly speculative assumptions. One forecaster, Lester Brown of the Washington, D.C.–based Worldwatch Institute, has advanced a dire scenario in which China's water shortage forces it to import so much grain that poorer nations are priced out of the international grain market, inducing widespread starvation. More plausibly, others argue that in many developing countries water scarcity is the most significant component of environmental degradation, which in turn is an underlying cause of mass migration, peasant revolt, and urban insurrection. Such notions have not escaped the attention of U.S. policymakers, as evidenced by meetings of officials from the Department of Defense, the CIA, the State Department, and the White House last September to consider the global implications of water conflicts. At a time when the First World is obsessed with computer technology, genetics, and the froth of media entertainments, we would be well advised to remember our relationship to the two atoms of hydrogen and one of oxygen that, bound in nature, support all life.

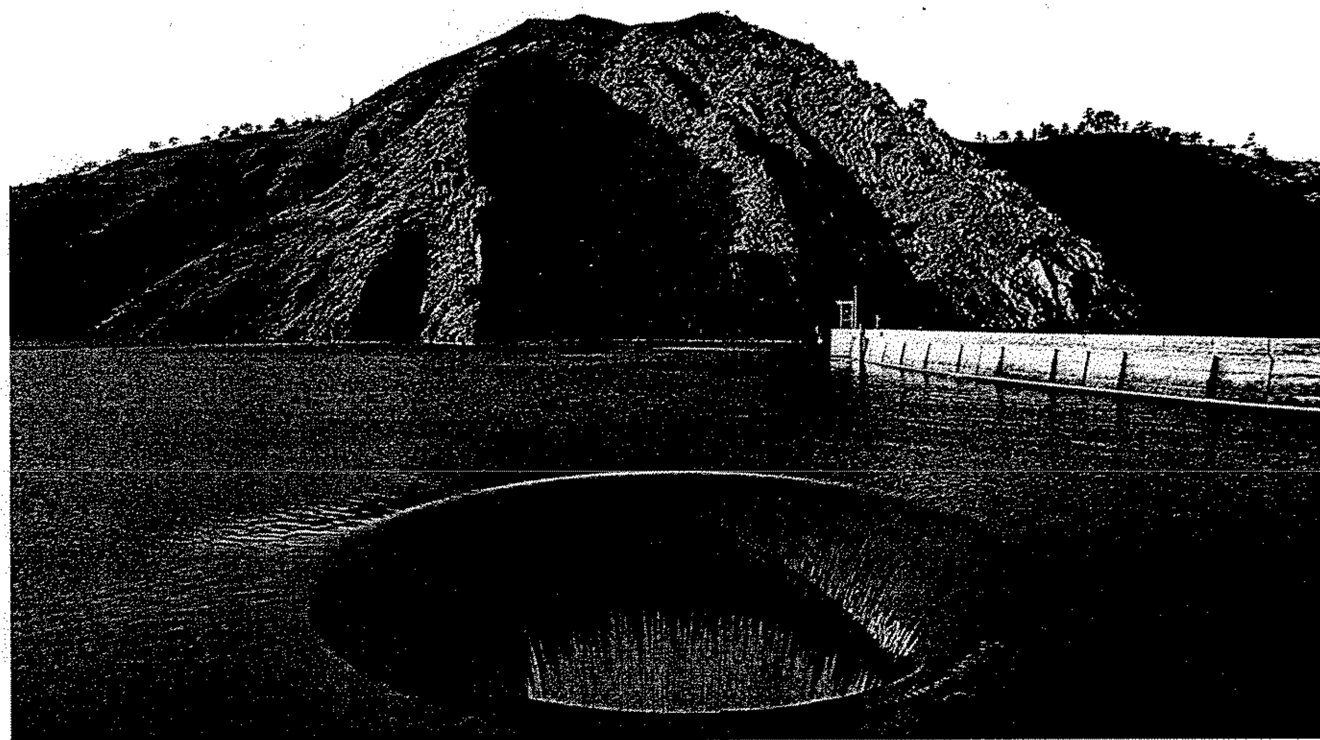
At a time when the First World is obsessed with technology, genetics, and media froth, we'd be well advised to remember that water supports all life

IRRIGATION AND ITS DISCONTENTS

In the Tigris-Euphrates, Indus, and Yellow river basins, ancient civilizations flourished when they devised ways to grow crops with irrigated water and foundered when the systems collapsed, either because sediment clogged their canals or waterborne salt poisoned their soils. We like to think that we've mastered irrigation—indeed, in the last two centuries humans have increased land under irrigation thirtyfold. Yet the daunting obstacles we face in maintaining irrigation systems are not so different from those that brought down the Sumerian and Indus civilizations. "The overriding lesson from history is that most irrigation-based civilizations fail," writes Sandra Postel in her compelling survey of the global water crisis, *Pillar of Sand: Can the Irrigation Miracle Last?* "As we enter the third millennium A.D., the question is: Will ours be any different?"

Now, more than ever, humans depend on irrigation: less than a fifth of the world's cropland is irrigated, but because irrigation typically enables higher yields and two or three crops a year, irrigated land produces two fifths of the world's food. Even so, the planet's reliance on irrigated crops undoubtedly will intensify in the coming decades. The world's food supply comes from three major sources: cropland, rangeland, and fisheries. Livestock have already grown so numerous that 20 percent of the earth's rangeland has lost productivity because of overgrazing, and most of the world's fisheries have been decimated by overfishing. By default, the likely source of food for the roughly 3 billion additional humans expected in the next fifty years will be cropland. Yet the amount of cropland is not likely to grow much: newly cultivated land probably will barely surpass the amount of land lost to agriculture because of erosion, urbanization, and salination. Moreover, the best cropland is already in use; much of the land still awaiting cultivation has the potential to be only marginally productive. The result is that population growth is already outstripping growth of irrigated land. In fact, the area of global per capita irrigated land peaked in 1978 and has dropped 5 percent since then. Projections by international agencies suggest that by 2020, per capita irrigated land will have dropped 17–28 percent from the 1978 peak. Success in feeding all the people who will populate the earth in the mid-twenty-first century therefore depends largely on increasing the productivity of existing cropland. "The difference between the Malthusian pessimists and the cornucopian optimists," says Postel, "comes down to little more than an assumption about grainland productivity over the next several decades—specifically, whether yields will grow at closer to the 1 percent rate of the 1990s or the 2 percent rate of the previous four decades."

There's reason to worry. The 2 percent rate occurred as farmers applied Green Revolution techniques to land irrigated by groundwater or reservoirs, but those techniques have largely fulfilled their promise, and yields in recent years have either stagnated or declined. One reason may be irrigation itself: some scientists believe that soils become depleted when repeatedly subjected to the two or three annual crops that irrigation enables. In addition, Green Revolution agriculture depends on copious applications not just of pesticides and fertilizer but of water: between 1950 and 1995 grainland productivity increased 240 percent while water use for irrigation increased 220 percent. With global depletion of groundwater and increasing diversions of agricultural water for industrial, urban, and environmental needs, the scarcity of water is likely to become the most important factor in limiting agricultural production. That means that more people may hunger for relatively less food.



Spillway, Lake Berryessa, California

UNSEEN LAKES, PUMPED DRY

Compared with the earth's visible freshwater—in lakes, ponds, and rivers—the amount of water stored in underground aquifers is sixty times as large. A stock that immense might seem beyond our capacity to exhaust, yet in many parts of the world groundwater is being depleted at an unsustainable rate. The Ogallala Aquifer, one of the world's largest stores of groundwater, covers 225,000 square miles beneath parts of eight U.S. states, from Texas to South Dakota, and feeds a fifth of the nation's irrigated lands. Although its stock is "fossil water"—water locked underground for thousands of years, with few sources of replenishment—it is being depleted so rapidly that many farmers who once depended on it now must rely on rainwater, significantly lowering yield. The amount of acreage supported by the Ogallala in six states fell from its peak in 1978 by nearly 20 percent in less than a decade; despite efforts to limit use of Ogallala water, substantial withdrawals continue.

Photograph by Robert Dawson

Of course, unlike the Ogallala, most aquifers are naturally "recharged"—replenished by rain and runoff—but even these are being depleted dramatically, as the rate of withdrawal easily surpasses the recharged amount. India's volume of annual groundwater overdraft is higher than any other nation's. Almost everywhere in the country, water withdrawals are proceeding at double the rate of recharge, causing a drop in aquifers of three to ten feet per year; in the state of Tamil Nadu, groundwater levels have dropped as much as ninety-nine feet since the 1970s, and some aquifers there have become useless. The cost of land subsidence caused by aquifer depletion in the United States is about $400 million per year, with incidents occurring in Houston, New Orleans, and California's Santa Clara County and San Joaquin valley; Beijing is sinking at an annual rate of about four inches a year; and certain Mexico City barrios sink as much as a foot a year. In both Florida and the Indian state of Gujarat, the water table has dropped so low that seawater has invaded the aquifers, limiting their usefulness for drinking or irrigation. In Palestine's Gaza Strip, which relies almost entirely on groundwater, saltwater intrusion from the Mediterranean has been detected as far as a mile inland, and some experts predict that the aquifer will become totally salinized. Groundwater depletion, says the International Water Management Institute, a World Bank–supported group in Sri Lanka, is "the single most serious problem in the entire field of water resources management. . . . Many of the most populous countries of the world—China, India, Pakistan, Mexico and nearly all of the countries of the Middle East and North Africa—have literally been having a free ride over the past two or three decades by depleting their groundwater resources. The penalty of mismanagement of this valuable resource is now coming due, and it is no exaggeration to say that the results could be catastrophic for these countries, and, given their importance, for the world as a whole."

Di Bin well, North Yemen

Humans alone cannot deplete aquifers: we lack the strength to draw that much water or dig wells that deep. Rather, groundwater depletion is a phenomenon of the late twentieth century, made possible by the availability of electricity and cheap pumps. IWMI calls the spread of small pump sets throughout the world "one of the most dramatic yet generally unappreciated revolutions in water resource technology." In some ways pump irrigation is ideal: the water is stored underground and shielded from evaporation, so it can be used during the dry season, when crops need water most. In many Asian countries pump irrigation alone deserves much of the credit for high Green Revolution yields.

Yet in many countries the new technology shattered traditional water-sharing arrangements that had worked for centuries. John Briscoe, a senior water adviser at the World Bank, cites the example of Yemen, which once had "very sophisticated ancient water management techniques" that handled everything from floods to water allocation. "Then you come to the post–Second World War, with deep wells and electricity and diesel pumps for groundwater, and people pump like there's no tomorrow. You have a lot of food production as a result of this, but in the basin around San'a, the capital; for instance, four times more water is being pumped out than is being recharged, and the aquifer is dropping three meters a year."

Often the new technology combines catastrophically with government policies.[1] Until the early 1990s, individual farmers in Mexico used powerful pumps, concluding, "If I don't pump fast,

[1] *Saudi Arabia provides perhaps the world's best example of extravagant groundwater depletion. After helping to launch the OPEC oil embargo of 1973, Saudis feared other countries might retaliate with a grain embargo, so they embarked on a program to make the country self-sufficient in grain. As Postel explains, the nation subsidized farmers' land, equipment, and water, and paid them several times the world market price for grain. The result was that for a short time Saudi Arabia managed to become a grain exporter. Because of the country's hot, arid climate, each ton of grain required 3,000 tons of water, triple the usual ratio. When Saudi Arabia was forced to make budget cuts in the mid-1990s, the effort could not be sustained. The curtailment of subsidies caused grain production to fall by 60 percent. That may be just as well, since Saudi Arabia otherwise would have run out of groundwater by 2040. Even now, with a more modest agricultural program, the Saudis continue to run a significant groundwater deficit.*

Photograph by Tiziana and Gianni Baldizzone / CORBIS my neighbor will, so I might as well pump faster than he does." On top of this, the government subsidized everything from fertilizer to energy costs and imposed tariffs on competing foreign crops, accelerating the waste of water. "The whole thing was a total disaster," Briscoe says. The government finally phased out tariffs and created subsidies to encourage sustainable water use. The reforms forced thousands of Mexican farmers off the land, yet, Briscoe says, there are "very clear signs" that the remaining farmers have begun to manage their water use.

Many of the most populous countries—China, India, Pakistan, and Mexico—have severely mismanaged their groundwater. The results could be catastrophic

In places such as Punjab and Haryana, India's breadbasket states, the new technology also widened the gap between rich and poor. As water tables dropped, farmers had to drill deeper wells and buy more powerful pumps, but only rich farmers could afford the new equipment. Poor farmers, whose shallow pumps became useless, were forced to rent their land to richer farmers, for whom they became laborers. The IWMI report lists the consequences if this trend is not reversed: "Lakes and rivers dry up as the aquifer recedes. ... The costs of pumping become so high that the pumps are shut down and the whole house of cards collapses. It is not difficult to believe that India could lose 25% or more of its total crop production under such a scenario."

From the earth's surface, groundwater is invisible: farmers don't realize they've used up an aquifer until it's too late. Even in countries where limits on withdrawals exist, enforcement is virtually impossible, so no governments have established regulations for sustainable groundwater use. Yet reliance on groundwater in agriculture causes food to be grossly undervalued. Postel estimates the global annual groundwater overdraft in the mid-1990s at about 163 million acre-feet, or roughly enough water to grow about 198 million tons of grain, a tenth of the global harvest. Agricultural prices are now at their lowest point in two decades and have forced some American farmers out of work, but if overpumping were to cease, grain prices probably would rise significantly. Instead, the mounting cost of pumping groundwater from deeper and deeper levels may eventually produce the same result.

FOREVER DAMMED

What aquifers are belowground, dams create aboveground. Many environmentalists will tell you, however, that the very concept is faulty, that anything as destructive as a dam cannot be an uncomplicated good. Even by their reckoning, however, the best dam—the one that is the closest to the ideal—surely is Hoover Dam, the first of the modern water era. Hoover is America's Great Pyramid, whose face was designed without adornment to emphasize its power, to focus the eye on its smooth, arcing, awe-inspiring bulk. Yet the dam nods to beauty with a grace that seems more precious year by year: its suave Art Deco railings, fluted brass fixtures, and three miles of polished terrazzo granite walkways are the sort of features missing from the purely utilitarian public-works projects of more recent decades. Hoover is a miraculous giant thumbnail that happens to have transformed the American West. Take it away, and you take away water and power from more than 20 million people. Take it away, and you remove a slice of American history, including a piece of the recovery from the Depression, when news of each step in the dam's construction—the drilling of the diversion tunnels, the building of the earth-and-rock cofferdams, the digging to bedrock, the first pouring of foundation, the accretion of five-foot-high cement terraces that eventually formed the face—heartened hungry and dejected people across the land.

The dam and Las Vegas more or less vivified each other; if Hoover evokes glory, Las Vegas, only thirty miles away, is its malignant twin. Even now, Hoover provides 85 percent of Las Vegas's water, turning a desert outpost into the fastest-growing metropolis in the country—so, by all means, take away Las Vegas. Take away Hoover, and you might also have to take away the Allied victory in World War II, which partly depended on warplanes and ships built in southern California with Hoover's hydroelectric current. And take away modern Los Angeles, San Diego, and Phoenix: you reverse the twentieth-century shift of American economic power from East Coast to West. Take away Hoover and the dams it spawned on the Colorado—Glen Canyon, Davis, Parker, Headgate Rock, Palo Verde, all the way to Morelos across the Mexican border—and you restore much of the American Southwest's landscape, including a portion of its abundant agricultural land, to shrub and cactus desert. Above all, take away Hoover, and you take away the American belief in technology, now on a millennial crest of enthusiasm. At Hoover's September 30, 1935, dedication, Interior Secretary Harold Ickes reflected the common understanding when he declared, "Pridefully, man acclaims his conquest of nature." After Hoover every country wanted dams, and every major country, regardless of ideology, built them. (Even now, the ubiquitousness of dams is one of their most striking features: the world's highest dam is in Tadzhikistan, the largest reservoir is in Uganda, and the dam with the biggest hydroelectric capacity is on the Brazil-Paraguay border.) At its completion Hoover towered 280 feet above the world's second-highest dam, the Arrowrock in Idaho, and was the planet's largest source of electricity, but its current ranking, sixteenth in height and lower than twentieth in hydroelectric capacity, reflects the momentum that the dam movement eventually gathered. Take away Hoover Dam, and you take away a bearing, a confidence, a sense of what nations are for.

What we have learned is that human beings have overestimated dams and underestimated the water that runs through them

Yet in a sense that's what's happening. Even if Hoover lasts another 1,100 years (when Bureau of Reclamation officials say Lake Mead will be filled with sediment, turning the dam into an expensive waterfall), its teleological edifice is crumbling. In sixty-five years we have learned that if you take away Hoover, you also take away millions of tons of salt that the Colorado once carried to the sea but which have instead been strewn across the irrigated landscape, slowly poisoning the soil. Take away the Colorado River dams, and you return the silt gathering behind them to a free-flowing river, allowing it again to enrich the wetlands downstream and the once fantastically abundant, now often caked, arid, and refuse-fouled delta. Take away the dams, and the Cocopa Indians, whose ancestors fished and farmed the delta for more than a millennium, might again have a chance of avoiding cultural extinction. Take away the dams, and the Colorado would again bring its nutrients to the Gulf of California, helping that depleted fishery to recover the status it held a half-century ago as an unparalleled repository of marine life. Take away the dams, finally, and the Colorado River returns to its virgin state: tempestuous, fickle, in some stretches astonishing.

What we have learned is that we have overestimated dams and underestimated the water that runs through them. In the era of big dams that has at last peaked and started to decline, river water that reached the sea was considered wasted because it had not been turned to human ends. Only recently have we noticed that the human good is not served by the depleted rivers and wetlands that the diversions create. We would have been wise to listen to Aldo Leopold, the celebrated naturalist, who wrote in 1933, two years before Hoover Dam's dedication: "We build storage reservoirs or power dams to store water, and mortgage our irrigated valleys and our industries to pay for them, but every year they store a little less water and a little more mud. Reclamation, which should be for all time, thus becomes in part the source of a merely temporary prosperity."

The prosperity is evident, but so, increasingly, is its transience. Dams have lifetimes as surely as any natural thing. The rate at which a reservoir fills depends on its size and the amount of sediment flowing into it. Sediment has filled more than half the storage capacity of some dams within a decade. Other dams, like Hoover, have a projected lifetime of more than a thousand years—though Hoover is deceptive because the Glen Canyon Dam upstream traps most of the sediment that would otherwise reach it. On average, sediment annually reduces by 1 percent the storage capacity of the world's reservoirs. In China, where soil erodes easily, reservoirs fill at a rate of 2.3 percent a year. One dam on the silty Yellow River, the Yangouxia, lost almost a third of its storage capacity even before it was commissioned.

Radiating outward from any dam, irrigated water slowly poisons the land with salt. Salinity has affected a fifth of the world's agricultural land; each year it forces farmers to abandon a million hectares and affects an additional 2 million hectares. If in the course of a year a farmer applies the unremarkable sum of 10,000 tons of water to a single hectare, the land will collect two to five tons of salt. It's precisely the process by which ancient Mesopotamia turned into the barren desert of contemporary southern Iraq. Salt problems are severe in China, India, Pakistan, Central Asia, and the Colorado and San Joaquin river basins of the American West. In many arid areas the soil is naturally saline. As rainwater and snowmelt flow through a saline watershed to a river, they collect salt throughout their path. A few billion years ago the oceans were full of freshwater, then were gradually turned saline by riverborne salt. Now, in the modern water era, dams divert both the water and the salt. Because reservoirs expose so much water to the sun, those in hot climates lose a huge quantity to evaporation: for example, a full third of the Colorado's flow evaporates from reservoirs. In the remaining water, salt concentrations increase. Some water is distributed to surrounding croplands, where the salt collects. As the water permeates the soil, it accumulates more salt, then returns to the river with a more concentrated share; on a single trip down the Colorado, the same water may be used for irrigation eighteen times. Human use of the Colorado has approximately doubled its salinity. Neither the environment nor urban areas are spared salt's effects: it kills aquatic organisms in the lower river and corrodes pipes in Los Angeles, San Diego, and Phoenix.

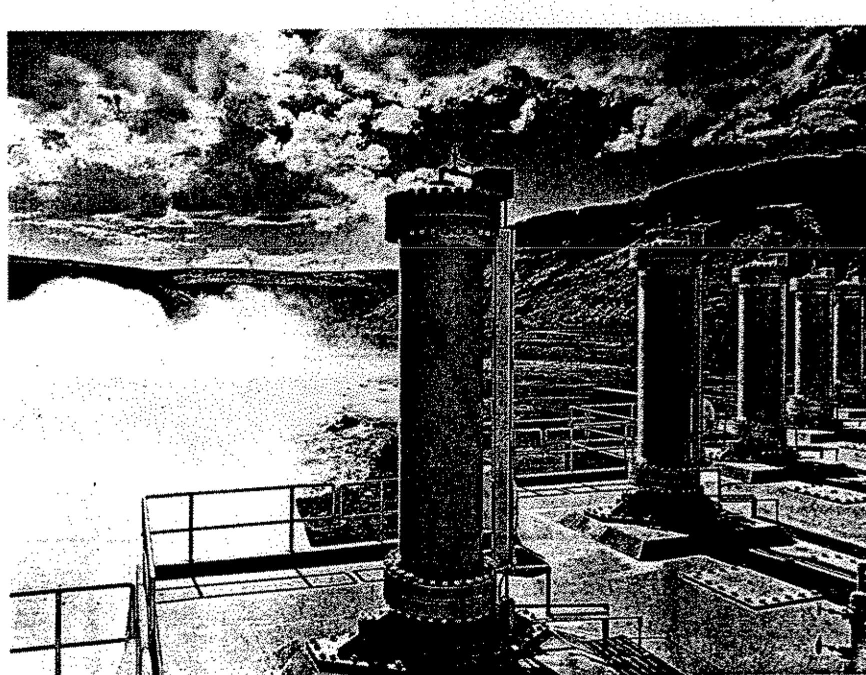
The world's most spectacular saline catastrophe is Central Asia's Aral Sea. Decades ago Soviet planners diverted two major rivers that feed the Aral in order to turn the surrounding desert into a cotton cornucopia. As cotton bloomed, however, the sea wilted: it now contains a third of its former volume and may disappear.

All twenty-four native fish species in the Aral have already vanished, and the fish catch has dropped from 48,000 tons to none. The regional climate has declined, producing less rainfall and greater temperature extremes. Each year windstorms pick up 44 million tons of salt and dust from the dried seabed and scatter them over the river basin. Cotton output is dropping. The drinking water is contaminated with high concentrations of salt and agricultural chemicals. Inhabitants suffer plagues of cancer, respiratory illnesses, and waterborne diseases such as hepatitis and typhoid fever.

All dams cause environmental damage: they fragment the riverine ecosystem, isolating upstream and downstream populations, and, by preventing floods, cut off the river from its floodplain. Within the reservoir lake, water temperature changes dramatically. Deep reservoir water is usually colder in summer and warmer in winter than river water. Thus water leaving Glen Canyon Dam never varies more than a few degrees from its 46 degree average. For 240 miles below the dam the water is too cold for native fish to reproduce.[2]

The reservoir lake traps not just sediment but nutrients. Algae thrive on the nutrients and end up consuming the lake's oxygen, turning the water acidic. It comes out of the dam "hungry," more energetic after shedding its sediment load, ready to capture new sediment from the riverbed and bank. As it scours the downstream river, the bed deepens, losing its gravel habitats for spawning fish and the tiny invertebrates they feed on. Within nine years after Hoover Dam was sealed, hungry water took 89,000 acre-feet of material from the first 87-mile stretch of riverbed beneath. In places the riverbed dropped by more than thirteen feet, and it sometimes took floodplain water tables down with it. In addition, riverbank erosion has undermined some embankments and flood-control levees.

"A dammed river," Wallace Stegner wrote, "is not only stoppered like a bathtub, but it is turned on and off like a tap." Instead of varying with snowmelt and rainfall, its flow is regulated to meet the requirements of power generation and human recreation. Most fluctuations reflect electricity demand: the river level changes hour by hour and is lower on Sundays and holidays. These quick fluctuations intensify erosion, eventually washing away riverbank trees, shrubs, and grasses as well as riverine nesting areas. Riverside creatures lose needed food and shelter.



Lucky Peak Dam, near Boise, Idaho

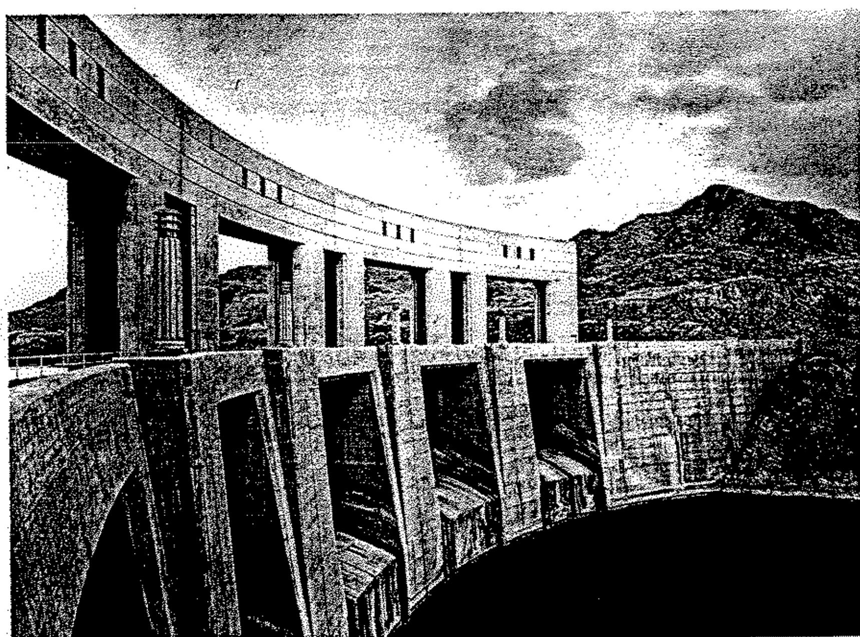
The changes are registered all the way to the river's mouth and beyond. Because of dams, many major rivers—including the Colorado, the Yellow, and the Nile—flow to the sea only intermittently. Without its customary allotment of sediment, the coastline is subject to erosion. By one estimate, dams have reduced by four fifths the sediment reaching the southern California coast, causing once wide beaches to disappear and cliffs to fall into the ocean. Estuaries, where riverine freshwater mixes with ocean saltwater, are crucial in the development of plankton, which in turn supports a huge abundance of marine life; deprived of

[2] *In the new lakes, sport fish stocked for humans' recreation—catfish, bass, and sunfish, and minnows for all of them to feed on—arrive previously adapted to stable lake environments and thrive. They prey on the native fish, which are now disadvantaged by being suited to river conditions. The humpback chub, native to the Colorado, has an odd-looking hump behind its head that contains extra muscles connecting to its tail; before the dam era, it used those muscles to survive in the Colorado's occasionally torrential waters. Now the chub, like virtually all other native Lower Colorado fish, courts extinction. In little more than half a century a foreign fish population has essentially replaced the Colorado's native one.*

Photograph by Robert Dawson

large portions of freshwater and nutrients, the estuaries decline, and with them so do fisheries. Migrating fish such as salmon and steelhead trout find their paths obstructed, both as juveniles swimming downstream to mature and as adults going upstream to spawn. For this reason, the Columbia River, where 2 million fish returned annually to spawn just before the dam era began, has hosted half that number in recent years, and most remaining stocks in the upper river are in danger of extinction.

Only by multiplying all these effects by the number of the world's river basins studded with dams—an overwhelming majority—can the full environmental impact of dams be appreciated.



Parker Dam, on the Colorado River between California and Arizona

The numbers are stunning. The planet accommodates 40,000 large dams—dams more than four stories high—and some 800,000 small ones. They have shifted so much weight that geophysicists believe they have slightly altered the speed of the earth's rotation, the tilt of its axis, and the shape of its gravitational field. Together they blot out a terrain bigger than California.

The most obvious beneficiaries of dams are politicians, bureaucrats, and builders, all of whom profit from the dams' huge price tags. Think of the towering political leaders of the twentieth century—Roosevelt, Stalin, Mao, Nehru. They all loved dams. Dams provide jobs and a generous amount of money to constituents, some of whom don't mind donating a portion back to the politicians. Bureaucrats like dams because that's where the action is: the expense of dams ensures power to its overseers. The constituents include dam builders, road builders, engineers, electricians, carpenters, cooks, plus every sort of professional boomtowns attract, from developers to prostitutes. In fact, dams, which provide nearly a fifth of the world's electricity, are also among the world's costliest public-works projects; by the time China's Three Gorges Dam is completed (in about 2009), it will have become the world's largest and most expensive, with an estimated cost of up to $75 billion.

The attraction of dams to farmers is obvious. Supported by funding from central governments and international agencies, farmers rarely pay more than 20 percent of the real cost of the irrigated water. The subsidies distort the farmers' economic outlook: instead of planting crops that match the hydrology of their fields, farmers take advantage of abundant cheap water to plant crops that guzzle water, even if the crops bring a low return. In the San Joaquin valley of California, the richest irrigated land in the world, some farmers grow water-guzzling cotton, or, worse (because it is fed to cows, the most notorious guzzlers of all), alfalfa. It takes at least 15,000 tons of water to produce a ton of beef and nearly that much to produce a ton of cotton; comparatively, a ton of grain requires 1,000 tons of water.

Still, many farmers founder. For one thing, canal maintenance is often underfunded and neglected, particularly in developing countries. Planners often overestimate the amount of water available to the system and underestimate leakage, evaporation, and waste. Farmers near a canal head—the "head-enders"—almost invariably receive much more water than those far down the canal—the "tail-enders." The head-enders may have bought their position with bribes; they are often wealthy enough to afford the new equipment, seeds, fertilizers, and pesticides that irrigation farming promotes. At the other end, the tail-enders may be forced to borrow money at high rates; deeply indebted, they often end up as tenants on their own land.

The biggest losers are people displaced by dams. They're usually minorities, often uneducated and powerless, and therefore hard to count or even notice, particularly by a government's ruling elite. If the government bothers to relocate them, it's usually to inferior land, where settled residents resent them. Rates of illness and death usually increase after relocation. One estimate puts the worldwide total of people displaced by dams at 30 to 60 million. As startling as that sum is, it omits another huge group, the floodplain residents living downstream from dams whose livelihoods are jeopar-

Photograph by Martin Stupich

dized by the sudden loss of regular nutrient-bearing floods or other hydrological changes.

If dams are so destructive in so many ways, why don't we tear them down? The most obvious answer is that we can't afford to; dismantling dams is nearly as expensive as building them. Some dams may be decommissioned and drained, but in the foreseeable future even those will be few, for the world's reliance on dams for electric power and irrigation has grown too great to do without them: a world abruptly deprived of a fifth of its electricity and a significant portion of its food supply would not remain tranquil for long. Boxed in by the size of our population, we have approached a natural limit, damned if we do dam and damned if we don't dam.

The result is a kind of standoff. While dam building has largely stopped in the United States and northern Europe, companies based in North America, Europe, and Japan continue to lead construction efforts in developing nations. But even Third World governments increasingly must finance dams themselves or look for support from private investors. The World Bank once enthusiastically financed dams throughout the Third World, until a series of embarrassments, culminating in militant opposition to a project to build 30 large dams, 135 medium-sized ones, and 3,000 small ones in the Narmada valley of India caused it to reconsider. "We now build very few dams," says Briscoe, the World Bank water specialist.

Although most water experts appreciate the destructive impact of dams, few oppose them entirely. IWMI, the World Bank–supported water agency, concluded a gloomy survey of global water needs in 2025 by noting that "medium and small dams will almost certainly . . . be needed." Postel, whose book enumerates dams' many liabilities, nevertheless told me, "I think there's no way we could be supporting a population of 6 billion today without dams. Water comes at uneven times of the year, and we've got to have a way to store it. The question is how."

RAIN, RAIN, GO AWAY

Global warming, we know, is here. Some people think the change chiefly involves temperature, but the phrase is misleading—it leaves out water. Nearly every significant indicator of hydrologic activity—rainfall, snowmelt, glacial melt, evaporation, transpiration, soil moisture, sedimentation, salinity, and sea level—is changing at an accelerating pace. Alaskan and Siberian permafrost is beginning to thaw; in Antarctica scientists are finding beaches and islands exposed after being covered by ice for thousands of years. The sea level has risen between four and ten inches in the last century. Precipitation is increasing, but so are evaporation, floods, and droughts.

Pick any point of the hydrologic cycle and note the disruption. One analysis of 1900–1998 data pegged the increase in precipitation at 2 percent over the century. In water terms this sounds like good news, promising increased supply, but the changing timing and composition of the precipitation more than neutralizes the advantage. For one thing, it is likely that more of the precipitation will fall in intense episodes, with flooding a reasonable prospect. In addition, while rainfall will increase, snowfall will decrease. This means that in watersheds that depend on snowmelt, like the Indus, Ganges, Colorado, and San Joaquin river basins, less water will be stored as snow, and more of it will flow in the winter, when it plays no agricultural role; conversely, less of it will flow in the summer, when it is most needed. One computer model showed that on the Animas River at Durango, Colorado, an increase in temperature of 3.6 degrees Fahrenheit—the global change predicted from now to 2100—would cause runoff to rise by 85 percent from January to March but drop by 40 percent from July to September. The rise in temperature increases the probability and intensity of spring floods and threatens dam safety, which is predicated on lower runoff projections. Dams in arid areas also may face increased sedimentation, since a 10 percent annual increase in precipitation can double the volume of sediment washed into rivers.

Most significant indicators of hydrologic activity—rainfall, snowmelt, glacial melt, salinity, and sea level—are changing at an accelerating rate

The consequences multiply. Soil moisture will intensify at the highest northern latitudes, where precipitation will grow far more than evaporation and plant transpiration but where agriculture is nonexistent. At the same time, precipitation will drop over northern mid-latitude continents in summer months, when ample soil moisture is an agricultural necessity.

Meanwhile the sea level will continue to rise as temperatures warm, accelerating saline contamination of freshwater aquifers and river deltas. This already has occurred in Florida, Gaza, and the Nile River delta. The temperature rise will cause increased evaporation, which in turn will lead to a greater incidence of drought. In fact, extreme water-related events such as storms, floods, and droughts will become more frequent and intense.

Perhaps most disturbing of all, the hydrologic cycle is becoming increasingly unpredictable.

This means that the last century's hydrologic record—the set of assumptions about water on which modern irrigation is based—is becoming unreliable. Build a dam too large, and it may not generate its designed power; build it too small, and it may collapse or flood. Release too little dam runoff in the spring and risk flood, as the snowmelt cascades downstream with unexpected volume; release too much and the water won't be available for farmers when they need it. At a time when water scarcity calls out for intensified planning, planning itself may be stymied.

Rapid population growth threatens to turn five of the world's most contentious water basins, including the Ganges and the Nile, into cauldrons of hostility

WATER WARS OF THE FUTURE

In the modern era we fight wars over oil and take water for granted, yet of the two liquids water is far more capricious and confounding. Oil induces fear because we sense it can make or break empires; water has already made and broken quite a few. Think of oil, and you conjure up gushers, cartels, and economic dominance; think of water and you contemplate the elixir of life. Oil belongs to whoever owns the land above it; water, with its sprawling underground aquifers and long sinuous rivers, complicates ownership and intertwines nations' fates. Oil promotes grandiosity; water teaches humility.

The handy cliché is that sooner or later water will cause war. In a quote that caroms ceaselessly from one water publication to another, World Bank vice president Ismail Serageldin declared in 1995, "The wars of the next century will be over water." Many foreign leaders have expressed similar sentiments. In the late 1980s, Egyptian foreign minister and soon-to-be U.N. secretary general Boutros Boutros-Ghali said that the next Middle East war "will be over the waters of the Nile, not politics." Jordan's King Hussein said in 1990 that water was the only issue that could prompt a war between Jordan and Israel.

Yet such wars haven't quite happened. Aaron Wolf, an Oregon State University specialist in water conflicts, maintains that the last war over water was fought between the Mesopotamian city states of Lagash and Umma 4,500 years ago. Wolf has found that during the twentieth century only 7 minor skirmishes were fought over water while 145 water-related treaties were signed. He argues that one reason is strategic: in a conflict involving river water, the aggressor would have to be both downstream (since the upstream nation enjoys unhampered access to the river) and militarily superior. As Wolf puts it, "An upstream riparian would have no cause to launch an attack, and a weaker state would be foolhardy to do so." And if a powerful downstream nation retaliates against a water diversion by, say, destroying its weak upstream neighbor's dam, it still risks the consequences, in the form of flood or pollution or poison from upstream.

So, until now, water conflicts have simmered but rarely boiled, perhaps because of the universality of the need for water. Almost two fifths of the world's people live in the 214 river basins shared by two or more countries; the Nile links ten countries, whose leaders are profoundly aware of one another's hydrologic behavior. Countries usually manage to cooperate about water, even in unlikely circumstances. In 1957, Cambodia, Laos, Thailand, and South Vietnam formed the Mekong Committee, which exchanged information throughout the Vietnam War. Through the 1980s and into the 1990s, Israeli and Jordanian officials secretly met once or twice a year at a picnic table on the banks of the Yarmūk River to allocate the river's water supply; these so-called picnic-table summits occurred while the two nations disavowed formal diplomatic contact. Jerome Delli Priscoli, editor of a thoughtful trade journal called *Water Policy* and a social scientist at the U.S. Army Corps of Engineers, believes the whole notion of water conflict is overemphasized: "Water irrigation helped build early communities and bring those communities together in larger functional arrangements. Such community networking was a primary impetus to the growth of civilization. Indeed, water may actually be one of humanity's great learning grounds for building community. . . . The thirst for water may be more persuasive than the impulse toward conflict."

On the other hand, water has often been the goal, tool, or target of conflicts that fall just short of war or that contain non-water-related dimensions. Recent history is full of examples. In 1965, Syria tried to divert the Jordan River from Israel, provoking Israeli airstrikes that forced Syria to abandon the effort. Colin Powell, chairman of the U.S. Joint Chiefs of Staff during the 1991 Gulf War, said in 1996 that the United States considered bombing dams on the Euphrates and Tigris rivers north of Baghdad but desisted, apparently because of the likelihood of high civilian casualties. The allies also discussed asking Turkey to reduce the Euphrates flow at the Atatürk Dam upstream from Iraq. As it was, the allies targeted Baghdad's water-supply system while the Iraqis destroyed Kuwait's desalination plants.

Postel believes water hostilities are most likely to occur when a river's water is insufficient to meet projected demand, water allocation is considered inequitable, and involved nations have made no water-sharing agreement. In five of the world's most contentious water basins—the Aral Sea region, the Ganges, the Jordan, the Nile, and the Tigris-Euphrates—rapid projected population growth—up to 75 percent by 2025—threatens to turn the basins into cauldrons of hostility. For instance, in the Tigris-Euphrates basin, Turkey's position upstream gives it enormous leverage over its downstream neighbors, Syria and Iraq. It's likely that Syria's longtime support of the separatist Kurdistan Workers' Party in Turkey was at least partly a way of countering Turkey's control over 80 percent or more of Syria's water supply. But once Turkey captured Abdullah Ocalan, a Kurdish guerrilla leader who had lived in Syria for nearly two decades, Syria's leverage against Turkey declined. Turkey is now in the midst of a huge dam-building program that will further diminish the Euphrates's flow into Syria, increasing Syria's grievances.

In the Nile basin the situation is more volatile, because the downstream nation, Egypt, dominates the region. Egypt already diverts so much Nile water that the river barely flows to its mouth in the Mediterranean Sea and the Nile delta is subsiding because sediment no longer reaches it. Nevertheless, Egypt is launching vast new irrigation projects that will divert even more Nile water. One project will irrigate about 500,000 acres of Egypt's southwestern desert; another will divert water beneath the Suez Canal to irrigate 625,000 acres of the Sinai Desert. At the same time, Ethiopia, the source of 86 percent of the Nile's flow, intends to launch its own irrigation and hydroelectric projects, which could dramatically reduce downstream water. Steve Lonergan, a specialist in water and security issues at the University of Victoria, British Columbia, told me, "I don't doubt that if Ethiopia starts building water projects that restrict the flow of the Nile, Egypt will bomb them."

Even if water wars remain rare, other sorts of water-related violence already occur frequently and are certain to increase. Thomas F. Homer-Dixon, a pioneer in the emerging field of environmental security, cites the Israeli-Palestinian conflict as an example of how environmental scarcity affects politics. In his 1999 book, *Environment, Scarcity, and Violence*, he argues that the capture by a dominant group of such resources as water, cropland, and forest occurs most often just at the point when the resource is becoming scarce and its price is rising, enabling speculation and increased profits. In the case of water, that time is now. In Israel water is growing increasingly scarce; although the nation has been a trailblazer in the development of water-conservation technologies, it continues to extract groundwater at an unsustainable rate.

Soon after the occupation of the West Bank in 1967, Israeli authorities instituted a rationing program that by the early 1990s gave four times as much water per capita to Israeli settlers as to Arabs. Israelis also required Arabs to seek permission to drill wells. When Arabs sought approval to drill over the West Bank's "Mountain" aquifer, the biggest aquifer in Israeli-controlled territory, they were invariably turned down; in other areas permission was given to Arabs infrequently. In addition, because Israelis had access to more sophisticated technology, their wells went deeper, often sucking Arab wells dry or exposing them to saltwater intrusion. Partly as a result, irrigated Arab farmland dropped from 27 percent to as low as 3.5 percent of the area of all West Bank cropland. Many Arab farmers abandoned their fields for towns, where they worked as day laborers, if at all. When the Palestinians revolted in 1987, the disenfranchised farmers were

Carrying water in Tanzania

Photograph by Gilles Peress / Magnum Photos presumably primed to participate. "It is reasonable to conclude," Homer-Dixon writes, "that water scarcity and its economic effects contributed to the grievances behind the *intifadah*."

In this manner, water scarcity encourages insurgencies. It reduces economic productivity and forces migration from depleted countryside to ill-prepared city. Social institutions may break down. Division into ethnic, religious, or linguistic groups increases. "Water scarcity rarely causes interstate wars," Homer-Dixon writes. "Rather its impacts are more insidious and indirect: it constrains economic development and contributes to a host of corrosive social processes that can, in turn, produce violence within societies."

OVER THE HORIZON, CHINA

China is not only the world's most populous nation, with 1.3 billion people now and 1.5 billion projected by 2050; it also embodies the planet's extremes of water management and water disaster. China suffers from both severe droughts and severe floods. It is building what will be the world's largest dam, and the number of people that the dam will displace—at least 1.2 million—also will be a record. The Yellow River is the world's siltiest river by a factor of nine. At least 50 million rural Chinese live with an extreme scarcity of drinking water, never mind water for less immediate uses, such as bathing and sanitation.

The essence of China's water problem is that while the nation possesses 21 percent of the world's population, it has access to only 7 percent of the globe's freshwater. More specifically, densely populated northern China includes one third of China's territory, two fifths of its population, and produces 45 percent of its industrial output but receives only a quarter of the country's precipitation. One result is a profound reliance on irrigation: 70 percent of China's grain crop grows on irrigated land (compared with 15 percent in the United States). This hydrologic riddle is nothing new: failure to resolve it has ended dynasties and may yet again. With its ideological claims to legitimacy nullified by its abandonment of Communism, the current government draws what strength it can from the nation's huge economic expansion. But the expansion, volatile and vastly uneven, already has created enormous waves of social change, such as tens of millions of destitute rural migrants to the cities and the rising expectation among city dwellers of running water, indoor toilets, and diets rich in water-intensive beef and pork. China's recent displays of wealth are deceptive, since the nation's leaders are forever trying merely to hold a course amid the country's turbulent demographic currents. The government consequently takes food-related issues seriously. Most officials lived through the country's 1959–61 famine, which killed 30 million people, and have no desire to repeat the experience. That famine only increased Chinese leaders' desire for grain self-sufficiency. Through the 1990s, that policy required that at least 95 percent of China's grain be produced domestically.

The irrigation system, unfortunately, is a mess. Of China's 30,000 miles of major rivers, 80 percent are too polluted to support fish. Every year since 1985, the Yellow River, which flows through the heart of northern China's farmlands, has failed to reach its mouth for weeks, and the number of dry days each year has grown progressively, all the way to 226 days in the drought year of 1997. For long stretches, the Yellow hasn't even flowed to Shandong Province, the last province it waters before reaching the sea. Shandong farmers grow a fifth of China's wheat and an eighth of its corn; these days many of them are contemplating a return to rain-fed agriculture, which means they must drop back to one crop a year instead of two or three. More serious still, farmers all over northern China have been depleting aquifers to grow food. One Chinese survey reported that the water table beneath the North China Plain had dropped roughly five feet a year over a recent five-year period.

Rapid industrialization has intensified water scarcity. Water used in Chinese industry produces seventy times as much economic value as water used in agriculture, so industry's needs routinely take precedence over farmers'. Indeed, one reason Shandong farmers get so little Yellow River water is that it is being diverted to factories upstream. Moreover, as cities grow, farmland is taken out of production and turned into industrial and residential areas. Chinese officials are so desperate to develop new sources of water for northern China that they are planning a mammoth diversion that would dwarf Three Gorges Dam in cost and scope. One route would siphon water from a Yangtze River tributary, pump it under the Yellow River, and deliver it to the Beijing region, more than 600 miles away. A U.S. intelligence study places its cost in the hundreds of billions of dollars, enough to dampen government expenditures for other projects for many years into the future. Even that project would probably serve industrial and residential needs before agricultural ones, and its environmental damage would be enormous.

In 1994 the extremity of China's water situation produced an argument across the globe, in Washington. Lester Brown, the environmental researcher and founder of the Worldwatch Institute, claimed that within four decades China's water scarcity would compel a huge drop in the country's grain production, forcing China onto the world market in such volume that it would price out poorer countries and induce widespread famine. Most American China experts thought Brown egregiously overstated China's predicament, but the U.S. National Intelligence Council took him seriously enough to sponsor an expensive study. At Sandia National Laboratories intelligence officers gathered satellite photos to determine precisely the extent of Chinese agricultural acreage. They found that Brown greatly underestimated the acreage, which seemed to discredit his theory, but then, having deflated Brown, the NIC concluded that China still would need to import 193 million tons of grain by 2025—an estimate falling only slightly short of Brown's low-range forecast of 238 million tons by 2030. Meanwhile, Brown's critics were tossing around numbers far below 100 million tons.

Chinese officials considered Brown's claims an affront: instead of commending them for their remarkable economic gains, a Westerner was accusing them of being poised to starve the world. Brown's motive was to persuade the Chinese to begin conserving water, but they drew nearly the opposite conclusion: instead of switching to more lucrative and water-thrifty export crops, as even Brown's critics (and the NIC) advocated, Chinese officials tried to prove Brown wrong by *increasing* grain production. This meant that Chinese rivers and aquifers would be depleted at an even faster rate. Although Chinese officials lately have shown signs of revising this policy, the argument over Brown's claims still festers. I found this out when I mentioned his name to Vaclav Smil, author of the estimable 1993 book *China's Environmental Crisis*. Smil went off like a firecracker: "Stay off Brown! He's a nut! He's a guy who predicts the end of the world and massive food shortages and high prices, yet year after year we have the biggest surpluses of food and the lowest food prices in history. . . . Come on, get serious." And Smil was just getting started.

Of course, all these estimates are certain to be wrong, or, at best, right for the wrong reasons. The volume of Chinese grain imports thirty years from now is unknowable, because so many variables will influence the outcome. Every estimate takes into account only a fraction of all the variables and makes different assumptions about the variables used. Brown downplays the impact of prices, which the optimists believe will limit meat, grain, and water consumption; on the other hand, Brown thinks the optimists underestimate the impact of water scarcity. Will China's agricultural yields increase, as the optimists assume, or will they stagnate, as Brown believes? How much money will China invest in agricultural research? At what rate will China's land erode, its dams fill with sediment, its water become fouled by industrial waste and raw sewage? The questions go on and on, and suggest the folly of predicting production levels decades into the future.

In fact, the China debate is a microcosm of the larger argument over the impact of water scarcity on global food production half a century from now. In this dispute the optimists and pessimists are more evenly divided. Among the optimists are the U.N. Food and Agriculture Organization and the International Food Policy Research Institute, a World Bank–supported nonprofit; the pessimists include Brown, Postel, and IWMI, another World Bank–supported nonprofit. In preparation for a chapter of *The World's Water 2000–2001*, Peter Gleick found himself getting into arguments with people on both sides. "I realized that you can't answer the question without understanding what they're assuming, whether they tell you that they're assuming it or not," Gleick said over the phone. "My conclusion is that people in both camps don't know the answer—they're making a whole bunch of assumptions that they aren't telling us. And their crystal ball is no better than anybody else's."

The essence of China's water problem is that the nation possesses 21 percent of the earth's population but only 7 percent of its freshwater

Gleick focused on elucidating the disputed range of each of the key variables that will determine whether the world will be able to feed itself. Among his variables: Will the world's population in 2050 be closer to 10.7 billion, the U.N's high projection, or 7.3 billion, the U.N's low projection? Will most people eat 2,300 calories a day, the minimum level for health set by the FAO, or will they eat 3,300 calories a day, as people in the wealthier industrialized nations do? What portion of those calories will come from meat? This is a significant statistic, since meat consumption requires that grain be fed to livestock instead of humans. By one estimate, all the grain fed to U.S. livestock is equivalent to the amount needed to feed 400 million people. What will crop yields be? What fraction of crops will be lost to plant disease, pests, storm damage, harvesting inefficiency, spoilage, and waste? These sums now are enormous. Diseases, insects, and weeds destroy about a third of all crops, and a 1997 study estimated that in the United States, 27 percent of all edible food for humans was lost at the retail, consumer, and food-service levels.

Water scarcity dictates another set of questions: What will be the water requirements of the crops grown? A ton of potatoes, for instance, needs 500 to 1,500 tons of water, while a ton of chicken needs 3,500 to 5,700 tons of water, and a ton of beef needs 15,000 to 70,000 tons of water. What percentage of cropland will be irrigated? How efficiently will irrigation water be used? At one extreme, flood irrigation requires a low capital expenditure but wastes a vast amount of

Tucurui Dam, Amazon River Basin, Brazil

water. At the other extreme, drip irrigation requires expensive technology but uses water with high efficiency. And will the water come from rainfall, rivers and streams, lakes and reservoirs, groundwater, or reclaimed wastewater? As groundwater is depleted, will other sources be available?

What, finally, will be the impact of climate change? Gleick calls this "the down card in the poker game—you can't see it, but you know it's going to be a factor in all the other answers." If we ignore these questions, he says, the likelihood increases that food and water shortages will be a pivotal feature of twenty-first-century life. "The bottom line," he notes, "is that a lot of things have to go right to avoid a severe crisis."

THE MIRAGE OF BIG TECHNOLOGY

It is indicative of the bind we're in that even though technology helped get us into it, technology also will have to help get us out. Of course, "technology" includes a wide range of tools, from five-dollar drip-irrigation bucket kits to the Three Gorges Dam. The optimists' preference is for big technology, which, as always, seems to promise a painless way out. The gleam in their eye now is desalination, the process of turning saltwater into freshwater. "As soon as desalination technology gets water below, say, thirty cents per cubic meter, you really run out of a problem," says Aaron Wolf, in what the pessimists would call an overstatement. Desalination is useful chiefly as a source for industrial and municipal water in coastal areas, but the plants are usually too far from farmland to justify the ample pumping expense—and agriculture consumes 70 percent of all water used by humans. Of the 11,000 desalination plants that now exist, 60 percent are in the Middle East, where fuel is cheap and state budgets are relatively flush. The price of desalinated water has dropped in recent years, but it still typically costs $1 to $2 per cubic meter. Tantalizingly, a new desalination plant planned for Tampa, Florida, will sell water at 55 cents per cubic meter, but the Gulf water it treats is less saline than ocean water, and the plant enjoys financing and energy advantages that may make it unique. As it stands, desalination accounts for less than 1 percent of human water needs.

If desalination can't help us dramatically expand the supply of water, we have no choice but to reduce our demand for it. Here again, some optimists look to a high-tech, big-money solution—genetic engineering, which could produce crops with lower water requirements and higher resistance to insects, disease, and toxic substances. But the future of genetic engineering is uncertain because of safety concerns and political opposition in both Europe and the United States. "I absolutely believe we need to work on crop genetics," Gleick says. "But do we bet the house on it? That's dangerous. I think you have to address all the food and water questions."

Inevitably, this means increasing water productivity, getting more "crop per drop." The potential here is vast, since by some estimates the worldwide efficiency of agricultural water is 40 percent, which means that most water diverted for agriculture never even contributes to food production. Instead, it's lost to evaporation, leaky pipes, unlined canals, and wasteful irrigation practices. But whereas the Green Revolution offered a single strategy for increasing crop yield,

Photograph by Pritt Vesilind / National Geographic Image Collection no single equivalent exists for increasing water yield. In place of one approach, many have emerged. They usually use fewer resources, cause less environmental disruption, and cost less than their twentieth-century predecessors. In contrast to big projects such as dams, many of these approaches give local farmers a stake in the outcome and catalyze them to improve management techniques. "There is considerable evidence that farmer-controlled small-scale irrigation has a better record of performance than government-controlled large- or small-scale systems," writes Mark Rosegrant, an IFPRI analyst. The list of potentially useful small-scale methods is long and encompasses technical, managerial, institutional, and agronomic realms. In some places the best technique is a traditional one, such as rooftop or mountain-slope water-harvesting that was ill-advisedly superseded by a big but ultimately wasteful project.

At the top of most lists of appropriate water technology is drip irrigation, which was developed in Israel in the 1960s after cheap plastic tubing became available. Drip systems deliver water directly to individual plant roots, eliminating evaporation and saving water and energy. Drip irrigation not only produces water efficiency as high as 95 percent but also increases yields, since plants receive water on a regular basis instead of the boom-and-bust cycle of flood irrigation. Studies in many countries show that drip irrigation reduces water use by 30 to 70 percent and increases yields by 20 to 90 percent. Since only 1 percent of the world's irrigated lands now use drip and other high-efficiency methods, the potential for water conservation is huge. In India, for instance, 20 percent of irrigated land may be suitable for the technology.

Drip irrigation's major liability is its expense, typically $500 to $1,000 per acre, which has meant that only large farmers growing high-value crops use it. This is one facet of a huge income gap that irrigation technology has helped foster: a large majority of the farmers in developing countries can't afford the tools of irrigation and so are left out of the global economy. Among them are most of the world's 790 million undernourished people. To Paul Polak, president of a Lakewood, Colorado, nonprofit called International Development Enterprises, this is "a market chasm instead of a market niche." IDE has tried to fill it by working with small businesses in developing countries to design, field-test, manufacture, and market irrigation technology for poor farmers. At the low end of its product line is an easy-to-maintain $5 drip bucket kit, which can irrigate a 10- by 16-foot kitchen garden with two buckets of water a day. If a farmer grows income-generating crops, he can make enough money to move up to the next product in the line, a 55-gallon-drum kit for $26 that can water a 1,300-square-foot field. In China, where most farms are smaller than an acre, a poor farmer eventually could irrigate his entire field with a $300 system. In Nepal and India, IDE-assisted businesses have sold 10,000 drip kits in two years, enabling farmers to double yields without increasing water consumption.[3]

THE DREAM OF THE OASIS

Las Vegas is America's city of fantasy, and water, not wealth, is its greatest fantasy of all. The city that Hoover Dam made possible is the nation's fastest-growing metropolis in the country's driest state, the perfect manifestation of the notion that water will never run out. Las Vegas and the desert don't match: the city looks as if it didn't so much emerge from its surroundings as get deposited on them. In this desert of ostentation, water is displayed more lasciviously than sex. Among the city's hotel casinos,

Las Vegas is America's city of fantasy, and water, not wealth, is its greatest fantasy of all, displayed more lasciviously than sex

Caesars Palace laid down the archetype, festooning its property with fountains and aqueducts in 1966. Now the Mirage sports a one-acre outcropping of terraced waterfalls, and a rain forest has been installed beneath a glass canopy at the entrance. At Treasure Island the main

[3] *The path of appropriate water management often isn't smooth. IDE's biggest success is in Bangladesh, where it has overseen the sale and installation of 1.3 million treadle pumps since 1984. Treadle pumps are useful in areas like Bangladesh's Ganges delta, where aquifers are replenished during summer monsoons and the major problem is finding water during the scorching dry season. Farmers peddle the treadles for two to six hours a day; the difficulty of pumping water this way assures its judicious use. Treadle pumps cost $35 and enable farmers to earn at least $100 a year in increased crop production. In recent years, however, scientists have discovered that much of the underground water in the Ganges delta is contaminated with naturally occurring arsenic. The result has been what the World Bank calls "perhaps the largest mass poisoning in history"; 20 million people may be poisoning themselves, and several hundred thousand already display symptoms. The difficulty arose after officials promoted wells to counter a more immediate health problem, the spread of waterborne diseases as a result of drinking dirty pond water. Although IDE's treadle pumps are used chiefly for agriculture, not human consumption, Polak says he assumes that even crops grown with contaminated groundwater are affected, and IDE has joined a massive effort to replace contaminated wells. The larger lesson, of course, is that testing should occur when wells are dug.*

feature is a naval battle between British and pirate ships that employs live actors and a large supply of fireworks; this event attracts a few hundred sidewalk onlookers five times a night. The Mandalay Bay's grounds include a sandy beach with three- to four-foot waves. In pursuit of an impressive water display, I recently chose to stay at the Venetian, which features—can you guess?—canals, but unfortunately they resemble nothing so much as brightly lit, elongated bathtubs. The Venetian even contains a Grand Canal and a Basilica di San Marco, whose dissimilarities from the originals include being miniature and plasterboard and on the second floor. Bewildered tourists wait in line for the chance to pay money to stripe-shirted "gondoliers," who pole them down the hall, singing into the air-conditioning ducts.

For all its hydraulic glory, the Venetian has been upstaged by the Bellagio half a mile away. There, hotelier Steve Winn spent $40 million on choreographed spigots that dance to "Singin' in the Rain" and other tunes. Created by "water feature" specialist WET Design of Universal City, California, the installation is set within an 11-acre artificial lake for which the hotel serves as backdrop. Inside the lake are 27 million gallons of water (which a WET Design press release points out are equivalent to 3,000 swimming pools), 4,500 lights, 798 "MiniShooters," 213 "Oarsmen," 192 "SuperShooters," 350 miles of electrical wires, 120 miles of electrical cables, and 5 miles of pipe. The electrical load of this assemblage is 7.5 megawatts, enough for 7,500 homes. Every half hour, speakers all around the lake introduce a melody, drawing from an eclectic repertoire that gives equal billing to Aaron Copland, Luciano Pavarotti, Lionel Richie, and Marvin Hamlisch. Then, as the music plays, the nozzles rhythmically spew water in sinuous, synchronous arcs or in pulsed skyward streams as high as 250 feet. Mist rises lubriciously from the lake. If the sweating spectators are lucky, some of it wafts their way. When I asked Carolyn Nott, WET Design's vice president for business development, why so many Las Vegas hotels feature water, she had a quick answer: "People in the desert have always been fascinated by water. It's the idea of the oasis."

I mentioned this notion to the voluble Pat Mulroy, who as general manager of the Southern Nevada Water Authority is one of the state's most prominent officials. Mulroy, whose poufed and bejeweled appearance belies a canny grasp of western water issues, understands that the "oasis" is a construct created for Las Vegas's 30 million tourists a year. The real Las Vegas is so short of water that even if it adheres to its current conservation plan, it will probably run out of Colorado River water by 2007; then, Mulroy says, "other mechanisms have to come into play." The "mechanisms," however, are uncertain bets. In the short term, Mulroy is trying to persuade reluctant Arizonans to sell part of their allotment of Colorado River water. In the long run, she is pinning her hopes on California water, which she thinks could become available if desalination plants start supplying California. "That's the only logical place to go," she says.

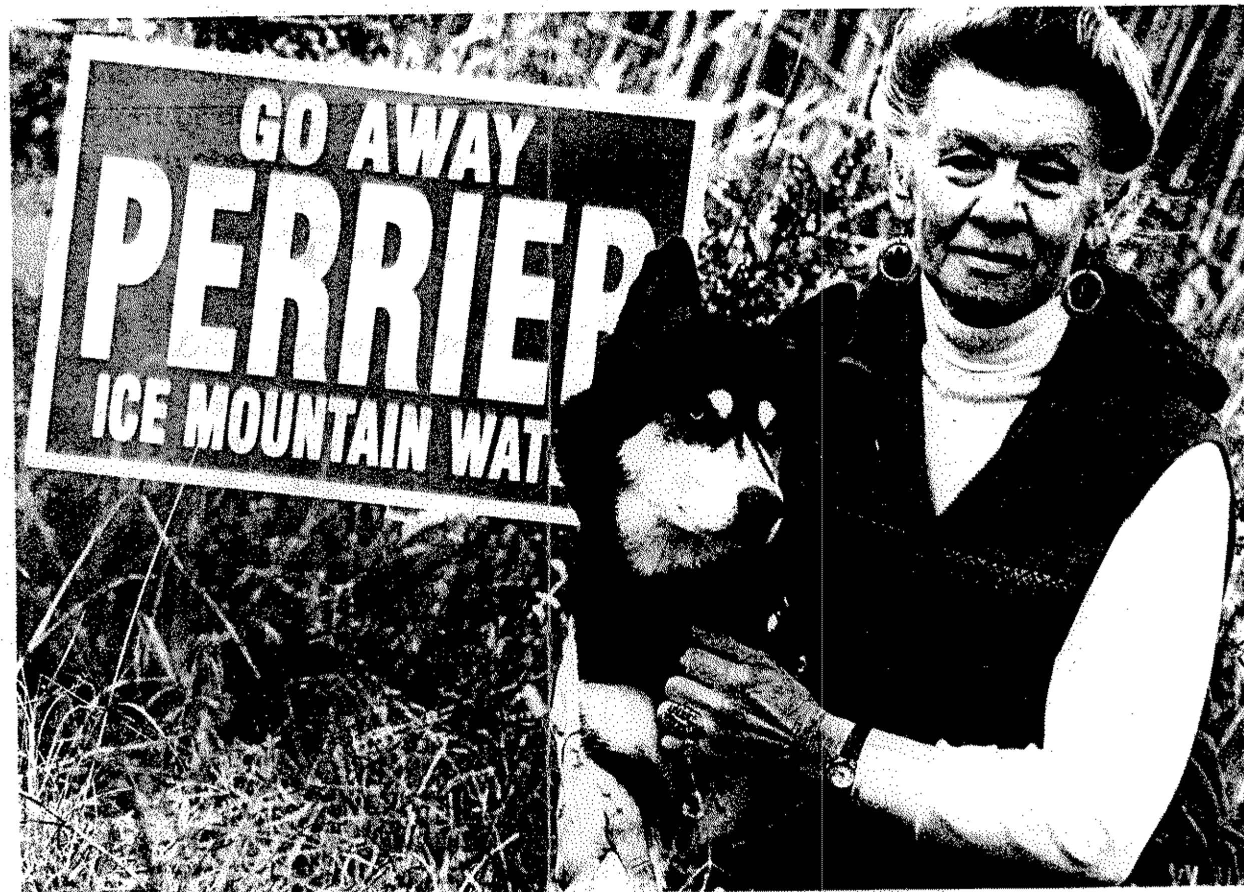
Since its institution in 1995, Las Vegas's conservation plan has already pared 16 percent off the city's projected water use and is calibrated to reach 25 percent by 2010. The biggest problem, Mulroy notes, is the insistence by so many residents on growing lawns: two thirds of the city's water is used outdoors. The conservation plan has instituted tiered water rates that force profligate residential users to pay $900 a month or more for water, and the city limits the size of front lawns. The hotels, on the other hand, are forgiven their conspicuous use of water because they are central to Nevada's economy. "The hotels generate somewhere around 70 percent of the state's gross product, and they use 8 percent of all the water we deliver," Mulroy says. "That's not a bad investment." Even so, the hotels pay top-tier rates for their water, and most use treated gray water for their displays: the Mirage and Treasure Island share one underground water-treatment plant, while the Bellagio houses another. Of course, these facilities are hidden from the hotels' guests, for whom the illusion of bountiful water is carefully preserved. I found this out when I asked Mulroy why the hotels don't advise their guests to reuse towels and stint on water use, as other desert resorts do. She said, "Las Vegas sells fantasy. Anything that jars people back to reality is viewed by those who run the hotels as a disincentive." It was the next sentence that clicked inside my brain, as I realized that it summed up the human approach to water at the end of the twentieth century. "People don't want to live in reality," she said.

But reality has a way of forcing its way into human consciousness, and sooner or later we must acknowledge that our relationship to water is intimate, complex, and primal: if we abuse it, we inevitably suffer the consequences. Remove trees from the watershed, and the river below floods; deplete aquifers, and the land above subsides; pollute or obstruct the river, and the effects flow all the way to the sea. We must accommodate ourselves to water, not the other way around. Neither the pollution of our air and soil nor the destruction of wilderness nor even the probable extinction of a majority of the earth's creatures with the threat of catastrophic climate change has prompted us to change our behavior. Now it is the turn of water, the very foundation of life, to teach us to be good animals. ■

SB44

Fighting for Mother Nature

A retired teacher takes up the fight to preserve Wisconsin's natural resources from becoming just another shelf of bottled waters.



Mark Hoffman

After 48 years of teaching, **Joan Christopherson-Schmidt** retired—and immediately jumped into a battle to preserve the pristine water of Big Springs near her Wisconsin Dells family farm.

Christopherson-Schmidt, who turned 70 last July 4 while a delegate to the NEA Representative Assembly in Chicago, spent her first official day of retirement testifying before the Wisconsin State Senate.

The issue: Whether Perrier/Nestle should be allowed to mine Wisconsin's spring waters for a new brand of bottled water.

Christopherson-Schmidt inherited 160 acres of marshland from her father. He made her promise never to let anyone drain or commercialize it, saying, "that land is for the animals, plant life, and water of the state of Wisconsin. We don't really own the land, we're only renters and must leave it as good or better than we found it for our children and grandchildren."

"Ms. Chris," as her Milwaukee students liked to call her, taught art, English, drama, and debate from the preschool level all the way through college.

"As educators," Christopherson-Schmidt says, "we must help children learn to appreciate and respect their environment and its natural beauty. That way they won't destroy it. They'll help protect it for the future."

Perrier recently received a permit from the Wisconsin Department of Natural Resources (DNR) to tap Big Springs water at a rate of 500 gallons per minute without getting an environmental impact study.

Christopherson-Schmidt is part of a group called Concerned Citizens of Newport, a leading force for preserving the land. CCN is suing DNR for failing in its public trust to protect Wisconsin's waters.

"The fight is worth it to me," she explains. "Wetlands are important to the environment, and if we lose this fight, we lose the environment." ✔

For more information and free documentary video, E-mail hirok8@aol.com or go to www.saveamericaswater.com; phone 608/253-7266 or 414/961-2200.

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OPINION

Wisconsin State Journal

Thursday, March 1, 2001

OUR OPINION

Squeezing bottlers yields drop in bucket

The debate over protecting Wisconsin's vast supply of groundwater shouldn't be limited to a relative handful of water bottling wells.

Here's a groundwater information quiz: How many high-capacity wells (which pump 100,000 gallons or more of water each day) are there in Wisconsin? Twenty? One hundred? One thousand?

The correct answer is 9,400, of which fewer than a dozen are operated by bottled water companies such as Perrier.

So why is the Senate Environmental Resources Committee holding a hearing today on a bill (SB 44) that requires water bottlers, and water bottlers only, to prepare expensive environmental impact statements before they can get state approval to sink high-capacity wells?

The answer to this part of the quiz is simple: Politics. Because Perrier managed to anger half of central Wisconsin with its efforts to open a spring water bottling plant there, it's easy picking for legislators to regulate water bottlers as if they're the biggest single danger to the state's groundwater supply.

In fact, there are far more serious draws on the estimated 2 million billion gallons of water stored in Wisconsin's vast aquifers. It starts with the fact that groundwater is being pumped out at a rate of 759 million gallons per day, versus about 570 million per day 15 years ago. The state's 1983 groundwater law does a good job of regulating threats to the quality of water stored underground, but it does not address the related issue of protecting the quantity of groundwater for future generations.

What's needed is a comprehensive approach to managing Wisconsin's groundwater supply, something that has been lacking in state law since 1945, when the high-capacity well law was passed. That law allows the state Department of Natural Resources to deny permits where such wells "adversely affect the water supply of a public utility," but it doesn't allow the DNR to deny wells for other reasons.

While he refuses to criticize SB 44, state Rep. Spencer Black, D-Madison, is quietly pursuing a more comprehensive route. He is writing a bill to address the range of demands on Wisconsin's groundwater supply, including how withdrawals from that supply affect surface water. State Rep. DuWayne Johnsrud, R-Eastman, is taking a similar approach.

It makes little sense to pass a bill that would target only water bottlers. In fact, SB 44 essentially bans small water bottlers, because only companies the size of Perrier could afford the environmental impact statements.

Take a thorough look at the management of Wisconsin's groundwater supply. Involve paper companies, utilities, farm groups, environmentalists and sportsmen in the debate. Passing a bill aimed only at water bottlers might make some lawmakers feel good about themselves, but it's quite literally a drop in the bucket.