The Sinking City

Joel Simon

Arguably the most egregious cost of Mexico's desperate attempts to modernize is a major environmental catastrophe. Although Mexico's environmental problems are diverse and multifaceted and have affected virtually every corner of the country, they have come to be symbolized by Mexico City's world-famous air pollution. Horror stories about Mexico City's air abound: it has been linked to chronic respiratory and gastrointestinal ailments, headaches, sore throats, exhaustion, irritability, skin disease, heart attacks, and mental retardation. Simply breathing in Mexico's capital has been likened to smoking two packs of cigarettes a day; it is, in the words of New York Times *correspondent Julia Preston, "one of the most dangerous places on the planet to take a breath."*[1]

Given horrors of such magnitude, Mexicans can scarcely take comfort in journalist Joel Simon's assertion that air pollution is not the worst of the city's environmental woes. Simon's remarkable book, Endangered Mexico, *details the clash between a mentality that emphasizes "progress"—conceived in terms of epic infrastructural projects, massive consumption of resources, and monumental growth—and a delicate ecosystem ill-suited to such ambitions. Mexico City's growth in the past decades has been phenomenal. In 1950, its population was a modest three million; today, according to some estimates, it tops twenty million. In 1940, it covered 43.3 square miles; today it accounts for about 571 square miles. Mexican authorities apparently have not found such growth as alarming as one might expect. To the contrary, it has been a source of great pride, a clear indication that Mexico was in step with the modern, industrial world. Indeed, perhaps the most troubling aspect of Simon's work is his account of the attitudes he encounters among both high officials and ordinary folks, who seem to regard their country's environmental debacle as either an unfortunate inevitability—one exaggerated in the media—or as a reasonable price to pay for the blessings of modernity. Among the many costs of Mexico's development strategy is the severe exacerbation of a problem dating back at least to the start of the Spanish colony: Mexico City's troubled relationship with its water supply.*

Anyone who has lived through Mexico City's rainy season, when the sky blackens each afternoon and lets loose a thunderous deluge, would never suspect that the city is running out of water. . . . But that is only because they cannot see what is happening under their feet. The underground aquifer that provides 70 percent of the city's water is being rapidly emptied—its useful life can be measured in decades.

Air pollution receives so much attention because it is so obvious. It is everywhere and its effects are immediate. The water threat is long term—and it takes a trained eye to see the damage. The only visible evidence that the city is running out of water is the fact that it is sinking. So much water has been pumped out of the underground aquifer that the clay soil underlying the city has contracted like a sponge left to dry in the sun. The sinking is not uniform; it varies from street to street, from building to building. After a century of slow subsidence, downtown Mexico City resembles a fun house at an amusement park. Streets are buckled; buildings are pitched forward or balanced at impossible angles. . . .

The problem would be bad enough if only the buildings were affected. But of course, pipes, cables, subway tunnels and the whole underground infrastructure are sinking along with the rest of the city. So many water pipes have burst that 30 percent of the water flowing through the system is lost to leaks. The sinking undermines foundations, making buildings vulnerable to collapse in the earthquakes that periodically strike the city. Sometimes the ground simply collapses and a sinkhole swallows a piece of the city. On July 6, 1996, Pati Ortiz was selling quesadillas on the street corner of a poor neighborhood called Iztapalapa when she heard a loud crack. She grabbed frantically at the skirt of her friend Hortencia Gener, but the ground had fallen away and she was sucked screaming into a twenty-foot sinkhole. The falling earth ruptured an abandoned septic tank, filling the sinkhole with poisonous methane gas. Ortiz and three bystanders who jumped into the sinkhole to save her were all killed.

Because nearly twice as much water is being pumped out of the aquifer as naturally flows in, the water has higher and higher concentrations of salts and other minerals. And because the water level is subsiding at a rate of about three feet a year, it is more and more costly to pump it up from the depths.

Thirty percent of the city's water is piped from distant reservoirs at enormous cost. In fact, 10 percent of Mexico's total energy output is used to meet Mexico City's water needs—pumping drinking water into the city and pumping waste water out.

The situation is clearly untenable. "We've looked at all of the alternatives—every one," said Alfonso Martínez Baca, the head of Mexico City's Water Com-

mission, when I met him in his wood-paneled office. "Not one of them is viable." Martínez Baca has the unenviable task of managing the city's water system. "There is no nearby source that can give us the water we need," he said. "Some people have pointed out to me that we have an inexhaustible source of water, which is the Gulf of Mexico. But you'd have to transport it four hundred kilometers and raise it two and a half kilometers. It's impossible. It would be cheaper to move Mexico City to Veracruz."

Martínez Baca leaned across the conference table and spoke in a conspiratorial whisper. "Water is the most serious threat facing the city," he said. "Tomorrow everyone could ride on bicycles and the air pollution would clear up. But where on earth are we going to get our water from?" . . .

[Editor's summary: The Spaniards, according to Simon's account, destroyed the sophisticated hydraulic works of the Aztec city of Tenochtitlán, which led to problems of chronic flooding. In the early 1600s, the Spaniards began the greatest engineering project of the colonial era: the famous *desagüe*, or drainage canal, which siphoned off the waters of Lake Texcoco. (See the selection by Zorita in Part III.) The project brought flooding under control, but created a host of new problems, including depletion of the water content of the soil, which caused the city to sink, and perennial shortages of potable water. In the late nineteenth century, the modernizing dictator Porfirio Díaz attacked these problems with new engineering feats, which included digging new wells to tap the water of the aquifer and constructing a "Gran Canal," a thirty-six-mile drainage ditch which finally dried up what was left of the lakes that had once covered 736 square miles of the Valley of Mexico.]

AFTER THREE CENTURIES of abuse, the valley's hydrology had been permanently and irreparably damaged. Buildings were cracking, water pipes were snapping, and no one could figure out exactly why. It was not until 1946 that the problem was finally solved. Engineers announced that so much water was being pumped out of the underground aquifer that the ground supporting the city was collapsing.

The Mexican government was not ready to hear the bad news. The economy was poised for takeoff and Mexico City was a big part of the plans. Commercial agriculture had been largely dismantled by President Cárdenas, who had put through the largest land reform in Mexican history. The new landowners were told not to grow crops for the gringos, but for the new factory workers in Mexico City. World War II had spawned the country's great industrialization. Nothing could stand in the way of Mexico's bright future, not even nature itself.

Despite the report on the sinking, the Mexican government went right on pumping water from the aquifer. Between 1948 and 1951 the city sank 4.4 feet; the next decade it sank another 4.75 feet. In one single year—1950—it sank a remarkable 18 inches.

By the mid-1950s, Mexico City was no longer merely the capital of the country. It had become, like Tenochtitlán, an imperial city that demanded tribute from the hinterlands. The tribute was brought in various forms—campesinos provided cheap corn, the rural migrants provided their labor, raw materials from throughout the country were channeled to Mexico City. Like Tenochtitlán, the ever-larger Mexico City embarked on an era of expansion in which it subdued its neighbors and took their water. While the Aztecs could only capture water from within the valley, new technology allowed Mexico City to look farther afield. In the late 1930s, the city's gaze fell on Almoloya del Río, a backwater town of four thousand fishermen on the other side of the 12,620-foot Ajusco volcano.

Eladio Casteñeda was a thirty-one-year-old schoolteacher when President Cárdenas motored into town with a group of engineers. They all took a quiet walk along the lakeshore, staring intermittently down at the water and up at the 14,600-foot Nevado de Toluca, a snow-covered volcano rising above the valley like a jagged crown.

The villagers were honored by the visit but did not think too much about it—not until 1942, anyway, when the engineers returned in droves with slide rules and note pads. They set up camp along the lakeshore in a field where water percolated up through the ground "like it was overflowing from a boiling pot," according to Casteñeda. The water trickled down into Lake Chiconahuapan ("nine waters" in Nahuatl) and then formed a series of other, smaller lakes before settling down to become the Lerma River. The Lerma flows through the states of Querétaro and Guanajuato before emptying into Lake Chapala, near Guadalajara.

"This was the source of the Lerma River," Casteñeda said with a certain pride as he waved a hand over the landscape visible outside his second-story home. "The whole plain was covered with water—and it was clean, Señor. You could see the fish." Casteñeda had spent his childhood fishing and scavenging in the lake. The Mazahua- and Otomi-speaking Indians who had first settled the valley eight hundred years ago had lived much the same way.

The plan to bring the water to Mexico City got off to a poor start. The engineers dynamited the spring in an attempt to increase the flow of water, but instead the water stopped flowing altogether. Undaunted, the engineers sank pumps into the ground. They sucked up 1,600 gallons of water per second and sent it along a large pipe parallel to the old river channel. In the town

of Atrasquillo, the pipe turned east at a ninety-degree angle and climbed the Sierra de las Cruces. Then the water flowed through a three-mile tunnel into the Valley of Mexico. The hundreds of springs in Almoloya quickly ran dry.

The inauguration in September 1951 drew a long line of dignitaries from Mexico City. Once again, the public was assured that the new system would end Mexico City's water problems forever, and that the sinking city would be quickly stabilized.

Meanwhile, Eladio Casteñeda watched as the lake that had sustained him, his village, and his ancestors slowly dried up. "It was like a dream," he said. "One day we woke up and it was gone." More than thirty years later, Casteñeda took me for a walk along what used to be the lakeshore. With the springs gone, what remains of the lake is now filled by sewage and runoff. A small flock of pelicans rested on the water. Casteñeda laughed when I asked if it reminded him of his childhood. "Oh, it was much bigger," he said. "The lakes were not deep, but you could go in a canoe from here all the way to Lerma."

When I asked Casteñeda whether he missed the village life of his childhood, he was less definitive. The engineers who took the water later brought roads, schools, sewage systems, potable water, and a wave of industrial growth. The town's economy shifted from fishing to shoe making and the standard of living rose accordingly. Among Casteñeda's nine children one is a doctor, another a lawyer, and a third an engineer. During a later visit to Almoloya, I asked seventy-eight-year-old Taurino Ariscorreta whether he missed the lakes. He sat back in his chair and thought for a few moments. "It was a beautiful life," he said finally. "But we were very, very poor.

Meanwhile, the diversion of the water from Almoloya to Mexico City meant that the Lerma River now began downstream. Unfortunately, it was exactly the same spot where the government of Mexico State had decided to build an enormous industrial park. Today, the Lerma begins its journey carrying 1,000 gallons per second of partially treated sewage and industrial waste. Along its route, it is fed with chemicals from tanning factories, tar from a Pemex plant, and pesticides and fertilizers from the fields that line its banks. It disgorges the muck into Lake Chapala.

The sacrifice of the Lerma River bought Mexico City only partial relief from its water woes, and for only about fifteen years. In 1965, with demand for water continuing to increase and with downtown Mexico City continuing to sink, authorities decided to expand the pumping around the headwaters of the Lerma from 1,500 gallons per second to 4,000 gallons per second. Five hundred new wells were drilled throughout the Ixtlahuaca valley north of the town of Lerma. But the engineers had vastly overestimated the size of the aquifer. By 1970 the land was sinking so rapidly that cracks began to open

up in the ground. Still they kept pumping until the aquifer was completely depleted. Today only 1,400 gallons a second can be pumped from the Lerma Valley—a mere drop in the bucket of Mexico City's water needs.

The government had known from the beginning that the Lerma system would buy the city only a few more years. A report released at the time that the Lerma system was inaugurated acknowledged that the next water crisis was only a few years away. . . .

[IN 1952], MEXICO CITY was hit with a terrible flood. As in colonial times, people moved through downtown streets in canoes. The city flooded because, after decades of pumping water from the aquifer, the city had sunk below the level of the drainage canal and the flood water could not be evacuated. When the Gran Canal del Desagüe was built in 1900, it was graded to carry the sewage downhill and out of the valley. After the 1952 flood, pumping stations were installed to take the water uphill. Authorities recognized that this was only a temporary solution. As the city grew, more and more water needed to be drained. The pumps consumed large amounts of electricity, and the city remained vulnerable because they could always break down.

Attacking the underlying problem by reducing water consumption and thereby stabilizing the sinking would have been politically unpopular and would have brought the country no glory. Authorities argued that the development process required the consumption of large amounts of resources, and they were convinced that technology and growth would create a solution. Enormous public works were always favored over conservation because they strengthened the power of the central government and became a source of national pride. Mexico would solve the flooding problem with an infrastructure project on the scale of [the colonial] *desagüe.*

Studies for a deep drainage tunnel began in 1959, but ground was not broken until May 1967. The plan was to build a fifty-mile tunnel at a depth of 650 feet, making the system impervious to the sinking. Thirty thousand workers labored on the project, raising 4.57 million cubic yards of dirt from the depths. Workers hoisted from the bowels of the earth had to be put in decompression chambers to avoid getting the bends. The official cost of the project was $43.2 million (540 million pesos), a figure many believe to be far less than the actual investment.

Completing the tunnel took nearly a decade. President José López Portillo personally opened the floodgates in 1975. Supporters were bused in and given T-shirts and banners and instructed to cheer the president and thank him for liberating them from the floods. Officials made a host of self-congratulatory political speeches. . . .

It was another decade before the deep drainage canal was operating at full capacity, but the Gran Canal continues to handle the bulk of the city's sewage. The pumping stations, viewed as a stopgap measure, still move the water along its uphill journey out of the valley.

There was one last detail to be worked out. What do you do with the 23,200 gallons of raw sewage and industrial waste that Mexico City produces every second? In order to find out, I decided to follow the Gran Canal. It was easy to find—I could smell it from blocks away. The canal begins appropriately enough just behind the Mexican Congress. I followed it a few blocks north and stopped at the first bridge to take a look. The "water" was a thick black sludge, the consistency of syrup. It did not seem to flow so much as percolate. I drove through working-class neighborhoods and stopped again at the border of Mexico State, where the canal intersects with the Rio de los Remedios; the sludge carried by the river backed up with the canal, forming an enormous swamp of sewage that spread out over acres. I had to hold my breath as I ran across a hanging bridge to a dusty soccer field. Jesús Fuerte García, a sixty-year-old truck driver, covered his mouth with a handkerchief as he crossed behind me and then spat on the ground. "It's a source of infection, of course," said García as we watched the soccer game together. "It hurts your throat. The kids who play soccer here are always getting sick. And when it rains, it overflows the banks."

When I crossed back over the bridge to return to my car I noticed a large object floating under the bridge. It was the carcass of a dog. I recognized it only because of the outline of a jaw poking through the muck.

Despite the stench, houses line the banks of the Gran Canal as it passes through the shantytowns north of the city. Then it flows through open fields until it reaches the town of Zumpango. There, it ducks into a tunnel and then reappears outside the valley in the state of Hidalgo. . . .

I caught up with the black waters in Hermanejildo Estrada's cornfield. Detergents agitated by the passage through the tunnel floated along the irrigation ditch. Foam was everywhere, blowing through the landscape like sagebrush across the prairies. The water is used to grow vegetables. The Mexican government has repeatedly claimed that there are no health risks, but in 1992 a United Nations study found extremely high levels of arsenic, chromium, and selenium and moderately high levels of cadmium, nickel, and zinc in the soil. What effects, if any, these high levels could have on human health is much debated, and from a scientific standpoint the answer is by no means clear. But logic would suggest that there are health risks associated with eating anything grown in raw sewage. Certainly, there are serious risks to the farmers and to the land itself.

When I visited the Mezquital Valley in 1991, cholera was raging through the region. Doctors at local hospitals told me there had been hundreds of cases but added that the government was not releasing the official figures. Farmers, however, defended the waters, saying the organic waste fertilized their fields. Estrada, for example, was undaunted by the recent outbreak. "I've worked with the black waters for twenty years and I've never gotten sick," he told me as we stood beside the toxic canal. "If cholera gets me, so be it."

Cornelio Rosas, meanwhile, was back in his fields only a day after suffering a cholera attack. The doctors told him to wash his hands better. "The black waters don't do anything bad," insisted Gerardo López as he loaded squash into the back of his pickup truck. "We will never let the authorities take them away from us."

As the black waters retreat, they leave the fields coated with a thick crust of salt. The Tula and Salado Rivers, which receive the effluence from the Valley of Mexico, empty into the Moctezuma River. The Moctezuma, like every river in the whole watershed, is dead. In most of the world, large cities are in valleys, along river banks, or on the coast, so that if you hike up into the mountains you can find a less-disturbed landscape. But Mexico City's sewage feeds the headwaters of several major rivers. Even if you hike into a remote canyon downstream, you will have to wade through a river full of foam and chemicals.

The black waters have a second destination as well, as I discovered during my travels along the city's sewage canals. On the highway from Mexico City to the city of Texcoco, signs announced a government-funded "ecological rescue" project to restore Lake Texcoco. I pulled off the highway on a dirt road and drove half a mile to a locked gate. A policeman, dressed in black and carrying a machine gun, emerged from a small cubicle. "Entry is prohibited," he told me. "Those are my orders."

The effort to revive the lake began in 1971 as a means of controlling the dust storms caused when dried sediment is whipped up by strong winds. Engineers who began work on the project discovered a major obstacle: the city had sunk so far that Lake Texcoco, once the lowest point in the valley, was now six feet higher than the city center. Allowing the lake to fill with water would have created a serious flood risk. So the engineers did what they knew best—they begun pumping water from the soil around Lake Texcoco until the whole area started to sink. Today Lake Texcoco, which is filled by partially treated sewage water, is two feet below the city. It seems absurd that in an area once covered with water, lake beds have to be created artificially. It is equally absurd that up to 23,200 gallons—both sewage and rainwater—are artificially channeled out of the basin, while approximately 5,300 gallons are

pumped in from neighboring valleys. The city is running out of water, and yet it is perennially flooded.

Something in the policeman's tone suggested to me that he thought his orders to keep me out were as stupid as I did. Since he was unmoved by my press pass, I started chatting about the ancient lake. I told him that five centuries ago we would have been under water—or if we were lucky, in a canoe. We could have paddled from where we stood to the town of Texcoco, where the poet-king-engineer Nezahualcóyotl once ruled. We could have paddled or poled across the shallow waters to Tenochtitlán; we would have seen the pyramids rise into the sky as we drew close. If we had some business there, we could have paddled through the streets of the city, directly into Moctezuma's palace. We could have paddled to Lake Chalco, or among the *chinampas* (floating gardens) of Lake Xochimilco. The lakes would have been full of ducks and pelicans; we would have been able to see the fish swim below us.

I do not know if I bored or amused him, but he finally realized that the easiest way to get rid of me would be to let me see the lake. He opened the gate. "Park your car in the bushes," he said. "I could get in trouble."

I walked a few hundred yards over a rise and looked down across a dark lake. Yes, the lake had returned, but the water had not been sent by Tlaloc, the water god. Lake Texcoco was filled with the sewage from Mexico City. The freshwater springs that once filled the lake had been replaced by millions of flushing toilets and the industrial waste from thousands of factories. The tragic cycle had been completed. The pelicans did not seem to notice. They gathered along the lakeshore and flapped lazily into the darkening sky.

As I walked back to my car for the drive back into the smoggy city, I thanked the policeman for breaking the rules. He seemed strangely disappointed that I was leaving. The poor guard was going out of his mind with boredom. "This is my job," he said, as I climbed into my car. "But I hate it. There's nothing here. This spot is so lonely you can't imagine." . . .

IN 1972, AROUND the time that air pollution finally became a public concern, the government was working quietly to find a new source of water. The millions of newcomers were a problem, not only because they needed water but also because they often settled on the aquifer's wooded "recharge" areas. As trees were cut down and roads were paved, less rainwater was absorbed into the aquifer.

The 1965 strategy to increase pumping in the Lerma Valley was clearly a failure—the friatic level (the depth at which water is found) was dropping rapidly, and water could be guaranteed for only a few more years. The Mexico City aquifer was being exploited at full capacity, and the sinking, though slowed, continued to be a serious problem.

The solution to the water crisis had to be another massive infrastructure project. Los Angeles, it was pointed out, had brought water from the Colorado River two hundred and fifty miles away, and Mexico City could do the same. In fact, it would have to do more. Los Angeles is at sea level, and the water from the Colorado is carried in an aqueduct that flows downhill. At an elevation of 7,347 feet and surrounded by mountains, Mexico City is on one of the highest plateaus in Mexico. Water from surrounding river valleys would have to be pumped at tremendous cost.

On a map, the engineers drew concentric circles around Mexico City. They evaluated various factors—the distance the water would have to be transported, the height of the intervening mountains, the existing infrastructure. The engineers noticed a major dam built in the 1940s at Valle de Bravo in the pine-forested mountains of Mexico State. There was a second dammed reservoir forty miles away at Villa Victoria. The engineers calculated that they could tie the two dams together and then send the water to Mexico City through the tunnel that had originally been built to bring the water from the Toluca Valley. There was only one problem: Valle de Bravo is at 5,700 feet and Mexico City is nearly 1,700 feet higher. Not only that—there is an even higher pass (8,300 feet) between the two. Getting the water to Mexico City would require building dozens of miles of aqueduct, a ten-mile tunnel, a five-mile canal, six power plants to raise the water up the mountains, and an enormous water treatment plant, plus the installation of pipes and tunnels to distribute the water once it reached the city. The system would be a project to rival Hoover Dam. It would fundamentally transform the entire landscape and put it at the service of Mexico City.

When ground was broken on the Cutzamala ("watershed") project in 1974, Mexico was flush with oil money, and future growth seemed ensured. The government did not flinch at the prospect of subsidizing the water delivery system, since its actual cost would be well beyond the means of most Mexicans. But by 1982, when the first part of the system was brought on line, oil prices had collapsed, and Mexico had begun a decade of deprivation and economic stagnation. Still, the work continued apace. In 1985, 1,600 gallons of water per second were being pumped from the Valle de Bravo dam. Over the next few years several other small dams were added to the system, and in 1995 the third phase was completed, bringing the total output of the system to 4,200 gallons per second—about one quarter of the 16,400 gallons per second consumed by the city. It takes 1,650 million kilowatt-hours per year to pump

the water to Mexico City—approximately 6 percent of the city's total energy consumption.

The use of surface instead of subterranean water has made the Cutzamala system the most reliable of all of the city's water sources. But it is some of the most expensive water in the world.

One day I tried to follow the aqueduct from the Valle de Bravo back to Mexico City. Valle de Bravo is a quaint cobblestoned village where the Mexican elite have their weekend houses. To get there, I drove through the treeless plains around Toluca and then followed a snaking road that descended from the plateau into a pine-covered valley.

What is ironic about the Cutzamala system is that a city that first trashed its own hydraulic system and then that of its neighbor is now dependent on the conservation and careful management of a third one. All dams have a limited life; over decades they fill with sediment washed down in tributaries, and their capacity diminishes. When the Valle de Bravo dam was built in 1944, the capacity of the reservoir was 108 million gallons; today sedimentation has reduced it to 89 million gallons. Preventing deforestation and erosion in the Valle de Bravo is the responsibility of Santiago Zepeda González, the local delegate from Probosque, the federal forestry agency. With a tiny office and an annual budget of $10,000, Zepeda tries to stop illegal logging, prevent forest fires, and encourage reforestation. In an area in which the Mexican federal government has invested billions of dollars in infrastructure, it has been miserly in funding programs to protect that investment. "Illegal logging is the biggest problem," said Zepeda. "You can get 200–300 pesos for a tree. That's a lot of money for a poor campesino."

The next morning I followed the road to Los Berros, the enormous water treatment plant that purifies the water sent to Mexico City. Five pumping stations raise the water 2,300 feet from Valle de Bravo. What surprised me was that what had appeared as a solid mass of trees was actually forest interspersed with cornfields. Some of the cleared areas were plowed and planted with corn in anticipation of the summer rains: others were eroded and abandoned. At a clearing full of shacks made from freshly cut timber, I talked to Genaro Mari Carranza, who along with about a dozen other men was returning from an afternoon fighting a small forest fire. "It's volunteer work," said Carranza. "We want to save something for our children."

Rangers patrol the woods to ensure that only dead trees are logged, but cutting down a live pine is an incredible temptation for families without enough to eat. Carranza and the 155 Mazahua Indian families who settled in the clearing in 1993 subsist on the corn they produce. But the land they cultivate has been depleted of nutrients; every year they have to add more fertilizers. Carranza leaned against the hoe he was carrying when I asked if logging should be allowed. "For the people who live here, yes, but the government says it's illegal." It must seem nonsensical to be told essentially that a tree is more important than the lives of their hungry children.

Just a few miles up the road was a sad example of why the government is taking a hard line. The forest revealed itself as a veneer, a tree theme park. The trees simply vanished as I drove through them and emerged onto an open plain full of small towns and scraggly cornfields. A few miles farther on I reached the Los Berros water treatment plant, the center of operations for the whole Cutzamala system. In Mexico City I had been told that all visits to the plant had been suspended for "reasons of security," but after a little cajoling Absalón Domínguez, the engineer who runs the facility, consented to give me a tour. We stood in the control room amidst blinking yellow and red lights, as Domínguez used a wall-sized map of the Cutzamala system to make his points. "The Villa Victoria dam was built only fifty years ago and is already full of sediment," he said. "It's only got another fifteen to twenty years of useful life. Valle de Bravo is in much better shape—I give it thirty years, assuming that there is no more deforestation." He pointed to light green spots on the map where the forest had been removed. "This is what worries me," he said. "At some point we'll need to find more water."

The enclosed pipe that carries the water to Mexico City ran across a field and disappeared over an 8,300-foot ridge. From there it is all downhill. The water flows through lonely valleys, across the Toluca plains and through a tunnel in the Sierra de las Cruces before arriving in Mexico City. By the time it comes out of the tap, the cost of a gallon of water is nearly four-tenths of a cent (a liter costs one-tenth of a cent). What you pay, if you pay at all, is less than half that amount. That means that every time you open the tap and take a drink of water in Mexico City (assuming you are brave enough to do so), you strain Mexico's national treasury. The government picks up 60 percent of the tab every time you flush the toilet, take a shower, wash your car, or water your lawn. The total deficit according to Mexico City officials is $125 million a year. An independent study of the water system came up with even more alarming numbers: although the real cost of a cubic meter (1,000 liters) of water is one dollar, the government recovers only ten cents. The annual deficit for water services is $1 billion. Subsidizing the water not only strains the budget; it encourages the illusion that water is plentiful and that there is no reason to conserve it.

The lesson to be drawn from the Cutzamala system is that it is not economically feasible for the government to transport water from other basins. Not only is the infrastructure investment prohibitive, but the government

must also make an indefinite commitment to covering the annual budget shortfall. The only way to restore some sort of environmental equilibrium is to treat the valley as much as possible as a closed system. Nearly thirty inches of rain fall in the Valley of Mexico each year, enough to provide a good deal of the city's water needs if it were properly managed. The problem is that the rains in Mexico City are torrential, and the terrain in the surrounding mountains is extremely steep. Left to its own devices, the rainwater would refill the dried lake beds. Unfortunately, they are now occupied by millions of people. The handful of reservoirs within the metropolitan area are used not to store potable water but rather raw sewage, which cannot be accommodated by the city's overloaded drainage system. Because of the danger of flooding, the city must pump rainwater runoff out of the valley as quickly as possible. There are simply no places left in the valley to store large quantities of water for human consumption.

But there is another option: the aquifer itself. The city needs to do a careful study of the exact composition of the aquifer and then inject rainwater collected in smaller reservoirs equal to the amount that is being extracted. One of the greatest untapped sources of water in the city is the water system itself; the sinking has ruptured so many pipes that 30 percent of the water is lost. Alfonso Martínez Baca told me that if he could cut that figure in half, he would suddenly have another 18,000 liters (4,760 gallons) per second of water available for distribution. The city also has a billion-dollar plan to improve drainage and build water treatment plants. If the authorities can find a way to better police industry so that the sewage is less contaminated by chemicals and heavy metals, the water could be treated sufficiently so that it could be reused by industry or perhaps reinjected into the aquifer. There is simply no other solution: Mexico City must find a way to live within its means.

NEARLY FIFTY YEARS after the first scientific report confirmed that extracting water from the aquifer was causing the city to sink, 70 percent of Mexico City's water continues to come from wells in the valley. Once you develop a trained eye you can spot the pumps throughout the southern part of the city—in highway medians, parks, and abandoned fields, and on street corners. There are 4,820 of them, and they pump 11,000 gallons a second out of the aquifer—double the amount that flows in naturally. Because of the "overexploitation" of the aquifer, the friatic level drops more than three feet a year. The danger is not so much that one day the wells will run completely dry, but rather that the quality of the water will continue to deteriorate. More and more of the water pumped up is "fossilized," meaning it has been in the aquifer for an eon. It is so full of minerals and salts that it is not potable. The

sinking threatens not only the buildings and the streets but the aquifer itself. In many areas, the direction of the natural drainage has changed; waste water that used to accumulate on the less permeable clay soils of the former lake now flows toward the recharge areas where it filters down into the aquifer. The sinking has opened deep fissures in the surface of the valley. During the 1985 earthquake an enormous crack opened up in Lake Xochimilco, and millions of gallons of untreated sewage poured into the aquifer. Contaminants from the open-air garbage dumps also eventually migrate down to water level. As the friatic level drops, the concentration of both natural and artificial contaminants increases. Since the water has to be pumped from about three feet deeper each year, it is also becoming more expensive.

Beginning in the 1950s, the city began using wells to the south of the valley rather than downtown. This change has reduced the sinking in the city center from a high of eighteen inches a year in 1951 to only four inches a year today—still a very dangerous amount. Meanwhile, the sinking has intensified in the south. Chalco, for example, a squatter settlement built partially on the extinct lake bed, sank about a foot a year between 1985 and 1990. As the south has become increasingly urbanized, it has begun to confront the same problems the city center has; foundations are cracking, roads dip for no apparent reason, overpasses pull away from the main road, and floods are growing worse. A depression formed by the sinking around Chalco becomes a fetid lake during the rainy season. In heavy rains it overflows and floods the town. Xochimilco—once a lake, now a suburb—has had similar problems. On October 4, 1990, fourteen-year-old Sol Aguilar Gallardo stepped off a city bus and was swept away in the raging river that had replaced the street.

Despite the fact that the city depends on the aquifer for its survival no one I talked to would give me a straight answer when I asked how much longer it would be able to provide water. "I wouldn't dare to guess," said water commissioner Alfonso Martínez Baca.

"But since the city would disappear if the aquifer ran dry," I asked, "why haven't you done a detailed study to find out how much water it contains?"

"There are a lot things that haven't been done," he said.

Even in the unlikely event that the aquifer is able to meet the city's water needs for the next few decades, the cost of the centuries-long battle against the water has already been paid in thousands of lives. At 7:19 in the morning on September 19, 1985, off the coast of Michoacán, the land ruptured along an area 240 miles long and 50 miles wide. The quake, which measured 8.1 on the Richter scale, killed tens of thousands in Mexico City and reduced whole neighborhoods to rubble. Certainly the earthquake was a "natural disaster." The impetus was a cataclysmic event that could not have been controlled or

predicted. But a great deal of the tragedy was also manmade, a result of centuries of environmental abuse in the Valley of Mexico.

While the earthquake leveled the small town of Lázaro Cárdenas near the epicenter, forty miles away the damage was relatively minor. That was because much of the energy liberated by the seismic motion was absorbed by the surrounding bedrock. But when the seismic waves passed under the mountains and entered the Valley of Mexico two hundred and fifty miles from the epicenter they were suddenly revitalized. The dried lake bed on which the city is built is made up of volcanic ash and sediments washed down from mountains over millions of years. The soil is highly saturated—in effect, Mexico City is built on mud. The seismic waves were trapped in the spongy soils under the ancient lakes; they bounced around wildly, hurling themselves against the denser basaltic rock that once marked the lakeshores, and then vibrating back through the soft soil until they hit something solid. It was as if four people, each holding onto a different corner, tried to shake out an enormous blanket. Buildings were pulled in two directions at once. In the marshy soil underlying the city center, the destructive force of the earthquake matched that at the epicenter. Meanwhile, in tony neighborhoods like Coyoacán and Lomas de Chapultepec, which were built on firm rock, the intensity was fifty times less.

Above the remains of Lake Texcoco, dust rose into the air. Nowhere was the damage more severe than around the Alameda [Park, near the center of the city]. Pumping from the aquifer had caused the park to sink more than twenty-five feet since the turn of the century, weakening the foundations of many of the hotels and government office buildings surrounding it. The Hotel Regis, the Hotel del Prado—both spilled their guts into the street, a tangled mass of twisted girders, concrete slabs, electrical cables, splintered furniture. Under tons of rubble were hundreds of bodies. Some were extracted and buried in common graves; others, never found, disappeared into the landfill along with the broken concrete. A block from the Hotel Regis, Lucas Gutiérrez stood outside his restaurant, the Super Leche, "and watched as a hole opened up in the ground into which disappeared his restaurant along with an apartment building in which 300 people had lived." Wrote Mexican journalist Elena Poniatowska: "It was as if a giant vacuum cleaner had sucked it up."

The earthquake represented a terrible payback for the centuries-long battle against the valley's natural environment. Despite clear evidence of its potentially disastrous consequences, city authorities continue to pump water from the aquifer.

The Aztecs believed that the fifth sun, the sun of motion, would be destroyed by earthquakes. Whether or not that prophecy is fulfilled, Mexico City must live under the weight of its history and with the consequences of poor

decisions made long ago. The Spanish city has a shallow hold on the land. Despite nearly four and a half centuries of progress, despite an enormous investment in monumental infrastructure projects, the city cannot escape the destiny ascribed to it by the Aztecs. Mexico City is condemned forever to be a city on the brink.

Note

1. "A Fatal Case of Fatalism," *New York Times*, February 14, 1999.