AN

UNNATURAL

METROPOLIS

WRESTING NEW ORLEANS FROM NATURE

CRAIG E. COLTEN

WITH A NEW PREFACE BY THE AUTHOR

LOUISIANA STATE UNIVERSITY PRESS

BATON ROUGE

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PREFACE TO THE 2006 PAPERBACK EDITION

IN LATE AUGUST 2005, hurricane forecasters watched as Hurricane Katrina blew over Florida and headed into the Gulf of Mexico. Warm waters fueled the storm as it moved slowly toward the west and gained intensity to a Category 5 storm with peak wind speeds of 175 miles per hour by August 28. As the storm veered northward, authorities pleaded with residents throughout the Louisiana delta to evacuate to higher ground, and some 800,000 managed to leave the New Orleans metropolitan area. At about 6:00 A.M. on August 29, Katrina, now a Category 4 storm with winds of about 140 miles an hour, pushed on shore near the mouth of the Mississippi River. As its eye continued toward the Mississippi coast, Katrina shoved a powerful storm surge across the wetlands east of New Orleans toward the city and into Lake Pontchartrain. By 10:00 A.M., the storm made landfall near the Louisiana-Mississippi border. Winds had diminished to about 100 miles per hour, but as the storm move inland, the cyclonic winds piled the storm surge up against the hurricane protection levees on the New Orleans lakefront and along the Industrial Canal.

Those who rode out the daylong storm breathed a sigh of relief as wind speeds began to lessen, and many briefly thought that they had come through the ordeal relatively unscathed. Yet the powerful surge had weakened hurricane protection levees in several places, and Lake Pontchartrain began to pour into sections of New Orleans, creating a massive embayment. In addition, levees along the Industrial Canal failed, and storm surge that had traveled up the Mississippi River Gulf Outlet rushed into the city's lower Ninth Ward. At the points of each levee failure, raging torrents poured through gaps in the protective bulwarks, ripped houses from their foundations, and tumbled cars across the landscape. Near the lakefront, floodwaters stood 5 to 7 feet high, filling countless houses. Waters exceeded 10-foot depths in parts of the lower Ninth Ward and, reminiscent of Hurricane Betsy in 1965, trapped many residents who had not been able to evacuate.

For days, the nation watched, transfixed, as New Orleans contended with this most brutal encounter with nature. The structural protection system that gave so many a false sense of security crumpled before the exceptionally potent wind-driven water. As the mayor issued a mandatory evacuation for the approximately 100,000 remaining residents, the city ceased to function as a metropolitan center. First, ad hoc rescue teams of residents commandeered boats from their neighborhoods and struggled to transport the elderly, the very young, and the infirm to higher ground. Flotillas of state powerboats and fleets of federal helicopters arrived and swarmed over the approximately 80 percent of the city that was under water to carry the survivors to safety. Meanwhile, crews rushed to close the gaping holes in the levees and then began the slow process of pumping the excess water out of the city.

While the news media quickly descended on the city, outbreaks of violence stalled the mobilization of National Guard, Red Cross, and FEMA crews. Reporters and their camera crews broadcast a national shame, images of thousands of survivors who were stranded for days in the stifling muggy heat at the Superdome and the Convention Center. Their desperation rose as food and water supplies dwindled and the anticipated assistance from disorganized government authorities was slow to arrive. Ultimately, National Guard convoys rumbled into the city to restore order and distribute emergency rations. Soon afterwards, charter buses began transporting the newly homeless to distant evacuation centers.

A week after the storm's landfall, national guardsmen became the most numerous residents. They patrolled the streets and manned checkpoints

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to prevent all but emergency personnel and news media from wandering the flooded city. After initial rescue efforts concluded, military and emergency personnel inspected houses for survivors, pets, and corpses, painting grim messages on the fronts of houses indicating they had completed their searches. At nightfall, operations paused and the city fell into an overwhelming darkness due to pervasive power outages. Food left behind in refrigerators soon began to rot.

New Orleans residents had evacuated many times before, but they had always been able to return after a few days. The unanticipated delay caused by flooding and power failure forced a protracted displacement of nearly a million people and completely overwhelmed all shelters and emergency plans in Louisiana and neighboring states. Many evacuees took up temporary residence with friends and family in nearby towns, while others hunkered down in cavernous and impersonal sports arenas, school gymnasiums, military bases, and convention centers across the South and beyond. Generous communities and organizations across the country took in the evacuees who were bused and airlifted to distant quarters. As it became apparent that it would be months before the city could accommodate its citizens again, many began setting up homes in new locations. New Orleans became a truly dispersed city, with its populace residing in all fifty states.

Trapped within the rings of levees built to protect the city, the floodwaters presented the most immediate problem. Concern about contamination contributed to the mandatory evacuation order and probably helped prevent disease outbreaks from contact with the foul waters. The slow process of pumping the water from sections of the city below sea level presented a second challenge. Temporary pumps took over the work of the disabled municipal pumping system and had nearly completed the task when Hurricane Rita overwhelmed the temporary patch jobs on the levees and inundated sections of the city a second time in late September. Not until mid-October was "Lake Orleans" expelled from the levee system.

With the removal of the floodwaters, the real destruction surfaced. While the many homes and trees that sustained considerable wind damage throughout the metropolitan area had been visible from the outset, receding waters revealed the thousands of houses that became vessels of standing water for weeks. Inside homes, mud-caked furniture and appliances appeared to have been tossed about by a giant agitator. Saturated wall and ceiling materials fell to the floor, adding to the mucky disarray. Cars left be-

hind by evacuees acquired a drab gray mud finish, and many tossed about by floodwaters found precarious perches on stumps and fences. Downed trees, their branches tangled in disabled power lines, obstructed countless streets. Most ornamental shrubs and trees drowned in the salty water that encircled them for a month or more. The normally lush landscape was a depressing brown and grey.

As the city gradually cleared its thoroughfares and began reopening neighborhoods in late September, residents returned to an almost unimaginable expanse of devastation. Mile after mile of flood-stained and eerily empty residences lined the mud-caked streets near the lakefront and in New Orleans East. Some returnees launched into the sweaty labor of restoring their dwellings. Their efforts transferred mounds of moldy furniture, ruined electronics, discolored family mementos, and armies of rank refrigerators sealed with duct tape to the roadside. Eventually heaps of soggy Sheetrock and ruined household fixtures found their way to the curbs. Throughout the city, temporary landfills occupied medians as waste haulers completed the massive chore of transporting the mountains of refuse to more permanent disposal grounds. Thousands of flooded automobiles abandoned after the storm have been hauled away as well. Early estimates suggest it will take a year for the convoys of trucks to remove all the storm's debris to formerly closed landfills now reopened near the city's wetland fringes.

Government-provided tarps transformed the city's roofline into an ironically playful blue hue. The "blue roof" program provides temporary covering for damaged roofs until owners can line up crews to complete permanent repairs. With the prospect of ample construction employment, workers have descended on the city en masse. In the absence of housing for residents, to say nothing of outsiders, laborers have occupied city parks and vacant shopping center parking lots with tents and camper trailers. These workers along with residents who must commute from nearby communities transformed a nearly empty street system in September into a snarled highway system by November. During rush hour, traffic jams exceed pre-Katrina congestion.

Three months after the storm, some sections of the city appear virtually unfazed. For much of suburban Jefferson Parish—which did not endure flooding—life is somewhat normal. Repair work is still under way, and most residents have reoccupied their homes. Government, commerce, and education are running at near normal levels. The French Quarter and other neighborhoods in New Orleans that were built on the slightly higher

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natural levee are active. Many businesses have reopened in these districts, and residents have returned as power and water have been restored. Public and parochial schools are resuming instruction. Yet estimates place the city's full-time population at about 80,000, compared with 460,000 before the storm. Restoration of the city proceeds slowly and uncertainly.

Hurricane Katrina exemplifies the inability of human artifice to exclude nature from cities. Natural forces, in the form of a massive hurricane, present obvious hazards and are responsible for extreme events. Yet human actions can amplify the effects and actually make an extreme event into a disaster. This can come about by a combination of factors made all too evident by Katrina. Preparations for extreme events may not equal the scale of the hazard—as exemplified by the effects of a Category 4 storm on the levees built to withstand a Category 3 storm. Additionally, response procedures may be inadequate, as illustrated by the evacuation plan's heavy reliance on personal automobiles and by a frustrating lack of coordination of emergency response efforts by local, state, nongovernmental, and federal agencies.

The extreme event that became a disaster was not just the result of Katrina but the product of three centuries of urbanization in a precarious site. New Orleans occupies a place created and sustained by river floods. The drainage and levee system, built to protect the city from floods, has contributed to the regional coastal land loss and locally has produced subsidence in the neighborhoods toward the lakefront. When the storm surge came through the human-made barriers, the earthworks constructed to keep the lake out captured lake water. In those same areas, urban sprawl had pushed residential development into former marshlands that had subsided well below sea level. Additionally, wetland soils offered poor footing for heavy levees built to protect suburbs, and this probably contributed to the system's failure.

Within New Orleans, the history of class and racial segregation created an uneven landscape in terms of vulnerability. Over the years, low-income residents have found the only affordable housing on the lowest ground. Consequently, some of the worst flooding affected those with the least means, and in pre-Katrina New Orleans the low-income population was largely African American. Not only were some of the poorest in the most vulnerable locations, but without personal automobiles to evacuate, they faced a double jeopardy. Floodwaters, it must be understood, also devastated middle- and high-income neighborhoods, but residents of these dis-

tricts had the means to evacuate and escape the suffering encountered at the Superdome and the Civic Center.

Both the city and the state have convened special commissions to advance plans for rehabilitating the city, the Urban Land Institute has issued recommendations, and numerous other groups have offered guidance for restoring the city. Congress is also involved in providing funds for some components of redevelopment through such agencies as FEMA and the Corps of Engineers. As scores of committees and planning task forces meet to deliberate the city's future, they *must* keep the environment in mind. Over the past century, urban growth has proceeded within a rigid structural flood-protection system. Such artifice tends to diminish—not eliminate—the realities of topography and weather. Granted, engineers made design decisions based on past storms and certainly factored in the threat of hurricanes. But when a storm exceeds the design criteria and structural protections fail, families, business owners, and municipalities that thought they were safe face staggering expenses. The massive costs of rebuilding following Hurricane Katrina should force those engaged in city building to think carefully about the place of nature in the city. Sensible adjustments in land-use practices can reduce risk and prevent another calamitous outcome when another potent storm sweeps over the city. And there will be major storms in the future. How soon we cannot say, but environmentally sensitive plans that address the needs of all the citizens of the metropolitan area should be made and put into action before the next one blows ashore. And the lessons learned from Katrina should be shared with other cities that also have not fully wrested themselves from nature.

December 2005

INTRODUCTION

THE CITY AND THE ENVIRONMENT

STROLLING THROUGH THE Vieux Carré, the historic French Quarter, or ambling beneath the live oaks in Audubon Park, one gets the impression that New Orleans is a city without relief. Only the massive levees that stand between the city and the river provide a discernible change in elevation. Across the lower Mississippi River delta, subtlety is the key to topography. While far from obvious, the lay of the land in New Orleans has been critical to the city's development. Slopes of a few inches per mile make a tremendous difference in this low-lying city. What little relief there is directs the flow of water, of which there is an abundance in southern Louisiana: precipitation averages nearly 60 inches a year, while the river carries about 600,000 cubic feet per second by the docks; the water table lies just below the land surface, and Lake Pontchartrain laps at the levees guarding the city's northern shore. Since a sizable portion of the city rests below sea level and collects whatever water is not pumped out, managing the surplus fluid is critical. With little topographic assistance, massive engineered water-

control devices help drain the city and keep the river and lake water at bay, and they have become key to New Orleans's continued viability. Wresting the site from its watery excesses and the associated problems was, and remains, a central issue in this city's existence. Recent mayor Marc Morial criticized the city's founders for selecting a site with so many inherently expensive water management problems.[1] Keeping the city dry, or separating the human-made environment from its natural endowment, has been the perpetual battle for New Orleans.

At its founding, New Orleans was an unlikely city. Geographer Peirce Lewis went so far as to call it the "impossible but inevitable city."[2] Surrounded by swamps, with little solid footing, threatened by floods, the site impressed the French founders with its many locational liabilities and its questionable suitability as a colonial capital.[3] Ultimately convinced that the portage between the river and the lake via Bayou St. John was the best strategic location, French authorities began the task of planting a city on the less than hospitable terrain. Situation, according to Lewis, won out. That is, New Orleans's strategic position as the gateway to the Mississippi River valley bestowed upon it commercial advantages that outweighed any inherent site shortcomings. Overcoming those physical inadequacies is the struggle that the city still contends with.[4]

New Orleans's site makes it unique, although how the city dealt with environmental circumstances places it within larger technological and political frameworks. Thus the site's environmental characteristics have proved significant both on the level of local urban development and on a national scale. Through and through, New Orleans's physical geography is interlaced with its local history. While race and slavery were the burdens of southern history, the environment is the burden of New Orleans history. From the city's founding to twenty-first-century political battles, dealing with the inappropriate site imbues all aspects of urban life there. When the brothers Iberville and Bienville navigated up the Mississippi River in 1699, indigenous people introduced them to a well-worn pathway that served as a portage between the river and Lake Pontchartrain. The portage spanned the slightly higher natural levee, while Bayou St. John linked the better-drained ground with the lake (Fig. I.1). The natural levee has had a defining impact on the city in two key ways: as a swath of high ground, it influenced selection of the city's site, and through its effect on drainage, it influenced urbanization patterns.

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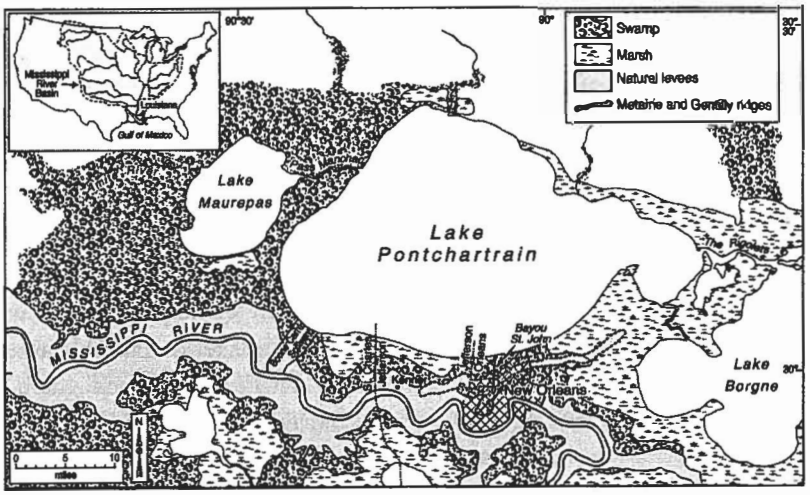

FIG. I.1. NEW ORLEANS'S LOCAL SETTING. After Roger T. Saucier, *Recent Geomorphic History of the Pontchartrain Basin, Louisiana* (Baton Rouge: Louisiana State University Press, 1963).

Large river systems like the Mississippi create the land adjacent to their courses. Over the last several millennia, the Mississippi River has been extending its delta into the Gulf of Mexico while building up the expansive alluvial floodplain, particularly south of Baton Rouge. Spring floods filled the waterway to overflowing. As the floods escaped the channel, the water slowed and the sediment that it carried settled out. The material deposited by the river built up the land mass adjacent to its channel—a process described in the eighteenth century by the historian Le Page du Pratz.[5] In the case of the Mississippi River, the initial deceleration of water caused coarser sands and silt to settle out closer to the river's edge. This created a pair of matching ridges parallel to the stream. Their cross section resembles a wedge. The riverside slopes discernibly into the waterway, while the land tapers off imperceptibly from the crest in the opposite direction for about two miles. At New Orleans, the peak of the natural levee rose about 12 feet above sea level.[6] It was on this high ground that Bienville had the city platted. Thus the land-building forces of the river created the very site upon which the settlement stood. The Place d'Armes, now known as Jackson Square, occupies that strategic location. Although subject to regular flooding, this relatively higher site was the place least susceptible to inundation and the first to emerge from abating floods.

The gentle slope away from the river descended gradually toward sea level at Lake Pontchartrain over a distance of about 1.5 miles. A relict natural levee, created by the Mississippi River when it followed a different course several thousand years ago, stands about 7 feet above sea level and runs from what are now the western suburbs eastward toward the Rigolets. Bayou St. John has cut through the ancient land form, creating remnants known as the Metairie and Gentilly ridges, which are about a mile wide at their broadest point and taper off to the east.[7] These modest ridges have been truly significant in shaping New Orleans. While water from the natural levee along the river's current location tends to drain toward the lakefront, the Metairie and Gentilly ridges stand as a barrier to this flow. River-made topography has created a "bowl." On three sides the natural levees that followed the river around its giant crescent made lips to this basin, and the Metairie Ridge closed it on the north side. Heavy rains and river flooding could fill this ill-drained area, creating a breeding ground for disease-carrying mosquitoes and an impediment to urban growth. Since the ridge was lower than the natural levee, high water found an outlet to the lake via Bayou St. John. This watercourse served as the critical link in the colonial-era portage by shortening the distance canoes had to be dragged across land. It was also a prominent feature in later transportation and drainage efforts, as were other bayous (which offered routes for colonial-era smugglers) and their natural levees (which provided solid footing for an invading British army). Artificial levees built on the crest of the river's natural levee beginning in the eighteenth century and, much later, along the lakefront have secured the city against regular flooding but accentuated the bowl-like features and make drainage a bigger challenge today than in the past. Intense thunderstorms and hurricane-spawned rain have replaced the river as the greatest threats to the city in a saucer.

Lakeward of the Metairie and Gentilly ridges was a low-lying area of cypress swamp that graded into a grassy marsh. Soils made of fine-grained river sediments and decaying plant material have accumulated from 5 to 20 feet in thickness.[8] While these soils have a tendency to subside under their own weight, regular rejuvenation of sediments by floodwaters and ample moisture in the ground kept these soils above sea level before urbanization. Initial settlement avoided these zones in favor of the more solid natural levees and the Metairie and Gentilly ridges. As the city grew, developers using massive drainage schemes and levees transformed these wetlands

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into suburbs. Much of the mayor's critical remarks about the founders' poor site selection related to problems encountered in draining and maintaining these former wetlands. None of New Orleans's site was above the level of river floods, and much of it barely deserved to be called land. With drainage and encirclement by levees, the peaty soils compressed, and without the regular delivery of fresh sediment by flooding, these areas have subsided. Much of New Orleans that was drained for residential development is now below sea level and continues to subside, further exacerbating the city's drainage problem. Manipulating the site to accommodate a great city has been and continues to be a centerpiece of the New Orleans story. The decline of New Orleans as a major American city has paralleled it physical subsidence.

In addition to the low-lying site, New Orleans faces an additional situational challenge. The very river that created the site is a monstrous entity that drains a vast portion of the interior United States. While other cities have occupied wetlands, few have the combination of poorly drained and flood-susceptible territory of New Orleans. Portions of Washington, D.C., occupied wetlands, but there was ample solid ground above the reach of the Potomac's worst floods. Chicago's founders platted their city on a wetland site, but the sluggish Chicago River did not drain the massive territory of the Mississippi. Unlike any other riverfront city, as New Orleans grew, it expanded not toward higher elevations but onto lower ground surrounded by levees. This circumstance was made even more critical by the city's being situated near the outfall of the continent's largest natural drainage system. Spring snow melts combined with frontal rainstorms throughout the Ohio and Missouri basins could induce river stages that exceeded the capacity of a municipally funded flood protection system. The continental scale of the river's drainage basin made flood control more than a local issue, and leaders have had to battle constantly to secure federal assistance to deal with the flood hazard.[9]

Situational interpretations present cities as part of larger global political and economic systems. William Cronon's magnificent *Nature's Metropolis,* for example, opened with the nineteenth-century boosters' proclamations that Chicago had natural advantages inherent in its location. Entrepreneurs translated those advantages into a domination over nature across vast agricultural and resource hinterlands.[10] While local businessmen proclaimed similar advantages for New Orleans, this account will steer away from large-scale political and economic concerns and focus instead on the *site* and hu-

man efforts to transform it into an urban place. After all, without a viable site, no gateway could have developed. This volume will explore the fundamental struggle to make a habitable city, to transform the flood-prone, ill-drained, mosquito-infested site into a metropolis. To use Matthew Gandy's term, it will examine "reworking nature."[11] Certainly, regional, national, and international markets and New Orleans's economic hinterland were vital elements in the city's development.[12] Additionally, external concepts of engineering, public health, urban planning, and resource management affected practices in the Crescent City, as did national environmental laws that intruded on the lower delta. This volume will examine how these external influences affected New Orleans's efforts to remake its site. Such mundane concerns as rainfall, spring floods, sewerage, garbage, insects, shade, and hurricanes have also been of fundamental significance in building the city. In reshaping the city to deal with a troublesome nature, there has been a continuous effort to squeeze obviously undesirable aspects of nature out of the setting. Lewis Mumford has suggested that cities displace nature, and Henry Lawrence has written that cities stand as the antithesis of nature.[13] Activity to transform New Orleans has reflected the urge to remove nature. New Orleans has so thoroughly reworked its original setting through forest removal and drainage that one could call it the "unnatural city"—although it never completely escaped nature. The city's efforts to manage nature, as well as global politics and economic influences, have shaped the city's internal geography and the resulting urban landscapes.

It is the historical geography of New Orleans that I want to explore here, the geographic evolution of the Crescent City. Obviously it is difficult to cut a city out from its setting while still claiming to examine its relationship to the larger environment. Therefore this account will focus on the city itself but also draw in adjacent suburban parishes and critical environments that have close connections with the city. Jefferson Parish, in particular, has absorbed much of the expansion of the central city. Lake Pontchartrain, an essential influence on the city, will be included, as will various tracts of swamp and marsh that became part of a late-twentieth-century effort to reclaim nature. Of course, the entire Mississippi River basin also plays a role. The territory treated here will be more than Orleans Parish, but less than the Isle of Orleans (bounded by Bayou Manchac, Lake Maurepas, and Lake Pontchartrain on the north; the Mississippi River on the south and west; and the Gulf of Mexico on the east).

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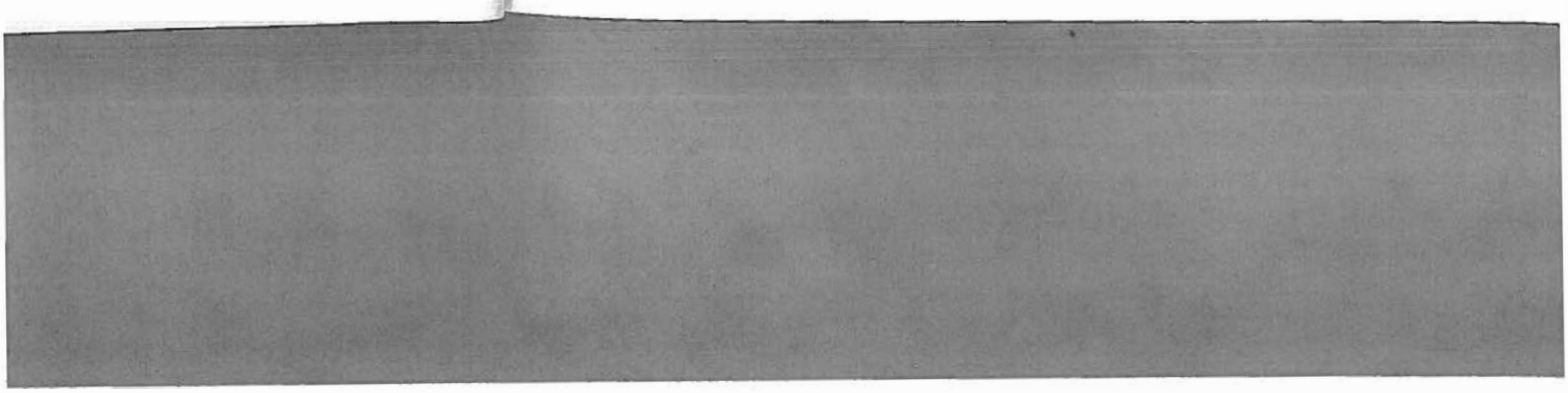
The city comprises multiple components: streets and structures, people and businesses constitute the superficial urban expression. Geographers have considered the cultural significance of street patterns and the built environment.[14] They have analyzed the evolving pattern of commercial development, industrial location, and residential expansion.[15] Additionally, they have considered periods of urban expansion driven by advances in transportation systems.[16] But typically the central concern is with the human overlay on the site—the pattern of economic systems and infrastructure. Nonetheless, manipulation of the earth's surface is an essential precursor to the construction of roads and buildings. In addition, human modifications inevitably have both direct and indirect impacts on the environment. Urban heat islands stir up increased precipitation, paved surfaces and buildings divert rainfall into surface runoff, waste disposal sites contribute to groundwater contamination, and urban sprawl consumes open space, expanding the urban heat island. Further, the weight of buildings on top of alluvial soils causes subsidence, deterring some construction. It is these intimate interactions between human society and the urban setting that I hope to examine. And New Orleans, the unnatural metropolis, with its unlikely and inappropriate site, will provide the focus.

NATURE IN THE CITY

For many years geographers have sought to explain city-building as an economic process. In doing so, they largely excluded any mention of the environment. Models of urban growth presented urban sites as "isotropic plains" with no topographic or hydrologic irregularities. Land values decreased away from the city center, causing land uses to assume concentric rings of decreasing intensity. Residential patterns developed similar arrangements, with rings arranged by outwardly increasing income levels. The models acknowledged that a coastal or lakefront city would have only partial circles, but they dismissed the physical setting.[17]

The economic depictions could not account for the irregular distribution of clay pits or quarries essential for extracting raw materials used in city building. They did not factor in the expense of creating new land where there was none by dumping waste into the ocean, lakes, and rivers to build sites for urban expansion. They offered no consideration of amenities such as favorable winds, scenic vistas, or parks that distorted the concentric rings.



Furthermore, they ignored the spatial patterns of flood risks and noxious industrial emissions. Some assumed that such irregularities were deviations that did not alter the models' overall clarity. But in fact the deviations were fundamental parts of the urban pattern, and their particular arrangement distorted the models' regularity.

Economic explanations of urbanization, while powerful, deny some of the very real problems faced by city builders at the municipal, corporate, and individual level. In particular, they do not factor in the costs borne by the city and its private and corporate citizens to make a site suitable for economic development and, conversely, how they contend with urbanization's environmental impacts. How does a municipality gain control of its territory through its infrastructure—the roads and other public utilities—and preserve open space for parks? How do these efforts affect land values? How do cities regulate the placement of undesirable activities? How do manufacturers modify sites to make them viable to their trade? How do individual landowners contribute to a city's size and its vegetative cover? Certainly economic factors drive many site selection choices, but reworking property to suit other needs and desires sometimes defies neat land-rent models. The city that results from the interplay between actors on the urban stage and environmental considerations is highly complex.[18] Recognition of this fact led to more sophisticated models that suggested development occurred along major arteries, which in turn produced sectors rather than circles, and subsequent models that identified nucleated land uses were attuned to various transportation and economic influences. These models, like their predecessors, attempted to portray cities as they *were,* not how they *became.* In effect, they presented static cities and neglected the multiple stages and phases of urban evolution. They failed to consider how cities directed development through environmental modifications. While perhaps more attuned to reality, the second generation models also largely ignored how the physical features of the city dramatically altered the pace of growth or prompted certain land uses. By considering the temporal nature of urban growth, James Vance's urban realms model accommodated the physical geography of the city more than prior models.[19] But like others, it failed to incorporate land-use adjustments made by property owners in order to conform to environmental regulations.

A contrasting approach has been to look at the city as an ecological system. The emphasis of those who follow this tack is on urban air, land, and

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water quality, along with the survival of urban wildlife and forests.[20] Humans are considered invading species that disturb, disrupt, and often degrade vulnerable systems. Roads and buildings become "impermeable cover," not the urban fabric woven by decades of human endeavor. The human-environment approach focuses on the "transactions" between human society and the environment.[21] Humans cope with hazards or they exploit resources. In either scenario, human efforts to contend with the environment are the focus of this type of investigation. The resulting landscape is one of "risk surfaces," waste sinks, and zones of resource extraction.[22] While the human-environment approach places much greater emphasis on the human role in urban environments, like the ecological approach, it does not deal effectively with the broader topic of landscapes as spaces created and inhabited by people.

Environmental historians have begun the task of looking at cities as places where humans affect the environment. In the work of these historians, the environment is typically one actor in a complex cast. Much of their work has emphasized the infrastructure, which provides essential services such as water delivery and sewerage and garbage removal.[23] This fine scholarship brings to light important technological and political issues that influence environmental modification and, in many cases, emphasizes those aspects over the environmental relations society has with urban places. Historians have also begun the work of examining questions of environmental equity as a part of human-environmental interactions in cities.[24] The expanding emphasis on urban environments can also be found in multiauthor collections that portray the range of complex issues in urban environments.[25]

From a geographer's perspective the role of the environment is fundamental.[26] Gandy has argued for the essential role of nature in New York City's development, using the city's reach into its expansive watershed and the influence of Central Park on land values to demonstrate his point.[27] This viewpoint has been made evident in several contexts. Considering metropolitan-scale activity, geographers have noted the relationship between high-income neighborhoods and elevation and the relationship between natural resources extracted to build the city and waste disposal.[28] Public health issues have also shaped urban development. Shifting theories of medicine—from the environment as the source of illness to bacteriology—altered how urban authorities managed urban environments, and this in turn directed the social and economic patterns of the city.[29] In the twentieth

century, the development of the basic infrastructure was a key force in shaping urban growth.[30] While geographic interpretations may emphasize the significance of human-environment interactions in molding land use or medical geographies, the fact that humans cannot operate outside of the environment is a cornerstone to their approach.

This volume will start and conclude with the environmental circumstances that city builders faced. Economics and politics certainly matter, but they will not be the central reference points. This work will also consider the human-environment transactions as key processes in shaping an elaborate lived-in urban landscape. I will structure the chapters chronologically, always considering how society's view of nature and its technical capabilities to manipulate and manage nature affected urbanization in each time period. *Nature,* of course, is a word fraught with complex meanings. If we think of nature as conditions untouched by humans, then there might be no corner of the globe that deserves the title "natural."[31] Even wilderness preserves are modified by their designation as "wilderness," to say nothing of the other types of historical and prehistoric modifications they have endured.[32] In cities, the most humanized landscapes, nature still exists—and not just in parks. Cold Canadian air masses sweep across the continent delivering clean air to urban areas, and snow melting in the Rocky Mountains sends water past the cities lining the Mississippi River. These natural systems, while not so obviously visible as a forest, still directly affect cities, and urbanized areas do little to disrupt these massive natural systems.

At the local level, Native Americans and colonial settlers had modified the site of New Orleans by 1803, when this account begins. Midden heaps had created viable settlement sites, and regular use of the well-worn portage between the river and Bayou St. John made the site strategic before Europeans first set foot on the natural levee.[33] The French and Spanish initiated the never-ending chore of levee building and digging drainage canals to the rear of the site.[34] They had begun the process of manipulating the nonhuman environment. Yet even at the local level, elements of nature persisted in the city. The combination of warm temperatures and moisture from the Gulf of Mexico resulted in frequent rain. Wetlands harbored disease-bearing insects. Gravity constantly pulled at the alluvial sediments underlying the city, causing a slow settling. The low-lying position of the city kept the water table near street level, affecting building and burial practices. Nature never fully disappeared from the city. Urban residents meagerly

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Human effort to manage the environment has been a vitally important dimension in shaping New Orleans's landscape, and the landscape is the visible record of human transactions with the environment. The mighty levees encircling the city serve one fundamental purpose: flood protection, from both high river stages and hurricane-driven storm surges from the lake. The numerous canals that dissect the city bespeak the longstanding need for drainage. Shaded boulevards and lush parks reflect various programs that sought environmental solutions to social ills. Massive landfills and derelict incinerators testify to the gargantuan challenge posed by the city's refuse. Protected marshes and swamplands mark fundamental shifts in attitudes toward nature and the public policy adjustments that accompanied them. The landscape created by humans in New Orleans is the social response to concerns with environmental conditions.

People live in and constantly rework this landscape. Consequently the human dimension is also a fundamental part of this story. Access to amenities as basic as water and sewerage has not been even in this racially complex city. Questions of environmental equity have found answers that are sometimes unpleasant but nonetheless have played a part in shaping New Orleans's landscape. From recreational facilities to flood protection, environmental equity emerges as a concern. Whether a function of racism or white privilege,[35] the presence of landfills and toxic chemical manufacturers in African American neighborhoods is a fact of life in New Orleans. Additionally, suburbanization during the 1960s and 1970s fractured the urban area along racial lines and created different environmental concerns for suburbanites and city-center dwellers.

REMAKING NEW ORLEANS

At the outset, I will consider how society dealt with hazards presented by the environment. Nineteenth-century assessments and reassessments of conditions that threatened the city—namely, floods and miasmas—chronicle both the identification of hazards and the creation of plans to minimize them. Instituting a defense against floods and miasmas involves a selection of techniques within the available technologies and within the cost a society is willing to pay. It also requires a social commitment, in the form of policy

at some level, to create a mechanism to finance, build, and maintain the bulwarks. Choices are shaped by what decision makers view as hazards at the time and the control options available. Concepts embraced by engineers and physicians directly influenced the choices made in nineteenth-century New Orleans. Notions of environmental health promoted forest removal and swamp drainage around the city; and expectations that a river confined between levees would scour its channel deeper encouraged the use of levees as the exclusive means to control floods.

Loss of environmental quality, or desired resources, gave rise to policy reformulations to manage the most dominant threats to desirable conditions. As geographers Jacque Emel and Elizabeth Brooks tell us, the diminishment of natural resources, in this case clean air and water, leads to policy adjustments.[36] In this country, policy typically proceeds from an unregulated, common-law approach in which individuals file suits to seek compensation for some damage to their personal property or government actions attempt to protect the public good. Once society recognizes a resource scarcity, it creates a specific statutory definition and administrative controls. In New Orleans, with increasing population and industry, clean air and water quickly became imperiled resources. The city took steps to define particular activities as nuisances, to regulate the location of industrial activity, to prescribe proper places for burial grounds, and to issue regulations regarding garbage and water services. In doing so, the municipal government took steps to preserve environmental quality within the scope of social expectations at the time. Specifying certain land uses as nuisances and regulating them had direct environmental consequences. Steps to provide urban amenities such as clean drinking water and parks also furthered the imposition of the urban will on nature. Where the city was unable to meet the expectations of providing a suitable environment, the social elite took flight from the city to their rural summer retreats.

Early-nineteenth-century projects to manage environmental conditions in New Orleans were piecemeal, fragmented efforts that did not even attempt to deal with the entire city. In the late nineteenth century, a fundamental shift in public health concepts based on the germ theory of disease along with an emerging engineering profession and political reform movements that sought to deal with problems on a citywide basis led to a new era of environmental transformation. Investment in new, costly infrastructure accomplished many of the objectives of failed prior attempts. In particular,

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new sewerage, drainage, and water systems delivered numerous improvements to the city as a whole. However, as historian Martin Melosi tells us, once a particular approach is chosen, "path dependence" results, and the infrastructure employed continues to be used beyond its functional obsolescence.[37] Thus choices made in the early twentieth century still confront public works officials in New Orleans today and contribute to the mayor's complaints about the city's site. Those choices not only influence current decisions but limit the options available to renew the old systems. Thus, in turn, environmental conditions are also affected in areas still served by the last century's infrastructure.

Extension of the urban infrastructure and environmental improvements under the principles of rational engineering should have been consistent across the cityscape. But in fact, racial and economic attitudes deflected the even extension of services. Inequities in environmental conditions resulted, and some remain, contributing to charges of environmental inequity.

Following World War II, urban residents participated in an unprecedented expansion of the nation's cities. Residents moving to the urban fringes brought with them desires for environmental amenities, and a coalescing ecological consciousness shaped their expectations. In search of bucolic settings and armed with new technologies, suburbanites contributed to a major overhaul of the urban environment. The physical expansion, accommodated by personal automobile transportation, altered the scale and form of the city, intruding on vast wetlands around New Orleans—many of which were unsuited to suburban construction techniques.

During the 1950s and 1960s, as metropolitan sprawl was in full swing, a shifting emphasis in public policy followed scientific and public concern with environmental quality—in the modern sense of the term. Within the city, demographic change produced new environmental relationships—some decidedly unfair to minority residents who were unable to escape undesirable conditions at landfills that became hazardous waste sites. The "hazardous" label attached a long-lasting stigma on places, unlike the older nuisance designation. That stigma radiated outward and affected entire neighborhoods, creating landscapes of tragedy.[38] In addition, the entire city faced revelations about its public water supply that recast drinking water from an occasionally foul-tasting liquid into a toxic brew. As part of a broader social questioning of the hubris of massive engineered solutions to environmental problems, Louisiana and New Orleans had to rethink the

safety of consuming the effluent coming from cities and factories throughout the Mississippi basin. Policy and public actions responded to the threat posed by upstream industries by restricting what they could discharge and by seeking an alternate potable water supply.

Suburbanization itself contributed to a new set of environmental relations. In Jefferson Parish and east New Orleans, drainage of former wetlands produced problems with subsidence and flooding. By hemming itself in with levees, the urban area became a giant catchment basin for heavy rains produced by summer storms or hurricanes. The city has continually struggled to deal with excess water since a spate of heavy rains began in the 1970s. Dependence on structural flood protection methods has deterred the adoption of federally mandated land-use solutions.

New Orleans, after nearly three centuries of trying to exclude nature, now has rediscovered its environment—in the form of swamps and marshes. With rising federal efforts to preserve wetlands, local concerns with eroding coastal marshes, and heightened appreciation for untouched nature, several steps being taken in the New Orleans area demonstrate a desire to bring the swamp back into the city. A zoo exhibit devoted to local swamp life spurred local rediscovery of a vanished part of the local urban site. Subsequent creation of both a national park unit and a wildlife refuge consisting of wetlands within the urban territory exemplify this urge. In a more commercial vein, the growth of swamp tourism allows New Orleans to trade on its natural history.

ENVIRONMENT AND GEOGRAPHY

While there is new interest in the environment surrounding New Orleans, nature still presents complex challenges at a more rudimentary level. The same conditions that inspired early drainage systems still exist and remain a focus of New Orleans's infrastructure development. Without huge investments in drainage and pest control, the city would not exist as it does today. Furthermore, real concern exists about the threat of a hurricane pushing the contents of Lake Pontchartrain over the levees surrounding the city. The environmental context is rooted deep in the city's physical geography and history and is as critical today as it was three centuries ago. Indeed, human transactions with the environment have been as powerful an influence as any other factor in shaping the Crescent City's unique landscape. In New Or-

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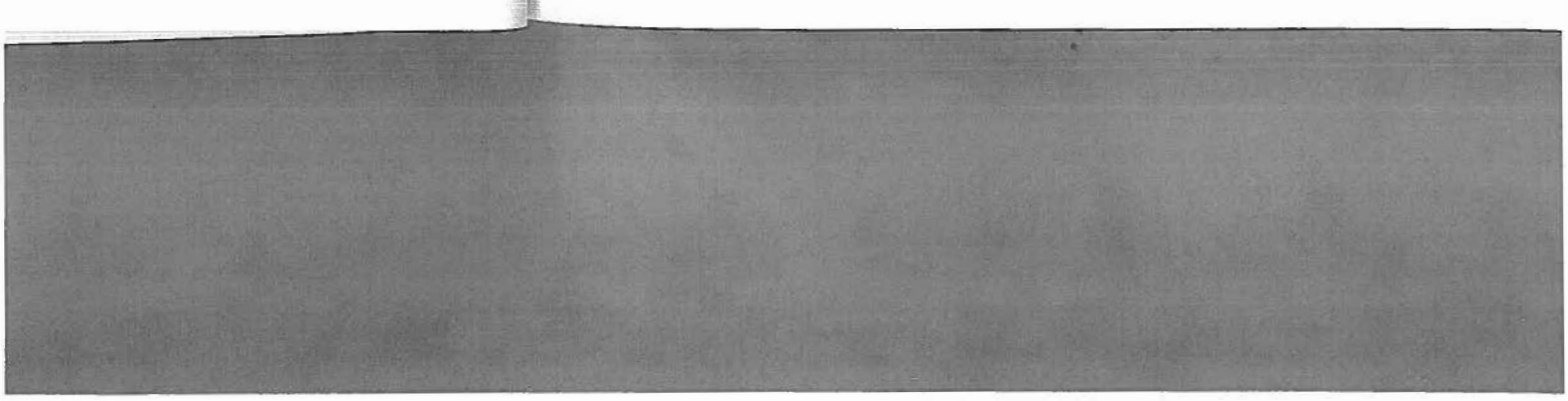
leans, and other cities, the environment matters. Without understanding the human response to nature's challenges, our understanding of urban growth is only fragmentary.

New Orleans, through massive environmental transformations along with fundamental shifts in public attitude toward nature, has been able to reverse the public perception of its local geography. Once viewed as an unhealthy place that local residents sought to flee in the summer, it now is an attraction for hordes of tourists. The nineteenth-century open sewers carried filth and disease, while the swamps generated miasmas that ravaged the unacclimated. Manipulation of nature altered these conditions and public perceptions of them. Summer heat and humidity may deter some visitors today, but the wide boulevards, that once were sewage ditches, and nearby moss-covered cypress swamps now appeal to visitors. The current geography of New Orleans has been thoroughly shaped by the city's long-term relationship with its environment.



CHAPTER 1

WATER HAZARDS

THE MISSISSIPPI RIVER surges around the sweeping crescent that gives New Orleans its nickname and into a sharp bend at the foot of Jackson Square. Even at low stage, the river's width is considerable in comparison with European waterways that were known to colonial explorers and settlers. When the river rises above its banks, its size becomes even more impressive. In the early eighteenth century, floodwaters could spread out over several miles on either side of the mighty stream, destroying spring crops and ruining homes. The floods of the lower Mississippi were destructive by shallow immersion, not due to a torrential current. A thin veneer of water could spread over the countryside, stand on the fields for several months, and drown young plants. Floodwaters also crept into houses, softening their foundations, transformed firm roadways into quagmires, and interrupted urban life for extended periods of time. French colonial leaders recognized these hazards, and they debated the viability of the site that became New Orleans before reluctantly deciding to plant the capital there.[1]

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topography of New Orleans was, in many respects, the reverse of what settlers were accustomed to. Rather than a broad concave valley with safely elevated settlement sites on land that rose with greater distance from the waterway, the Mississippi delta was a nearly level surface, with subtle but significant topographic undulations. The river built the land with its frequent inundations, and thus New Orleans's original plan occupied a tract subject to regular flooding. The high ground was not set back from the river but consisted of only the relatively narrow natural levee. The crests of the high ground stood only about 12 feet above sea level. The *batture,* or actual river bank, dipped into the waterway, while the back side of the natural levee followed an invisibly gentle gradient in the other direction. Most of the city naturally drains away from the river. Less danger existed atop the elevated and better-drained natural levee (Fig. 1.1), where French settlers built New Orleans and where most of the city stood in 1800. Although subject to seasonal inundation, the ridge that paralleled the river was the last land to go under water and the first to emerge from receding floods. Indeed most flooding occurred when crevasses, or breaches in the natural levee and later the artificial levees, allowed water to break through the higher terrain and flow directly to the low ground farther from the river.

Areas to the rear, or away from the natural levees, remained under water longer and formed the cypress swamps draped with Spanish moss. These dark, foreboding wetlands harbored not only alligators and clouds of mosquitoes but the mysterious and dreaded miasmas. In the minds of nineteenth-century residents, the swamp and its pestilential emissions posed as much of a hazard as the river to those dwelling in New Orleans. Efforts to control flooding concurrently sought to eliminate the backswamps as a source of disease. William Darby's 1817 geography of Louisiana stated: "It must be observed, that there are two evils, arising from surplus water, to be remedied on the Mississippi; one, the incumbent waters in the river; the other the reflux from the swamps. It is in most instances very difficult to remove one inconvenience, without producing the opposite."[2] Floodwaters contributed to the moist conditions of the backswamp, and thus the two threats were thoroughly mixed. Efforts to control one, as Darby pointed out, often exacerbated the other.

Geographers portray the realm of human-environment interaction as a two-sided process. Relations with positive outcomes define *resources,* while negative results constitute *hazards.* The river and backswamps in and around

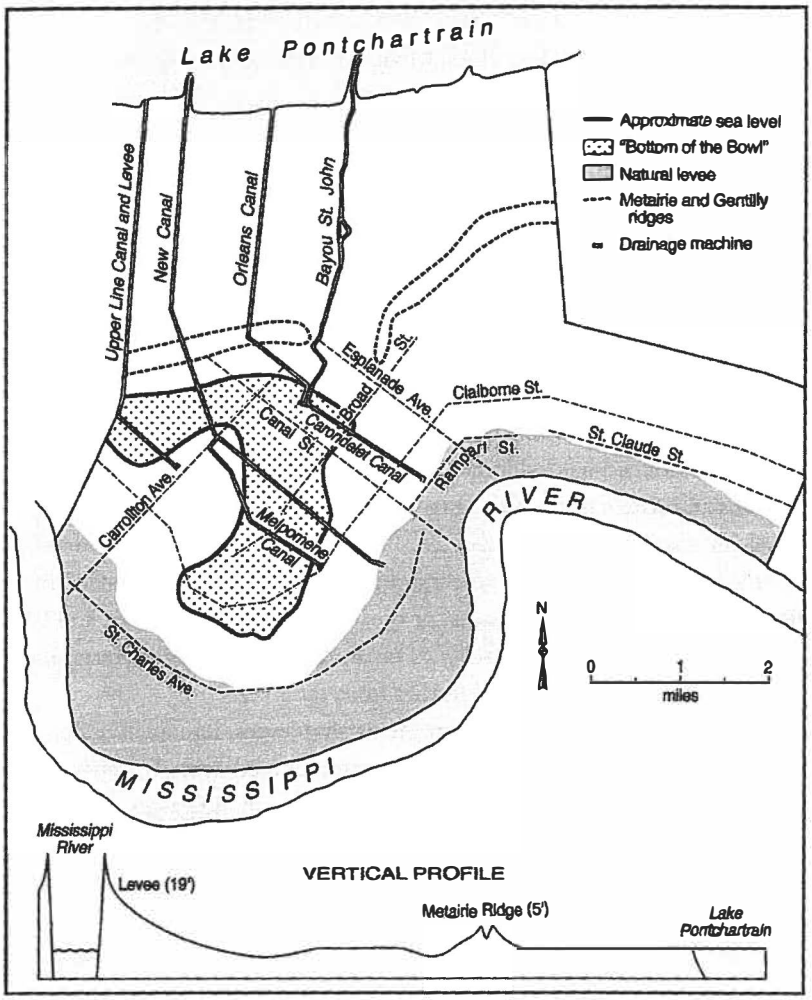
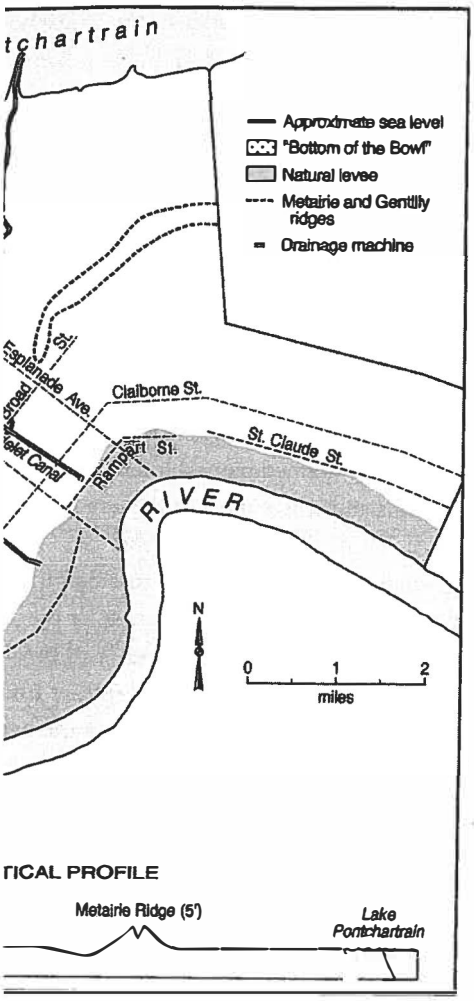


FIG. 1.1. TOPOGRAPHY OF NEW ORLEANS, CA. 1900. The natural levees formed the best-drained and highest ground, while the Metairie and Gentilly ridges provided secondary bands of high ground. The natural levee sloped from the river to a flood-prone area below sea level, riverward of the Metairie Ridge. From the narrow ridge, land sloped to sea level and Lake Pontchartrain.

nineteenth-century New Orleans represent both sides of this connection, and thus the human-environment perspective is useful for beginning our discussion. As resources, the river served as a vital communication link, and the swamps provided durable cypress timber. At the same time, the waterway and the wetlands posed undeniable hazards to lower river val-



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ley residents. This chapter will examine the hazards side of the human-environment relationship. Dealing with hazards involved appraising them, creating plans to contend with them, implementing these plans, and then maintaining the means used to defend against unwanted environmental conditions. Preparing for and responding to water hazards were powerful influences in shaping the largest city on the lower Mississippi. While flood and environmental disease were only two of many hazards, they were perhaps the most frequently discussed and also prompted the most sweeping transformations of New Orleans's environs. These manipulations were the measure of transactions between humans and nature.[3]

CONFINING THE RIVER

By 1800 the two prominent hazards at New Orleans had elicited significant human response. The French reaction to floods was to erect levees (from the French word *lever*, "to raise"), ridges of soil heaped up along the natural high ground to hold back high waters. In the urban setting, where the concentration of people and public buildings was greatest, the corporate sponsor, the Company of the Indies, initially took on the levee-building responsibility. In other words, the initial protection device was a public project and not financed by private landowners. By 1727 a bulwark 4 feet high stretched about a mile along the waterfront, on top of the natural levee. However, isolated stretches of levees did not keep high water from finding its way to the backswamps upstream or downstream from the protected territory. Since the natural levee sloped back from the river over 10 feet to the city's low point, high water that escaped the river upstream from the city could rise from the back side. Consequently New Orleans continued to endure backswamp flooding on a regular basis, and occasionally floods would crest the 4-foot mound along the waterfront. Company of the Indies officials understood the settlement's topographic situation and constructed a pair of levees perpendicular to the river that extended toward the backswamp. Another levee, along the current route of Rampart Street and roughly parallel with the riverfront bulwark, tied the levees together and completed the enclosure. This first levee system enclosed a mere forty-four square block area. Although it fended off most high water, the most formidable levee in the valley collapsed before the 1735 flood, and the city suffered extensive damage.[4] Despite such failures, efforts to protect the colonial capital remained a cen-

tralized function. Through the Spanish rule of the Louisiana colony, public funds underwrote the urban levee system's maintenance.[5] This underscores the obvious importance of the city to the colony and exhibits the public, as opposed to private, responsibility for shielding the urban population and property from floods. This practice set the city apart from the rural countryside in terms of both policy and protection.

Coordination with its expanding agricultural hinterland was necessary to effect a viable flood protection barrier for New Orleans. To guard the growing agricultural district and link rural levees with the urban bulwark, colonial laws enacted in 1728 and in 1743 required individual landowners to build levees—a type of labor requirement that did not exist in the city.[6] In effect, the second thrust of urban environmental change was the requirement that rural property owners build their own levees that would contribute to New Orleans's protection. The city's economic success depended on a thriving agricultural hinterland, and without adequate flood protection neither city nor hinterland could survive. The French long-lot, or arpent, survey system arranged individual holdings in narrow parcels of land stretching back some distance from the river and suited the private levee-building requirement well. Individual grants typically ranged from 2 to 8 arpents (384 to 1,536 feet) in width and were usually 40 arpents (7,680 feet) deep. Proprietors were thus responsible for constructing levees along their property's short axis. By dispensing grants in contiguous parcels, French authorities sought to encourage a continuous line of levees fronting the agricultural "coast," but this goal was never realized. Levee construction became a sizable investment for landowners and was only feasible for wealthy planters using slave labor. Consequently, most small landholders were unable to complete their protective structures. Although even wealthy planters may have been reluctant to make such a large investment, the threat of confiscation for failure to comply motivated most to participate—to some extent. When Spain took over the colony in 1768, the Spanish government seized on the precedent established by the French, continuing to encourage contiguous settlement and also requiring landowners to construct protective barriers against floods.[7]

Despite a sound policy, privately built structures were notoriously inconsistent in design and effectiveness, and floods continued to breach these ever-lengthening earthen embankments. Nonetheless, levees stretched along about 50 miles of riverfront above New Orleans by 1763.[8] The leveed

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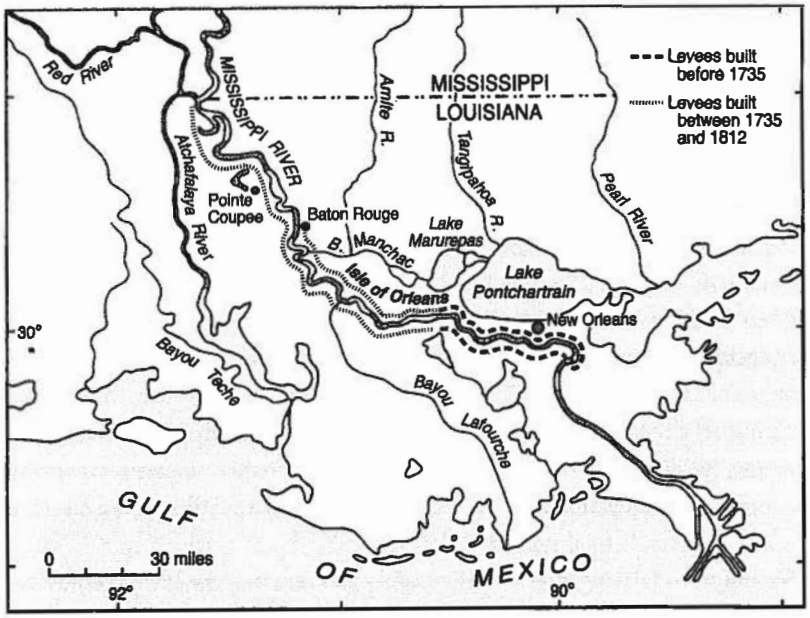

FIG. 1.2. LEVEE DEVELOPMENT TO 1812. Levees stretched several miles up the river by the mid-eighteenth century and nearly to the mouth of the Red River by the early 1800s. After Albert E. Cowdrey, *Land's End: A History of the New Orleans District, U.S. Army Corps of Engineers, and Its Lifelong Battle with the Lower Mississippi and Other Rivers Wending Their Way to Sea* (New Orleans: U.S. Army Corps of Engineers, 1977).

territory served as the productive agricultural base for the port of New Orleans, while the unprotected territory remained subject to inundation. When the new U.S. territory of Louisiana passed its first levee law in 1807, it assigned authority for maintaining levees to the parishes, which in turn held rural landowners accountable—perpetuating traditional landowner responsibility.[9] When Louisiana became a state in 1812, levees paralleled the Mississippi River from almost as far as the mouth of the Red River to below New Orleans on the west bank and from the bluff at Baton Rouge to below New Orleans on the east bank (Fig. 1.2).[10] But without an overarching design and in the absence of a central flood protection authority, levees continued to present a piecemeal barrier and offered only erratic effectiveness.

New Orleans, by contrast, continued to maintain its municipal levees after it became a U.S. possession. To fund this ongoing project, it taxed watercraft tied up along its waterfront. In 1805 the *Conseil de Ville* issued a resolution that read: "considering that the levees are being constantly damaged

by the ships, lighters, boats, etc. that land and stay in the port of the city, and that it is quite justifiable to make them contribute to the expenses occasioned by the considerable damages they cause daily and whose repair has been, up to the public chest."[11]

This resolution replaced a preexisting anchorage assessment with a levee tax that set up a fee schedule and assigned an individual to collect the taxes. Owners of vessels weighing more than 100 tons paid up to $40, while owners of craft weighing less than 100 tons paid $12. Flatboats, keel boats, and rafts of timber were charged from $3 to $6 for the privilege of tying up alongside the city's levee. In 1819, the city collected over $12,000 for levee maintenance with this tax.[12] Thus the city passed a share of the cost of maintaining its desperately needed levees on to transient shippers while maintaining local control of construction and maintenance. Indeed, when the U.S. Congress questioned New Orleans's authority to collect a tax on what was considered federal property, the city council sent a strong resolution to Washington claiming that "it is an established fact that the Port of New Orleans would not exist, that the whole city would soon be submerged if the waters of the Mississippi were not confined by levees." It concluded with the assertion that "the existence of this tax is therefore indispensable for the maintenance of the Port of New Orleans."[13]

It was apparent by the early 1800s that levees, while essential, did not eliminate the flood hazard. One reason for their ineffectiveness was that levees displaced high water into unprotected territory. As New Orleans raised barriers along its waterfront, the need for levees outside the city increased. Flood protection in one location redirected risk to open floodplains elsewhere. By necessity, levee building proceeded up and down the river and along both banks. The priority of protecting the city propelled similar action in the countryside.

William Darby pointed out a second reason for the levees' limited effectiveness in his 1817 geography: "The confined body of water increased in height."[14] As the width of the floodplain available to the river was restricted, the same volume of water reached higher stages. In other words, the levees raised the flood level. As levee construction extended along more and more of the banks, the area open to high water decreased, further heightening the flood stages. Consequently, society on the lower river faced a continual struggle to raise the levees in order to offset the higher flood stages they created. The prevailing policy exacerbated the growing flooding problem

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and may have contributed to the massive flood of 1785, which inundated New Orleans and much of the lower valley.[15] By the early nineteenth century, the 4-foot levees fronting New Orleans had been raised to about 6 feet to compensate for the rising flood stages.[16] The city surveyor oversaw this effort and used chain-gang labor to maintain the protective barrier.[17] Levees remained the only realistic option. Under a policy that called for localized (city or individual plantation) flood protection, there could be no coordinated regional planning. Neither state nor federal governments were ready to step in at the time. Although people along the river understood the implications of levee building, no one had the wherewithal to do anything more than heap up a mound of dirt in between their property and the river and hope for the best.

Even as protective devices displaced some of the risk, the rising crests continued to threaten New Orleans. After a pair of urban inundations in the late Spanish occupation (1791 and 1799), sizable floods occurred in rapid succession during the early American period. High water in the lower valley threatened the piecemeal levee system in 1809, 1811, 1813, 1815, 1816, and 1817. During that spell of successive floods, the New Orleans city council passed an ordinance that made individual landowners responsible for building and maintaining levees within the "liberties" of New Orleans—or the urban fringe. Much like the territorial law of 1807, the municipal ordinance called on proprietors to construct levees at least one foot higher than the "highest swell." By doing so, it sought to enforce a more consistent level of protection and placed the cost on those living outside the more densely built-up urban territory. To ensure compliance, the ordinance empowered the mayor to have the work inspected and to order contractors to complete any unsatisfactory sections at the owner's expense.[18] This ordinance shifted a portion of the city's burden to those who lived within Orleans Parish but beyond the city limits. Like the territorial laws that applied to other parishes, it functioned to protect the city.

Despite great efforts to create impenetrable barriers, contemporary accounts highlight obvious failings of the antebellum levees. Henry Brackenridge, who visited the city in the early years of statehood, provided some of the most extensive descriptions of the levees as they existed at that time. He noted that landowners set them back from the river about 30 to 40 yards—seeking to prevent undercutting by the meandering river, while not sacrificing too much agricultural land. The preferred construction material was

a stiff clay, which provided a more effective waterproof barrier. Once the 4- to 6-foot-high levees were in place, builders added sod to prevent erosion and cypress slabs to the inside to prevent leakage through the levees during high water. Drainage ditches had to be dug to move away any water that did seep through. Nonetheless, weaknesses existed, and Brackenridge pointed out crawfish holes as one serious problem.[19] Building levees entailed an enormous initial expense to landowners, but perhaps the greatest challenge was long-term maintenance. Erosion due to waves and current, slumping and subsidence of poorly built sections, and damage by wildlife made the chore of maintaining levees perpetual for both public and private builders.

Dispersing responsibilities to rural landowners did not keep the city dry, however. The 1816 flood broke through the levee at Carrollton, an upstream suburb, and inundated much of the New Orleans's rear quarters for nearly a month.[20] Writing about the variable quality of the levees, Edward Fenner confidently commented on the city-maintained section: "So firm and compact is the levee on the river bank before the city, that it is almost impossible for it to give way."[21] Weaker sections upriver, maintained by individuals, did fail, and water entered the city from the rear. Floodwaters rose three blocks into the French Quarter, as high as Dauphine Street, and reportedly inundated the lower parts of both the Marigny and St. Mary faubourgs, plus the Tremé, Gravier, and St. John neighborhoods. Apparently, the old enclosure levee had not been maintained, and private levee-building efforts gave urban residents a false sense of security from backswamp flooding. Fenner's report on the 1816 flood focused on the impact caused by water rising from the city's rear and stated that "inundation has driven many poor families from their homes; and should not those in affluent circumstances come to the aid of their less fortunate fellow citizens, great indeed, we fear, will be the distress of the latter, from poverty, famine, and perhaps pestilence."[22] Only by carving a channel through a shell embankment along the lakefront and permitting the trapped floodwater to flow into Lake Pontchartrain were citizens able to expel the floodwaters. After about a month, the city finally emerged from the standing water.[23] Planters suffered some losses due to levee failure, but the urban poor endured the most extensive privations due to the failure of private landowners to adequately protect the floodplain.

"Backdoor" floods prompted no fundamental change in the city's hazard management policy, and it was not long before the city's levees failed again.

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In April 1823 high water on the Mississippi, augmented by extreme floods on the Red River, began to break through the agricultural levees upstream. Water remained high through July, and the saturated levees began to give way, producing extensive flooding throughout the rear, low-income sections of New Orleans.[24] Another massive flood, the greatest since the 1785 event, caused extensive damage throughout the valley in 1828. The crest reached 15.2 feet at the Carrollton gauge, threatening the city once again, although never breaking through.[25] Human barriers were flimsy protection from the mighty river's excesses, and weaknesses in the rural levees could work to New Orleans's advantage. If the levees broke on the opposite bank or sufficiently distant from the city, pressure on the New Orleans levees subsided. So although urban residents expected rural landowners to complete the flood barrier, weak links in that chain of protection were tolerated—in part because the city could not legally compel planters to do their bidding and because it was advantageous to the city.

During a period of relative flood security in New Orleans, political fragmentation within the city prompted the creation of three separate municipalities with one mayor. Beginning in 1836, each municipality had responsibility for maintaining its own levees, and the respective municipal surveyors tended the levees along the urbanized waterfront. Since the three municipalities differed greatly in terms of their tax base, levee maintenance was uneven.[26] In the midst of this flood hiatus, the politically influential planters and New Orleans politicians were able to defer some of the levee construction costs to the state. In the mid-1840s, Louisiana created an office of the state engineer, who was to oversee public works construction and maintenance for the state. In particular, his responsibilities included clearing snags from navigable streams and improving the levee system. The imperfect levee system inherited by this office extended from below New Orleans to near the Atchafalaya River. Despite the existence of this massive construction, the state engineers began to question the viability of a continuous wall of levees and to challenge the de facto levees-only policy.

In 1846, P. O. Hebert, the state engineer, cautioned that New Orleans and the entire lower river were in "imminent danger of inundation" annually:

> Every day, levees are extended higher and higher up the river—natural outlets closed—and every day the danger to the city of New Orleans and to all the lower country is increased. Who can calculate the loss by an

> overflow to the city of New Orleans alone? Instead, therefore, of throwing suddenly a larger quantity of water into the Lower Mississippi and elevating its level by opening cut-offs above, we should, on the contrary, endeavor to reduce this level, already too high and too dangerous, by opening all the outlets of the river. We are every year confining this immense river closer and closer to its own bed—forgetting that it is fed by over 1500 streams—and regardless of a danger becoming every year more and more impending.[27]

The following year, the engineer reemphasized his main point: "For local and temporary purposes, levees will answer, but as forming a general and permanent system, they are defective." Indeed, Hebert maintained that "in addition to a great and constant expense, the gradual elevation of the bed of the river is the inevitable consequence of confining its turbulent water between levees. This operation of course increases the danger of inundation."[28] And yet neither New Orleans nor the rural planters were willing to give up levees in favor of outlets. Outlets would mean huge expenses for the state, and it would expose plantations along the bayous used as floodways to damaging inundations. Both these factors precluded support for Hebert's plan. In practice, the poor state of the existing levees created a constant pull for the state engineer to attend one minor disaster after another, particularly in politically powerful districts, and negated any effective development or implementation of an outlet plan. The next severe flood dramatically fulfilled the state engineer's prophesy of imminent danger.

Despite firm barriers along its waterfront, the urban center of the lower river remained subject to backdoor flooding, as the 1849 Sauvé Crevasse proved. After two months of rising water during the spring, upstream crevasses began breaking through the saturated levees and the river reclaimed much rural floodplain. In early April, a crevasse on the west bank let water loose over a massive area extending from 18 miles above New Orleans to 45 miles downstream. Water rose to about 3 feet in the backswamps and to lesser heights on the natural levees. Typically a breach on the west bank would lessen the pressure on the east bank levees. Nonetheless, softened levees combined with the exceptional volume of water to produce a second break on the east bank 17 miles above New Orleans—the notorious Sauvé Crevasse (Fig. 1.3). The Sauvé levee was weak because during the previous year the landowners had rebuilt a portion farther back from the river's edge.

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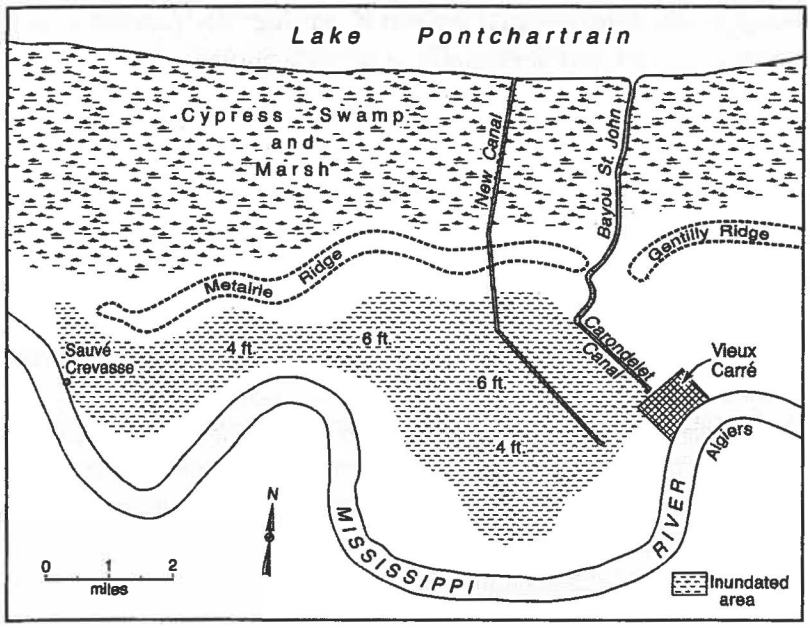

FIG. 1.3. FLOODED AREA, 1849. A crevasse at Pierre Sauvé's plantation upriver from New Orleans caused extensive urban flooding in 1849. Water flowed between the Metairie Ridge and the natural levee collecting in the "bottom of the bowl." The towpath along the Carondelet Canal served as a dam at the lower end of the flooded area. After George E. Waring, Jr., and George W. Cable, *History and Present Condition of New Orleans, Louisiana* (Washington: U.S. Department of the Interior, 1881).

Additionally, one expert thought it was too steep or had too narrow a base and therefore a less stable foundation. On May 3, this fragile link gave way, and within three hours there was a 30-foot-wide gap allowing water to pour over the floodplain. A natural spine of land that ran west to east across the floodplain, the Metairie Ridge, funneled the water directly into New Orleans's lowest portion (Fig. 1.3). Confined by the ridge to the north and the crescent-shaped natural levee on three sides, floodwater simply rose within this natural basin. Despite efforts to plug the gap, water continued to fill the bowl and reached Rampart Street (the rear of the French Quarter) by May 15 and continued rising into "the heart of the city" by the seventeenth. It proceeded an additional three blocks into the French Quarter by the end of the month, when it reached it peak. In the backswamp, water stood as high as 6 feet.[29]

Topography, in part, defined the social geography of New Orleans and,

during floods, created inequity in terms of suffering. The highest ground a the Place d'Armes and in the wealthier districts remained above the inun dation, but "the utmost distress prevailed among the poor" who lived in th lower sections that went under water first. Water surrounded over 200 squar blocks of the city and about 2,000 tenements. This forced 12,000 residents mostly poor, to vacate their homes or "live an aquatic life of much privatio and suffering."[30] Most business and commerce ground to a halt, while olde cemeteries were under water, displacing all burials to the new cemetery ato the Metairie Ridge. Overall, the most pronounced and prolonged suffer ing was concentrated in the low-income quarters, exacerbating preexistin inequities.

Initially the flood response concentrated on blocking the crevasse, bu these futile efforts gave way to attempts to accelerate the drainage of th bowl between the natural levee and the Metairie Ridge. Workers tried cut ting through the ridge to allow water to flow toward Lake Pontchartrain Some water passed through these cuts, but excavating 2 to 4 feet for half a mile was costly, and officials abandoned the effort. Ultimately, the bulk o the water drained through existing outlets. Bayou St. John carried about one-third of the excess, while the New Canal handled the balance. The sep arate municipalities worked against each other in some cases, attempting to drain their high water onto the next community downstream. It was not un til June 20 that a municipal engineer directed the closing of the crevasse, and with the water supply finally cut off, the city drained in a few days. Heavy rains that soon followed "washed off the terrible filth which for forty days had stood stagnant over street, yard, and tenement." While the city's levees held, its political fragmentation handicapped its response to the upstream levee break and exacerbated the flood's impact.[31]

While not disastrous in the sense of ripping houses off their foundations, the high water destroyed several bridges, interrupted business throughout the city, contributed to health problems, disrupted the lives of thousands, and caused extensive property damage throughout the city. Considering such consequences, city officials assessed future flood risks and concluded that the cost of erecting higher levees was worthwhile. Soon after the 1849 crevasse, the city once again raised its levee system.[32] In addition, the Sec ond Municipality constructed a levee from the river to the Metairie Ridge to protect the rear of the city from a flood like the Sauvé Crevasse. Journal ists, with questionable optimism, proclaimed that "a small sum of money,

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judiciously expended on this work, will hem the city around with an impregnable barrier against the truant waters."[33] Indeed, the following year when water broke through the Sauvé levee again, the new traverse levee fended off backdoor flooding, adding to the false sense of security. By constructing the new levee, the city showed less confidence in the protection offered by plantation levees but still relied on rural owners to bear a portion of the flood protection costs. Within the city's politically fractured structure, piecemeal projects did not afford a consistent protective barrier for the entire urban territory.

A. D. Wooldridge, the new state engineer in 1850, questioned the total reliance on levees, saying, "I find myself forced to the conclusion that entire dependence on the leveeing system is not only unsafe for us, but I think will be destructive to those who shall come after us."[34] He criticized both the initial expense and the long-term costs required by repeated levee enlargements. From the 4-foot embankment in colonial New Orleans, the barrier system had risen to 15 feet in some places. The meandering river undercut levees on its outer banks, necessitating repairs and realignments. Wooldridge saw value in diverting some of the floods to the sea by way of outlets. He contended that both urban and rural dwellers had to recognize they had a "community of interest," although his was an urban perspective. Wooldridge also argued that the "dweller on the remote bayou" should be willing to "receive and convey" a portion of the floodwaters. Specifically, he suggested that the Atchafalaya River should be "the great natural drain of Southern Louisiana."[35]

Farmers and those in the swamps did not embrace the notion that they shared a community of interests with New Orleans residents. They did not subscribe to the concept that they should sacrifice their crops for the city's security. Wooldridge's suggestion began an ongoing debate over diverting floodwaters through the Atchafalaya Basin as a way to displace risks away from the city and plantations to a politically weak territory.[36] Wooldridge also argued that the best place for an outlet would be at the Bonnet Carré crevasse, about 35 miles upstream from New Orleans. This was the site of a naturally occurring crevasse and provided the shortest path between the river and Lake Pontchartrain.[37] Levees, nonetheless, remained the primary flood protection structure through the nineteenth century, although the preference for them did not mean the city sympathized with the bayou dwellers. They were merely the less costly of the two options, given the prior invest-

ment in them and the price of acquiring land for outlets. Levees were the status quo, and to modify the existing system would mean major manipulations of both public policy and the environment. Neither the city nor the state was up to that challenge.

The levee system had helped New Orleans become an exceptional city in the largely rural South by 1850. Its 116,000 citizens made it the fifth largest city in the country, far larger than its closest rival in Dixie. It had earned its entrepôt status by controlling the movement of cotton, rice, sugar, and other agricultural produce that flowed through its port. Consequently, its factors and bankers relied on the production of floodplain and upland farmers. This city was tied to its hinterland economically, and the problem of flooding created an equally important connection. Thus decisions to protect the agricultural holdings served the city as well as the countryside. When the federal government passed the Swamp Land Acts of 1849 and 1850, Louisiana was able to collect revenue from the sale of swamplands and apply it to levee improvements. In effect, this provided a federal subsidy for rural and urban residents alike.

An 1850 U.S. Senate report indicated that Louisiana had begun the process of selling former federal lands to improve its levee system. The fact that the federal government transferred the lands to the state reflected a realization that the federal government, and thus the country as a whole, stood to benefit from land reclamation on the lower Mississippi. The transfer also acknowledged, as New Orleans advocates had claimed for years, that the problem was much larger than Louisiana—it was as vast as the 1.2 million square miles in the Mississippi River drainage basin. The first tracts alienated to private purchasers were those already protected by levees. The author of the Senate report noted that "the government has so far benefitted at the expense of the people of Louisiana, for none of these lands would have been disposed of had they not been reclaimed."[38] In effect, a levee system, built largely with private resources and erected initially to protect the primary city of the lower valley, benefitted the entire nation. This realization, pushed hard in later discussions about levee improvements, contributed to the gradual shift of rural levee financing from private, to state, and ultimately to the federal government.[39] Urban interests, of course, championed this transition since it reduced their financial burden.

On the eve of the Civil War, which left the levee system greatly deteriorated, New Orleans had protected itself with a feeble flood barrier built largely by slaves and convicts and paid for by taxes on shippers, mandated

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contributions from upstream planters, and the state. Although the city could not require outside interests to pay for its protection, its prominence in state politics and the obvious rural and urban benefits of levees ensured that others would share the cost of protecting the urban territory.

Floods continued to be a part of urban life in New Orleans during the nineteenth century, even as flood control shifted from local to federal responsibility. State programs, underwritten with federal assistance through the swamp lands sales, prevailed until 1879. During the interval from the Sauvé Crevasse in 1849 until the 1870s, water filled the city's streets on several occasions. In 1862, riverfront levees failed in several locations, and water ponded behind rail lines and flowed toward the city's rear districts. A local newspaper claimed that "there is not cause to fear any serious damage from the overflow spoken of unless the river rises much higher than it is at present."[40] Whether this calm response was to lull occupying Union forces into complacency or a reflection of the regularity of crevasses, the water disrupted urban life for several weeks. Again in 1871 water invaded the city. This time, a crevasse at Bonnet Carré allowed water to flow into Lake Pontchartrain and raised the lake level a couple of feet. Although the riverfront levees held, a rear barrier failed, and water rose in the urbanized territory.[41] Again in 1874, flooding occurred along the New Canal due to elevated lake levels caused by a crevasse at Bonnet Carré.[42] By the 1870s, the greater flood hazard had shifted to the lakefront. The city's riverfront defenses were firm, but weak levees upstream allowed floodwaters to fill Lake Pontchartrain, which then rose sufficiently to inundate low areas along the city's drainage outlets.

The post–Civil War floods had much more devastating effects on rural agricultural lands. High water in 1865, 1867, 1868, 1871, and 1874 delivered sequential blows to the valley. The rural levees, which suffered serious deterioration during the sectional conflict, were no match for these crests, and southern politicians clamored for federal assistance with the recurrent problem. Following the particularly severe 1874 flood, a federal board of engineers assessed available corrective options. Although recommending improvements, their report produced no action. In 1879, a second review of flood control options by army engineers concluded that a consistent levee system could be an aid to navigation. By citing navigational concerns as a device to garner greater national support for protecting riparian plantations, the engineers offered a package acceptable to Washington politicians. Subsequently, Congress created the Mississippi River Commission in 1879 to develop a federally designed levee system that was to provide flood control, although

authorization of the program explicitly limited funding of the gargantuan project to navigational improvements.[43] Rural floods in 1881 (which also affected New Orleans) and again in 1882 compelled the commission to press its plans for a well-designed and consistent levee system along the lower river into action. Gradually they shored up the weak links and closed the outlets.

Nonetheless, another great flood in 1890 produced numerous crevasses in the agricultural hinterland.[44] During that event, New Orleans also suffered the highest water ever in the city's rear districts. An upstream crevasse again caused lake levels to rise, and stiff east winds piled water along New Orleans's lakefront. Water stood 2 feet deep in houses along the lakefront, roads and railroads disappeared beneath the pervasive flood, vast tracts adjacent to the Metairie Ridge became a lake, and the city's drainage canal spilled over into neighboring streets. The lake was so high that the city's drainage machines could not lift water from the drainage canals and had to be shut down till the water level subsided. Reporters pointed out that, once again, the city's poor suffered the most.[45] Although high water threatened the city with some regularity after 1890, the river never again breached the riverfront barrier. The levees had effectively made the lakefront the principal flood threat.

The city was not impregnable, although the Mississippi River Commission made notable strides in protecting the rural floodplains, and this offered New Orleans additional security. Most significant is the fact that Louisiana and other lower valley interests finally deflected the principal cost of levee building and maintenance to the federal government. The scale of the flooding problem was truly national, and New Orleans officials had made that point to federal authorities since territorial days. From the city's standpoint, the federal government had an obligation to build and maintain the massive bulwarks. With the creation of the Mississippi River Commission, the transfer of flood protection responsibilities was finally accomplished. However, the great flood hazard of the Mississippi River had not been eliminated; it was merely hidden behind a now federally maintained earthen curtain between the city and the waterway.[46]

DRAINING THE SWAMPS

Historian Anne Vileisis suggests that colonial settlers took advantage of swamps across the country—using some as pasture, others for rice produc-

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INING THE SWAMPS

gests that colonial settlers took advantage of -using some as pasture, others for rice produc-

tion, and in Louisiana as a source for timber.[47] Although valued as resources, there was a prevailing view expressed in such literature as *Pilgrim's Progress,* that swamps were dangerous and evil places. Attaching such names as "dismal" to the Virginia–North Carolina wetland reflected this view. Setting aside the moral associations of swamps as treacherous places, there was another critical concern that caused settlers to be wary of wetlands—their function as an ostensible harbor for disease.

As early as 1720, Jean Baptiste Bernard de la Harpe, a prominent French explorer and respected chronicler of early conditions in Louisiana, criticized the selection of New Orleans's site owing to its unhealthy circumstances, among other reasons.[48] New Orleans's initial plat called for ditches encircling each block to provide drainage, and the early levee included a ditch to accelerate passage of any water that seeped through.[49] Spanish officials argued that vacant lots that collected water contributed to ill health by emitting "vapors that are pernicious to health" during the summer months.[50] Near the end of the colonial period, French settler and chronicler James Pitot commented on the "pestilential fever that manifests itself in a most violent way" during the late summer months, particularly among "strangers" (nonnatives). He claimed that clogged drains along with stagnant water contributed to this situation, which was aggravated by the lack of government action to reduce the "deficiencies of a swampland" and make the city a salubrious location.[51] He further contended that "Lower Louisiana is not an unhealthy place. Only in its city is centered the pollution that tears it down. . . . [S]urveys, landfills, and, of course, drainage, would generally provide in healthfulness of the area what other colonial countries freely provide under similar conditions."[52] Pitot's comments also reveal that part of the problem was the concentration of people in a city with wholly inadequate public works. This notion that health problems afflicted the city more than the countryside prevailed during the early nineteenth century. At the time New Orleans became an American city, however, the prevailing wisdom, or at least hope, was that although health hazards existed in the wetland, drainage could eliminate them.

Several aspects of the wetland site contributed to public health fears. Stagnant water and putrefying organic material found in both the swamps and in the city's lower sections were thought to generate effluvia or miasmas that contributed to diseases such as yellow fever. Swamp forests, in the minds of some, or the lack thereof to others, contributed as well. Shallow privies and outhouses, along with cemeteries, added their own foul air to the local

atmosphere and posed additional problems. Finally, water supplies also were suspected as still another source of ill health. Depending on the authority, nineteenth-century New Orleans residents faced an assortment of hazards, and each had roots in the city's physical site. The common factor was the low-lying site, which produced a high water table and an ideal habitat for the cypress forest. It also inhibited downward percolation of rain and sewage, thus adding to an overabundance of standing water and decaying biological material. The bowl-like topography and minimal grade between the rear of the city and Lakes Pontchartrain and Borgne made it nearly impossible to drain off the excess moisture.

A medical view commonly expressed in the first half of the nineteenth century, drawing in part on Noah Webster's medical treatise, held that epidemic disease derived from environmental conditions. Webster had argued that places like Egypt's delta that were subject to annual inundations had to deal with disease outbreaks, and New Orleans certainly faced regular inundations.[53] Colonial historian Le Page du Pratz spoke of the process by which the river carried "a prodigious quantity of ooze, leaves, canes and trees," which, when the river escaped its banks, accumulated on its flanks. He described the land of the lower delta as aggrading, or building up slowly. As evidence of this gradual buildup, he noted that the numerous lakes on the riverside were "remains of the sea."[54] The protracted land-building process had not yet filled in the lakes and wetlands that surrounded the city, and the vegetable matter in the "ooze" contributed to the miasmas. Pitot reported that these "pools of stagnant and fetid water" produced unhealthy conditions.[55]

Early-nineteenth-century beliefs in environmental disease attributed ill-health to those water bodies. Geographer William Darby flatly claimed that "the stagnant state of water has ever been considered the fruitful source of disease." He added that "the deadly effluvia that imperceptibly arises from water in a stagnant state, must come from the putrefaction of animal and vegetable matter."[56] Climatic conditions prompted medical authorities to refine the notion that stagnant lakes alone caused the disease outbreaks. Jabez Heustis, a physician, noticed that disease was most prevalent in New Orleans during the late summer, particularly August. In 1817 he explained this condition by differences in seasonal precipitation and temperatures. During the spring and early summer rainy seasons, the ponds and lakes filled with fresh water, "rendering New Orleans healthy." The prevalence of sick-

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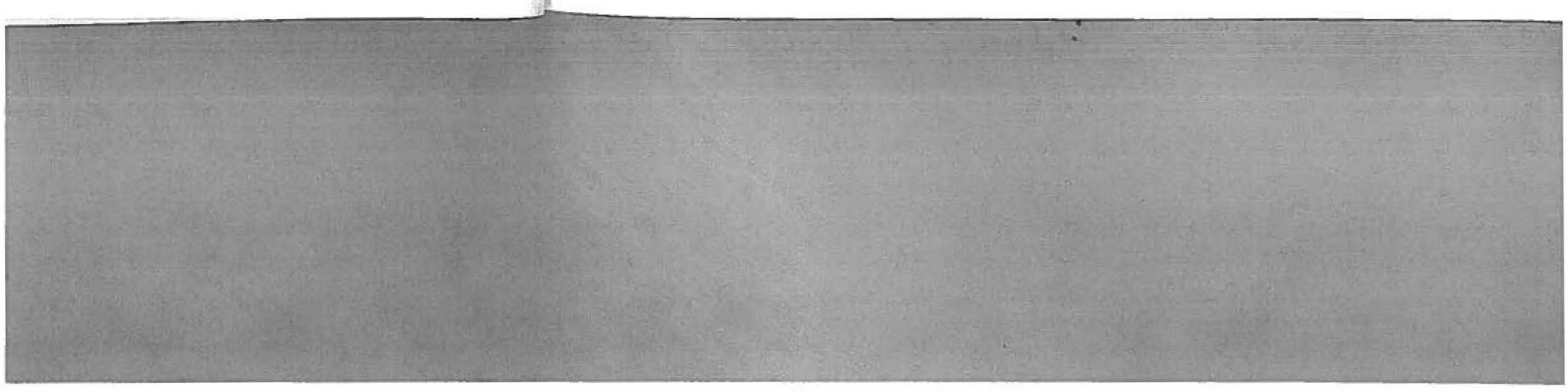
ness in late summer arose from the dessication of the lakes and the high temperatures that caused the vegetable material to decompose and release effluvia to the atmosphere.[57] A decade later, author Timothy Flint joined those who observed the massive number of fatalities due to the insalubrious site. He noted stagnant water as a contributing factor, but he also pointed out an old view that was taking on greater prominence, claiming that newcomers or "strangers" were more susceptible to disease. This view attempted to assign a social cause and thereby link recent "unacclimated" immigrants with spreading the deadly illness.[58] Public policy, however, did not drop environmental causation as the key source of pestilence.

Edward Fenner, a noted New Orleans medical authority, contributed to the ongoing discussion of stagnant water as a source of miasmas. He pointed out the large number of vacant lots that collected water during wet weather and released "deleterious effluvia."[59] In addition, he noted the ability of people to become acclimated to the local conditions and noxious emissions. The New Orleans Board of Health also cited standing water as hazardous: "of all the external causes affecting the salubrity of the city, probably moisture and filth are more instrumental than all others combined. . . . This liability to undue moisture arises from our being surrounded by swamps, large lakes and rivers in our neighborhood, but particularly the former."[60] Again in 1851, the eminent physician E. H. Barton reiterated the need to drain impounded water. Offering a more refined medical explanation, he claimed that stagnant water was the most favorable environment for the decomposition that produced miasmas. He also pointed out that the very canals used to drain the urban territory contributed to the problem by holding the offensive brew.[61] Trying to remedy a hazardous situation with open drains, the city actually worsened the conditions they sought to alleviate.

Conflicting views about forests' contribution to insalubrity existed. A thriving colonial cypress timber trade had reduced the forests around New Orleans by the 1750s.[62] With little forest remaining within the built-up sectors, Spanish authorities recommended planting forests, particularly around waste dumps and cemeteries. They argued that by shading decaying matter from the sun they would reduce putrefaction and prevent disease outbreaks. Furthermore, they claimed that trees would "intercept the said exhalations and vapors preserving the city from one and the other."[63] Apparently considerable forest remained toward the lakefront in the early nineteenth century. C. C. Robin observed between 1803 and 1805 that behind the city the



forest had been cleared, but "further away a curtain of tall cypress trees blocks the horizon."[64] Additional descriptions mention limited forests along various bayous and the Mississippi River.[65] Estimates to construct a canal from the city to the lakefront in 1831 calculated that laborers would have had to remove some 3,500 trees, including many cypress, along the 6.5 mile canal pathway.[66] In 1839, the Louisiana legislature authorized the removal of the "woods which at present nearly cover the entire space between lake Pontchartrain and the city [New Orleans]" in order to allow lake breezes to reach the city free of "exhalations" from the swamp.[67] The local board of health claimed that forest removal in the vicinity of the city would, when combined with drainage, make the area much drier and healthier. These reports indicate that cypress forests remained around New Orleans and that medical opinion saw forested wetlands as health risks.[68] E. H. Barton challenged this view, in part. He claimed that trees should be planted to absorb noxious gases and moderate heat, which induced decay of organic matter in stagnant water.[69] His support of trees was limited to public parks and principal streets, while he encouraged their removal at the city's fringes.[70] The city's municipalities followed this advice and planted trees along the principal thoroughfares.[71] Nonetheless, by the 1860s lumbermen had yet to clear the entire cypress forest surrounding New Orleans, and the threat remained (Fig. 1.4).[72]

The concern with epidemic diseases in New Orleans was not unfounded even though the causation might have been misunderstood at the time. The first outbreak of yellow fever, the most pervasive bacterial threat to the city, occurred in 1796, followed by a second in 1799. A more devastating flare-up took some five hundred lives in 1803. By the 1820s the "saffron scourge" appeared every summer, and it reached epidemic proportions in 1822 and 1824. With increasing numbers of recent immigrants who had no immunity to the illness, the death tolls rose, and according to medical historian John Duffy, municipal authorities showed relatively little concern for the city's population, particularly recent immigrants. After several ill-fated attempts to organize a local health board to respond to epidemics, the city suffered its most severe yellow fever epidemic in 1853. An estimated 10,000 people died out of a total population of about 150,000, but that number is made more dramatic by the fact that about half the city fled at the epidemic's outset. All told, physicians treated about 30,000 to 40,000 cases of the fever that summer.[73] Such were the realities of the disease hazard. Although the disease was attributed to effluvia from the swamps and stagnant bodies of water around the city, it was in fact mosquitoes, which bred in the wetlands and standing

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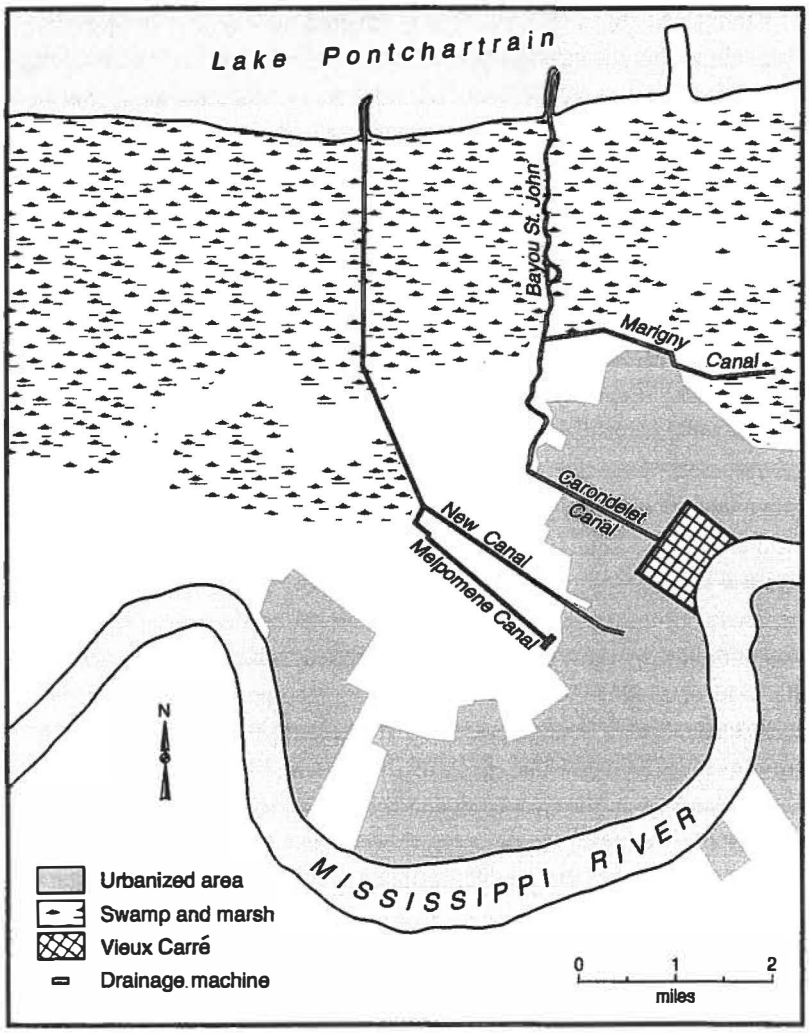

FIG. 1.4. NEW ORLEANS IN 1863. In the 1860s cypress forests still separated the city from the lakefront. Three canals offered some drainage for New Orleans, and drainage machines or pumps helped lift water from the low ground and out of the city. After Gen. Nathan P. Banks, "Approaches to New Orleans, 1863." Courtesy The Historic New Orleans Collection, Museum/Research Center, Accession No. 1974.25.18.122.

water, that delivered the fatal virus. Concern about standing water was not ill-placed; it merely focused on the habitat and not the disease vector. Coincidentally, a common medical belief held that mosquitoes were valuable warnings of the disease since they thrived in settings where "unwholesome exhalations" prevailed.[74]

Outbreaks often and most severely afflicted the city's poorer quarters—those districts either along the waterfront where imported cases first appeared or closest to the wetlands behind the city (the same areas that were also subject to flooding). The limited range of mosquitoes concentrated the outbreaks to relatively small territories—in the places of the disease's initial introduction, particularly along the waterfront and secondarily to the rear of the city. Medical authorities assigned the filth commonly found in immigrant neighborhoods as a contributing factor. This made the problem particularly urban. In the eyes of contemporary physicians, population density, which was greatest in the low-income quarters, and its associated problems made the city more susceptible to the generation of effluvia and the transmission of disease. Contributing to the situation were the many shallow privies, most of which extended only about four feet into the ground.[75] Into those shallow cavities New Orleans residents deposited some 5,633 tons of fecal material and 43,000 tons of urine annually. Although laws required the removal of night soil to the river, health authorities still feared that the "putrefactive fermentation" of this waste contaminated the atmosphere.[76] This was undoubtedly most severe in neighborhoods where residents could not afford regular night-soil service. In addition, the open drains, which carried surface runoff and sewage, presented an intolerable nuisance. The lack of current made drainage canals particularly offensive in summer months. Food wastes dumped on the river bank and the numerous aboveground cemeteries also attracted the attention of authorities as sources of unhealthy emissions.[77] The greater the population density in the already soggy site, the more voluminous the filth that created hazardous conditions.

There was one obvious, though difficult, solution—drainage. It was not enough to keep river floods from the city; additional measures were essential to rid the city of water that accumulated after every rain and became particularly problematic during high river stages. The initial plat of New Orleans included drains along each block of the Vieux Carré, and the Spanish commenced digging a canal that linked the rear of the city to Bayou St. John. This artificial waterway functioned primarily as a transportation link with Lake Pontchartrain but also as a sluice for runoff and sewerage when lake levels allowed movement in that direction. Completed in about 1796 and named after the Spanish governor who authorized its construction, the Carondelet Canal improved drainage in the Vieux Carré (Fig. 1.4),[78] but the gentle grade between its headlands and the lake made it only marginally

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effective for the city's lower districts. By 1810, local observers claimed that the canal had "become an unwholesome morass, from which pestilential emanations are continually evaporating," and that boats "plough through mud at the bottom, and large bubbles of poisonous gas are seen rising and exploding at the surface."[79] North winds could waft these offensive emissions toward the city and reverse the canal's flow. Flooding along the headwaters of the canal during prolonged periods of northerly winds completely negated its effectiveness. To revitalize the canal, the municipal government granted rights to a private company to enlarge and clean it. The job was completed by 1817, but the improvements were short lived, and indeed, the modifications did little to relieve the problem.[80] The restored canal's larger volume simply meant it could hold more sewage and create a greater menace.

Despite the physical obstacles to efficient water movement, drainage remained the most attractive and feasible solution. Even President Thomas Jefferson offered advice. In a letter to local resident M. du Plantier he recommended that a ditch 3 feet deep could drain an area subdivided into lots; proceeds from the sale of the lots could be used to underwrite the excavation of the ditch and construction of protective levees.[81] Though lacking in engineering adequacy, Jefferson's recommendation that drainage be linked with real estate development was a model attempted in subsequent years. Timothy Flint noted some successful drainage efforts in 1818 (the enlargement of the Carondelet Canal) and encouraged the city to continue them. "Tracts of swamp about the town are draining, or filling up," he wrote in 1828, "and this work, constantly pursued, will, probably, contribute more to the salubrity of the city, than all other efforts to this end united."[82]

A series of marginally successful efforts punctuated the drainage program of the early 1800s. Three canals dug through the ridges by 1830 drained separate sections of the city. The Melpomene Canal offered an outlet for the uptown American district in 1825, the Poydras Canal followed the path of the current street by the same name (later replaced by the New Canal in the 1840s), and the Marigny Canal offered minimal drainage to the lower faubourgs (Fig. 1.4). Neither individually nor jointly did the canals remedy the problem. The absence of gradient was a chief obstacle, and without sufficient current the large ditches became open-air septic troughs[83] and permitted wind-driven water from Lake Pontchartrain to back up into the city. Water from the lake inundated areas within several blocks of the Mississippi in 1831, 1837, 1844, and 1846.[84] Typically these events occurred during the

winter months and were unlikely to contribute to conditions that favored the spread of epidemic diseases. If hurricane driven, however, they could coincide with summer heat. Once again, efforts to alleviate one problem contributed to another.

By the 1830s, steps to provide more effective drainage were underway. Unable to shoulder the financial burden, the city, as often occurred in public works projects, allowed entrepreneurs to fashion its infrastructure. In 1831 the state legislature chartered the New Orleans Canal and Banking Company and made it responsible for building a second major canal from Poydras Street to Lake Pontchartrain. This construction was to improve navigation to the heart of the city, while offering the side benefit of drainage. Real estate speculation ran rampant in areas that it would drain. The canal and banking company made huge profits when it subdivided and sold lots in suburban Carrollton in 1832–33, reflecting both the growing city's need for additional space and its desperate need for drainage. Following the financial panic of 1837, the company collapsed and turned the completed "New Canal" over to the state.[85] The New Canal extended from the rear of the American section of the downtown area (Fig. 1.4) through the lowest portion of New Orleans to Lake Pontchartrain, and it attracted considerable attention. Visitors to the city liked to take carriage rides to the lakefront along its shell road, built on the spoil from the canal excavation. The embankment that served as the roadway also provided a levee that stretched from the rear of the city to the lakefront, offering some hope of protection from upstream crevasses. Despite obvious commercial success, the lowest portions of the city enjoyed little benefit from this huge ditch because, once again, the subtle topography of New Orleans inhibited current. Furthermore, the raised roadway stood between much of the lowest ground and the drainage canal—obstructing any flow from the city's natural basin. As demonstrated by the Sauvé Crevasse of 1849, the roadway/levee also provided ineffective flood protection.

Seeking improvements it simply could not afford, the city convinced state lawmakers to pass legislation in 1835 initiating an effort to drain "off the stagnant waters which accumulate on the low and marshy grounds" in the city's rear. The legislation created a private company, the New Orleans Draining Company, to execute the improvements. To finance the project, the city and state committed to purchase stock in the enterprise. In theory, the company would profit by selling the lands it drained.[86] Due in part to

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the economic panic of 1837, this speculative venture failed to put an effective drainage system in place and the city remained at the mercy of the surrounding wetlands.[87]

Despite the new canals, an 1840 report called for further improvement. It charged that the various drainage efforts to that time had been piecemeal and without an overarching design. Political subdivision of the city into three separately governed municipalities in 1836 fractured effective public works projects and prevented adequate coordination, even where it was obviously necessary. Without coordination, the three municipalities undertook assorted drainage and filling projects that sometimes offset one another. This problem was further aggravated by inconsistency from administration to administration and a chronically strained city treasury.[88] Consequently, the separate drainage projects remained largely ineffective after any substantial rainfall. George Dunbar, the state engineer and author of the 1840 report, argued for a more coordinated system that employed steam engines to supplement the meager pull of gravity.[89] By 1849, Edward Fenner reported that substantial progress had been made. He noted that the territory within two miles of the city had been "pretty thoroughly drained" and large tracts of valuable land reclaimed. Drainage machines, or large waterwheels (Fig. 1.5), were in place to force water from the two principal canals into Bayou St. John and the lake.[90] A special report on fevers released in 1850 claimed that the ground between the city and Metairie Ridge had been well drained, "causing an extensive swamp to be dried up by the rays of the sun."

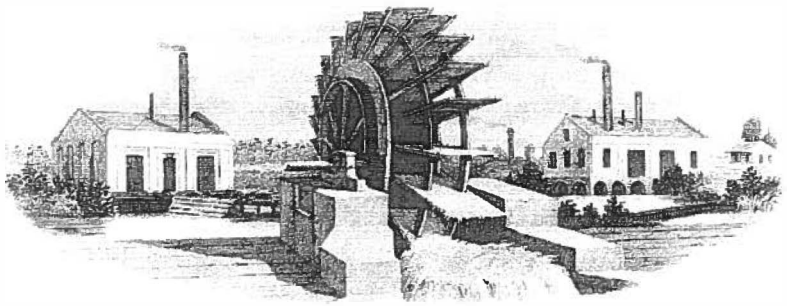

FIG. 1.5. DRAINAGE MACHINE, CA. 1860. Steam-driven waterwheels lifted excess water from low areas of the city into the drainage canals flowing into Lake Pontchartrain. Courtesy Tulane University Special Collections, New Orleans Municipal Papers, MS Collection 16, Public Works folder.

This, it suggested, had produced a "beneficial influence upon the health of the city."[91] But such optimism was premature.

The great yellow fever outbreak of 1853 soon followed with its devastating toll on human life. This tragedy prompted Louisiana's leaders to take another look at solutions to New Orleans's drainage problems. Local leaders had long denied public health problems, using their fiction to justify a lax response to the excess water problem.[92] The urban elite, with long family histories in the region, were better acclimated and less susceptible to the yellow fever onslaughts. By contrast, the immigrant community, the Irish in particular, labored in digging the new canals and were most susceptible to mosquito bites as they extended the drainage system into the backswamps. E. H. Barton estimated that more than 200 of every 1,000 Irish in New Orleans died during the 1853 epidemic.[93] In part because of the relative immunity of long-term residents and high fatalities among the laboring poor, urban leaders were less vigorous than their counterparts in other major cities to seek out and put into place remedies to the drainage dilemma. The outbreak of 1853 left them facing an undeniable reality with severe economic ramifications. Their denials that New Orleans was unhealthy sought to prevent the diversion of commerce to other ports.[94] Local leaders, however, were unable to suppress or distort the severity of reports about the 1853 epidemic. National recognition of this event threatened the economy, and leaders grudgingly acknowledged that concrete remedies were essential. E. H. Barton's report in 1854 argued for better drainage and the filling of low lots. Spurred into action, the state legislature authorized an investigation that also pointed out the need to improve drainage, specifically in the area between the city and the lakefront.[95] The report claimed that public health had improved in countries such as England that had implemented drainage projects. Although the report called for getting rid of surface waters, converting swamps to meadows, and removing forests to improve ventilation, no fundamental changes ensued.[96] Once again inadequate resources hampered the city's response.

In a follow-up report to the state legislature, Lewis de Russy prepared an estimate for draining the swamps between the city and Lake Pontchartrain. His novel plan emphasized not drainage but filling the low area—mimicking the process of sedimentation that had been terminated by levees. His concept called for a series of parallel levees from the river to the lakefront, where a perpendicular levee would link the bulwarks extending toward the

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lake, creating enclosed basins. He recommended diverting floodwater into these basins, where sediment would settle out and, over the course of several years, gradually raise the land level.[97] The de Russ scheme exposed a serious flaw in the levee system—it eliminated the regular delivery of sediments, which reduced flood risks and could actually aid in drainage efforts by raising the land level. The legislators, as might have been expected, preferred the more expeditious system of drainage machines, and de Russy's plan suffered the fate of other discarded recommendations.

As the legislature searched for a solution, New Orleans's common council called on its municipal surveyor, Louis Pile, to report on the feasibility of draining the swamps behind the city. Expressing obvious frustration with the council for ignoring previous reports that had been "unhappily filed without action in the city archives" and charging that the state's survey was a waste of public funds, he offered a plan following the Dutch solution. Referring to the "Hollanders" as the fathers of drainage, he advocated dividing the swamps into four polders—areas surrounded by ring levees with pumps to remove the water. In addition, he argued that existing canals needed to be enlarged and new draining machines, with weirs to block reverse flow of lake water, situated near the Metairie Ridge. These improvements would prevent flooding from the lake and would allow the machines to move water from the inhabited sections into the lake more expeditiously. This work, he estimated, would cost the city $1.3 million.[98] Like so many previous plans, the city was unable to fund Pile's recommendation. Despite repeated efforts and numerous critical reports about the city's drainage, New Orleans remained plagued with a host of problems associated with excessive water in 1860.

During the first half of the nineteenth century, residents with means took flight from the summer pestilence and avoided the most serious epidemics. The selection of rural retreats emphasized the notion that pestilence was a byproduct not just of the swamps but of filth associated with crowded urban living. New Orleans's elite had begun their search for refuge outside the city by the 1820s. Timothy Flint observed in that decade that the threat of disease "compels the rich to fly" to hotels and homes in places like Madisonville on the north shore of Lake Pontchartrain. He also described the coastal resorts east of New Orleans as attracting summer residents seeking healthful breezes from the Gulf of Mexico.[99] Benjamin Latrobe likewise noted that those who could afford to ventured to Bay St. Louis, Mississippi,

or similar resorts between July and October, emphasizing the rural-urban distinction by noting that "bilious fevers are the common disorder, and the wealthy fly to the country."[100] Prevailing medical opinion held that residents of urban areas breathed impure air, while those in rural territories enjoyed air diluted and purified by the sun. Such a prescription obviously drove the annual exodus from New Orleans. But arguments for better drainage began to point out that solutions had to apply to those who had to live in the city for twelve months a year and not just those "who can take the 'wings of the morning and fly to the outermost part of the earth.'"[101] Drainage, along with the removal of forests to enhance lake breezes through the city remained the favored options, but delivering them was costly and beyond the city's financial capabilities.

Throughout the early nineteenth century, the city had been unable to pass the costs of drainage on to others as it had the levee building expense. The one attempt to have the state subscribe to bonds for the draining company failed to transfer the expenses or to drain the city. A combination of ineffective leadership and fiscal inadequacies, along with the considerable technological and financial challenges posed by the problem, allowed the costs of poor drainage to fall on the city's citizenry. This cost weighed disproportionately on the poor in the form of huge death tolls during the frequent yellow fever outbreaks. Wealthy citizens paid for inadequate drainage through the expense of taking refuge in the country.

Preparing for and responding to hazards are fundamental social activities. Writers on environmental hazards suggest that society first appraises a hazard and then develops plans to adjust to hazardous events, which it then may or may not adopt in full or in part. The dual threats of high water and environmental disease in New Orleans inspired different appraisals, plans, and responses, with contrasting results. Indeed, steps taken to remedy one problem often exacerbated the other. The scale of the hazards, which were continental in scope, were beyond the control of a single municipality. When the city could disperse the costs to a larger group it was fairly successful in implementing adjustments, but when it had to bear the full costs it failed to put effective adjustments into place, at least by 1860.

The appraisal and adjustment process for floods involved observations of prior flood stages, based on flood marks on trees. Colonial policy called for a public response to protect the city itself with a set of levees sufficiently high

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to keep out the highest known flood. As floods entered from the rear of the city, policy adjustments required rural landowners to construct levees that would aid urban flood protection. By the time of the Louisiana Purchase, the city had effectively transferred a portion of the costs to plantation owners. The municipality continued to maintain the levees at the urban core, although shippers subsidized this effort. Later, the state took on a portion of the expense, and ultimately the federal government subsidized levee building with the Swamp Lands Acts of 1849 and 1850 and later through the Mississippi River Commission. Although the flood protection system was imperfect and rural crevasses continued to damage the city, the structures erected along the urban riverfront proved remarkably effective after about 1865. A policy that called for continual monitoring and maintenance and required that levees be raised to the most recent high stage offered both a means to keep the levees in good condition and a flexible standard. This environmental transaction worked to the advantage of urban dwellers.

Drainage presented a far less manageable problem. The high water table, stagnant lakes, and decaying organic material represented a public health threat—an indirect hazard—particularly to the poor. The city sought to eliminate the disease hazard by draining the low-lying districts in and around the municipalities. Due in part to a fragmented municipal government, financial constraints, and limited technological capabilities, moving water from the soggy city remained a vexing problem through the mid-nineteenth century. Initial attempts to drain the city relied simply on gravity to propel water from the built-up portions of New Orleans to the lake. With inadequate gradient, this approach was hopeless, despite the construction of several canals by 1840. The addition of pumps, or draining machines, yielded better results, but poor coordination among the three municipalities and inadequate maintenance of the drainage systems rendered the overall effort ineffective. The city had turned to private developers and the state to help underwrite the drainage effort, but ineffectual management of the private projects produced little public health benefit. As long as the urban elite could escape the summer pestilence, there was little compulsion to fulfill the various costly and complex drainage plans.

The management of water hazards in New Orleans, and throughout the lower delta, is a tale of sharp contrasts. While far from perfect, the levee system was remarkably successful in New Orleans. It protected the city and, to a lesser extent, a large portion of its economic hinterland. Tied together

by the ribbon of levees, the city and the plantations blockaded the threat of high water. As that task became more expensive, they were able to defer some of the costs and maintain their economic well-being. By contrast, an expanding city faced increasing costs as it pushed back away from the better drained natural levee into the swampy mire behind New Orleans. Colonial governments endowed the American city with a single ineffective drainage canal. Even when supplemented by additional outlets and pumps, the canal system remained useless as a means to drain the swamps and eliminate disease threats. Unable to secure effective outside finances for a drainage system, the city still faced much the same problem in 1860 as it had in 1800.

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weeps by this unnatural metropolis.

NOTES

NOTES TO INTRODUCTION

1. "Mayor: N.O. Location 'Lousy Place to Put a City,'" *Baton Rouge Advocate,* 17 May 2001, 14A.

2. Peirce F. Lewis, *New Orleans: The Making of an Urban Landscape,* 2nd ed. (Santa Fe: Center for American Places, 2003).

3. Baron Marc de Villiers, "A History of the Foundation of New Orleans (1717–1722)," trans. Warrington Dawson, *Louisiana Historical Quarterly* 3: 2 (1920): 157–251.

4. A fine discussion of New Orleans's relationship to the river is Ari Kelman, *A River and Its City: The Nature of Landscape in New Orleans* (Berkeley: University of California Press, 2003). Essays on New Orleans's environmental history appear in Craig E. Colten, ed., *Transforming New Orleans and Its Environs: Centuries of Change* (Pittsburgh: University of Pittsburgh Press, 2000). A lavishly illustrated work that examines New Orleans and its site is Richard Campanella, *Time and Place in New Orleans: Past Geographies in Present Day* (Gretna, LA: Pelican, 2002).

5. M. Le Page du Pratz, *The History of Louisiana,* ed. J. G. Tregle, Jr. (1774; reprint, Baton Rouge: Louisiana State University Press, 1975), 128–29. Du Pratz cites the discovery of a buried tree trunk in a well as evidence the river was building the land where New Orleans stood.

6. An excellent account of the formation of the land surface at New Orleans is Roger T. Saucier, *Recent Geomorphic History of the Pontchartrain Basin* (Baton Rouge: Louisiana State University Press, 1963), 18–21.

7. *Ibid.*, 18–21.

8. *Ibid.*, 18–21.

9. See Albert E. Cowdrey, *Land's End: A History of the New Orleans District, U.S. Army Corps of Engineers* (Washington: U.S. Army Corps of Engineers, 1977).

10. William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York: W. W. Norton, 1991). Cronon has inspired a growing body of literature on urban environmental history—both internal and external in its scope. James Lemon has argued that North American cities benefitted from nature's largesse within a larger urban system. See *Liberal Dreams and Nature's Limits: Great Cities of North America since 1600* (New York: Oxford University Press, 1996). The present volume, by contrast, will maintain an internal focus.

11. The concept of "reworking nature" in a major urban area is developed by Matthew Gandy, *Concrete and Clay: Reworking Nature in New York City* (Cambridge: MIT Press, 2002).

12. See John G. Clark, *New Orleans, 1718–1812: An Economic History* (Baton Rouge: Louisiana State University Press, 1970), and N. M. Miller Surrey, *The Commerce of Louisiana during the French Régime, 1699–1763,* Columbia Studies in the Social Sciences, no. 167 (New York: Columbia University Press, 1916).

13. Lewis Mumford, "The Natural History of Urbanization," in *Man's Role in Changing the Face of the Earth,* vol. 1, ed. William L. Thomas (Chicago: University of Chicago Press, 1956), 382–98; Henry Lawrence, "The Greening of the Squares of London: Transformation of Urban Landscapes and Ideals," *Annals of the Association of American Geographers* 83 (1993): 90–118.

14. The classic example of this genre is Edward T. Price, "The Central Courthouse Square in the American County Seat," *Geographical Review* 58 (1968): 29–60. For an overview of urban landscape studies, see Michael P. Conzen, "Analytical Approaches to the Urban Landscape," in *Dimensions of Human Geography: Essays on Some Familiar and Neglected Themes,* ed. Karl Butzer, Research Paper 186 (Chicago: University of Chicago, Department of Geography, 1978), 128–65. A recent interpretation is Richard Schein, "Place of Landscape: Conceptual Framework for an American Scene," *Annals of the Association of American Geographers* 87:4 (1997): 660–80.

15. David Ward, *Cities and Immigrants: A Geography of Change in Nineteenth-Century America* (New York: Oxford University Press, 1971); Alan R. Pred, *The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800–1914* (Cambridge: MIT Press, 1966); John Adams, "Residential Structure of Midwestern Cities," *Annals of the Association of American Geographers* 60 (1970): 37–62. Good overviews of urban landscape evolution are Larry R. Ford, *Cities and Buildings: Skyscrapers, Skid Rows, and Suburbs* (Baltimore: Johns Hopkins University Press, 1994), and Richard Harris and Robert Lewis, "Constructing a Faulty Zone: American Suburbs 1900–1950," *Annals of the Association of American Geographers* 88:4 (1998): 622–39.

16. John R. Borchert, "American Metropolitan Evolution," *Geographical Review* 57 (1967): 302–32.

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17. General overviews of these theories and models appear in Paul Knox, *The Restless Urban Landscape* (Englewood Cliffs, NJ: Prentice Hall, 1993), and Harold Carter, *The Study of Urban Geography,* 4th ed. (New York: Arnold, 1995). The clear exception to neglect of the physical environment in general urban texts is Risa Palm, *The Geography of American Cities* (New York: Oxford University Press, 1981).

18. At the height of the early-1970s environmental movement, several volumes appeared that emphasized the role of the environment in the city. See Brian J. L. Berry and Frank E. Horton, *Urban Environmental Management: Planning for Pollution Control* (Englewood Cliffs, NJ: Prentice-Hall, 1974), and Brian J. L. Berry et al., *Land Use, Urban Form, and Environmental Quality,* Research Paper 155 (Chicago: University of Chicago, Department of Geography, 1974).

19. James E. Vance, *The Continuing City: Urban Morphology in Western Civilization* (Baltimore: Johns Hopkins University Press, 1990).

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22. Susan Cutter, *Living with Risk: The Geography of Technological Hazards* (New York: Arnold, 1993); Robert W. Kates, ed., *Managing Technological Hazards: Research Needs and Opportunities* (Boulder: University of Colorado Program on Technology, Environment, and Man, 1977); Joel A. Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, OH: University of Akron Press, 1996).

23. Joel A. Tarr and Gabriel Dupuy, eds., *Technology and the Rise of the Networked City in Europe and America* (Philadelphia: Temple University Press, 1988), and Martin V. Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present* (Baltimore: Johns Hopkins University Press, 2000) are prominent examples.

24. Andrew Hurley, *Environmental Inequalities: Class, Race, and Industrial Pollution, 1945–1980* (Chapel Hill: University of North Carolina Press, 1995).

25. A spate of urban environmental histories has followed the pioneering work in Andrew Hurley, ed., *Common Fields: An Environmental History of St. Louis* (St. Louis: Missouri Historical Society Press, 1997). See Colten, *Transforming New Orleans and Its Environs,* Char Miller, ed., *On the Border: An Environmental History of San Antonio* (Pittsburgh: University of Pittsburgh Press, 2001), Martin V. Melosi, *Effluent America: Cities, Industry, Energy, and the Environment* (Pittsburgh: University of Pittsburgh Press, 2001), and Joel A. Tarr, ed., *Devastation and Renewal: The Environmental History of Pittsburgh and Its Region* (Pittsburgh: University of Pittsburgh Press, 2003).

26. For a discussion of the importance of environment in historical geography see Stanley Trimble, preface to *The American Environment: Interpretations of Past Geographies,* ed. Lary M.

Dilsaver and Craig E. Colten (Lanham, MD: Rowman and Littlefield, 1992), xv–xxii, and the essays on urban environments in a special issue of *Historical Geography* 25 (1997) guest edited by Christopher Boone.

27. In particular he states that water was essential in the city's economic viability. Gandy, *Concrete and Clay*, 74.

28. William Meyer, "Bringing Hyspography Back In: Altitude and Residence in American Cities," *Urban Geography* 15 (1994): 505–13; Craig E. Colten, "Chicago's Waste Lands: Refuse Disposal and Urban Growth, 1840–1990," *Journal of Historical Geography* 20:2 (1994): 124–42.

29. W. B. Meyer, "Urban Heat Island and Urban Health: Early American Perspectives," *Professional Geographer* 43 (1991): 38–48; Felix Driver, "Moral Geographies: Social Science and the Urban Environment in Mid-Nineteenth Century England," *Transactions of the Institute of British Geographers*, n.s., 13 (1988): 275–87; Pyrs Gruffudd, "'A Crusade against Consumption': Environment, Health, and Social Reform in Wales, 1900–1939," *Journal of Historical Geography* 21:1 (1995): 39–54; Graham Mooney, "Did London Pass the 'Sanitary Test'? Seasonal Infant Mortality in London, 1870–1914," *Journal of Historical Geography* 20:2 (1994): 158–74.

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NOTES TO CHAPTER 2

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3. Jacque L. Emel and Elizabeth Brooks, "Changes in Form and Function of Property Rights Institutions under Threatened Resource Scarcity," *Annals of the Association of American Geographers* 78:2 (1988): 241–52. The shift from common-law solutions to regulatory approaches is