Unnatural Disasters, Natural Solutions

Lessons From The Flooding Of New Orleans

A Report by American Rivers

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EXECUTIVE SUMMARY

The images are seared into our memories. As Hurricane Katrina roared ashore, the long-ignored warnings about the inadequacy of New Orleans' defenses came shockingly, vividly alive.

The flooding of New Orleans that followed was a tragic and appalling disaster. But it was not a natural disaster. Poor project planning, flawed project design, misplaced priorities, and the destruction of the city's natural flood protection – Louisiana's coastal wetlands, were the root causes of the city's ruin. Each of these causes lies firmly within the hands of man.

Piecemeal – and at times, wholesale – destruction of healthy rivers and wetlands, development in floodplains and other high risk areas, and an over-reliance on structural flood prevention reach far beyond New Orleans to communities across the country. These problems are exacerbated when the federal government insists on constructing low priority and poorly planned water projects that impair natural flood protection systems, promotes large scale structural projects as a panacea for flooding, and ignores scientific and local concerns.

To prevent future unnatural flood disasters across the country, we must address these problems where they begin. Fortunately, the means for doing so are well within our grasp. We must—

Modernize the Corps: The U.S. Army Corps of Engineers (Corps) is the federal agency with primary responsibility for building and maintaining our nation's defenses against flooding. Its responsibilities also include building and operating river navigation projects and carrying out restoration projects across the country. Katrina shed a bright spotlight on problems that have plagued the Corps for decades. Corps projects destroyed coastal wetlands that would have buffered Katrina's storm surge, funneled and intensified that surge into New Orleans, and encouraged development in high-risk areas. With this stage set, the Corps sealed the city's fate when it used flawed designs to build the levee and floodwall system that was supposed to protect the city – but clearly did not.

We cannot let outdated policies and unchecked planning continue to put communities at risk. The U.S. Senate has taken an important step towards addressing the problems at the Corps by passing reforms championed by Senators Russ Feingold (D-WI) and John McCain (R-AZ) that would propel Corps project planning into the 21st century. The safety of communities across the nation rests on Congress' passage of these reforms.

Adopt Natural Flood Protection: We must begin in earnest to protect and restore rivers and wetlands that provide natural flood protection. The dramatic loss of coastal wetlands that would have buffered Katrina's storm surge was a major factor in the flooding of New Orleans. Wetlands act as natural sponges, storing and slowly releasing floodwaters after peak flood flows have passed, and coastal wetlands buffer the onslaught of hurricanes and tropical storms. Restoring a river's natural flow and meandering channel, and giving at least some floodplain back to the river, slows down floodwaters and gives the river room to spread out without harming homes and businesses.

The eight case studies in this report show that natural flood protection works. They tell the stories of communities that have chosen to protect themselves by protecting and restoring nature's own capacity to reduce the size and power of floods, and by simply moving out of harm's way. These communities have reduced or eliminated flood disasters while preserving the environment for present and future generations. They are now safer, healthier, and more livable.

Abandon Over-Reliance On Structural Protection: Hurricane Katrina sent a stark reminder of the danger of relying solely on structural fixes such as levees and floodwalls to protect communities from flooding. Structural flood protection creates a false sense of security for people living in the floodplain, provides only a fraction of the flood storage capacity of healthy wetlands and floodplains, often increases flood heights, and typically causes significant environmental harm. And, as Katrina showed in graphic detail, structural protections can, and do, fail.

While flood protection structures and complex engineering approaches will continue to have a place in protecting communities, Katrina has shown us all too vividly that they must be the last line of the defense against floods, not the only one.

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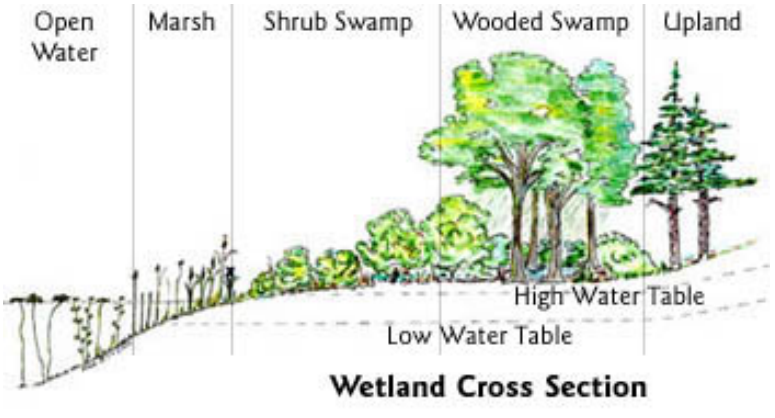
We can – and must – change the nation's approach to flood protection. Until we do, lives, homes, businesses, and entire communities will continue to be at risk from unnatural flood disasters.

What is a wetland?

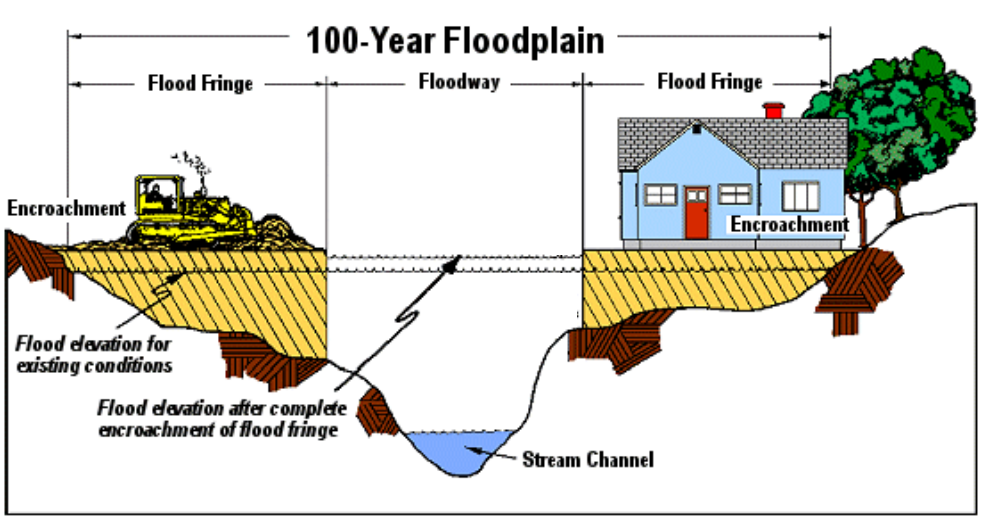
A wetland is a type of land that is regularly saturated by surface water or groundwater but may not be wet all year round. Wetlands are transition zones between land and aquatic ecosystems. Because of the many different types and functions of wetlands—they are found on every continent except Antarctica, and in climate zones from the tundra to the tropics—they are difficult to define. The three major distinguishing characteristics of wetlands are the level of water saturation, soil chemistry, and types of vegetation found in the wetland. One method of grouping these complex ecosystems classifies wetlands as in-stream or aquatic systems, riparian systems (along the river's edge), isolated basins, and coastal systems.



Rhode Island Department of Environmental Management

What is a floodplain?

Comprised of wetlands, a floodplain is the low-lying area adjacent to rivers and other bodies of water that is periodically inundated by floodwaters. Although the size of the floodplain is delineated by the frequency of the flood that is large enough to cover it (the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood), the Federal Emergency Management Agency defines floodplains as "any land area susceptible to being inundated by flood waters from any source." The floodway is the channel of a river and adjacent land areas that must be preserved so that the flood elevation of a 100-year flood does not rise over a designated height. The flood-fringe is the portion of the floodplain outside of the floodway, which is covered by floodwater during the 100-year flood and is subject to a community's building codes.



Virginia Department of Conservation and Recreation

THE MAKING OF AN UNNATURAL DISASTER

On August 29, 2005, Hurricane Katrina made landfall along the Gulf Coast. The devastation of coastal Mississippi was immediate and almost incomprehensible in its magnitude. But for a few hours at least, New Orleans appeared to have dodged catastrophe. The Hurricane came and went with seemingly little harm. It was not until the next morning that it became clear to the rest of the nation that New Orleans was drowning.

What followed was a tragic and appalling disaster. But it was not a natural disaster. Poor project planning, flawed project design, misplaced priorities, and the destruction of the city's natural flood protection – Louisiana's coastal wetlands, are the root causes of the city's ruin. And each of these causes lies firmly within the hands of man.

To prevent future unnatural flood disasters in New Orleans and throughout the nation, we must address these root causes. Fortunately, the means for doing this are well within our grasp.

- We must modernize the rules and policies that govern the U.S. Army Corps of Engineers (Corps), the agency that planned the water projects that failed New Orleans so miserably. We cannot let outdated policies and unchecked planning continue to put communities at risk.

- We must begin in earnest to protect and restore rivers and wetlands that provide natural flood protection. As the case studies in this report show, natural flood protection works to safeguard communities and the environment.

- We must abandon the dangerous over-reliance on structural fixes such as levees and floodwalls to protect communities. We can no longer continue to jeopardize lives with false promises of safety.

Katrina's lessons are hard learned. We cannot ignore them any longer.

The Making Of An Unnatural Disaster

The flooding of New Orleans was an unnatural disaster. The tragedy was the direct result of over-engineering of the Mississippi River and other flawed projects planned and designed by the Corps of Engineers. The Corps' complicity was succinctly addressed by Senator Russ Feingold (D-WI) when he spoke on the Senate floor in support of reforming the Corps:

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> "I am here to say that if you were outraged by [the Federal Emergency Management Agency's] poor response, like me, then you should be equally outraged by problems with the Corps."[1]

Corps projects destroyed coastal wetlands that would have buffered the hurricane storm surge, funneled and intensified that surge into New Orleans, and encouraged development in high-risk areas. With this stage set, the Corps sealed the city's fate when it used flawed designs to build the levee and floodwall system that was supposed to protect the city. These flaws led to the drowning of one of America's greatest cities and, as the New Orleans Times Picayune wrote, "to the deaths of more than 1,000 residents."[2]

Corps projects on the Mississippi River destroyed vital wetlands that would have buffered New Orleans from Katrina's storm surge. Corps-built levees and navigation projects cut off the Mississippi River from more than 90 percent of its floodplain and continue to interfere with the river's ability to carry sediments downstream, preventing the river from sustaining and replenishing coastal wetlands.

These projects are the primary culprits in the loss of some 1,900 square miles of Louisiana's coastal wetlands. Before Katrina, Louisiana was losing about 30 square miles of coastal wetlands each year – the equivalent of a football field of land dissolving into water every 30 minutes.[3] Since every 2.7 miles of wetlands between the Gulf of Mexico and solid land reduces ocean storm surges by

Before Katrina, Louisiana was losing about 30 square miles of coastal wetlands each year – the equivalent of a football field of land dissolving into water every thirty minutes.

about one foot, this massive wetlands loss made New Orleans particularly vulnerable to Katrina's onslaught.[4]

A little used navigation channel built and constructed by the Corps was also a major factor in the devastation. The highly controversial Mississippi River Gulf Outlet (MRGO) destroyed well over 20,000 acres of coastal wetlands that would have helped reduce Katrina's storm surge. But the MRGO did far more than eliminate this crucial storm buffer. It greatly exacerbated the hurricane's impacts by funneling and intensifying the storm surge into New Orleans. The initial flooding that overwhelmed the lower Ninth Ward and St. Bernard Parish came from the MRGO. The MRGO is discussed in detail below.

The stage for the disaster was set when the Corps designed the New Orleans hurricane protection project that failed the city so miserably. Congress told the Corps to develop the project after Hurricane Betsy slammed into New Orleans in 1965, killing at least 75 people.[5] In response, the Corps opted to build an elaborate new levee system stretching miles into uninhabited wetlands. The Corps used the improved property values from the wetlands drained by the project to justify the project's significant cost (estimated in 1978 at $409 million).[6] Like so many structural projects before and since, this system lured people directly into harm's way. Many of the wetlands that were developed as a result of the project became the eastern Orleans Parish neighborhoods that suffered the brunt of Katrina's flooding.

The final blow came when the Corps – in an appalling dereliction of duty that one investigator said was driven by "lethal arrogance" and a "rejection of technology"[7] – suffused multiple layers of design flaws into the levee and floodwall system. The Corps acknowledged that "a 'design failure' led to the breach of the 17th Street Canal levee that flooded much of the city during Hurricane Katrina."[8] Independent engineers investigating the levee failures have pointed out design flaws at many other locations, and the American Society of Civil Engineers has said the catastrophic failure is undeniable proof that the Corps' design contained "fundamental flaws."[9]

Hurricane Katrina was no more than a Category 3 storm by the time it reached New Orleans, a storm event that the Corps-built levees and floodwalls were supposed to protect against. But Ivor Van Heerden, Deputy Director of the Louisiana State University Hurricane Center and Director of the Center for the Study of Public Health Impacts of Hurricanes in Baton Rouge, has said that the Corps' hurricane protection system "wasn't even capable of withstanding a Category One hurricane."[10] The floodwall design did not meet the Corps' own guidelines, and the Corps knew that the floodwalls were being built on extremely unstable soils that likely warranted a much stronger design.[11]

As disturbingly, the Corps ignored crucial data on the need to increase the levee heights. The Corps was told as early as 1972 that new weather data showed that the levees needed to be higher than planned to protect New Orleans from stronger hurricanes. This data was not incorporated into the hurricane system's design specifications even though construction did not begin until the 1980s.[12]

Remaining Wetlands Provided Key Protection

Even amidst the ruin in New Orleans, the value of natural flood protection stands out. After the storm, studies by Louisiana State University and Texas A&M researchers showed that levees with wetland buffers had a much greater chance of withstanding Katrina's fury than those levees without wetland buffers. Models of both Hurricane Katrina's and Rita's storm surges also indicated that existing wetlands reduced the surge in some New Orleans neighborhoods by two to three feet. Data collected by the state confirmed the researchers' findings.[13]

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The Mississippi River Gulf Outlet – Flawed Planning Leads To Disaster

Initially promoted as a boon for the port of New Orleans, the MRGO was the product of a decade of lobbying by businessmen seeking a shortcut from the Mississippi River to the Gulf of Mexico. The MRGO was approved by Congress in 1956, and the Corps finished the 76-mile long, 650-foot wide, and 36-foot deep navigation channel in 1965, after moving more earth than during construction of the Panama Canal.[14] The project cost federal taxpayers $92 million to construct, but the flow of federal money did not stop there. During just the last 20 years, federal taxpayers paid out $322 million dollars to maintain the outlet (with recent maintenance costs exceeding $12,600 per vessel per day).[15] Despite this enormous investment, the MRGO has never produced the economic boom promised by the Corps. In 2004, less than one ship a day traveled through the MRGO – just 226 deep water ships all year, carrying only 3 percent of the port's cargo.[16]

While the MRGO was being pushed by economic interests, many local residents warned that the project would convey salt water deep into the coastal marshes harming hunting, fishing, and trapping industries; and would funnel hurricane storm surges directly into the city.[17] The Secretary of the Interior added his concerns to the mix just one year after construction began, telling the Secretary of the Army that dredging would in fact injure local fishing industries.[18]

These warnings started to come true even before the channel was completed. In 1963, salinity levels spiked, oyster reefs started to disappear, and marsh grasses began to die.[19] When the MRGO opened two years later it funneled the fury of Hurricane Betsy into New Orleans, helping "Hurricane Betsy ravage St. Bernard Parish, exactly as the critics had warned."[20]

Unfortunately, these initial problems were just a shot across the bow. Eroding dramatically over time, the MRGO is now a 1,000 to 2,000 foot wide gash through the heart of Louisiana's coastal wetlands.[21] It has destroyed well over 20,000 acres of vital coastal wetlands,[22] facilitated significant saltwater intrusion that has spoiled valuable oyster beds and killed marsh grass leading to more wetland erosion, and significantly impaired the health of the massive Lake Pontchartrain. In May 2005, hydrodynamic modeling by the Louisiana State University's Hurricane Center scientifically established the funneling effect of the MRGO and a nearby waterway.[23] This modeling was tragically prescient.

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During Hurricane Katrina, the funnel created by the MRGO increased the velocity of the storm surge to almost 7 feet per second, more than twice as fast as the 3-foot-per second velocity of the storm surge traveling over nearby marshes.[24] It also increased the surge height. The impact was heartbreaking. The 18 to 25 foot high onslaught of water that hurtled down the funnel leveled many of the levees and floodwalls along the MRGO,[25] overwhelming both St. Bernard Parish and New Orleans' lower Ninth Ward. Only 52 of the 28,000 structures in St. Bernard Parish escaped unscathed from Katrina.[26]

Levees with wetland buffers had a much greater chance of withstanding Katrina's fury than those levees without wetland buffers

For years, community leaders – including the St. Bernard Parish Council, activists, and scientists – had called on the Corps to close the MRGO because of its horrific environmental impacts and the threat it posed to the safety of New Orleans.[27] These calls were repeatedly ignored by the Corps, which as late as 2004 officially declared that the MRGO should remain open. The calls for closure grew even louder, however, in the aftermath of Hurricane Katrina and were finally heard by Congress.

In June 2006, Congress passed legislation directing the Corps to devise a plan that would, at a minimum, reduce the depth of the MRGO and restore the wetlands lost to its construction and operation.[28] Scientists at the Louisiana State University Hurricane Center have already developed a MRGO closure plan that would protect New Orleans and restore lost wetlands. The plan would re-claim the MRGO's original bank lines with dredged material and place a number of lateral fills across the outlet to create a series of pools. The pools would help eliminate the funneling effect of the MRGO, and the lateral closures would facilitate the natural filling-in of the channel and the restoration of lost wetlands.[29] But if history is a guide, scientists and the public will have to work hard to make sure this simple and highly feasible plan is adopted by the Corps.

> "Louisiana's fortunes are also tied, for better or worse, to the U.S. Army Corps of Engineers."
> The Times-Picayune

Preventing the Next Flood Disaster

While the magnitude of destruction makes New Orleans a rallying cry for changing the nation's approach to flood protection and water resource planning, the problems that led to the drowning of New Orleans plague communities across the country.

Piecemeal – and at times, wholesale – destruction of healthy rivers and wetlands, development in floodplains and other high risk areas, and an over-reliance on structural flood prevention projects all put communities at risk. These problems are exacerbated when the federal government insists on constructing low priority and poorly planned water projects that add to the destruction of natural systems, promotes large scale structural projects as a panacea for flooding problems, and ignores scientific and local concerns.

Katrina points to the following key changes that will help turn the tide toward safer and healthier communities and rivers.

- Congress must modernize the rules and policies governing the planning and construction of Corps water resources projects. We cannot let outdated policies and unchecked planning continue to put communities at risk.

- We must begin in earnest to protect and restore rivers and wetlands that provide natural flood protection. As the case studies in this report show, natural flood protection works to safeguard communities and the environment.

- We must abandon our dangerous over-reliance on structural fixes such as levees and floodwalls to protect communities. We can no longer continue to jeopardize lives with false promises of safety.

Modernize the Corps of Engineers

The rules and policies governing Corps project planning must be modernized to protect lives, communities, the economy, and the environment. This was made tragically clear by the Corps' role in the flooding of New Orleans. But New Orleans is by no means the only place where Corps planning has proved problematic.

During the past decade, the National Academy of Sciences, the Government Accountability Office, the Army Inspector General, federal agencies, and independent experts have issued a flood of studies highlighting a pattern of stunning flaws in Corps project planning, and have urged substantial changes to the Corps' planning process.[30]

In March of this year, the Government Accountability Office (GAO) testified that recent Corps studies were "fraught with errors, mistakes, and miscalculations, and used invalid assumptions and outdated data."[31] The problems were so pervasive that the studies "did not provide a reasonable basis for decision-making."[32] The GAO also told Congress that the problems at the Corps were "systemic in nature" and "prevalent throughout the Corps' Civil Works portfolio."[33]

The New Orleans Times Picayune has also called for reform: "Louisiana's fortunes are also tied, for better or worse, to the U.S. Army Corps of Engineers. Efforts to reform the agency are critical for this state, which – after the levee failures during Hurricane Katrina – could serve as the poster child for the corps' shortcomings."[34]

In July of this year, the Senate took an important step towards correcting the problems at the Corps by passing reforms championed by Senators Russ Feingold (D-WI) and John McCain (R-AZ) that would propel Corps project planning into the 21st century.[35] As the bill containing these reforms (H.R. 2864 EAS) moves to conference this September with the House version (which was passed *before* Katrina hit and does not address Katrina's lessons), it is essential that the Senate reforms be adopted.

The reforms in the Senate bill would:

- *Require outside independent review of costly or controversial Corps projects*. This outside review is necessary to ensure that those projects are properly designed, and are based on the best available science, economics, and engineering. The Senate bill would also require a safety assurance review during design and construction of flood control projects whose failures could endanger public health, safety, or welfare. Independent review will ensure that communities get projects that are properly designed, cost less, and provide more benefits with less environmental harm.

- *Require mitigation for any unavoidable impacts to rivers and wetlands caused by Corps projects.* The Corps has proposed no mitigation for almost 70 percent of its projects,[36] damaging healthy systems that provide the first line of defense against flooding, filter pollutants, sustain fish and wildlife, and support vibrant economic activity. To ensure effective mitigation for impacts to rivers and wetlands that cannot be avoided, the Senate bill would require the Corps to meet the same mitigation requirements as everyone else, and would establish procedures to ensure that the Corps completes the promised mitigation.

- *Modernize the Corps' woefully out of date planning guidelines.* The Corps' planning guidelines, which have not been updated in more than twenty years, promote the destruction of healthy natural ecosystems that should be the first line of defense against storm surges and flooding; allow the Corps to recommend projects that encourage development of high risk areas, luring people into harm's way; and fail to adequately address potential loss of life. The Senate bill would require a cabinet-level interagency working group to revise the guidelines to address these and other failings. The Corps would be required to adopt those revisions, subject to public comment.

A single acre of wetland, saturated to a depth of one foot, will retain 330,000 gallons of water – enough to flood thirteen average-sized homes thigh-deep.

Adopt Natural Flood Protection

Healthy rivers, wetlands, and floodplains provide effective and sustainable flood protection, while structural approaches like levees, floodwalls, and dams can generate a cascade of problems that in the long run create, rather than abate, flood disasters.

Natural flood protection can be attained by maintaining healthy uplands and watersheds that slow the rate of runoff, protecting and restoring wetlands and floodplains, and by restoring a river's natural flow and meandering channel. Examples of projects that provide just some of the many approaches to natural flood protection are highlighted in the case studies that follow.

Giving at least some floodplain back to a river will give the river more room to spread out, with enormous benefits. In some areas, this can be done by setting levees back farther from the river, or even removing them altogether. Some communities have opted to move buildings entirely out of the floodplain. Policy changes implemented after the 1993 Mississippi River floods allowed federal contributions to this process. Neighborhoods in places like Arnold, Missouri; Trenton Island, Wisconsin; and Kampsville, Illinois took advantage of these policy changes to permanently move people out of harm's way and give the floodplain back to the river.

Wetlands act as natural sponges, storing and slowly releasing floodwaters after peak flood flows have passed. A single acre of wetland, saturated to a depth of one foot, will retain 330,000 gallons of

American Rivers Photo Library

water – enough to flood thirteen average-sized homes thigh-deep.[37] As discussed above, coastal wetlands reduce storm surge and slow its velocity.[38]

Even comparatively small expanses of wetlands can have a profound impact on reducing flooding. Scientists estimate that in general just 4 to 5 percent wetland coverage in a watershed would reduce peak floods by 50 percent.[39] On average, returning just 7 percent of the Mississippi watershed to wetlands would be sufficient to prevent extreme floods.[40] More extensive wetland restoration would produce even greater benefits. Restoration of just half of the historic wetlands drained in the Upper Mississippi River basin (approximately 13 million acres) would have contained the 39 million acre-feet of floodwater from the Great Mississippi River Flood of 1993.[41] That flood killed 47 people, displaced 54,000, ravaged 50,000 homes, and inundated 20 million acres.[42]

Natural flood protection produces a multitude of benefits to communities.

Maintaining and restoring healthy rivers, watersheds, wetlands, and floodplains provide a host of benefits in addition to reducing flood damages. These systems:

- *Provide Clean Water.* Wetlands and floodplains improve water quality. Water slows down as it moves through the wetland, allowing plants to serve as natural filters, absorbing nutrients and other pollutants. Suspended sediments will also settle out of the water column in wetlands. This filtration process makes rivers healthier for drinking, swimming, and supporting plants and animals. For example, wetlands remove excess nitrogen and phosphorus that enters the water from fertilizers, manure, leaking septic tanks, and municipal sewage. This in turn helps reduce algae blooms that could eventually deplete the amount of oxygen in the water, suffocating fish and other aquatic organisms.[43]

- *Control Erosion.* Floodplain trees and plants anchor river banks, preventing bank erosion. Excess sediments produced by erosion can cloud river water and coat the leaves of aquatic vegetation, depriving them of sunlight. Too much sediment can also increase flood heights by raising the level of the riverbed as it settles.

- *Sustain Commercial Fisheries.* Wetlands and floodplains support a multitude of animal life that is the mainstay of the nation's multi-billion dollar fisheries industry. American consumers spent about $54.4 billion for fishery products in 2000. In 2004, fin fish and shell fish sales totaled $3.7 billion, and fueled a $7.2 billion fishery processing industry.[44]

- *Support Recreation.* More than 82 million hunters, fishermen, birders and photographers spend $59.5 billion in the United States each year. The overall economic impact of recreational fishing is estimated at $116 billion. In 2001, approximately 3 million people hunted migratory birds (which rely extensively on wetlands), spending more than $2.2 billion in the process.[45]

- *Provide Vitally Important Habitat*. Seasonally inundated wetlands are some of the most biologically productive ecosystems in the world.[46] They are comparable to tropical rain forests and coral reefs in the number and variety of species they support. Although wetlands cur-

rently make up only about 5 percent of the land area of the lower 48 states, they are home to 31 percent of plant species. More than one-third of federally threatened and endangered species live only in wetlands, and up to 43 percent of threatened and endangered species rely directly or indirectly on wetlands for their survival.[47] Floodplain wetlands also provide essential habitat during the life cycle of 75 percent of commercially harvested fish and shellfish, and up to 90 percent of the recreational fish catch. Nearly 70 percent of all vertebrate species rely upon the land along the river's edge – the riparian zone – during their life cycle.

Abandon Over-Reliance On Structural Protection

The value of natural flood protection is particularly striking when compared to the record of structural efforts. Despite spending $45.2 billion federal tax dollars – $123 billion adjusted for inflation – on structural projects nationwide, flood damages continue to rise. Before Hurricane Katrina, average annual flood damages were topping $6 billion a year, more than double the average annual damages (in real terms) in the first half of the 20th century.[48]

Structural flood protection provides only "a fraction of the storage of natural wetlands and floodplains without providing any of the natural benefits."[49] Dams, dikes, levees, and floodwalls typically cause severe environmental harm, and often do not provide the promised levels of protection. Engineered structures:

- *Can – And Do – Fail, Often With Catastrophic Results.* While engineered structures provide tangible lines of defense, as we saw in New Orleans they can, and do, fail. The New Orleans levee failure has been recognized as "the greatest engineering failure in American history, measured by lives lost, people displaced and property destroyed."[50] But any type of structural failure will likely cause significant damage. As John Barry wrote in his book *Rising Tide*, "Without levees, even a great flood – a great 'high water' – meant only a gradual and gentle rising and spreading of water. But if a levee towering as high as a four-story building gave way, the river could explode upon the land with the power and suddenness of a dam bursting."[51]

"Without levees, even a great flood – a great 'high water' – meant only a gradual and gentle rising and spreading of water. But if a levee towering as high as a four-story building gave way, the river could explode upon the land with the power and suddenness of a dam bursting."
John Barry, *Rising Tide*

While some failures are the result of design flaws, others are literally built into the project design. Structural flood projects are designed to provide only a certain level of protection, often protection from a 100-year flood (which is a flood magnitude that has a 1 percent chance of occurring each year).[52] When a larger flood hits, the project will not keep a community safe even if it has been properly designed, built to specifications, and regularly maintained.[53] During the Great Mississippi Flood of 1993 – which ranged from a 500-year to less than a 100-year flood, depending on the location – more than 1,000 levees were overwhelmed.[54] Thirty-two Corps levees were not high enough to withstand the flooding and overtopped, and 4 other Corps levees "were breached or otherwise allowed water into protect areas before the levees' design capacity was exceeded."[55] Damages caused by the over topping and breaching of these 36 levees was about $450 million.[56]

- *Increase Flood Heights.* Levees and floodwalls unnaturally constrict rivers within a narrow channel, causing the waters to rise higher and flow faster than they otherwise would.[57] This leads to more powerful and rapid flooding. As the Government Accountability Office has noted, "[t]hat levees increase flood levels is subject to little disagreement."[58]

  This can be seen quite clearly on the Mississippi and Missouri rivers where construction of levees and other intrusions into the floodplain have increased the magnitude and frequency of flooding "dramatically during the past century."[59] Levees along the Lower Missouri River have increased flood heights at St. Louis by up to 13 feet.[60] Levees along the Mississippi River have also raised flood heights.

"Computer simulations of the 1993 flood estimated that the nearby Corps levees added up to 2.7 feet to the flood crest at St. Louis and up to 7.3 feet to the flood crest at other locations."[61] In 1973 the Mississippi experienced a record flood even though 36 percent less water was flowing in the river than during the previous record flood event.[62] The difference between the two floods was attributed directly to the construction of Mississippi River levees.[63] River gage data clearly shows that the Mississippi floods of 1973, 1982, and 1993 were higher than they would have been in 1927, before many flood control structures had been constructed.[64]

- *Lure People Into Harm's Way.* Structural flood protection provides a false sense of security about living in the floodplain, luring people into high-risk areas. When rivers rise, as they inevitably will, those within the floodplain can quickly become victims. While flood control structures have been credited with saving hundreds of billions in flood damages, it is equally clear that most of the "protected" infrastructure would not have been located in the floodplain in the first instance without the historic reliance on levees for protection.[65] One just needs to look at the history of development in the Mississippi River Valley or the development of the eastern Orleans Parish neighborhoods of New Orleans (discussed above) to see how this phenomenon plays out.[66]

  The trend of building in the shadow of structural projects in the mistaken belief that they will stop flooding shows no sign of letting up. Indeed, the "levee effect" – investing in property after structural flood control "improvements" are constructed – has been documented in the Midwest with statistical significance. In Chesterfield, Missouri, a suburb of western St. Louis, the average amount of annual new construction increased from 3.6 to 9.5 after the Monarch-Chesterfield Levee was reinforced in 1983. The town of Hannibal, Missouri saw a significant increase in home renovations – from an average of 0.46 to 3.7 – upon the completion of a floodwall in 1993.[67] New development can in turn create future flooding problems by covering the land with impervious surfaces that push water quickly into rivers and streams rather than allowing the water to be absorbed slowly into wetlands and ground water.[68]

- *Destroy Systems That Provide Natural Flood Protection.* Engineered structures contribute to flooding by destroying natural wetland and floodplain systems that should be a community's first line of defense against high water and storm surge. Levees separate the river channel from its floodplain, starving wetlands of water and the entire river basin of soil and nutrients. Dams, dikes, reservoirs, and detention basins block the flow of sediment and bed material that are necessary to sustain downstream wetlands. Levees, floodwalls, and concrete-lined riverbeds shoot sediments into open water before they can settle at the river's mouth.

  Levees along the Mississippi River have cut off more than 90 percent of the floodplain from the river, and eliminated 80 percent of the watershed's flood storage capacity.[69] The river's twenty-nine locks and dams also interfere with the Mississippi River's natural process of carrying sediments downstream to rebuild coastal wetlands.[70]

- *Damage The Health Of Rivers And The Wildlife That Depend On Them.* Floods are natural events that are vital to sustaining the health of rivers, and are the major force controlling life in river systems. Floods carry nutrients downstream, depositing them along floodplains. In addition to creating fertile soil for farming, sediments transported by floods also form islands and backchannels that are home to fish, birds, and other wildlife. By scouring out river channels and riparian areas, floods prevent rivers from becoming choked and overgrown with vegetation. Floods check and balance aquatic and floodplain populations and flush out invasive species. Fish that travel upstream to

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spawn, like salmon and sturgeon, are adapted to receive reproductive cues from high water and cooler temperatures.[71]

Flood control structures have severe impacts on the downstream hydrologic cycle and ecosystem. Indeed, this is precisely what they are designed to do. For example, during dry spells, dams and reservoirs change what should be moving water systems to still water systems. In preparation for high water events, dam and reservoir managers often discharge water downstream, disrupting habitat and changing the water temperature. Such discharges can also send false cues for fish populations to spawn and migrate, and resulting temperature changes can favor some species over others.[72]

While flood protection structures and complex engineering approaches will continue to have a place in protecting communities, Katrina has shown us all too vividly that they must be the last line of the defense against floods, not the only one.

Towards Sustainable Flood Protection

The nation is at a crossroads. We can continue to betray our fellow citizens by letting them rely exclusively on concrete walls and other suspect structures with a long history of failure, or we can choose to safeguard our communities by using the gifts of nature to provide simple, reliable, and cost-effective flood protection.

The eight case studies in this report show that natural flood protection works. They tell the story of communities that have chosen to protect themselves by protecting and restoring nature's own capacity to reduce the size and power of floods, and by simply moving out of harm's way. These communities have reduced or eliminated flood disasters while preserving the environment for present and future generations. They are now safer, healthier, and more livable. These efforts are summarized as follows.

Charles River, Massachusetts – Unbridled suburban growth paved over much of the Charles River watershed in eastern Massachusetts, triggering flooding from stormwater runoff in Boston and other downstream communities. The Corps partnered with local stakeholders to pursue a floodplain management plan that protects and restores critical wetlands, averting major flooding, increasing property values, and providing an array of recreational opportunities.

St. Johns River, Florida – Florida has a long history of flooding caused by hurricanes, tropical storms, and heavy rainfall. When large-scale structural approaches proved too destructive, the State turned to a project that centered on large-scale floodplain restoration along with smaller structural elements, providing enhanced wetlands habitat, improved water quality, and recreational opportunities.

Tulsa, Oklahoma – Once known as the "Flood Capital of the World," Tulsa has removed more than 900 buildings from the Mingo Creek floodplain, restoring open space where floodwater can safely overflow. Tulsa's flood damages have dropped dramatically and the city now receives the highest flood insurance discounts available in the nation.

Grand Forks, North Dakota and East Grand Forks, Minnesota – The communities of Grand Forks and East Grand Forks have suffered through 12 major flood since 1871. After the 1997 flood, the communities worked with the Corps to develop a flood protection strategy featuring a space to give the river room to expand. The aptly named Greenway has produced considerable flood insurance savings and provides open space for year-round recreation.

Napa, California – The town of Napa twice rejected old-style Corps' plans for levees-only flood protection. A broad coalition then developed a "living river" plan that is reconnecting portions of the Napa River to its floodplain and, though only 40 percent complete, is already reducing flood damages.

Healthy rivers and floodplains provide simple, reliable, cost-effective flood protection.

Missouri Community Buyout Program – After years of repetitive flood damage to buildings and cropland, Missouri state officials decided to pursue a new and more practical solution to flooding. They established the Missouri Community Buyout Program to move homes out of harm's way and create open space where rivers can safely overflow. The state witnessed the program's dramatic success a mere two years later during the 1995 flood.

Grafton, Illinois – The 1995 Mississippi River flood left Grafton, Illinois relatively unscathed. That's because in 1993, after experiencing extreme flooding almost biannually for more than 150 years, community leaders moved 70 homes and 18 commercial properties out of the floodplain to higher ground. The restored floodplain provides more room for the Mississippi and Illinois Rivers to spread out, reducing flood levels and damages, and providing recreational opportunities during dry periods.

Louisa Levee District 8, Iowa – In 1993, when an oxbow levee breached for the 17th time since its construction, farmers in the Louisa Levee District volunteered for a federal buyout program. The land was converted into the Horseshoe Bend Wildlife Refuge, a combination of grassland, meadows, and wetlands, which provides natural flood protection and serves as a stopover for migrating waterfowl.

Each of these examples provides a vision of a safer, healthier, and more vibrant future for communities plagued by flooding. We can – and must – change the nation's approach to flood protection. Until we do, lives, homes, businesses, and entire communities will continue to be at risk from unnatural flood disasters.

Virginia Department of Conservation and Recreation

Virginia Department of Conservation and Recreation

American Rivers Photo Library

King County Department of Natural Resources

Charles River, Massachusetts

The Charles River snakes through 25 towns and cities in eastern Massachusetts before emptying into Boston Harbor. The river's 308 square mile watershed is the most densely populated watershed in New England. It is home to nearly one-sixth of the state's population – 900,000 people living in 35 thriving municipalities that include Boston, Cambridge, and Charlestown. Twenty-seven of these towns lie entirely within the drainage area of the Charles.[1]

The slow-moving Charles and its roughly 80 tributaries have a long history of intensive use by the region's inhabitants. They provided ideal navigation routes for Native Americans and were used extensively by European settlers who, for example, built 43 mills along just one 9.5 mile stretch of stream. Twenty dams continue to interrupt the river's natural flow, cause localized flooding, and prevent anadromous fish from swimming upriver to spawn. Concerted clean up efforts since passage of the Clean Water Act in 1972 have produced major improvements in the water quality of this notoriously polluted river. The river is home to 20 species of fish, including two species of herring that migrate from the sea to spawn each spring.

The Charles attracts hundreds of thousands of sightseers and thousands of boating enthusiasts each year. Each April, more than 1,500 racers and thousands of spectators participate in the annual Run of the Charles Canoe and Kayak Race, the largest in the Northeast. The Charles River Basin, created in the early 1900s by the construction of a dam at the mouth of the river, is one of the nation's most popular urban river recreation areas, drawing hundreds of thousands of visitors each year.[2]

A Long History of Flooding

Stormwater runoff has been a persistent problem in the Boston metropolitan area, and flooding became a regular problem in the 1950s and 1960s after unchecked suburban growth encroached on the floodplain and paved over many of the area's wetlands.[3] Despite billions of dollars invested in storm sewer improvements in the 1980s, the region continues to struggle with both flooding and pollution from stormwater runoff.

The area also sees serious flooding from occasional hurricanes that make their way to New England. For example, in 1955, Hurricane Diane unleashed up to 19 inches of rain on Massachusetts and other New England states just one week after an earlier hurricane had drenched the Mid-Atlantic coast. Diane claimed at least 180 lives and inflicted $800 million – $5 billion in 2006 dollars – in damages.[4]

A New Approach To Flood Protection

In response to calls from local and state leaders for more flood protection, in the late 1960s the Corps of Engineers (Corps) was poised to build a $100 million levee and dam project along the middle portion of the Charles River.[5] But the Corps chose another path when a study it conducted in 1972 showed that upstream wetlands were playing a critical role in reducing flooding in the middle and upper reaches of the Charles. Those wetlands were storing millions of gallons of water in addition to reducing erosion, providing recreational opportunities, and providing vital wildlife habitat. The Corps study concluded that the loss of the wetlands would cost the region $17 million annually in flood damage.[6]

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The Corps wrote:

> "Nature has already provided the least-cost solution to future flooding in the form of extensive [riverine] wetlands which moderate extreme highs and lows in streamflow. Rather than attempt to improve on this natural protection mechanism, it is both prudent and economical to leave the hydrologic regime established over millennia undisturbed. In the opinion of the [Army Corps] study team, construction can add nothing."[7]

Instead of pursuing the new structural project, the Corps partnered with local stakeholders, like the Charles River Watershed Association, and other agencies to preserve over 8,000 acres in 17 existing wetlands in the watershed.[8] This approach was sanctioned by Congress in 1974 when it authorized the Charles River Natural Valley Storage Area.

By 1983, the Corps had purchased more than 3,000 acres of land and acquired easements on almost 5,000 acres of floodplain wetlands in the upper Charles River watershed. [9] At the same time, municipalities in the watershed began to regulate wetland use to reduce development in the floodplain.[10] Zoning ordinances were adopted by 75 percent of the local governments in the watershed to restrict building in 43 percent of the storage area. The remaining 57 percent of the storage area is permanently protected.[11]

Land and easement acquisitions for the Natural Valley Storage project totaled less than $10 million, a fraction of the $100 million price tag for structural control methods formerly proposed by the Corps.[12]

Natural Flood Protection Works

The Charles River Natural Valley Storage Area is working to protect people, homes, and businesses. Wetlands throughout the basin have the capacity to store 50,000 acre-feet of water – enough to fill more than 24,600 Olympic-size swimming pools with water.[13]

Those wetlands helped reduce major floods in 1979 and 1982.[14] In 1987, the Corps estimated that the storage area prevented an additional $3.2 million in damages when it helped avert another major flood.[15] When extensive rains hit the Boston area in 2006, the Natural Valley Storage Area again proved its value. The Charles River saw only a 2-year flood event, while the Merrimack and Ipswich rivers north of Boston reached 40 and 100-year flood levels, respectively.[16]

The Natural Valley Storage Area also provides a host of other benefits to communities in the Boston Metropolitan area. The storage area attracts tens of thousands of visitors who enjoy fishing, canoeing, bird watching, picnicking, cross-country skiing, and hiking every year. According to the Corps, two-thirds of the revenues generated by tourism go back to the local economy.[17]

A survey of appraisers and realtors also shows that protecting the storage area wetlands provides direct benefits to local residents through increased property values. A statistical analysis verified that homes adjacent to the protected wetlands were worth 1.5 percent more than other homes in the region.[18]

Land and easement acquisitions for the Charles River Natural Valley Storage project totaled one tenth of the $100 million price tag for structural control methods.

Upper St. Johns River, Florida

The St. Johns is the longest river in Florida, flowing 310 miles through the state's east-central plains as it winds its way north to Jacksonville and the Atlantic Ocean from its headwaters in Indian River County. While the river's drainage basin historically encompassed over 400,000 acres of floodplain wetlands, more than 62 percent of those wetlands had been lost by the 1970s.[19]

As in much of Florida, the river's floodplain wetlands were ditched, dammed, and drained through the first half of the twentieth century to graze cattle and grow citrus, sugarcane, indigo, and row crops. Thousands of additional acres of marsh were destroyed when the river's headwaters were channelized. The wetlands that remained were further degraded by drainage canals, private levee systems, and agricultural runoff.[20]

A significant portion of the region's natural flood protection was lost with the wetlands. Water quality plunged, too much freshwater was sent to the Indian River Lagoon, and fish and wildlife populations plummeted. Despite these assaults, the upper St. Johns floodplain continues to support an estimated 60,000 wading birds;18 federally or state-protected species, including bald eagles; and a host of other species including large-mouth bass, blue herons, and alligators.[21]

A Long History of Flooding

Florida has a long history of flooding from hurricanes, tropical storms, and heavy rains. The infamous 1926 Miami Hurricane generated enough force in Lake Okeechobee to breach the dike wall, flooding the town of Moore Haven and claiming 386 lives.[22] Two years later, the Okeechobee Hurricane caused the dike around Lake Okeechobee to fail again, killing 2,700 people. The region suffered $75 million in damages (about $1.5 billion in 2005 dollars).[23]

In the past 50 years the state has had 29 federal disaster declarations due to hurricanes and tropical storms, with heavy rains causing an additional 17 flood-related disasters.[24] During the last 30 years, Florida has had the dubious distinction of receiving the second highest total flood insurance payments in the nation – more than $3.3 billion in all.[25] In 1998, the state also recorded the sixth highest number of properties suffering repeated flood losses.[26]

A New Approach To Flood Protection

In 1966, the Corps of Engineers (Corps) began constructing an enormous structural flood protection project that was supposed to protect east-central Florida. In the lower St. Johns basin, a series of reservoirs would store floodwater; in the upper basin, a network of canals would divert 6,000 cubic feet – almost 45,000 gallons – of floodwater per second into the Indian River Lagoon. By 1969, the largest of these canals, the C-54 canal, was open and other components of the project were almost complete.

But passage of the National Environmental Policy Act (NEPA) in 1969 helped shed light on the project's extensive adverse ecological impacts. When the comprehensive environmental impact study required by NEPA was completed in 1974, the State of Florida withdrew its support for the Corps' project. The study showed that stormwater being flushed into the Indian River Lagoon through the drainage canals was disturbing the lagoon's delicate salinity balance. Excess nutrient-laden agricultural runoff was also degrading habitat, diminishing water quality, and jeopardizing the State's shellfish industry and public water supply.

While the Corps' project was abandoned, public calls for improved flood protection were not. In 1974, the newly organized St. Johns River Water Management District assembled a technical advisory team to develop a plan that would avoid the environmental problems that stopped the Corps' 1966 project. The advisory team, which included local stakeholders and state and federal agencies

The restored Upper St. Johns River floodplain will hold enough to cover 86 square miles with 10 feet of water. When complete, the project will have restored one of the largest contiguous freshwater marshes in the state.

including the Corps, developed a basic concept plan that grew into the Upper St. Johns River Basin project authorized by Congress in 1986.[27] The $200 million project combines large scale floodplain restoration with structural flood prevention measures.[28]

The backbone of the project is the restoration of 200,000 acres of floodplain covering parts of three counties.[29] The restored floodplain will hold more than 500,000 acre-feet of water – enough to cover 86 square miles with 10 feet of water. The restored floodplain will accommodate surface water runoff from a more than 2,000 square mile area.[30]

Restoration efforts include plugging drainage canals (the direct connection from the C-54 Canal to Indian River Lagoon has already been severed) and setting levees back farther from the river to reconnect the river to its floodplain. The project also calls for restoring wetlands on 40,000 acres of retired agricultural land, and enhancing 70,000 additional wetland acres. When complete, the project will have restored one of the largest contiguous freshwater marshes in the state.[31]

Natural Flood Protection Works

When it is completed in 2007, the project will provide important flood protection for east-central Florida as far south as Lake Poinsett – 50 miles southeast of Orlando.[32] The Corps predicts that the project will reduce flood damages by about $215 million during a 100-year flood event, and provide average annual benefits of $14 million.[33]

The project will also reduce freshwater discharges to the Indian River Lagoon by 70 percent, restore some of the region's natural hydrologic regime, restore and enhance wetland habitat, restore native plant species, improve water quality, and create recreational opportunities.[34] These benefits are already evident. For example, in 1990 and 1991, the endangered snail kite returned to its historic nesting areas in the upper St. Johns basin and an estimated 25 percent of the entire state-wide population was utilizing the project area.[35]

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Tulsa, Oklahoma

The city of Tulsa is located on the banks of the Arkansas River and among several of its local tributaries, including Mingo Creek. The region's first permanent settlers were Lockapoka Creek Native Americans, who had been driven from their native Alabama, and cattle ranchers. The pressure of westward expansion, the arrival of the railroad, and discovery of oil contributed to the city's burgeoning growth since the town's incorporation in 1898. Oil continued to dominate the city's economy until the oil industry bust of the mid 1980s, when the city took steps to diversify its economy.[36]

Rising from its headwaters near Leadville, Colorado, the Arkansas River flows for 1,450 miles through Kansas, Oklahoma, and Arkansas before emptying into the Mississippi River 600 miles north of New Orleans. Mingo Creek, a low-lying tributary of the Arkansas, drains 61 square miles of east Tulsa as it feeds into Bird Creek, another Arkansas River tributary. Most of the Mingo Creek watershed was rapidly developed after it was annexed by Tulsa in 1966 in response to a 25 percent increase in the city's population. Ninety percent of the creek's watershed lies within the city limits.[37]

A Long History of Flooding

Until the mid-1980s, Tulsa was the most flooded city in America and had earned the dubious distinction of being called the "Flood Capitol of the World." [38] Tulsa led the nation in federally declared flood disasters with 9 declared disasters in just 15 years.[39] Not surprisingly, the city also had the highest flood insurance rates in the nation.[40]

Severe flooding from the Arkansas River affected Tulsa as early as 1908, washing out the railroad and producing today's equivalent of $13 million in damages.[41] A 1923 flood left 4,000 people homeless and caused the equivalent of $12 million in damages. Levees and the upstream Keystone dam did not put an end to the flooding from the Arkansas River. In 1986, the reservoir behind the Keystone dam filled to capacity and the resulting water releases caused major flooding downstream. When a private Tulsa levee failed, the flooding caused $1.3 million in damages to 64 buildings.

As Tulsa grew, it fanned out across low lying areas among the city's network of tributary streams, many of which flooded on a regular basis. This tributary flooding is the result of over-development combined with periodic torrential rainfall events. Large storms have dumped as much as 15 inches of rain on Tulsa in just a few hours – almost half of the city's 36 inches of rain a year.[42]

During the 1960s and 1970s, the city flooded every two to four years with most of the flooding in the Mingo Creek watershed.[43] Three separate floods in 1974 caused more than $40 million in damages.[44] On Memorial Day in 1976, ten inches of rain poured onto the city in just three hours. The resulting flood killed three people and caused more than $75 million in damages to over 3,000 structures.[45]

The city's most devastating flood hit on Memorial Day in 1984. Fifteen inches of rain fell in just four hours, spawning a flood that ravaged the city. Fourteen people were killed, 288 were injured, and more than 6,800 buildings were damaged or destroyed. The Mingo Creek watershed suffered $125 million in damages with total damages soaring to $180 million.[46]

A New Approach To Flood Protection

Local citizens began pushing for more sustainable floodplain management in the early 1970s, and the movement gained strength after the floods of 1974. By 1977, the city had passed its first floodplain ordinance and had taken steps towards moving people out of harm's way. The city purchased 33 homes in some of the highest risk flood areas at a

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cost of less than $1 million. In 1979, the city agreed to purchase 30 more homes in the Mingo Creek floodplain at a cost of $1.8 million.[47]

But it was the 1984 flood that forced the city to undertake a major effort to move people out of harm's way. Immediately after the flood, newly elected city officials convened the city's first Flood Hazard Mitigation Team – a team of civil engineers, landscape architects, and urban planners led by three private consultants. The team was tasked with developing a flood protection strategy that would address the community's stormwater problems *and* meet its environmental, aesthetic, and recreational needs. Within days, a new approach to Tulsa's flood protection was being developed.

The city ultimately adopted the team's recommendations, agreeing to take the following actions.

Voluntary Buyouts of Flooded Homes. The city would buy 300 homes located in the areas most at risk from flooding so the homeowners could permanently move out of harm's way.[48] All buyouts would be voluntary, and homeowners would receive pre-flood fair market prices for their land based on appraisals ordered by both the city and the landowner. Because so many residents were interested in the buyout program, a Hardship Committee was organized to hear appeals from interested homeowners who were excluded from the buyout plan.[49]

The buyouts were paid for through a variety of sources. The city used the interest from the sale of revenue bonds to finance half of the acquisition project and negotiated with the Federal Emergency Management Agency (FEMA) to pay for the other half. Flood victims could also use federal funds for temporary housing assistance and involuntary relocation loans through the Small Business Administration (SBA). Total costs for the buyout came to just over $17.5 million, with a net cost to the city of $11.5 million.[50]

Rebuilding Restrictions. As recommended by FEMA and SBA, building permits would be required for any structure that suffered more than 18 inches of flooding or that had repair costs of more than $5,000. SBA loans could be used toward relocation if a structure was in an area where the city prohibited repair.[51]

Before the 1984 flood, the city had facilitated rebuilding immediately after flood events by waiving building permits and fees for flood victims. Recognizing the problems with encouraging people to rebuild in harm's way, the city issued a series of rebuilding moratoria immediately after the flood to give decision makers the time to determine whether they should change this policy. The first moratorium required a case-by-case review for mobile home hookups. This was quickly followed by a moratorium on repair permits in all high-hazard areas pending completion of the city's new mitigation plan, with some flexibility for case-by-case decisions.[52]

Community Outreach. The city established a hotline to answer questions, and distributed mailings and newsletters to citizens in the acquisition areas.[53]

Because of the success of the buyout program, additional buyouts were approved by the city after flooding in 1986. Tulsa voters approved a sales tax to fund even more floodplain acquisitions in 1991. Over the past 20 years, Tulsa has moved more than 900 buildings out of its floodplains.[54]

The city has further embraced floodplain management strategies and has permanently adopted policies to prevent future development in harm's way. These include watershed-wide building regulations, requirements to preserve floodplain valley storage, and a stringent permitting process for activities on property in the city. In 1986, the city took the additional critical step of creating a comprehensive stormwater management program within the city's Public Works Department. The program is funded by a stormwater utility fee of $3 to 4 per month. The $10 million a year raised by this fee is used exclusively for floodplain and stormwater management activities.[55]

The Corps of Engineers also proposed a structural flood protection project for Tulsa. In 1986, Congress authorized the channelization of 9 miles of Mingo Creek and the construction of 23 upstream detention basins at a cost of $143 million. The structural project was completed in 2001 and provides 65-year flood protection for the city.[56]

Until the mid-1980s, Tulsa led the nation in federally declared flood disasters with 9 declared disasters in just 15 years.

Natural Flood Protection Works

The removal of 900 structures from Tulsa's floodplains allows the floodplains to do exactly what they are supposed to – act as natural overflow and storage areas. Together, reconnecting Tulsa's creeks to their floodplains, a strong regulatory program, and flood prevention structures provide Tulsa with more than 100-year flood protection.[57]

Tulsa's flood damages have dropped dramatically. For example, a Mother's Day storm in 1993 caused only minor damage even though it was comparable to a 1970 Mother's Day storm that caused major flooding.[58] Heavy rains in May 2000 also did not cause any flooding problems.[59] Moreover, no structures built in compliance with the city's 1977 floodplain management regulations have been damaged by floods.[60]

The decline in repetitive loss properties – households that have received insurance payments for two or more flood loss claims exceeding $1,000 in a ten-year period – attests to the success of Tulsa's program. In 1984, Tulsa had 93 repetitive loss properties that flooded. That number decreased to 32 in 1986 and dropped to just 5 in 1995.[61]

Tulsa residents have also seen their flood insurance rates plummet by 25 percent.[62] Tulsa's ongoing efforts have earned it the highest flood insurance discounts available, a far cry from the time when Tulsa had the highest flood insurance rates in the country.[63]

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Grand Forks, North Dakota and East Grand Forks, Minnesota

The cities of Grand Forks and East Grand Forks bridge the Red River of the North approximately 90 miles south of the Canadian border. First settled by traders and trappers, Grand Forks and East Grand Forks developed around the river as the cities became regional trade centers. Today, the region's economy continues to depend on a healthy river, though furs have given way to agricultural produce as the primary export.[64]

The Red River drains almost 40,000 square miles in the United States as it runs 550 miles to Lake Winnipeg in Canada.[65] Forming the boundary between North Dakota and Minnesota, the river flows through some of the flattest stretches of land in North America. As recently as 100 years ago, channel catfish, smallmouth bass, northern pike, and lake sturgeon flourished in the river. While the Red River still supports many fisheries, hundreds of dams and other obstructions have virtually eliminated the sturgeon population and harmed other anadromous fish.[66]

A Long History of Flooding

The Red River is prone to annual flooding and to major flood events as a result of the region's flat topography and 41 inches of average annual snowfall that pour into the river during the spring thaw. Flooding is exacerbated by the regular creation and rupturing of ice dams along the river.[67] Twelve major floods have hit Grand Forks since it was founded in 1870.[68]

The flood of 1997 was particularly horrific. Following a wet fall and a series of winter blizzards that deposited 2 to 3 times the normal amount of snowfall on the region, the Red River reached flood stage in early April. When the river finally crested a few weeks later, it was 52 to 54 feet high at Grand Forks and East Grand Forks – almost twice as high as the river's 28-foot flood stage and almost 2 feet higher than the previous record set in 1897. The Red River remained at record flood stages for the next ten days. At the flood's peak, more than 1 million gallons of water hurtled past the cities each second. Normally just 110 yards wide, the flooded river swelled to 22 miles wide in some places.[68]

Ninety-nine percent of East Grand Forks and 75 percent of Grand Forks were flooded.[70] Most of the cities' 60,000 inhabitants were forced to evacuate, and the immediate vicinity suffered billions in damages.[71] More than 11,000 structures were damaged, and 13,000 head of livestock were killed by the flood.[72]

A New Approach To Flood Protection

After the 1997 flood, the cities turned to a new approach to flood prevention. Just four months after the flood, Grand Forks began relocating 1,100 of the most affected homes and businesses out of low-lying neighborhoods using $171 million in HUD Community Development Block Grants.[73] In one of these neighborhoods, water had reached the rooftops of 300 homes.[74]

The Corps of Engineers (Corps) also began planning a new flood protection project for the two cities. In November 1998, they released a proposal for new levees along the Red River. Wishing to keep the levee heights low, the cities helped establish criteria for the Corps' levee proposal. Because soils near the river were weak, the levees would be set back from the river. This would help reconnect the river to its floodplain and would help reduce flood levels by effectively widening the channel. The constructed levees are at least 300 feet from the river and range from 10 to 12 feet in height.[75]

The Corps' plan also included a recreational area along both sides of the river. But it was the cities of Grand Forks and East Grand Forks that developed that area into a 2,200 acre Greenway. With the help of private consultants who worked closely with the public and local, state, and federal stakeholders, the Greenway plan grew to include campgrounds, golf courses, hiking trails, and fishing holes that would provide key recreational opportunities for the two communities. When complete, 20 miles of trails will encircle the Greenway.

After the plan was implemented, the cities easily withstood the sixth-highest flood on record in the spring of 2006.

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A Greenway Alliance was formed to shore up political support for the Greenway and to help move it forward. Alliance members included representatives from local government, state and federal agencies, the business community, and stakeholder groups. Throughout the design process, citizen groups and grassroots activists, such as East Grand Forks' Citizen Action Recovery Team, also generated important momentum for the project. Collaboration on the Greenway successfully overcame a number of initial challenges, including different funding capabilities between North Dakota and Minnesota, competing political interests, and concerns over future management. Because of the early involvement of local stakeholders, the project has long enjoyed support from the entire community.[76]

Specifications for the plan were finalized in 2000. The 2,200 acre Greenway and structural features of the flood control plan will provide the two cities with 210-year flood protection at an estimated cost of $416 million. Currently in its last phases of construction, the project was 85 percent complete in the spring of 2006 and should be completely finished by the end of 2006.[77]

Natural Flood Protection Works

Grand Forks and East Grand Forks experienced another flood in the spring of 2006. Although estimated at a 30-year event, the flood peaked at almost 48 feet and was the sixth highest flood on record.[78] However, the two cities easily withstood the flood because their plan had given the floodplain back to the river and reduced pressure on the set back levees.[79]

The Greenway has also already bolstered tourism in the two communities by providing open space in the downtown area for year-round riverside outdoor recreation. In 2005, Grand Forks predicted direct profits of $630,000 and indirect earnings of $16 million from Greenway-related events. Across the river, East Grand Forks projected that 2005 tourism in the Greenway would increase sales tax revenues by almost 30 percent to over $60 million.[80]

Napa, California

The town of Napa is located along the Napa River, in the heart of northern California's world-renowned wine country. Since its first building was constructed in 1848, Napa has become home to some 75,000 residents spread out over 20 square miles.[81] The city center sits on a peninsula formed by a meander in the Napa River, just above its intersection with Napa Creek.

The Napa River flows 50 miles from its headwaters at Mt. St. Helena south to San Pablo Bay. Much of the river's 426 square mile watershed is intensely farmed or urbanized, and the river's once dense river side forests have been all but destroyed. Water diversions, agricultural runoff, and excess sedimentation plague the river, and previously plentiful populations of federally endangered Chinook salmon and threatened Steelhead trout have been reduced to only a few hundred returning each year. Despite these problems, the river still supports an active recreational fishery with such species as bluegill, black bass, and striped bass.[82]

A Long History Of Flooding

Located where the Napa River flattens out into the San Pablo estuary, the town of Napa is highly susceptible to flooding. The degradation of the Napa River has only added to the problem. Since 1862, Napa has flooded at least 28 times.[83] The most disastrous flood occurred in February 1986, when three people died, 3,000 homes were damaged or destroyed, and 5,000 people were forced to evacuate.[84] Between 1961 and 1997, property damage from flooding in Napa county reached $542 million.[85]

Napa has flooded more than 28 times since 1862.

Napa County Flood and Water Conservation District

A New Approach To Flood Protection

In 1995, the citizens of Napa demanded a new approach to flood protection after having twice rejected old-style structural plans proposed by the Corps of Engineers (Corps). In 1975, the Corps had proposed a plan to channelize the Napa and constrain it within levees.[86] Voters rejected this destructive, structural plan in two separate referendums, and the project was put on hold.[87]

The project was reactivated in 1988, in response to the devastating flood that hit Napa in 1986. Seven years later, the Corps presented the public with a so-called "new" plan for the Napa River. Released in April 1995, this plan followed the same flawed approach rejected by the voters almost 20 years earlier. As the Napa Flood and Water Conservation District wrote:

> "The plan's traditional approach – enlarging the River channel and constraining the river within that channel – was met with an underwhelming response in Napa. The proposal was seen to be 'environmentally insensitive' at best, and did not inspire aesthetically. Lacking local support, the new plan appeared to be dead on arrival."[88]

Rather than give up on a project altogether, the community came together in a precedent setting coalition of citizens, environmental organizations, and business groups ranging from the Friends of the Napa River and the Sierra Club to the local Farm Bureau and the Chamber of Commerce.[89] The community also hired consultants and worked closely with the Corps and other federal and state agencies.[90] After much deliberation spread out over a year and a half, the coalition reached consensus on a "living river" design for the Napa River.[91]

Rather than attempting to control the river, the Napa living river project works with the river's natural processes. It maintains the river's natural channel and reconnects portions of the river to its historic floodplain. Terracing the riverbank in some locations gives the river more room to spread out during high water events. A large area of pastureland at the downstream end of the project has been purchased and restored to wetland, and in all more than 650 acres of high value tidal wetlands will be restored. The project creates a unique dry bypass area so that the river can follow its traditional high water path without flooding homes and businesses. Bridges that blocked the flow of high water will be raised or removed, contaminated sites cleaned up, and riverside trails and promenades constructed. The living river plan also requires close monitoring of the project's impacts on fish populations.[92]

The project design was so popular that that the county's voters agreed to a half-cent sales tax increase to fund the local cost share for the project. The remaining costs are paid through monies appropriated by Congress to the Corps. Additional funding has come from Federal Emergency Management Agency grants, the Coastal Conservancy, and the state of California.[93]

The community remains an active participant in the continued planning and implementation of the project, and has established both a Technical Advisory Panel and a Financial Oversight Committee.[94] The project is scheduled for completion in 2011.

Natural Flood Protection Works

When complete, the project will protect 2,700 homes, 350 businesses, and more than 50 public properties from a 100-year flood. Savings from flood damages are estimated to reach $26 million annually.[95] In addition to protecting town residents, the project will improve fish and wildlife habitat and the health of the San Pablo Bay.[96]

Though the project is only 40 percent complete, key floodplain restoration projects have been finished and are already producing results. The Napa Flood and Water Conservation District reports that the partially completed project helped reduce the damages from a 25 to 50-year flood that battered Napa on New Year's Eve 2005.[97]

In addition, within one year of the plan's adoption, flood insurance rates in the county dropped 20 percent and real estate prices rose 20 percent. These benefits have been attributed directly to the natural flood protection to be afforded by the project.[98]

Napa residents rejected two structural flood control plans in favor of a 'Living River' plan that meets their flood control, recreational, and aesthetic needs.

The Missouri Community Buyout Program

Two of the nation's mightiest rivers – the Mississippi and the Missouri – flow through and along the borders of the state of Missouri.

The Missouri River flows more than 2,300 miles from its headwaters in the Rocky Mountains of southwestern Montana through North Dakota, South Dakota, Nebraska, Iowa, Kansas and finally, Missouri, where it feeds into the Mississippi River north of St. Louis. The river's 500,000 square mile basin drains one-sixth of North America.[99] The Missouri River watershed gained considerable fame when Meriwether Lewis and William Clark made their historic journey to the Pacific Ocean. Before completion of the transcontinental railroad in 1869, the Missouri served as the primary artery through the plains. In more recent times, the Missouri has been dammed for flood control, irrigation, hydroelectric power, water supply, and navigation. Only one significant stretch of the Missouri, the Missouri National Recreational River, is still free-flowing. Bordering Nebraska and South Dakota, this reach is a designated Wild and Scenic River.

The Mississippi River stretches 2,350 miles from its headwaters in Minnesota's Lake Itasca to the Gulf of Mexico. The river and its tributaries drain more than 1.2 million square miles in all or part of 31 states – the third largest drainage basin in the world. The Mississippi River is also one of the world's most diverse ecological systems. More than 400 different species of wildlife call the river home, including 326 species of birds and 40 percent of North America's migratory birds, 260 species of fish, 37 species of freshwater mussels, 45 amphibian and reptile species, and 50 mammal species.[100]

A Long History of Flooding

Before 1993, the state of Missouri attempted to control floods through construction of levees and other flood control structures. More than 740 flood control levees were built throughout the state between the Great Mississippi Flood of 1927 and the Great Midwest Flood of 1993, but the state still saw extensive flood damages.[101]

In the two decades before the 1993 Midwest Flood, 13 federal flood disaster declarations were issued for the state of Missouri. In the 15 years before the 1993 flood, more than 3,200 buildings in Missouri suffered repeated flood losses, with some owners filing as many as 23 claims for the same property.[102]

The Great Midwest Flood of 1993 was one of the worst floods on record, affecting both the Missouri and the Mississippi Rivers. The flood was caused by unusually heavy rains that soaked the region; rainfall across many areas of the central-northern plains was 200 to 350 percent above normal. Large portions of the Missouri and Mississippi exceeded the 100-year flood stage, and flooding at some locations exceeded the 500-year flood level. More than 1,000 levees were overtopped and 75 communities were completely inundated as high water moved downstream. Some communities were under water for 100 to 200 days. Across the Midwest the flood killed up to 50 people and inflicted $12 to $16 billion in damages. More than 530 counties in nine states were declared federal disaster areas.[103]

In Missouri, 37,000 residents had to evacuate the floodplain, 12,000 homes were destroyed or damaged, and more than 3.1 million acres of cropland – 34 percent of Missouri's agricultural land – was under water. The state's damages reached $3 billion, with cropland accounting for $1.8 billion of those losses.[104]

A New Approach to Flood Protection

The 1993 flood forced the state to change its approach to flood protection. Recognizing that communities would remain at risk as long as people continued to build in the floodplain, the state of Missouri developed the Missouri Community Buy-

FEMA

out Program to move people out of the floodplain. The program purchased at-risk property from homeowners at a pre-flood market price and turned the land into open space, where the river could safely overflow during high-water events.

Managed by the Missouri State Emergency Management Agency, the buyout program established the following criteria for buying flooded properties. First, properties would be purchased only from willing sellers. Second, the local community would be responsible for identifying primary residences that were damaged and approach owners with the buyout offer. Third, once the land was purchased, the community had the right to decide whether the acquired land would be set aside as recreational parkland or returned to natural wetlands. Fourth, volunteers for the buyout program would be required to relocate outside of the floodplain.[105]

The program took advantage of a relatively unused provision of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974 (Stafford Act) that authorized funding for buyouts. Additional funding came from the Department of Housing and Urban Developments Community Development Block Grants and the Federal Emergency Management Agency's Hazard Mitigation Grant Program (HMGP).

In 1993 alone, Missouri purchased 4,044 properties, almost two-thirds of the flood-prone homes, at a cost of $56.8 million – less than two percent of the damage caused by that year's flood season.[106] In the decade after the flood, FEMA provided an additional $54.9 million in HMGP funds to continue the buyout program.[107]

A comparison of the damages from the 1993 and 1995 floods demonstrates the benefits of moving out of harm's way.

State taxpayers will save more than $200 million in future flood disaster claims due to the buyout program.

Natural Flood Protection Works

The Missouri River Buyout program has been tremendously successful at significantly reducing flood damages. The value of this program was put to the test in 1995, when another flood inundated many of the same areas that had flooded just two years before, with flood heights in some places exceeding those of 1993.

A comparison of the damages from the two floods demonstrates that removing people from harm's way and giving the floodplain back to the river is an economically viable, socially practical, and environmentally sustainable solution to repeated flooding.

- In 1993, 37,000 Missouri households received $34.5 million in emergency assistance. In 1995, those numbers plummeted to just 4,000 households receiving $4.1 million.[108]
- In 1993, the Federal Emergency Management Agency's National Flood Insurance Program paid $22.1 million in insurance claims in Missouri. In 1995, flood insurance program payments dropped to just $563,000.[109]
- In 1993, more than 4,270 St. Charles county residents received more than $14 million in disaster assistance. In 1995, those numbers dropped to just 333 applicants receiving $216,000.[110]
- In 1993, more than 490 residents of Lemay, an unincorporated town outside of St. Louis, applied for disaster and housing assistance at a cost of $572,000. In 1995, only 16 households applied for the same services at a cost of less than $8,000. Between the floods, 105 homeowners had moved out of the floodplain.[111]
- In 1993, the city of Arnold received almost $1.5 million in public assistance grants from FEMA.[112] In 1995, after 89 homes had been purchased and removed from the floodplain, FEMA public assistance grants fell to just $71,000.[113] The town of Arnold continued to buy more homes in the floodplain, and by the end of 1995 had purchased 202 single family homes and 155 mobile homes.[114]

Because of the buyout program, it is estimated that state taxpayers will save more than $200 million in future flood disaster claims.[115]

Grafton, Illinois

The city of Grafton is located at the confluence of two of America's great rivers – the Mississippi and the Illinois. Seven creeks also run through this "real American River town"[116] which is home to fewer than 1,000 residents and is just two miles long and two blocks wide. Grafton's natural attractions draw visitors from around the country. Surrounded by rivers and limestone bluffs, Grafton is also close to Pere Marquette State Park which is home to the second largest winter population of bald eagles in the United States and provides recreational opportunities year-round.

The Mississippi River stretches 2,350 miles from its headwaters in Minnesota's Lake Itasca to the Gulf of Mexico. The river and its tributaries drain more than 1.2 million square miles in all or part of 31 states – the third largest drainage basin in the world. The Mississippi River is also one of the world's most diverse ecological systems. More than 400 different species of wildlife call the river home, including 326 species of birds and 40 percent of North America's migratory birds, 260 species of fish, 37 species of freshwater mussels, 45 amphibian and reptile species, and 50 mammal species.[117] More than 12 million people recreate along the length of the Mississippi each year sustaining 18,000 jobs in riverside communities.

The Illinois River flows west from the Ozark region of northern Arkansas until it meets the Mississippi at Grafton. The mainstem of the Mississippi before glacial activity redirected the Mississippi westward, the Illinois flows through narrow channels in its upper reaches then widens and meanders in its lower reaches. The Illinois River drains 28,906 square miles.[118]

A Long History of Flooding

Because of its location, Grafton suffers from frequent and sometimes extreme floods when waters rise in the Mississippi, Illinois, or Missouri Rivers. Throughout its 150 year history, Grafton flooded almost every two years.[119] In 1993, the Great Midwest Flood completely crippled the city.[120]

USGS

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The Great Midwest Flood of 1993 was one of the worst floods on record, affecting both the Missouri and the Mississippi Rivers. The flood was caused by unusually heavy rains that soaked the region; rainfall across many areas of the central-northern plains was 200 to 350 percent above normal. Large portions of the Missouri and Mississippi exceeded the 100-year flood stage, and flooding at some locations exceeded the 500-year flood level. More than 1,000 levees were overtopped and 75 communities were completely inundated as high water moved downstream. Some communities were under water for 100 to 200 days. Across the Midwest the flood killed up to 50 people and inflicted $12 to $16 billion in damages. More than 530 counties in nine states were declared federal disaster areas.[121]

Grafton flooded for 195 days. In some parts of the city, the water was 15 feet deep. The flooding damaged 262 structures, including 150 homes. Four homes were completely washed off their foundations and more than 100 homes suffered damages that exceed 50 percent of their assessed value. More than half the town evacuated in July, and many residents could not return to their homes for months.[122]

A New Approach to Flood Protection

Upon returning to town, the mayor created a Grafton Rebuilding Committee and sixteen other committees to lead rebuilding efforts. One of their first undertakings was to survey displaced residents to determine their emergency and long-term needs. Over 93 percent of the residents surveyed said they would consider moving out of the floodplain and relocating to higher ground if the government would buy their homes.[123]

In response to this overwhelming sentiment, the city began investigating funding options for buyouts, and eventually secured both federal and state grants to help build a new 235-acre community in the hills above the floodplain. FEMA's Hazard Mitigation Grant Program contributed more than $2.3 million to the acquisition program, and the Illinois Department of Commerce and Community Affairs provided $321,000 in matching funds. Within two years, 70 homes and 18 commercial properties were purchased and relocated to the safety of the new town of Grafton Hills.[124]

Open space, bike paths, and parkland have replaced the frequently flooded homes and businesses that were relocated to higher ground. With its strong tourism base, the city is using some of the acquired property to connect a bicycle trail that begins ten miles north of the city at Pere Marquette State Park to the city of Alton, fifteen miles to the south. Other buyout sites will be used for public fishing access, parking lots, and city parks. A large new flood-resistant marina is proposed for the riverfront.[125]

Natural Flood Protection Works

Five more floods hit the region between 1995 and 2002. But the new town of Grafton Hills remained safe, and the city was able to continue functioning and operating even during the flood of 1995, which was a 100-year flood event.[126]

Open space, bike paths, and parkland have replaced the frequently flooded homes and businesses that were relocated to higher ground.

Louisa Levee District, Iowa

With 89 percent of its land in farmland, agriculture is the foundation of Iowa's economy. The state produces approximately 19 percent of the nation's corn, 17 percent of the total soybean harvest, and 1.2 billion gallons of ethanol each year. The state's thriving cattle industry ranks second in the nation in production.[127] The Mississippi and Iowa rivers are essential to the state's agricultural production.

The Iowa River flows 366 miles from its headwaters in southern Minnesota before reaching the Mississippi River. The Mississippi River stretches 2,350 miles from its headwaters in Minnesota's Lake Itasca to the Gulf of Mexico. The Mississippi and its tributaries drain more than 1.2 million square miles in all or part of 31 states – the third largest drainage basin in the world. The Mississippi River is one of the world's most diverse ecological systems. More than 400 different species of wildlife call the river home, including 326 species of birds and 40 percent of North America's migratory birds, 260 species of fish, 37 species of freshwater mussels, 45 amphibian and reptile species, and 50 mammal species.[128]

Just north of the confluence of these two great rivers is an area that used to be known as Louisa Levee District 8. More than 2,500 acres of cropland in the old levee district, now the Horseshoe Bend Wildlife Refuge, have been returned to grassland, meadow, and seasonal and semi-permanent wetlands that support thousands of waterfowl during the spring and fall migrations. Songbirds, pheasants, and bobwhite quail are some of the many birds that inhabit the region.[129]

A Long History of Flooding

Farmers in Louisa Levee District 8 battled floodwaters for more than 100 years. A levee built around a large oxbow in the early 1900s provided only marginal protection to their cropland. When the Great Midwest Flood of 1993 ruptured the levee in two places, it was the seventeenth time the levee had been breached since its construction.[130]

Between 1963 and 1993, the Iowa River overflowed its banks 28 times.[131] In 1993, one of the worst floods on record, the Great Midwest Flood of 1993, once again brought major flooding to Iowa. The flood was caused by unusually heavy rains that soaked the region; rainfall across many areas of the central-northern plains was 200 to 350 percent above normal. Large portions of the Mississippi and Missouri rivers exceeded the 100-year flood stage, and flooding at some locations exceeded the 500-year flood level. More than 1,000 levees were overtopped and 75 communities were completely inundated as high water moved downstream. Some communities were under water for 100 to 200 days. Across the Midwest the flood killed up to 50 people and inflicted $12 to $16 billion in damages. More than 530 counties in nine states were declared federal disaster areas.[132]

Iowa suffered $2 billion in damages from the 1993 flood, with roughly half coming from agricultural losses.[133] In Louisa Levee District 8, the flood cost up to $3,000 per acre of farmland.[134] Sediment formerly trapped behind the levee was pushed onto the farmland creating sand bars two to three feet high. The floodwaters also left scour holes peppered throughout the region. Returning the land to agricultural production would have cost almost $3 million for debris removal, levee repairs, filling scour holes, and other recovery efforts. These costs would have been in addition to disaster and crop insurance payments.[135]

A New Approach to Flood Protection

Instead of spending millions to return the land to production only to await future flooding, many of the levee district's landowners opted to take advantage of the Emergency Wetlands Reserve Program (EWRP) passed by Congress in response to the 1993 flood.[136]

USFWS

Iowa suffered $2 billion in damages from the 1993 flood. In Louisa Levee District 8, the flood cost up to $3,000 per acre of farmland.

Like the Wetlands Reserve Program, the EWRP is a voluntary program in which farmers can grant easements to the U.S. Department of Agriculture to return farmland to wetland. Participants receive the fair market value of the land for the easement. But unlike the Wetlands Reserve Program, the EWRP requires that the land be permanently removed from agricultural production, although planting vegetation for wildlife is permitted.[137]

Property owners in Louisa Levee District 8 initially rejected the $863 per acre offer from the EWRP. But they reconsidered this decision when the Soil Conservation Service (now the Natural Resources Conservation Service) proposed combining funds with the U.S. Fish and Wildlife Service and the Federal Emergency Management Agency to raise the buyout price. After careful deliberation, the farmers voted to dissolve the levee district, and eleven of the thirteen landowners participated in the EWRP.

The multi-agency effort cost $2 million, and involved 27 real estate transactions carried out over a 15-month period.[138] The Iowa Natural Heritage Foundation facilitated and negotiated the real estate transactions, secured a commitment from the U.S. Fish and Wildlife Service to manage the newly acquired public lands, and helped obtain assistance from nonprofit funding sources. For example, the National Fish and Wildlife Foundation and the Conservation Fund set up a revolving fund so that the farmers would receive full compensation for the land in a short amount of time.[139]

The purchased lands were transferred to the U.S. Fish and Wildlife Service in 1995 and turned into the 2,500-acre Horseshoe Bend Wildlife Refuge, a division of the Port Louisa National Wildlife Refuge. In addition to reconnecting the river to its floodplain, approximately 130 acres of wetlands have been restored, 210 acres of cropland have been returned to native grasses, and 50 acres of bottomland hardwoods have been planted.[140] The refuges' wetlands provide critical habitat for numerous species of fish and wildlife, including bald eagles.[141]

Natural Flood Protection Works

Residents report that reconnecting the river with its floodplain and restoring the area's wetlands helped to reduce flooding in 1995.[142] Relocating the farmers out of the floodplain kept them and their agricultural land safe from future flooding at a cost that was about 50 percent less than the estimated cost of repairing flood damages from the 1993 flood.[143] The project also put a permanent end to repeated levee repairs and expensive damage payments.[144]

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