

APPENDIX G: LOOK FORWARD

The inescapable reality is that the United States - its governmental units and its society as a whole - is not now and never has been prepared adequately to deal with a disaster the scale of Hurricane Katrina. ... but while there were individual failures involved, the story is not principally a story of individual failures - it is, instead, a story of failures of systems and of failures to construct systems in advance that would have permitted and helped to produce better performance and outcomes. The leadership failures that contributed to the events we witnessed on the Gulf Coast last August and September began long, long before Katrina came ashore. It literally took centuries to make the mistakes that rolled together to make Katrina such a vast natural and human-made calamity.

First, for hundreds of years, people have been constructing and placing large amounts of previous (human lives) and expensive (infrastructure, homes, communities) value in New Orleans and along the Gulf Coast in the known path of severe storms. Second, for decades, we have been living with inadequately designed, built, or maintained man-made protections (levees, building codes, pumps, and so on), and have pursued policies and interventions that actively contributed to the destruction of the natural buffers (salt marshes, dunes, and other natural barriers) against the hazards created by placing value in harm's way. Third for years - at least since 9/11, but even before that - we have known that we had systems of preparation and response that would prove inadequate against truly large scale disasters. Fourth, in the days and hours before Katrina's landfall, we failed to mobilize as effectively as we might have those systems that we did have in place. And fifth, the days following the impact, we did not execute even the things that we were prepared to do as quickly and smoothly as we should have.

How do we not, in the future, find ourselves again with those same regrets? Our work needs to begin with a judicious and honest assessment of threats, followed by investments in prevention and mitigation and by construction of response systems that will be equal to a larger of class of disturbances than we have previously allowed ourselves to contemplate.

Herman Leonard and Arnold Howitt (2006)
Preparing for and Responding to Future Katrina-Class Disturbances in the United States
Testimony U.S. Senate Homeland Security and Governmental Affairs Committee
Washington DC, March 8.

G.1 High Reliability Organization: The USN Nuclear Propulsion Program

A high reliability organization (HRO) is one that successfully works with extremely complex, potentially hazardous technologies by operating at extremely high levels of reliability and safety. We can extend this definition to include organizations that operate at extremely high levels of quality. Quality is defined as freedom from unanticipated defects and the ability to satisfy the serviceability, safety, compatibility, and durability requirements of those that own, operate, design, construct, regulate, and are affected by the engineered system.

Research has shown that serious accidents involving hazardous systems can be prevented through intelligent organizational design and management. HROs are thus organizations that must operate in a challenging environment requiring the use of advanced engineering methods in which the cost of failure is so great that it needs to be avoided all together. High reliability theory does not take the naive stance that *people* have the ability to behave with perfect rationality. However the theory does assert that *organizations* can compensate for human frailties and can therefore be significantly more rational and effective than individuals.

Over the years, high reliability theorists have identified four critical causal factors that constitute a HRO (Sagan 1993):

...the prioritization of safety and reliability as a goal by political elites and the organization's leadership; high levels of redundancy in personnel and technical safety measures; the development of a "high reliability culture" in decentralized and continually practiced operations; and sophisticated forms of trial and error organizational learning.

While the exact mix of strategies appropriate in a given case depends on the nature of a particular problem, the catastrophe-aversion strategy outlined above should be applicable to virtually any risky technology (Marone and Woodhouse 1986). In this section, we will briefly look at some of the characteristics of the United States Navy's Nuclear Reactor Program under Hyman G. Rickover's leadership that made it a HRO.

G.1.1 The USN Nuclear Propulsion Program

... the Naval Nuclear Propulsion Program embodies unsurpassed engineering and sustained excellence that few technical programs in or out of government can claim. In every area of performance, standards, safety, and environmental care, the Naval Nuclear Propulsion Program has excelled. ...

Former President Bill Clinton

The Naval Nuclear Propulsion Program is a joint Department of Defense / Energy program formed between 1947 and 1948 following WWII under the direction of then Captain Hyman G. Rickover. Its goal was to utilize the new knowledge developed during the war to research, design, construct, operate, and maintain all nuclear-powered submarines. Later the organization's scope was broadened to include all U.S. nuclear-powered warships (i.e., aircraft carriers). Previous studies have shown that the Naval Reactors (NR) program is an archetypal HRO and has all four critical elements identified by high reliability theory (Columbia Accident Investigation Board 2003). NR has over 900 reactor-years of experience with nuclear technology with an unblemished safety record. As a result, many important observations regarding public

high reliability organizations can be drawn from looking at the NR program under Rickover's command including:

- People are the most important element to an organization. An extraordinary amount of time and resources are needed to ensure proper selection, education, and training of the personnel.
- Complex jobs cannot be designed reliably with transient personnel.
- Scientist or engineers should not make assumptions if they truly do not understand the environment of the problem.

HRO should be actively involved in organizations that have an influence on their operations as a means to control the external environment they must operate in (closed rational system). When a HRO must interact or rely upon other organizations to complete its clear and agreed upon goals, the personnel of the HRO should be at least as equally knowledgeable as the other organizations staff in the area you are working with them. HROs should be actively involved in organizations that have an influence on their operations as a means to control the external environment they must operate in.

One characteristic of a HRO is that it fits into what W. Richard Scott has called "closed rational systems" approach in organization theory. The HRO is *rational* in the sense that they setup highly formalized structures that are oriented toward the achievement of clear and consistent goals. They are *closed* in the sense that great effort is put into minimizing the effects the environment outside the organization has on the achievement of its objectives.

In this respect, the Naval Reactors program was intentionally formed under both the US Navy Bureau of Ships (BuShips) and the Department of Energy's Atomic Energy Commission (AEC). The BuShips has the authority to design, build, and maintain all US naval ships. NR's association with BuShips gave the agency the legal authority to sign contracts, spend money, and approve ship design features. The 1946 Atomic Energy Act on the other hand states that the responsibility and authority for anything atomic is in the AEC's hands. This includes atomic fuel procurement, fabrication, reprocess, reactor safety inspections & evaluations. Therefore Rickover intentionally established the NR program to be in the AEC to give it the legal authority to sign contracts and make arrangements to deal with atomic materials and secrets. This "dual citizenship" of sorts served to give the NR program the legal authority to do its job with a minimum degree of outside interference.

Within Naval Reactors, strong, clear, and open communications is paramount to the organization's success. Rickover continually made the point to the media that he had no organizational structure. In 1980, with a total of 359 engineering, financial, naval, and clerical personnel in his Washington office, he solemnly issued an elaborate organization chart to the media. Only the title, date, and signature were in English; the numerous squares bore Chinese characters (Duncan 1990). Rickover was attempting to communicate, albeit sarcastically, that NR has as little communication barriers as possible in the organization to enable people to communicate with whomever they felt was the most capable of answering their question. This quality is crucial in ensuring the future safety and reliability of the program. Regardless of how well trained and educated "a channel to communicate information to the highest levels of the organization management without barriers" is often needed.

It is worth mentioning while the NR program seeks to minimize the degree of outside interference other organizations had on its ability to design, construct, and operate nuclear submarines, NR is dependent on private contractors and institutions in both the public and private sector in fulfilling its mission. This does not only apply to public organizations, but private corporations as we move to a more global economy where outsourcing is the norm rather than the exception. NR addresses this challenge by seeking that their personnel be at least as knowledgeable as the outsourcer's staff. This allows NR to perform reliable oversight of outsourcing activities by decreasing the likelihood of being misled, and internally provides the capability of leading outsourced duties at the desired level of quality if the outsourcer is unable. Rickover for example had an extensive amount of knowledge about industry and the level of quality they can achieve after the war if appropriately encouraged. This allowed him to outsource work to private contractors and still maintain a high quality engineering product. This further highlights the importance of recruiting and maintaining a highly qualified engineering workforce even if the agency continues to expand its outsourcing efforts in the hope of improving efficiency.

As the nation begins to consider how it might 're-engineer' the Army Corps of Engineer's Civil Works program in light of Katrina, it is important that the Corps relationships with other private and public organizations that might enhance or diminish the quality of water resource projects also be evaluated. This includes relationships with the White House, Congress, local and state governments, and private contractors.

G.1.2 Personnel Recruitment and Retention

complex jobs cannot be accomplished effectively with transients.

Extensive historical investigations of engineered systems where quality was compromised and led to a catastrophic consequence (i.e., human life or financial) performed by the authors concluded that 80% of them were due to human or organizational factors. Of these HOF failures in engineering systems, most occur during their operation or maintenance as a result of errors in design or construction. Therefore, to effectively build and maintain an organization that reliably designs and constructs large-scale complex engineering systems, a lot of time and care must be put into its personnel. Rickover shared this belief and in 1979 testified before the subcommittee on energy research and production of the House Committee on Science and Technology following the Three-Mile Island incident (Rickover 1979):

Properly running a sophisticated technical program requires a fundamental understanding of and commitment to the technical aspects of the job and a willingness to pay infinite attention to the technical details. I might add, infinite personal attention. This can only be done by one who understands the details and their implications. The phrase, "The Devil is in the details" is especially true for technical work. If you ignore those details and attempt to rely on management techniques or gimmicks you will surely end up with a system that is unmanageable, and programs will be immensely more difficult to solve. At Naval Reactors, I take individuals who are good engineers and make them into managers. They do not manage by gimmicks but rather by knowledge, logic, common sense, and hard work and experience.

The challenging and exciting projects at the NR program have allowed the agency to recruit, select and maintain a highly qualified personnel workforce. At the time of its founding,

the US Navy Nuclear Reactors program was one of the most premier engineering organizations a young person could hope to work for. The organization was leading the world in advancing science and technology with respect to reactor design. The excitement of working on cutting-edge projects allowed the organization to successfully recruit from the cream of the Navy Engineering Duty Officer (EDO) community, National Laboratories, and the submarine force (Krahn, unpublished manuscript, 1992).

From this pool, the NR program's senior leadership (Rickover included) spent a significant amount of time evaluating and selecting prospective NR engineering personnel. As noted earlier in this investigation, approximately 80% of engineering system failures are caused by human errors (Bea 2006). In order to effectively reduce the probability of failure, it is critical that the performance of the men and women that directly interface with its design, construction, operation, and maintenance be improved. One way to effectively improve personnel performance is to spend more time selecting individuals who have "right stuff" and less time trying to "train" individuals who don't. The right stuff in the NR program was identified to be a combination of desirable technical and behavioral traits. Often times, especially in engineering, employees are selected almost exclusively on practical technical competence. In addition to this, the NR program also assesses the behavioral traits through personal interviews. In addition to other traits this interview serves to understand an engineer's ethics when exposed to anything from normal to high levels of pressure/stress. Rickover highlighted the objective of this part of the selection process in the NR program (Rockwell 1992):

...what I'm trying to find out is how they will behave under pressure. Will they lie, or bluff, or panic, or wilt? Or will they continue to function with some modicum of competence and integrity? I can't find that out with routine questions. I've got to shake 'em up. That's the only way I'll know....

Engineering organizations charged with designing, constructing, operating, or maintaining complex engineering systems can not do so successfully with low personnel retention. When an engineering organization has a large turnover, one can expect low morale and dedication amongst personnel as well as high error rates. Although the effect of turnover level on organizational performance depends critically on the nature of the system in which the turnover occurs, generally an organization can expect disruption of social and communication structures, increased training and assimilation costs, and decreased cohesion and commitment of members who stay (Arthur 1994). Additionally, the organization can expect lower levels of organizational memory and learning.

The NR program shared the belief that complex jobs cannot be accomplished effectively with transients. To minimize the agency's turnover rate, the NR program required that all prospective engineering personnel be volunteers. Furthermore, the personnel were continually offered the kind of challenges and rewards in their work where they could overlook the shortcomings of their monetary compensation typical in many public-sector organizations. This allows the organization to benefit fully from their knowledge, experience, and corporate memory (Rockwell 1992). This includes the reporting of near-misses, as we will see later is a crucial element to managing risk in a complex system (i.e., organizational learning).

Former director of the Naval Nuclear Propulsion program, Admiral "Skip" Bowman, discussed some of the program's issues with respect to retention following a decrease in submarine orders after the Cold War:

Although the build rate had changed dramatically, the importance of maintaining tight controls didn't change, and the demographics of the organization became an issue. Were we going to wake up six years from now and find that the old guard had tuned gray and gone away and that we hadn't watched closely enough the professional development of the youngsters who need to be stepping in as section heads? We looked at the retention pattern at Naval Reactors, and it wasn't good. So we dramatically changed the opportunities for professional development and worked at making young engineers feel more and more a part of this organization – to create a niche where they could feel comfortable supporting their own desires, aspirations, and families.

The Naval Reactor program would not survive very long if the personnel were not clearly dedicated to their jobs. For this reason the NR program can be said to follow what human resource researchers have called a *commitment* versus a *control* human resource system. Commitment human resource systems focus on developing committed employees who can be trusted to use their discretion to carry out job tasks in ways that are consistent with organizational goals (e.g., quality). In contrast, control human resource system's objective is to improve efficiency by enforcing employee compliance with specified rules and procedures and basing rewards on some measurable output criteria. Generally, organizations that adopt this strategy have a much higher percentage of non-dedicated personnel that are hence more likely to violate the formal and informal procedures in the organization and less inclined to adopt management's leadership in creating a quality culture within the organization (Arthur 1994).

G.1.3 Engineering Assumptions

A critical aspect to life-cycle engineering is the treatment of uncertainties. In design and construction, many traditional engineering approaches are deterministic and thus require "conservative" assumptions of random variables. These variables can include anything from the price of steel to the compressive strength of concrete. The industry has notably established a variety of inspection and testing activities that improve our ability to predict the performance of our systems.

In designing the first nuclear powered submarine, many engineers who have never been on a submarine were asked to make very important design decisions. Rickover felt it was critical that any engineer or scientist not make assumptions if they truly did not understand the environment the submarine must operate in. This includes the internal (e.g., temperature), external (e.g., squalls or blast loads), and social (e.g., training/knowledge of crew or variable operational stress climates). Rickover used videos to help impress upon engineers the nature of the problem they are being asked to design. Furthermore, the organization went to great lengths to minimize communication barriers so that information could be transferred freely directly to the people who need it.

G.1.4 Conclusion

... Particularly noteworthy are the conservative rugged designs, standardized plants, thorough testing, comprehensive plant maintenance, emphasis on correcting small problems before they can grow, and the high degree of selection, training, and qualification of officers and enlisted personnel who operate the plants. These high standards and achievements continue to be reflected in the quality and competence of the Naval Reactors Headquarters and field organizations, including their dedicated laboratories, shipyards, manufacturing activities, and training facilities. ...

Chairman, U.S. Nuclear Regulatory Commission, Shirley Jackson

Failure was never an acceptable option for Rickover. While this was largely due to the fact the Navy was looking for ‘any’ reason to get rid of Rickover and the program, but also because the consequences of a nuclear reactor failure are incredibly high. The flooding of New Orleans has made it abundantly clear that the consequences of a poorly designed, constructed, and maintained water resource infrastructure are also far too high for our country to sustain.

Many of the organizations responsible for building and maintaining flood protection in New Orleans, including the U.S. Army Corps of Engineers and the local levee districts, can learn a lot from High Reliability Theory and the example the Naval Nuclear Propulsion Program continues to set. The fluid organizational structure, vibrant exchange of ideas (coupled with developed communication skills), and coherent training programs are to be desired by many organizations. The structure of the organization allowed anyone to do whatever it is they saw that needed to be done and seek the necessary resources to do it. People were limited only by their own abilities and not by formal titles and organizational charts. The Corps leadership along with Congress and the White House must recognize the important role technical people have within the Civil Works program and take major steps to create an environment that stresses quality and reliability to its personnel and that can clearly be seen throughout the organization.

G.2 Findings from Other Studies: Organizing for Success

G.2.1 Report of the Committee on Homeland Security and Governmental Affairs (2006). Hurricane Katrina, A Nation Still Unprepared, United States Senate, Washington, DC, May.

A vital part of the Hurricane Katrina story lies in nearly two centuries of natural and manmade changes to the Louisiana coastline. When New Orleans was settled in 1718 the primary flood threat was the Mississippi River, not the Gulf of Mexico, which was separated from the city by an expansive coastal landscape that served as a buffer from storms emerging from the Gulf.

That protective landscape no longer exists. The ever changing and disappearing coastline left New Orleans more susceptible to hurricanes and contributed to the damage inflicted by Katrina. Should this trend continue, New Orleans and the rest of coastal Louisiana will become even more vulnerable to damage from future storms, and efforts to protect the city with levees and floodwalls will be undetermined.

While a comprehensive analysis of coastal Louisiana's environmental challenges and potential remedies is beyond the scope of this report, this section briefly examines some of the potential impacts of Louisiana's altered landscape on hurricane protection.

Louisiana's Changing Coastal Landscape is Increasing Hurricane Vulnerability

The Louisiana coastline is changing more rapidly than any other part of the country and, as a result, becoming more vulnerable to hurricanes. Over the last 70 years, Louisiana has lost over 1,900 square miles of coastal land - an area roughly the size of Delaware. At the peak of the trend in the 1960s and 1970s, Louisiana was losing 40 square miles of coastal land per year. This loss has slowed in recent years, primarily because the most vulnerable lands have already disappeared, but Louisiana is still losing 10 square miles of coastal land per year. As a civil-engineering magazine put it, "in southeastern Louisiana a football field worth of wetlands sinks into the sea every 30 minutes .

These coastal lands primarily consist of wetlands, including extensive cypress swamps and grass marshes. But Louisiana's barrier islands (an elongated chain of islands running parallel to the coast and serving as a barrier against waves) and even many higher ridges, which were formed by large amounts of sediment piling up along past banks of the Mississippi River, are also disappearing. The U.S. Geological Survey (USGS) projects that an additional 700 square miles could be lost by 2050 if no further actions are taken to halt or reverse current processes.

The Mississippi River is the single most important factor in sustaining coastal Louisiana. The river brings water, sediments, and nutrients from 41 percent of the land area of the contiguous U.S. to the coast of Louisiana. Prior to the extensive building of levees and dams along the Mississippi, the river carried nearly 400 million tons of sediment to the Louisiana Coast every year - enough to cover 250 square miles one-foot deep in sediment. The growing wetlands fed by the accumulating sediments, nutrients, and fresh water of the Mississippi have added 9,600 square miles of land to the Louisiana coastline over the last 6,000 years - a rate of 1.25 square miles per year. At its peak, this land, known as the Mississippi deltaic plane, accounted for nearly 20 percent of the land area of present-day Louisiana, including New Orleans.

Major causes of land loss in Louisiana have been identified. ¹⁰ Dams and diversions along the Mississippi River and its tributaries have greatly reduced the amount of sediment that reaches coastal Louisiana, and levees force the remaining sediment so far offshore that it falls directly onto the outer continental shelf and beyond, where it no longer contributes to sustaining or building coastal lands. By blocking natural flooding cycles, levees prevent fresh water and nutrients from the Mississippi River from nourishing and sustaining wetlands. Ten major navigation canals and more than 9,000 miles of pipelines servicing approximately 50,000 oil and gas production facilities in coastal Louisiana result in a large direct loss of land and also contribute to wetland loss from saltwater intrusion and dredging.

The Louisiana deltaic plane is essentially sinking, in a process known as subsidence, which occurs naturally as sediments deposited by the Mississippi are compacted over time. Oil and gas production further contribute to subsidence, potentially causing local subsidence three times greater than the highest natural subsidence rates. Finally, sea level is rising, primarily as a result of global warming.

The deterioration of Louisiana's coastal landscape of barrier islands, wetlands and higher ridges, and the effects of subsidence have made coastal communities more vulnerable to hurricane flooding. ¹⁷ New Orleans, in particular, is widely considered to be more vulnerable to hurricanes both because land in the city has subsided and because much of the barrier islands and wetlands that once surrounded the city have disappeared.

Many of the mechanisms by which barrier islands, shoals, marshes, forested wetlands, and other features of the coastal landscape protect against hurricanes are well-known. Geologic features such as barrier islands or the land mass associated with wetlands can block or channel flow, slow water velocities, and reduce the speed at which storm surge propagates. These effects can significantly restrict the volume of water available to inundate the mainland.

Forested wetlands can greatly diminish wind penetration, reducing surface waves and storm surge. Shallow water depths weaken waves via bottom friction and breaking, while vegetation provides additional frictional drag and further limits wave buildup. Where wetlands and shallow waters are in front of levees, they absorb wave energy and reduce the destructiveness of storm waves on the levees.

Depending on the rate of relative sea-level rise, healthy coastal wetlands can maintain a near sea-level landscape by trapping sediments or accumulating organic material, thus helping to counter subsidence and global sea-level rise. In contrast, when Louisiana's coastal wetlands deteriorate and disappear, the land held in place by the wetlands undergoes wave erosion, eventually washing away and leaving behind open water 10 to 12 feet deep.

On the other hand, the quantitative impact of wetlands and other coastal features on hurricane protection is poorly known. Anecdotal data accumulated after Hurricane Andrew suggests a storm-surge reduction along the Louisiana coast of about three inches per mile of marsh. During Hurricane Katrina, bottom friction and breaking reduced the average height of the highest one-third of waves from 55 feet in deep water (with peak waves above 80 feet), to 18 feet in shallower water outside of the barrier island east of New Orleans, to a fraction of that height in protected areas.

Researchers at the Louisiana State University (LSU) Hurricane Center found that, during Hurricane Katrina, levees protected by wetlands had a much higher survival rate than those bordering open water. For example, large sections of the Mississippi River Gulf Outlet (MRGO)

levees that had little or no wetlands separating them from Lake Borgne disintegrated, while the nearby 20-Arpent Canal levee, protected by a buffer of marsh and wooded wetlands, remained standing. According to LSU researchers, an area about the size of a football field with the tree density equal to that found in most Louisiana swamps would reduce wave energy in a storm by 90 percent. These researchers further found that friction from marsh grasses and shrubs reduced water speed from Hurricane Katrina in some places from seven feet per second to three feet per second.

Subsidence is also contributing substantially to hurricane vulnerability. Subsidence occurs across the entire region, and therefore impacts not only natural features such as wetlands and barrier islands, but also man-made structures such as buildings and levees. According to a recent report by the U.S. Army Corps of Engineers (Corps) Interagency Performance Evaluation Task Force (IPET), which examines the hurricane protection levee system, the average rate of subsidence across the area is 0.6 feet over a decade. The rate of subsidence is frequently greater under cities and towns than under natural features: when areas are drained in order to prepare them for buildings, organic material in the soil decomposes and leads to further subsidence. In addition, the levees themselves further subside due to their own weight pressing down on the unstable soils of the New Orleans area. As a result, the effectiveness of the levee system deteriorates over time as both the levees and the region subside. The IPET report concluded that some portions of the hurricane protection system around New Orleans are almost two feet below their original elevations, further increasing their own vulnerability, and that of the areas they are designed to protect, to the power of hurricanes.

The changes to Louisiana's coastline have serious implications for the long-term sustainability of the region. Land subsidence and predicted global sea-level rise during the next 100 years mean that areas of New Orleans and vicinity now 5 to 10 feet below mean sea level will likely be 8 to 13 feet or more below mean sea level by 2100. At the same time, the loss of wetlands, barrier islands, and other natural features could eliminate protection from waves and allow for higher and faster moving storm surges. According to the National Academy of Sciences, these trends will make much of Louisiana's southern delta uninhabitable without substantial new engineering projects. In the long-term, New Orleans and other regions of the Louisiana deltaic plane cannot be protected without taking proper account of the tremendous change that is continuing to occur to Louisiana's coastal landscape.

G.2.2 Senator Susan Collins (2006). "Opening Statement", Committee on Homeland Security and Government Affairs, Hurricane Katrina: Recommendations for Reform," Washington DC, March 8.

The excuse we have heard from some government officials throughout this investigation, that Katrina was an unforeseeable ultra-catastrophe, has not only been demonstrated to have been mistaken, but also misses the point that we need to be ready for the worst that nature or evil men can throw at us. Powerful though it was, the most extraordinary thing about Katrina was our lack of preparedness for a disaster so long predicted.

This is not the first time the devastation of a natural disaster brought about demands for a better, more coordinated government response. In fact, this process truly began after a series of natural disasters in the 1960s and into the 1970s. One of those disasters was Hurricane Betsy, which hit New Orleans in 1965. The similarities with Katrina are striking: levees overtopped and

breached, severe flooding, communities destroyed, thousands rescued from rooftops by helicopters, thousands more by boat, and too many lives lost.

Katrina revealed that this kaleidoscope of reorganizations has not improved our disaster management capability during these critical years. Our purpose and our obligation now is to move forward to create a structure that brings immediate improvement and guarantees continual progress. This will not be done by simply renaming agencies or drawing new organizational charts. We are not here to rearrange the deck chairs on a ship that, while perhaps not sinking, certainly is adrift.

This new structure must be based on a clear understanding of the roles and capabilities of all management agencies. It must establish a strong chain of command that encourages, empowers, and trusts frontline decision-making. It must replace ponderous, rigid bureaucracy with discipline, agility, cooperation, and collaboration. It must build a stronger partnership among all levels of government with the responsibilities of each partner clearly defined, and it must hold them accountable when those responsibilities are not met.

G.2.3 Newt Gingrich (2006). "Why New Orleans Needs Saving," *Time Magazine*, March 6.

Shortly after Hurricane Katrina devastated New Orleans, Speaker of the House Dennis Hastert wondered aloud whether the Federal Government should help rebuild a city much of which lies below sea level. The most tough-minded answer to that question demonstrates that rebuilding and protecting new Orleans is in the national interest. Reason: The very same geological forces that created that port are what make it vulnerable to Category 5 hurricanes and also what make it indispensable.

If engineering the Mississippi made New Orleans vulnerable, it also created enormous value. New Orleans is the busiest port in the U.S.; 20% of all U.S. exports and 60% of our grain exports, pass through it. Offshore Louisiana oil and gas wells supply 20% of domestic oil production. but to service that industry, canals and pipelines were dug through the land, greatly accelerating the washing away of coastal Louisiana. The state's land loss now totals 1,900 sq. mi. that land once protected the entire region from hurricanes by acting as a sponge to soak up storm surges. If nothing is done, in the foreseeable future an additional 700 sq. mi. will disappear, putting at risk port facilities and all the energy-producing infrastructure in the Gulf.

There is no debate about the reality of that land loss and its impact. On that the energy industry and environmentalists agree. There is also no doubt about the solution, Chip Groat, a former director of the U.S. Geological Survey, says, "This land loss can be managed, and New Orleans can be protected, even with project sea-level rise." Category 5 hurricane protection for the region, including coastal restoration, storm-surge barriers and improved levees, would cost about \$40 billion - over 30 years. Compare that with the cost to the economy of less international competitiveness (the result of increased freight charges stemming from loss of the efficiencies of the port of new Orleans), higher energy prices and more vulnerable energy supplies. Compare that with the cost of rebuilding the energy and port infrastructure elsewhere. Compare that with the fact that in the past two years, we have spent more to rebuild Iraq's wetlands than Louisiana's. National interest requires this restoration. Our energy needs alone require it. Yet the White Houses proposes spending only \$100 million for coastal restoration.

Washington also has a moral burden. It was the Federal Government's responsibility to build levees that worked, and its failure to do so ultimately led to New Orleans' being flooded.

The White House recognized that responsibility when it proposed an additional \$4.2 billion for housing in new Orleans, but the first priority remains flood control. Without it, individuals will hesitate to rebuild, and lenders will decline to invest.

How should flood control be paid for? States get 50% of the tax revenues paid to the Federal Government from oil and gas produced on federally owned land. States justify that by arguing that the energy production puts strains on their infrastructure and environment. Louisiana gets no share of the tax revenue from the oil and gas production on the outer continental shelf. Yet that production puts an infinitely greater burden on it than energy production from other federal territory puts on any other state. If we treat Louisiana the same as other states and give it the same share of tax revenue that other states receive, it will need no other help from the government to protect itself. Every day's delay makes it harder to rebuild the city. It is time to act. It is well past time.

G.2.4 Houck, O. (2006). "Can We Save New Orleans?", *Tulane Environmental Law Journal*, Vol 19, Issue 1, 1-68, New Orleans, Louisiana.

So What Do We Do? Here is what we know. It is not just the tire, it's the car. And it's not just the car, it's the driver. Nothing in the system has made a numero uno priority either of protecting New Orleans from hurricanes or to restoring even hanging onto - the Louisiana coast. We have a flood control program, a navigation program, a permitting program, a coastal management program, a flood insurance program, a coastal restoration program - just for openers - and they do not talk to each other. They are riddled with conflicts, basically headless, basically goal-less, weakened by compromises and refuse outright to deal with first causes and first needs. So, this is a tall order.

We also know this. As they came ashore, there were really two Katrinas. One blew through the levees into New Orleans and St. Bernard, and topped the ones further south. The other smashed into coast-front development in a wide swath from Alabama to Texas, wiping out the first half-mile or so of Pass Christian, Waveland, Gulfport, Biloxi, half of Grand Isle, and all the way over to Holly Beach. Same set of storms, but the run-up for one was negligence, and the run-up for the other was arrogance. Building behind levees is one thing; you have some reason to think they'll hold up. Building on the edge of the gulf and thumbing your nose at it is another.

The vision for New Orleans is relatively clean. the city is a given, fixed in its history, architecture, economy and culture and these contributions call for maintaining it, as is, for as long as we can. Nobody needs to reinvent new Orleans: we simply need to get it back. Its protection will cost a fortune, and will take more than anyone wants to concede (and no small amount of luck, as we race the clock against the near-term hurricane seasons). But at least we know what we are driving at. Whether we succeed will depend on levees, flood gates, rational storm water management within the city walls, conservative building elevations, levees and one thing more: a viable coastal zone to buffer them, without which the system will not hold over time.

So here is the starting point: exactly what we do want the Louisiana coast to look like, to do for us, for say, the next century? ...Earth to Louisianans: you really can't have this cake and eat it too. With all due respect, it is not just a matter of doing everything we want 'smarter.' It is a matter of getting straight what we want, and what comes first." ... what comes next is the hardest step for any American community to take, and all be heresy in South Louisiana. A plan. The mere mention of planning raises blood pressures and brings on cries of Godless Communism.

...What we have had in the city of new Orleans and along the entire gulf coast is planning by default (local attorney Bill Borah calls it 'planning by surprise'). Planning takes place. It's just that we haven't taken part in it. Where water resources are concerned, it starts with real estate developers, port authorities, levee boards and other outside-the-ballot-box enterprises, their projects facilitated and funded by the Army Corps of Engineers. In their minds, the only question is a technical one: what kind of engineering do we need to get our project done? The system has produced the expected results: more rip-rap here, more drainage there, and levees to the horizon. The goal is - although it is never stated anywhere - to develop as much of the coast as possible. When you add the projects up, they determine the destiny of the city and South Louisiana.

What is apparent is that these levees, designed by engineers and approved by Congress, are the basic planning documents for the future of South Louisiana. what is north of these levees will be developed. What is south of them will be anyone's guess, although not for long; the map on global warming shows these coastal marshes gone within a century. De facto, we end up with a wall. Not all that adequate a wall, by the way. Only Category three, if that. Can you imagine the costs of maintaining even a Category three levee system winding back and forth to the Gulf from New Orleans to Texas" Can we imagine what will happen when development piles in behind it, and then gets flooded? Do we already know, from Lakeview and New Orleans East, what happens to land elevations behind levees once they are drained and paved?

Our choice is to start this process from the other end. If we do, another range of options open. There are a dozen major towns across the southern tier with thousands of homes and residents, and they deserve protection. But the way to provide it may be with the same kind of ring levee systems that protects (or should) New Orleans and its surrounding parishes, supplemented by flood gates at the mouths of the main canals. Or, it may mean peninsular levee systems down the historic ridges of the bayous, protecting what has always been the high ground. ...Problem is, we have lacked the process - we have lacked even the language - for such a discussion. In addition to scientists and engineers, we may need some social workers. In saying this, I am most serious.

The Dutch have been fighting the North Sea for a thousand years, and their historic methods - dikes, drainage canals and pumps - look quite familiar, as does their continuing and accelerated rate of subsidence. Parts of the coast are now 23 feet below the level of the sea. the temporary successes of this engineering look familiar too, always followed by greater, catastrophic losses. finally, in 1953 a major hurricane blew in and left 1,800 bodies in its wake, 50,000 destroyed homes and 350,00 acres of flooded land. In a country half the size of Louisiana.

Vowing 'Never Again,' the country devised a new plan. Back in 1932, they had dikes off the Zuiderzee, an estuary twice the size of Lake Pontchartrain, with a barrier more than 20 miles long. Their new Delta Plan would apply that same strategy to the entire Atlantic Coast. They dammed every one of their major rivers, some of them multiple times. They diked off their estuaries, diked off entire seas, and reduced their coastline by more than two-thirds. The water is the enemy, explained a professor of engineering. 'You don't let the enemy, before the fight starts, penetrate your territory.'

They won. At a cost of about \$18 billion over some 40 years, they completed their first rounds of the Delta plan and they haven't flooded since. They predict their strategy to hold for the next 500 years. At the same time they moved aggressively to fill lands behind their coastal

barriers, 'polders' created literally from the sea. the polders produced fruit and vegetables. So far, it was all win-win.

Then another bill came in. Over half the estuaries disappeared, and those remaining were in trouble. Coastal fisheries were hammered. at the mouth of two of Europe's major rivers, the Meuse and the Rhine, the Grevelingen was the largest and most productive estuary on the Atlantic coast. Within two weeks of completing the barrier across it the mussels and shellfish were dead. the government tried to turn what is now a lake behind the barrier to tourism, but the water was, and remains, so contaminated that it is unfit for human contact. It is covered with toxic algae and more than 5 billion feet of polluted sludge has settled on the bottom. They had made a dead zone. ...Interfering with natural processes and natural systems is always a bad thing, says one. 'Mother nature is the best engineer'.

There is also a question of commitment. The Netherlands is a small country, and it has dedicated itself to fighting the sea. It cannot afford not to. Sixty percent of its land is below sea level. Louisiana, as valuable as it is to the nation and to those of us who live here, is only one piece of America, and America's attention span for this or any other endeavor is limited. so will be federal funding, and we are still in the heyday of a petroleum economy that cannot and will not, last. Unless Louisiana goes in a direction that is more self-sustaining over the long term, it could (end) up with a large white elephant on its hands.

Perhaps the most important lesson from the Netherlands experience is how it has since evolved. As noted, Dutch engineers have tried to retrofit their structures to accommodate natural processes, to recreate natural processes, with mixed success. Easier to do that from the start. As a matter of engineering strategy, they have now explicitly rejected big-levee and big-drainage solutions as unworkable. They have instead come to rely on multiple layers of defense, redundant in the safety they provide, and none designed to provide full protection on their own. Most significantly, they have changed their philosophy from 'flood control' to 'water management,' and are tiptoeing to the next logical, indeed the only logical step: people management. It is rather remarkable.

Meanwhile, it is most recent report, under the title Lessons Learned, the Netherlands Water Partnership says: The Netherlands is changing its approach to water. The country will have to make more frequent concessions. the report explains, we will have to relinquish open space to water, and not take back existing open spaces, in order to curb the growing risk of disaster due to flooding. Giving space does not mean the height of ever taller levees or depth by channel dredging. Rather, space in the sense of flood plains. ...Only by relinquishing our space can we set things right; if this is not done in a timely manner, water will sooner or later reclaim the space on its own, perhaps in a dramatic manner.

If a sustainable coast is the goal, we need a map of what we can sustain. That map, in turn, should drive what we do for restoration and for human development, and for its protections. ...If on the other hand, we start from the position of maintaining as much of the coastal zone and its natural storm barriers as we can, we meet a different set of possibilities. We interfere with natural processes as little as possible, remove barriers to them, and over time move to the traditional places Louisianans have always lived, the ridges of the natural bayous and distributaries leading to the gulf. We protect those zones. We also protect critical infrastructure for oil and gas, fisheries and essential navigation canals. For the rest, we let nature have the space it needs to rebuild and it will protect us in turn.

We also need new mapmakers. We have always thought of coastal management in terms of engineering, and engineering agencies are well funded at every level from the Corps to local levee districts, politically supported from top to bottom, and largely autonomous. ...The nice thing about engineering is that it seems so certain. It may be faulty and the building may fall over, but responds to numbers and rules of physics. We are comforted by it. Usually, it works, or we would never take an airplane ride. and so we like engineering solutions. among other things, they made living in this part of the world possible. They also look impressive, big dams and canals. And, down inside, they allow us to move dirt and water around which we have all done and enjoyed from early childhood. Hard structure engineering has a great deal of history, money, and human nature going for it. Which is why we have lots of engineering maps.

Coast 2100, We can now put the puzzle together. In a post-Katrina world of greater urgency, funding and public awareness of the plight of New Orleans and the Louisiana coastal zone, we have the opportunity to go beyond Coast 2050, take it off the leash and see where we can really go: Coast 2100. Before suggesting a few principles for that new plan, let us reach two understandings.

The first is that restoring coastal Louisiana is a national issue and will require remedies beyond this state. We lie at the receiving end of a large watershed, and some of what we need has been turned off and other stuff that is hurting us has been turned on. The Corps districts need to talk to each other, The EPA has to step up to the plate, upstream states have to change some habits too. If the nation's taxpayers are going to be asked to spend more money than America spent on the Marshall Plan to fix all of post-war Europe, then they have a right to expect a national effort.

The second is the funding. When it comes to restoring the city of New Orleans itself, the funding should be federal. Not just restoring the levees, the city. However you look at it, and with plenty of supporting actors, the Corps of Engineers drowned new Orleans and the sight of individual homeowners trying to rip out, detoxify and rebuild their homes is one of the most unjust features of a post-Katrina world. New Orleans is a federal responsibility. You flood somebody, you pay.

Conventional wisdom holds that the Corps is immune from liability for its role in the levee failures, and case law supports that conclusion. *United States v. James*, 478 U.S. 597, 612 (1986). On the other hand, it seems a far stretch to say that 1929 statute dealing exclusively with Corps works on the Mississippi River should minimize the Corps for activities in a different location, of a different nature, at a later time. Whatever the legal merits, the federal government's moral obligation to repair the catastrophic damaged caused by its own agents seems clear. The obligation is not simply to provide better flood control; it is to repair the harm.

With these understandings, here are ten criteria for a coastal plan with the maximum long-term chance of success:

1. Draw the maps. Not just a flood protection plan. ...To be sure, we need to know what the engineering possibilities are. But they beg the question, engineering to do what? Right now, we have the cart before the horse.

2. Review the bidding. the Corps and other agencies have projects pending that could seriously compromise an all-out effort to restore the coastal zone. ...That Congress has already authorized them is not persuasive. Like MRGO, they were authorized in a very different day

under very different circumstances. Katrina changed the equation. They need to be looked at again, new restoration map in hand. They should be consistent with the future, not the past.

3. Free the upstream sediments. The Mississippi today at the latitude of New Orleans carries about 80 million tons of sediment a year. An impressive figure, until we realize that a century and half ago it carried about 400 million....The point is that most of those silts today lie behind dams on the upper watershed. We need them, and the Mississippi is their natural conveyor belt. The bumper sticker should read: Free the Mississippi 400 Million.

4. Free the rivers. Which, until today, we have tiptoed around with a few, very expensive freshwater diversion structures whose efficacy has been further compromised by their capacity and politics....We can cut sills in the levees to replicate natural crevasses, and let the river do its thing.

5. Cut upstream fertilizers. ...The upstream states are in denial, so is Louisiana for that matter, and EPA is in hiding. It is time to insist. A less polluted river is not a matter of aesthetics. It is a matter of survival.

6. Heal the marsh. Which is hemorrhaging from the inside out. Push in the spoil banks. Crevasse the ones that remain. Plat grass. Pretend we're farmers. We can build wetlands, if necessary, by hand. Not fully - manmade marshes still come out looking a little weird - but we need to rebuild a base for natural processes to then improve upon. A coast fully ceded to open water will be harder to restore.

7. Stop the bleeding. We will have to make historic commitments to hold onto even the base of coastal wetlands we currently enjoy, an order of magnitude beyond the ambition of Coast 2050. Meanwhile, we continue to permit dredging and filling of the same wetlands for access canals, waste dumps, new subdivisions and the like. Every acre of the coast we allow to be destroyed is certain loss. ..An ounce of prevention is worth a ton of restoration.

8. Make space for natural processes. Elevate roads and railroads. Open new floodways. Move oyster leases, consolidate energy, port and navigation facilities, zone development within protected areas and let the rest rebuild. We shouldn't try to storm-proof the coastal zone, and the more we try to storm-proof the more we will loose.

9. Dare to think retreat. ...People and structures in the most vulnerable areas should be offered the opportunity to relocate in protected areas, at full and fair compensation. The costs of such a program will be more than offset by the savings in the attempt to protect these same residences forever, and in reduced losses to future storms. the more we delay this process, the harder it will be.

10. Face global warming. It is real. And it makes everything else we do to save the coast infinitely more difficult, if not impossible."

Senator Landrieu inserted an \$800 million appropriation into the 2005-06 budget, directing the Corps to conduct such a study for both New Orleans and all of South Louisiana on a very tight schedule; a scant six months for a draft plan. It may seem curious to some that, for these purposes, we would go back to the very agency that built failing levees in the first place and has shown historic resistance to thinking outside the box. Such is the abiding faith of the congressional delegation in its historic water resources partner. It is what Congress knows. The output of such a process is likely to be the maximum development model. It is what the Corps Knows. An alternative model is not yet on the table.

The technical decisions here, from the outset, call for a broader base than that of the Corps. The Corps is qualified to make engineering and technical decisions. But as history shows, decisions of this magnitude should be reviewed by an entity that is truly independent, also expert, and with the authority to remand an unsupported conclusion. It could be the National Academy of Sciences, although the Academy is not structured to provide long-term services. It could be an empowered state agency. Whatever the vehicle, well-qualified and independent review seems essential.

As the Katrina relief debacle illustrated, shared responsibilities are necessary, but joint command is fatal. ...but, our job calls for a new command with a single, unfragmented mandate - to save the Louisiana coastal zone - and the capacity to ensure that all other players are working towards that goal. This authority's first job is to prepare the maps that guide all that follows. Its second job is to review ongoing projects, flood-control and otherwise, that could affect the success of their plans. Its third job is to integrate restoration, development and flood control initiatives - in that order - to achieve long term sustainability. An agency with less autonomy, or with a different set of priorities, will not succeed.

Can We Save New Orleans? Here is our choice. We can live with nature next time around, or we can fight it for all the turf we can take and spend fortunes trying to defend it. When it comes to floods and hurricanes, a little space goes a long way.more problematically, we are likely to propose large outer barriers to protect the city as well, a second ring across the Rigolets and to the south. We are likely to extend these barriers, leaky or otherwise, across the entire Louisiana coast, for as far as the money will go. That is what we have always done, it is what the Corps of Engineers knows how to do, it avoids the need to plan, it sets up killings in real estate, and it is the easy path for politicians. Of course, it will be increasingly hard to maintain for even this century, the costs in trying will be enormous, and when there are failures more people will die. But those consequences are for another day. We are living now.

The point of this Essay is that we have a choice. Rather than start with the premise that we are going to protect as much of the Louisiana coast as we can from hurricanes and then graft on some restoration measures, we can start with the premise that we are going to restore as much of the Louisiana coast as we can and then see what we need to do, within that context, to protect people from hurricanes. The approaches are not the same, and they will lead to two very different futures. We are entitled to see the second one, before we are handed the first as a *fait accompli*. The first one is being prepared, by the Corps, on an unrealistically hasty schedule, as we speak.

There is another engineering outfit on the scene, however. Mother Nature. The best way to restore coastal Louisiana and to provide long-term safety for New Orleans and other coastal residents is to help nature get back in the game, and then stand back. Not very far back. Just far enough for it to work for us: a natural, self-sustaining, horizontal, first and major line of defense spinning off renewable resource dividends for generations to come. We can have a coast and live and work in it safely for a very long time. Just not everywhere, and doing every damn thing we want. Can we save New Orleans? It'll be a journey. Will we? Depends on no rain in the morning, and the path we choose.

G.2.5 Netherlands Water Partnership (2005). *Dutch Expertise, Water Management & Flood Control*, Delft, The Netherlands, November.

Climate changes are increasing the likelihood of flooding and water-related problems. In addition population density continues to increase, as does the potential for economic growth, and

consequently, the vulnerability to economic and social disaster. two undesirable developments that, in terms of safety, exacerbate one another - a grown risk with even larger consequences. As such, the safety risk is growing at a n accelerated pace (safety risk - chance multiplied by consequence).

The Netherlands is changing its approach to water. This change involves the idea that the Netherlands will have to make more frequent concessions. We will have to relinquish open space to water, and not take back existing open spaces, in order to curb the growing risk of disaster due to flooding, we will also need to limit water-related problems and be able to store water for expected periods of drought. By this we do not mean space in terms of the height of ever taller levees or depth through continued channel dredging, but space in the sense of flood plains. This approach will require more area, but in return we will increase our safety and limit water related problems. Safety is an aspect that must plan a different role in spatial planning. Only by relinquishing our space can we set things right; if this is not done in a timely manner, water will sooner or later reclaim the space on its own, perhaps [in a] dramatic manner.

We are developing a new risk management approach that includes determining how far the government can and should go in providing protection against high water levels and how much it can and should spend for that purpose. We will base the approach on factors including the 'safe Netherlands roadmap.' In that project, the Ministry has joined forces with provincial governments and water boards to gauge the likelihood and consequences of flooding in each levee 'ring' (an area that is completely surrounded by levees).

The consequences of flooding are also taken into account in the Dutch risk management approach. Human and economic values also determine risk standards. Which means that no just technical expertise on dealing with flood management is needed, but also socio-economic experience. We support the decision-making process by providing scenarios, alternatives and public relations advice.

The Netherlands is divided into compartments with different risk levels of flooding. High density areas with greater human and economic interest, like Rotterdam and Amsterdam, are surrounded with stronger levees than rural areas and therefore have a lower risk level from flooding than others. One of the most difficult policy decisions in the Dutch in the next decade is to decide what level of protection is necessary, acceptable and cost-effective for each compartment.

Our standards are accepted risks related to the design-criteria of our dikes. Those standards are laid down in the Flood Defense Act. For the economically most important and densely populated part of the country, we design our dikes and dunes to be strong enough to withstand a storm-situation with a probability of 1 to 10,000 a year. That means, that a Dutchman - if he should live a 100 years - has a chance of 1 percent to witness such an event. For our parliament, these odds became the acceptable standard. For the less important coastal areas we calculate the probability of 1 to 4,000 and along the main rivers 1 to 1,250.

G.2.6 Interagency Floodplain Management Review Committee (1994). *Sharing the Challenge: Floodplain Management into the 21st Century*, Report to Administration Floodplain Management Task Force, Washington DC, June.

Over the last 30 years the nation has learned that effective floodplain management can reduce vulnerability to damages and create a balance among natural and human uses of

floodplains and their related watersheds to meet both social and environmental goals. The nation, however, has not taken full advantage of this knowledge. The United States simply has lacked the focus and incentive to engage itself seriously in floodplain management. The 1993 flood has managed to focus attention on the floodplain and has provided the incentive for action.

The Interagency Floodplain Management Review Committee proposes a better way to manage the floodplains. It begins by establishing that all levels of government, all businesses and all citizens have a stake in properly managing the floodplain. All of those who support risk behavior, either directly or indirectly, must share in floodplain management and in the costs of reducing that risk. The federal government can lead by example; but state and local governments must manage their own floodplains. Individual citizens must adjust their actions to the risk they face and bear a greater share of the economic costs.

While development of the region has produced significant benefits, it has not always been conducted in a wise manner. As a result, today the nation faces three major problems:

First, as the Midwest Flood of 1993 has shown, people and property remain at risk, not only in the floodplains of the upper Mississippi River Basin, but also throughout the nation. Many of those at risk do not fully understand the nature and the potential consequences of that risk; nor do they share fully in the fiscal implications of bearing that risk.

Second, only in recent years has the nation come to appreciate fully the significance of the fragile ecosystems of the upper Mississippi River Basin. Given the tremendous loss of habitat over the last two centuries, many suggest that the nation now faces severe ecological consequences.

Third, the division of responsibilities for floodplain management among federal, state, tribal and local governments needs clear definition. Currently, attention to floodplain management varies widely among and within federal, state, tribal and local governments.

Now is the time to:

Share responsibility and accountability for accomplishing floodplain management among all levels government and with all citizens of the nation. The federal government cannot go it alone nor should it take a dominant role in the process.

Establish, as goals for the future, the reduction of the vulnerability of the nation to the dangers and damages that result from floods and the concurrent and integrated preservation and enhancement of the natural resources and functions of floodplains. Such an approach seeks to avoid unwise use of the floodplain, to minimize vulnerability when floodplains must be used, and to mitigate damages when they do occur.

Organize federal programs to provide the support and the tools necessary for all levels of government to carry out and participate in effective floodplain management.

G.2.7 Input from citizens of the greater New Orleans area Levees.Org

We the citizens of Levees.Org are pleased to submit the issues that we believe are critical to the future of New Orleans and southern Louisiana.

Mission. Flood protection must be the primary mission of the entity in charge of design and construction of the flood protection system. The US Army Corps of Engineers views their

mission as not rocking the boat and following Congress' authorization. We feel that is the wrong mission.

Cost/Benefit. The Dutch have developed sophisticated and rigorous cost benefit analysis focused on protecting property and lives. This has guided hard decisions about what to protect and what to give back to nature. Decisions must be based upon sound cost benefit analysis and not politics.

Peer Review. There must be real-time independent peer review of the Corps' projects and practices to assure that the right projects are being done right. This review can be done both at the state level via the local levee boards and via private groups formed by local business and environmental interest. The review must be done concurrently so as not to delay time-sensitive projects.

Outrage. Finally, we at Levees.Org wonder: Where is the outrage? Over a thousand have died, a hundred thousand homes have been destroyed, and a historic American city lies in ruins. This was not a natural disaster. This was a manmade disaster caused by deeply ingrained institutional problems of the US Army Corps of Engineers and Congress. Every American should be outraged.

It is our hope that, through the expert opinion revealed in the National Science Foundation report that the nation and Congress will come to a better understanding of the issues concerning August 29, 2005. Hopefully, finally, we can all agree on what caused the Greater New Orleans Flood and begin the process of rebuilding New Orleans and southern Louisiana and making its citizens whole.

Respectfully submitted by
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G.2.8 Congressional Research Service (2005). *Aging Infrastructure: Dam Safety, Report for Congress, K Powers, Washington DC, September 29.*

While dams have multiple benefits, they also represent a risk to public safety and economic infrastructure. This risk stems from two sources: the likelihood of a dam failure and the damage it would cause. While dam failures are infrequent, age, construction deficiencies, inadequate maintenance, and seismic or weather events contribute to the likelihood. To reduce the risk, regular inspections are necessary to identify deficiencies and then corrective action must be taken.

To identify deficiencies that could cause dam failures, the federal government established inspection requirements for the nation's federal dams. Once deficiencies are identified, most agencies finance repairs through their operation and maintenance accounts. Funding mechanisms vary for larger rehabilitation activities. At the Bureau of reclamation, for example, most larger repairs are conducted with annual appropriations to its dam safety program. At some other agencies, dam rehabilitation must compete with other construction projects for funding.

At non-federal dams, safety is generally a state responsibility, though some federal assistance has been provided. Funding through the National Dam Safety Program, which is authorized through FY 2006, helps states improve their dam safety programs and train inspectors. In addition, the Federal Energy Regulatory Commission and the Department of

Labor, Mine Safety and Health Administration require regular inspections at the non-federal dams within their jurisdiction. Even so, there are concerns that most state dam safety programs have inadequate staff and funds to effectively inspect or monitor all of the dams for which they are responsible. Further, there are concerns that states, local governments, and other non-federal dam owners may not have the financial resources to maintain and rehabilitate their dams.

Following the failure of the levee at Lake Pontchartrain in 2005, it is likely that there will be increased scrutiny of flood control infrastructure and the structural stability of high hazard-potential dams. Further, there has been periodic pressure for Congress to pass legislation authorizing federal support for rehabilitation work at non-federal dams. Demand for such assistance is likely to increase, but there is currently no federal policy that describes the conditions under which federal funding is appropriate, nor has congress established criteria for prioritizing funding among non-federal projects.

G.2.9 Sparks, R. E. (2006). "Rethinking, Then Rebuilding New Orleans," Issues in Science and Technology, National Academy Press, Winter 2006, p 33-39, Washington DC.

New Orleans will certainly be rebuilt. But looking at the recent flooding as a problem that can be fixed by simply strengthening levees will squander the enormous economic investment required and, worse, put people back in harm's way. Rather, planners should look to science to guide the rebuilding, and scientists now advise that the most sensible strategy is to work with the forces of nature rather than trying to overpower them. This approach will mean letting the Mississippi River shift most of its flow to a route that the river really wants to take; protecting the highest parts of the city from flooding and hurricane-generated storm surges while retreating from the lowest parts; and building a new port city on higher ground that the Mississippi is already forming through natural processes. The long-term benefits - economically and in terms of human lives - may well be considerable.

To understand the risks that New Orleans faces, three sources need to be considered. They are the Atlantic Ocean, where hurricanes form that eventually batter coastal areas with high winds, heavy rains, and storm surge; the gulf of Mexico, which provides the water vapor that periodically turns to devastatingly heavy rain over the Mississippi basin; and the Mississippi River, which carries a massive quantity of water from the center of the continent and can be a source of destruction when the water overflows its banks. It also is necessary to understand the geologic region in which the city is located: the Mississippi Delta.

If Hurricane Katrina, which in 2005 pounded New Orleans and the delta with surge and heavy rainfall, had followed the same path over the Gulf 50 years ago, the damage would have been less, because more barrier islands and coastal marshes were available then to buffer the city. Early settlers on the barrier islands offshore of the Delta built their homes well back from the beach, and they allowed driftwood to accumulate where it would be covered by sand and beach grasses, forming protective dunes. The beach grasses were essential because they helped stabilize the shores against wind and waves and continued to grow up through additional layers of sand. In contrast to a cement wall, the grasses would recolonize and repair a breach in the dune. Vegetation offers resistance to the flow of water, so the more vegetation a surge encounters before it reaches a city, the greater the damping effect on surge height. The greatest resistance is offered by tall trees intergrown with shrubs; next are shorter trees intergrown with shrubs; then shrubs; followed by supple seedlings or grasses; and finally, mud, sand, gravel, or rock with no vegetation.

Of Course, the vegetation has its limits: Hurricanes uproot trees and the surge of salt or brackish water can kill salt-intolerant vegetation. Barrier islands, dunes, and shorelines can all be leveled or completely washed away by waves and currents, leaving no place for vegetation to grow. The canals cut into the Delta for navigation and to float oil-drilling platforms out to the gulf disrupted the native vegetation by enabling salt or brackish water to penetrate deep into freshwater marshes. The initial cuts have widened as vegetation dies back and shorelines erode without the plant roots to hold the soil and plant leaves to dampen wind- or boat-generated waves.

The ecological and geological sciences can help determine to what extent the natural system can be put back together, perhaps by selective filling of some of the canals and by controlled flooding and sediment deposition on portions of the Delta through gates inserted in the levees.

If New Orleans is to be protected against both hurricane-generated storm surges from the sea and flooding from the Mississippi river, are there alternative cost-effective approaches other than just building levees higher, diverting floods around New Orleans, and continuing the struggle to keep the Mississippi River from taking its preferred course to the sea? Yes, as people in other parts of the world have demonstrated.

Could the same approach be taken in the Delta, in the new Atchafalaya lobe? Advocates for rebuilding New Orleans in its current location point to the 1,000+ year levees and storm surge gates that the Dutch have built. But the Netherlands is one of the most densely populated countries in Europe, with 1,000 people per square mile, so the enormous cost of building such levees is proportional to the value of the dense infrastructure and human population there. The same is not true in Louisiana, where there are approximately 100 people per square mile, concentrated in relatively small parcels of the Delta. This low population density provides the luxury of using Delta lands as a buffer for the relatively small areas that must be protected.

However, the Dutch should be imitated in several regards. First, planners addressing the future of New Orleans should take a lesson from the long-term deliberate planning and project construction undertaken by the Dutch after their disastrous flood of 1953. These efforts have provided new lands and increased flood protection along their coasts and restored floodplains along the major rivers. Some of these projects are just now being realized, so the planning horizon was at least 50 years.

Planners focusing on New Orleans also would be wise to emulate Dutch efforts to understand and work with nature. Specifically, they should seek and adopt ways to speed the natural growth and increase the elevation of the new Atchafalaya lobe and to redirect sediment onto the Delta south of New Orleans to provide protection from storm waves and surges. A key question for the Federal Emergency Management Agency (FEMA), the FEMA equivalents at the state level, planners and zoning officials, banks and insurance companies, and the Corps of Engineers is whether it is more sustainable to rebuild the entire city and a higher levee system in the original locations or to build a 'new' New Orleans somewhere else, perhaps on the Atchafalaya lobe.

Under this natural option, old New Orleans would remain a national historic and cultural treasure, and continue to be a tourist destination and convention city. Its highest grounds would continue to be protected by a series of strengthened levees and other flood-control measures. City planner and the government agencies (including FEMA) that provide funding for rebuilding must ensure that not all of the high ground is simply usurped for developments with

the highest revenue return, such as convention centers, hotels, and casinos. the high ground also should include housing for the service workers and their families, so they are not consigned again to the lowest-lying, flood-prone areas. The flood-prone areas below sea level should be converted to parks and planted with flood-tolerant vegetation. If necessary, these areas would be allowed to flood temporarily during storms.

At the same time, the Corps, in consultation with state officials, should guide and accelerate sediment deposition in the new Atchafalaya lobe, under a 50- to 100-year plan to provide a permanent foundation for a new commercial and port city. If old New Orleans did not need to be maintained as a deepwater port, then more of the water and sediment in the Mississippi could be allowed to flow down the Atchafalaya, further accelerating the land-building. The new city could be developed in stages, much as the Dutch have gradually increased their polders. The port would have access to the Mississippi River via an exiting lock (constructed in 1963) that connects the Atchafalaya and the Mississippi, just downstream of the Old River Control Structure.

This plan will no longer force the Mississippi River to go down a channel it wants to abandon. The shorter, steeper path to the sea via the Atchafalaya might require less dredging than the Mississippi route, because the current would tend to keep the channel scoured. Because the Mississippi route is now artificially long and much less steep, accumulating sediments must be constantly dredged, at substantial cost. Traditional river engineering techniques that maintain the capacity of the Atchafalaya to bypass floodwater that would otherwise inundate New Orleans also might be needed to maintain depths required for navigation. These techniques include bank stabilization with revetments and wing dikes that keep the main flow in the center of the channel where it will scour sediment.

Action to capitalize on the natural option should begin immediately. The attention of the public and policymakers will be focused on New Orleans and the other Gulf cities for a few more months. The window of opportunity to plan a safer, more sustainable New Orleans, as well as better flood management policy for the Mississippi and its tributaries, is briefly open. Without action, a new New Orleans - a combination of an old city that retains many of its historic charms and a new city better suited to serve as a major international port - will go unrealized. And the people who would return to New Orleans rebuilt as before, but with higher levees and certain other conventional flood control works, will remain unduly subjected to the wrath of hurricanes and devastating floods. No one in the Big Easy should rest easy with this future.

G.2.10 Curole, W. (2005). *Comprehensive Hurricane Protection Plan Guidelines, General Manager, South Lafourche Levee District Presentation to French Quarter Citizens Group, November 2005.*

Wendell Curole provided the following concepts for provision of a comprehensive hurricane protection plan for populated areas of southern Louisiana that included:

- *Protection of evacuation routes with a hurricane levee system or flood proofing.*
- *Plan for freshwater and sediment diversion projects to regain natural protection from storm surges.*
- *Coordinate on-going flood studies by the Corps of Engineers and others. State and local officials should decide when and where the flood protection should be directed.*

- *Keep the public informed of the threat a hurricane poses to them and their property.*
- *Increase level of already constructed hurricane protection levees to Category 4 or 5 standards.*
- *Plan for internal drainage from the upper reaches of the drainage basin to the barrier islands: a) Gravity drainage through water control structures in the hurricane levee, b) Interior drainage levees, c) Pump systems, d) Channel improvements.*
- *Protection of infrastructure (highways, navigation channels).*
- *Stress elevation in construction of buildings through education not regulation.*

Curole stressed that "the most dependable way to protect from all types of flooding (river, rainfall, or hurricane) is constructing buildings with as high an elevation as possible."

G.2.11 Lopez, J. (2005). *The Multiple Lines of Defense Strategy to Sustain Louisiana's Coast.* Report to Lake Pontchartrain Basin Foundation, New Orleans.

The tragedies of Hurricanes Katrina and Rita in 2005 have revealed to the world the enormous challenge Louisiana now faces. South Louisiana appears to have entered a period when the convergence of two powerful forces is working against its survival. Since the 1950's, the processes driving coastal loss have continued only slightly abated. Since 1990, meteorological and oceanic processes driving tropical systems have more frequently generated Category 4 and 5 hurricanes. More destructive hurricanes are predicted for coming decades. South Louisiana's ongoing peril is the continued overlap of weakened hurricane protection with more frequent and intense hurricanes.

In light of this predicament, how can the coast and culture of south Louisiana survive? The survival of a culture and a region is at stake. Hurricanes Katrina and Rita may have narrowed the field of discussion from what we might want, down to what we absolutely need. There is a growing consensus that what is needed is a pragmatic and effective strategy to integrate both coastal habitat restoration and engineered flood protection, such as levees. This strategy must be established soon and while under duress. The next hurricane season will always be just 180 days away.

Ibis is a plan of how to merge coastal habitat restoration and engineered flood protection. When both are achieved, the ecology and economy of the region can continue and together they will save and sustain Louisiana's Coast for future generations. Ibis can be achieved and this is how it may be done.

The examples shown and areas discussed in this report focus on the delta portion of the Louisiana coast; however, the same principles are applied to the entire coast of Louisiana. Maps of the chenier plain in southwestern Louisiana are under development.

The Multiple Lines of Defense Strategy proposes that two key elements of the coast be managed and perpetuated that will together sustain the coast. The two planning elements are:

- 1) Utilizing natural and manmade features which directly impede storm surge or reduce storm damage (Lines of Defenses),
- 2) Establishing and sustaining the wetland habitat goals (Target Habitat Types).

Ibis two, when integrated, can sustain the coast. This strategy is not a new restoration technology; rather, it is a new strategy to coordinate and prioritize conventional restoration

methods and projects for coastal habitats.

This coastal management vision acknowledges the reality that environmental habitat restoration and engineered flood protection are not separable goals. It is unlikely that sufficient flood protection in south Louisiana can be accomplished by a “levees only” strategy. It is also true that adequate flood protection cannot be accomplished by simply restoring coastal habitats. Both habitat restoration and engineered flood protection must proceed in a coordinated plan which maximizes regional benefits and minimizes costs. Because there are substantial costs associated with both coastal habitat restoration and engineered flood protection, their financial justifications are codependent on a sustainable coastal economy.

The Lines of Defense include the Gulf of Mexico shelf, the barrier islands, the sounds, marsh landbridges, natural ridges, manmade ridges, flood gates, flood levees, pump stations, home & building elevations, and evacuation routes. Identification of these Lines of Defense on a map allows hydrologists, levee district managers, emergency personnel, etc. to share a common landscape template to evaluate, abate, and monitor flood risk or other storm impacts.

The Target Habitat Types include swamp, fresh marsh, intermediate marsh, brackish marsh and salt marsh. Maintaining the target salinity regime and then optimally managing the habitat types, puts all the natural resources and resource managers on the same page with a unified biological and natural resource vision. Since each habitat has a differing profile of vegetation, fisheries, soils, hydrology, waterfowl, etc., it is imperative that geographic areas of each habitat be identified to optimize restoration and management for the needs for each habitat type. The establishment and maintenance of the Target Habitat Types requires a corresponding salinity gradient goal. This salinity gradient would be maintained by controlled river reintroductions and, if needed, hydrologic restoration.

Types for coastal planning are useful separately to articulate and develop projects. However, additional value is gained by overlaying of these elements on a single map. This integrated map becomes the central coastal management planning tool since it depicts a unifying landscape vision for the coast, embracing environmental habitat restoration and engineered flood protection. The Lines of Defense define priority areas for coastal habitat restoration; that is, the “where” of restoration. The target habitats types define potential restoration methods or limitations of coastal habitat restoration; that is, the “how” of restoration. This complimentary relationship together focuses restoration finding on priority areas and guides the type of restoration possible or required. Coastal habitat restoration using traditional restoration techniques may proceed while producing ecologic benefits and enhancing flood protection to the coastal infrastructure. The integrated map may satisfy the National Research Council recommendation to include an explicit map of the desired future condition or goals for the coast.

At least two important results of the Multiple Lines of Defense Strategy should be noted. One is that a natural ridge’s ecologic function is recognized as generally being a hydrologic barrier. This makes their ecologic function compatible with using them as economic corridors. Natural ridges such as Bayou Lafourche may be leveed and still retain its ecologic function, which opens an economic corridor with flood protection. A second result is that restoration is generally focused on remaining marsh, and avoids large areas where previous heavy wetland loss has occurred. This may avoid areas with chronic causes for wetland loss that may be ongoing, such as subsidence.

In summary, the proposal described here is a unified vision for the coast which embraces environmental habitat restoration as well as engineered flood protection. Goals can be clearly articulated through maps of the Target Habitat Types and Lines of Defense. The Multiple Lines

of Defense Strategy should be evaluated quickly for the entire Louisiana coast to begin implementation if it is deemed to be warranted.

The eleven Lines of Defense are:

1st: Offshore shelf within the Gulf of Mexico. The offshore shelf ranges in depth from 300 feet at the shelf edge to zero depth at the gulf shoreline. Its width varies from a few miles to hundreds of miles. The primary benefit of the shallow shelf is to dramatically reduce wave height and wave energy from an approaching tropical system. A negative aspect of the shelf is that it will promote higher storm surges inland. The variable influences on storm surges due to the geometry of the shelf needs to be considered for storm surge analysis. Also, dredging activities on the shelf should avoid increasing shoreline erosion by wave refraction around dredge holes. The gulf fisheries and the oil and gas industry are key economic aspects of the shelf. Examples: Narrow shelf at the mouth of Mississippi River & Wide shelf offshore from Cameron Parish

2nd: Barrier Islands. The Louisiana barrier island shoreline is characterized by fragmented barriers or shoals with low vertical profiles and low sand content. However, barrier islands provide an important wave barrier for interior sounds and coastal marsh. The primary benefits of barrier islands are the near-complete reduction in wave height and the slight reduction in storm surge further inland. A negative aspect of barrier islands is their ephemeral nature and unpredictable local impacts to them from hurricanes. Barrier islands also have significant recreational aspects such as fishing and birding. Examples: Chandeleur Islands and Grand Isle

3rd: Sounds. The primary benefit of the sounds is to provide a relatively shallow water buffer to deep water currents. Sounds do have a negative aspect during storms by allowing waves to regenerate on the on the sound side of barrier islands. Also, sounds may cause storm surge and wave erosion on the back side of barrier islands.

4th: Marsh Landbridges. Marsh landbridges are areas of emergent marsh with relative continuity compared to adjacent bays, sounds or areas of significant marsh/land loss. Ideally, landbridges connect other elevated landforms such as natural ridges. Since some ridges are developed and have adjacent levees, marsh landbridges may also bridge adjacent levee systems and economic corridors. Marsh landbridges compose much of the residual internal framework of the coast which reduces fetch and shoreline erosion of interior marshes and lagoons. Landbridges impede storm surge movement inland and protect other emergent marsh areas that may perform the same function. Some landbridges are threatened themselves by various processes of marsh loss and need to be sustained through restoration and maintenance. The landbridges represent an increasing fraction of the remaining emergent marsh of the coast and provide typical high productivity and fishery benefits typical of coastal wetlands. Examples: East Orleans landbridge, Biloxi Marsh landbridge, Barataria Basin landbridge, Upper Terrebonne Bay landbridge, Grand Lake-White Lake landbridge, Western Marsh Island landbridge, south Calcasieu Lake landbridge

5th: Natural Ridges. In southeast and central Louisiana, most natural ridges are the natural levees of abandoned distributary channels. These channels now act as tidal channels and are often colloquially named bayous or rivers. In southwest Louisiana, most natural ridges are cheniers running parallel to the Gulf coastline. Natural ridges may have continuous elevation of several feet and, therefore, will impede overland flow across the ridge and potentially reduce storm surge. Natural ridges often define (at least historically) the hydrologic basins of the coast. Natural ridges are most effective when they have at least 6 feet of elevation and well drained soils to maintain upland forests. Forests will also slow the movement of overland flow and may also provide a wind barrier. Natural ridges tend to be the economic corridors across the coast

including primary state highways and coastal communities. These highways are also likely to be evacuation routes. Examples: Bayou la Loutre, Bayou Lafourche

6th: Manmade Soil Foundations. Manmade soil foundations for transportation may provide incidental benefit to storm surges. Railroads, highways and spoil banks may run parallel to the coast and locally provide a manmade ridge several feet in height. These foundations may have settled and may need improvement to provide reliable transportation routes without chronic flooding. If highway improvements are contemplated, the effects of storm surge may be considered. Examples: Highway 90, Hwy 82.

7th: Flood Gates. Flood gates are typically designed to withhold flood water and, therefore, remain open under most conditions. Flood gates are generally open so as not to impede navigation or natural ebb and flow of tides and aquatic organisms. Flood gates would be closed during a threat of flooding and to reduce flood tides in channels. Because of the generally low elevation of the coast, the effectiveness of flood gates may depend on the nearby topography or constructed features such as levees or spoil banks. Examples: Bayou Bienvenue, Bayou Dupre

8th: Flood protection levees. Flood protection levees are designed and constructed for flood protection of municipalities or other coastal infrastructure features. Levees are generally designed to be an absolute barrier defining a flood side and a protected side. The intent is to have zero storm surge flooding on the protected side, but an unintended consequence may be to increase water levels on the flood side. Levees are generally not designed to be overtopped or to withstand significant wave erosion. Exceptions include “potato levees” or other low relief levees designed to reduce flooding from non-storm tides. Typical hurricane protection levees protect limited portions of the coast with intense economic development. Examples: St. Bernard levee, Jefferson and Orleans Parish levees on Lake Pontchartrain

9th: Flood protection pumping. Pumping stations are generally within leveed areas and are used to reduce flood risk from rainfall and are not designed to pump out flood water from a significant levee breach. Most pumping stations are not prepared with fuel, staff or other requirements to be effective to pump out flood water from a significant levee breach. Generally, these are large capacity pumps which displace water vertically above the water level on the flood side of the levee. Pumping stations are generally to protect areas of intense development. Examples: Orleans and Jefferson Parish’s pumping stations

10th: Elevated homes and businesses. All homes and businesses in south Louisiana are subject to being flooded if they are not elevated above the normal land elevation. Even those behind levees are not 100% safe. Hurricanes Katrina and Rita made this painfully clear. Any attempts to reduce storm surge height or its extent are limited by the intensity and attributes of particular storm events. Since there will always be the potential of a storm exceeding the limits of protection from storm surges, immovable assets such as homes and businesses should be elevated to the appropriate flood elevation risk. This is the last line of defense for immovable assets. Elevated homes also provide important side benefits such as improved protection from termites and more economic capacity to re-level or raise the houses due to settlement or increased flood risk. Example: pre-1940 housing in New Orleans, LUMCON, Marina del Ray in Madisonville

11th: Evacuation. Evacuation routes are typically highways, but could also include other means of transportation such as railroads, air transportation, etc. Evacuation routes are the last line of defense for people or moveable assets. Evacuation routes and procedures should be established for the coast. Ideally, evacuation routes may also serve as re-entry routes for first responders and

as routes to re-populate after a storm event. Evacuation routes are generally selected based on capacity to move a large number of people to safer areas as a storm approaches the coast. Some routes may be subject to flooding quickly and need to be improved. Examples: Regional contra-flow evacuation plan for southeast Louisiana."

G.2.12 Committee on the Restoration and Protection of Coastal Louisiana (2006). *Drawing Louisiana's New Map*, Ocean Studies Board, National Research Council, The National Academies Press, Washington DC.

Coastal wetlands develop within a fine balance of many geomorphologic and coastal ocean processes. Relative sea level rise, wave action, tidal exchange, river discharges, hurricanes and coastal storms, and the rates of sediment accretion due to sediment deposition and accumulation of organic material play particularly important roles. The interplay of these processes and the wetland's resilience to natural or anthropogenic perturbations determine its sustainability. Some of the processes of land loss and gain in the Louisiana coastal area are natural and have occurred for centuries. Others are the result of human activities in the wetlands and the watershed of the Mississippi River system.

Annual land loss rates in coastal Louisiana have varied over the last 50 years, declining from a maximum of 100 square kilometers (km²) per yr (39 square miles [mi²] per yr) for the period 1956—1978. Cumulative loss during this 50-year period in Louisiana represents 80 percent of the coastal land loss in the entire United States. Initial efforts to prevent catastrophic land loss were implemented under the federal Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) in partnership with Louisiana's efforts through Act 6 (L.A.R.S. 49:213 et seq.). Passed in 1990, CWPPRA called for the development of a comprehensive Louisiana Coastal Wetlands Restoration Plan (P.L. 101-646 §303.b). The first such plan was completed in 1993 and has been in use since that time. In addition, the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority prepared a plan for the coast in 1998 entitled *Coast 2050: Toward a Sustainable Coastal Louisiana* (Coast 2050).

Coast 2050 was developed under a number of federal and state legislative mandates and is the result of recognition by federal, state, and local agencies that a single plan and coordinated strategy were needed. Coast 2050 was then appended to the 1999 U.S. Army Corps of Engineers 905(b) reconnaissance report. In October 2003, a draft comprehensive study (*Louisiana Coastal Area, LA—Ecosystem Restoration: Comprehensive Coastwide Ecosystem Restoration Study* [draft LCA Comprehensive Study]) for implementing coastal restoration was released. After reviewing the draft LCA Comprehensive Study, the U.S. Office of Management and Budget requested a near-term approach to focus the scope of work and maintain restoration momentum. The resulting final version of *Louisiana Coastal Area (LCA), Louisiana—Ecosystem Restoration Study* (LCA Study) was released by USACE in November 2004. As plans for completion of the LCA Study were being finalized, Louisiana's Office of the Governor requested that the National Academies review the LCA Study's effectiveness for long-term, comprehensive restoration development and implementation.

The LCA Study and its envisioned successors are unique in many respects, including geographic scope, pervasiveness of the destructive processes involved, complexity of potential impacts to stakeholders, success of preceding efforts to achieve stakeholder consensus, and documentation of earlier planning and restoration efforts. Indeed, the environmental and social

challenges confronting coastal Louisiana in the near and distant future are without precedent in North America. Clearly, execution of the LCA Study alone will not achieve its stated goal “to reverse the current trend of degradation of the coastal ecosystem,” although successful completion of some of the projects outlined in the LCA Study will reduce this trend, thereby representing an important step toward the goal of sustaining or expanding wetlands in some local areas. By definition, the activities proposed in the LCA Study were intended to provide a foundation for successful future restoration and protection efforts, including those developed and implemented in response to hurricanes like Katrina and Rita.

Taken individually, the majority of the projects proposed in the LCA Study are based on commonly accepted, sound scientific and engineering analyses. It is not clear, however, that in the aggregate, whether or not these projects represent a scientifically sound strategy for addressing coastal erosion at the scale of the affected area. Thus, at foreseeable rates of land loss, the level of effort described by the LCA Study will likely decrease land loss only in areas adjacent to the specific proposed projects. As stated in numerous USACE policy statements and recommended in past NRC reports, planning and implementation of water resources projects (including those involving environmental restoration) should be undertaken within the context of the larger system. A group of projects within a given watershed or coastal system may interact at a variety of scales to produce either beneficial or deleterious effects. Cost-effectiveness analyses discussed in the LCA Study and in supporting documents reflect an effort to identify least-cost alternatives but do not appear to reflect a system-wide effort to maximize beneficial synergies among various projects. The selection of any suite of individual projects in future efforts to restore coastal Louisiana should include a clear effort to maximize the beneficial, synergistic effects of individual projects to minimize or reverse future land loss. Further, because there is a finite availability of water flow and sediment and many of the proposed projects must function for decades to deliver maximum benefit, care should be taken to ensure that implementation of an individual project does not preclude other strategies or elements that are being considered for the future. To achieve this, the development of an explicit map of the expected future landscape of coastal Louisiana should be a priority as the implementation of the LCA Study moves ahead.

The approaches advanced in the LCA Study focus largely on proven engineering and other methods to address land loss at the local scale. In general, individual projects appear to be based on commonly accepted, sound scientific and engineering analyses. The emplacement of 61 kilometers [kin]) (38 miles [mu]) of revetment along the banks of MRGO as one of the five major wetland restoration projects proposed in the LCA Study, however, does not appear to be consistent with the study’s stated goals. Despite an estimated cost of \$108.3 million,¹ this project is expected to reduce land loss by only 0.5 km² per yr (0.2 mi² per yr) over the next 50 years. (Louisiana is projected to lose an average of 26.7 km² per yr [10.3 im² per yr] over the next 50 years.) Although the location of the land loss may make it more significant, the need for and potential value of this project are directly related to the outcome of a study being conducted by USACE, scheduled for completion in FY 2005, to evaluate the potential decommissioning of MRGO for deep draft navigation. In addition to questions regarding the appropriateness of this particular project, its selection casts doubt on the rigor of the ranking and selection process. The selection of the restoration efforts of MRGO as one of the five major projects to be carried out as part of the LCA Study should be reconsidered in light of the limitations of expected benefits and the results of ongoing studies on the decommissioning of MRGO for deep draft navigation. If a decision is made to decommission MRGO, various options could be considered, including complete closure, that would significantly reduce the need to strengthen the levees along its

route. If partial closure is chosen, perhaps maintaining MRGO for shallow draft vessels, some of the work along the outlet may still be required. Restoration efforts requiring planning would be more fully informed once a final decision has been made.

"Conflicting stakeholder interests represent one of the greatest barriers to robust coastal restoration efforts in Louisiana. A dominant human-related component of land loss is the constraint on the river system imposed by spoil banks and levees, but these features also provide benefits to a range of stakeholders. By minimizing the cost of dredging and reducing uncontrolled flooding in inhabited and agricultural areas, these features support important local economic activities. Many of Louisiana's inhabited areas are located on natural levees formed by deposition on the floodplain during major floods. Valuable agricultural land was originally maintained at an elevation above water level through flood-derived sedimentation but is now protected by levees, which preclude new sediment introduction. Obviously, the prospects are low that sediment-rich water will be intentionally allowed to flood broad expanses of urban and agricultural land to maintain elevation with the pace of relative sea level rise.

As discussed above, locating individual projects in an effort to maximize positive synergistic effects will tend to concentrate efforts into selected areas within coastal Louisiana. Although distributing individual projects, and the benefits associated with them, across the entire region may be less contentious, such an approach will either drive up the total cost or reduce the likelihood of success for a given amount of effort and expenditure. Successfully implementing a project selection strategy that maximizes synergistic effects of individual projects will require greater popular support for a comprehensive plan both from within the state and at the national level. Such support will likely come about only through greater public involvement in the decision-making process of a comprehensive plan. Louisiana's restoration goals should be better defined and more clearly communicated to the public. This means that maps of the region and projected land-use patterns with and without various restoration projects should be circulated. Without a clarified definition of the temporal and spatial dimensions of "restoration," unrealistic expectations and disappointments are likely. The projections can be revised as additional data become available and a better understanding is developed through the adaptive management program and the science plan.

Although some inhabited areas will require relocation in order to carry out some proposed wetland restoration efforts, it will be difficult to persuade those affected by local relative sea level rise to abandon their property without a program of financial compensation and a social plan to maintain the cultural integrity of the affected communities. It is important that decisions involving relocation and compensation following Hurricanes Katrina and Rita, or in response to future events, be made in such a manner as to minimize the likelihood of additional relocation or disruption in response to future restoration efforts. The appropriate decisions and responses after major storms have to reflect a broad consensus about the future nature of coastal Louisiana and may have to include managed retreat. Managed retreat and various restoration strategies should include early and active stakeholder participation and concurrence. Relocation could occur either gradually with a few families at a time or at a much higher rate in areas severely affected by Katrina and Rita or future events. This is not intended to preclude reoccupation of the many areas affected by the recent hurricanes or similar events in the future. Rather, this approach is intended to minimize the potential for disrupting lives and property a second time as efforts to protect and restore Louisiana unfold in coming years.

Finally, the LCA Study calls for a long-term study of the possibility of establishing a new lobe of active delta development through a diversion near Donaldsonville, Louisiana. Termed the Third Delta, this proposed restoration feature was among a group of possible features² that was shown to yield limited benefits at a substantially higher cost than the projects identified for funding in the LCA Study. An alternative scenario for retention of sand and silt now lost beyond the shelf break would involve diverting the main flow of the Mississippi River toward the west of its present main channel somewhere between New Orleans and Head of Passes. An intermediate- and long-term consequence of this action would be the abandonment of the active Birdsfoot Delta by the Mississippi River. A clear benefit would be the nourishment of eroding coastal reaches to the west. Although this alternative has been widely acknowledged as possible, its feasibility, for various reasons, has not been considered seriously by USACE. Therefore, it is not yet possible to assess the potential advantages and disadvantages of Birdsfoot Delta abandonment at this time. Obviously, implementation of such a strategy would have to be accompanied by the creation of a deep navigation access channel somewhere downstream of New Orleans but upstream of Head of Passes. Though the size of the area it would impact would still make it controversial, some consideration should be given to an alternative or companion to the planned Third Delta, such as a larger-scale diversion closer to the Gulf of Mexico, that would capture and deliver greater quantities of coarse and fine sediments for wetland and barrier island development and maintenance.

The LCA Study states that “execution of the LCA [Study] would make significant progress towards achieving and sustaining a coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the nation.” The economic analysis provided within the LCA Study and its supporting documents, however, includes only cost-benefit analyses of alternative approaches to meet ecosystem restoration objectives, as is consistent with USACE policy for evaluating projects proposed as National Environmental Restoration efforts. Evaluating the benefits of restoring coastal Louisiana in terms of national economic interests, as implied by the statement of task, would have required USACE planners to carry out analyses more consistent with proposing the effort as a National Economic Development project. USACE officials appeared to view the efforts described within the LCA Study as falling under National Environmental Restoration as opposed to National Economic Development and, thus, did not attempt to identify and meaningfully quantify the contribution to the economy of the nation. Since the information necessary to evaluate proposed coastal Louisiana efforts in terms of the national economy is not provided in the LCA Study, there is insufficient information available for the committee to comment credibly. Carrying out such an analysis would require significant effort and resources beyond those available to the committee in the 10 months following the release of the LCA Study in November 2004. This said, some components of such an analysis can be articulated.

The LCA Study presents sufficient information about the importance of some components of the natural and built environment in coastal Louisiana (e.g., system of deep water ports, oil and gas receiving and transmission facilities, complex and extensive urban landscape, robust commercial fishery) to demonstrate that substantial economic interests are at stake in coastal Louisiana and that these interests have national significance. The immediate impacts of Katrina underscore the importance of New Orleans, and adjacent areas of the Gulf Coast, to the national economy. Establishing the true, national economic significance of efforts to restore coastal wetlands in Louisiana as proposed in the LCA Study, however, must go beyond simply identifying and characterizing these components and should include an analysis of how specific

restoration efforts will preserve or enhance the value of these components (i.e., some restoration efforts may have little influence on the vulnerabilities of specific components of the natural and built environment in coastal Louisiana) and should determine how the national economy would respond to the loss or degradation of components (e.g., what is the capacity for similar components in other regions to compensate for the loss and on what time scales?). If, as implied by the statement of task, greater emphasis is to be placed on the national economic benefits of restoring and protecting coastal Louisiana, future planning efforts should incorporate meaningful measures of the economic significance of these projects to the nation consistent with procedures normally employed to determine the value of a project or a suite of projects for National Economic Development. As a greater understanding of the short- and long-term economic impacts of Katrina and Rita becomes available, a more meaningful effort to evaluate the national economic significance of protecting the natural and built environment in coastal Louisiana will be possible. Such information would provide an important context for decision making; however, it will still be important to understand the role wetlands play in protecting specific components of the overall system and to determine how specific restoration efforts can enhance that protection. While wetlands and adjacent barrier islands and levees are known to reduce impacts from waves, their more complex role in reducing storm surge is less well known. Surges contain multiple components, including barometric tide effects, wind stress-induced setup, wave-induced setup, and Coriolis forces. As was pointed out repeatedly in the public media during Katrina and Rita, in the northern hemisphere the eastern side of a hurricane tends to drive water northward in a counterclockwise manner. If a storm stalls off a coast for a significant period of time, it will continue to drive water onshore for a prolonged period, regardless of the nature of any intervening wetland or barrier island. Thus, the potential for reducing risk due to storm surge from a particular storm is more difficult to predict.

Conversely, the significance of the coastal Louisiana wetlands to the nation in terms of both their inherent uniqueness and the ecosystem services they provide is more thoroughly documented in the LCA Study, its predecessor reports, and the scientific literature. Although efforts to restore and protect Louisiana's wetlands will likely provide some unknown but potentially significant protection against coastal storms and hurricanes, those efforts should not be evaluated primarily on their significance for National Economic Development.

The two major components of the LCA Study, a series of restoration and demonstration projects designed to be implemented over a 10-year time frame and the development of a robust intellectual infrastructure to inform future project design and implementation, are at the heart of the phased approach referred to in the statement of task. This approach has decided advantages and disadvantages. As is clear from the LCA Study, simply keeping pace with land loss in Louisiana will require an ongoing effort. Any substantial gains in the next few decades will require a robust effort, an effort that needs to be well informed by a thorough understanding of both the natural physical and ecological processes involved and the viability of various restoration techniques to address land loss at a massive scale. Establishing methods that allow projects to evolve in the face of increased understanding is prudent. Conversely, limiting project selection to those features where construction can be initiated in 5—10 years presents a significant handicap for laying the groundwork for a comprehensive, multidecadal effort.

For example, the 10-year implementation criterion resulted in the selection of projects that already existed in the USAGE and the CWPPRA planning process. This time constraint precluded consideration of projects with solid potential for long-term benefits that had not yet been fully designed (precluding the initiation of construction in 5—10 years). Similarly, this

criterion and the need to demonstrate solid near-term success likely precluded large-scale and innovative projects that (1) affect significant sediment delivery to the system (such as abandonment of the Birdsfoot Delta), (2) maximize synergistic effects for reducing land loss over longer time scales by the selection of strategically located or larger-scale projects, or (3) address some of the difficult issues associated with stakeholder response. While the efforts preceding the LCA Study have achieved a laudable degree of unanimity among stakeholders on the conceptual restoration plan, this unanimity will be tested by the difficult decisions associated with implementation of the larger-scale projects designed to achieve a more effective delivery of sediment, water, and nutrients over a larger area. The project selection procedure requires more explicit accounting of the synergistic effects of various projects and improved transparency of project selection to sustain stakeholder support. Furthermore, beneficial, synergistic interaction among projects cannot be assumed but should be demonstrated through preconstruction analysis.

It is important to note that, by definition, the activities proposed within the LCA Study are intended to lay a foundation for more effective and robust efforts to preserve and protect coastal Louisiana. By its own analysis, the LCA Study points out that constructing the five restoration features it proposes would reduce land loss by about 20 percent (from 26.7 km² per yr [10.3 mi² per yr] to 22.3 km² per yr [8.6 mi² per yr]) at an estimated total cost of roughly \$864 million (or \$39,400 per hectare [\$15,900 per acre]) over the 50-year life of the projects, not including maintenance and operational costs.

Actual land building will be experienced only in areas adjacent to the implemented projects. The significant investment represented by these projects and the efforts to develop the tools and understanding necessary to support future restoration and protection efforts will yield a substantial return of benefits only if future projects are carried out in a comprehensive manner. The funding required to carry out the activities described in the LCA Study should be recognized as the first of a funding continuum that will be required if substantial progress is to be made. A comprehensive plan to produce a more clearly articulated future distribution of land in coastal Louisiana is needed. Such a plan should identify clearly defined milestones to be achieved through a series of synergistic projects at a variety of scales. (While a comprehensive plan is needed, this does not necessarily imply endorsement of the draft LCA Comprehensive Study, which was not formally released or reviewed as part of this study.) The review detailed in this report found no instance where the proposed activities, if initiated, would preclude development and implementation of a more comprehensive approach. Conversely, many examples were identified where implementing the proposed activities would support a more comprehensive approach. Thus, the efforts proposed in the LCA Study should be implemented, except where specific recommendations for change have been made in this report and only in conjunction with the development of a comprehensive plan.

As the State of Louisiana and the nation begin to recover from Katrina and Rita, efforts to restore wetlands in Louisiana will likely compete with reconstruction and levee maintenance or enhancement efforts. As this report and numerous other NRC reports have pointed out, efforts to design and implement water resource projects (including environmental restoration and flood control projects) should be carried out within a watershed and coastal system context. Ongoing discussion of long-term response to Katrina and Rita underscores the need to consider restoration and reconstruction as a seamless process that should be informed by a coherent, comprehensive plan that addresses the issues raised in this report. Therefore, efforts to rebuild the Gulf Coast and reduce coastal hazards in the area should be integral components of an effective and comprehensive strategy to restore and protect coastal Louisiana wetlands.

G.2.13 Working Group for Post-Hurricane Planning for the Louisiana Coast, A New Framework for Planning the Future of Coastal Louisiana after the Hurricanes of 2005, University of Maryland Center for Environmental Science, Cambridge, January 26, 2006.

The principal messages abstracted from our report are the following:

1. The large-scale deterioration of coastal landscapes, particularly during the past fifty years, threatens the sustainability (viability over this century) of both human habitation and the rich natural resource base of coastal Louisiana. Storm events such as hurricanes have both negative and positive effects on wetlands that dominate these landscapes, but deterioration of these wetlands is mostly caused by human activities that both disrupt natural processes building the coastal landscape (river inputs, sedimentation, tidal fluctuation, etc.) and accelerate destructive processes (altered hydrology, subsidence, etc.). **In the long term, hurricane protection for larger population centers, including the New Orleans region, can only be secured with a combination of levees and a sustainable coastal landscape.** This will require adapting to changing conditions by re-establishing the constructive processes associated with distributing Mississippi River water and sediments across the coastal landscape, as well as alleviating the other destructive effects of past or future human activities.
2. The sustainable coastal landscape must include extensive marshes and swamps and the bayous, coastal barriers and ridges that characterize the Mississippi deltaic plain and the Chenier plain in the southwest. If natural processes are not interrupted, coastal wetlands are able to sustain themselves over hundreds of years even where the land is subsiding or the sea level is rising. **With presently observed subsidence rates and anticipated acceleration of sea-level rise, most-although not all-of the coastal landscape could be maintained through the 21't century. And with efficient management of the river's resources, this landscape could be expanded in some places.** However, this result can only be achieved with very aggressive, strategic, and well-informed restoration efforts, varying in size and objective but integrated within a landscape management plan.
3. Hurricanes Katrina and Rita provide poignant evidence that no longer can coastal ecosystem management and restoration, flood protection, and navigation be planned, executed and maintained independently. **We must integrate planning, investment and management decisions under a new framework in order to secure these multiple purposes, while recognizing: the forces of nature; the imperative to protect life, property and communities; the value of natural resources and ecosystem services; the environmental and economic sustainability of the solutions; and financial constraints.** Furthermore, planning to support this integrated decision making must be an adaptive process that creates and uses new knowledge about this "working coast." Integrated management requires that coastal landscape restoration alternatives be screened through a "storm damage reduction filter" (e.g., how might they reduce risks and how quickly might the result be realized?). Conversely, hurricane storm damage reduction or navigation alternatives should be screened through an "environmental consequences filter" (e.g., how might the elements affect ecosystem services and the sustainability of the landscape?). This does not mean that restoration features are justified only because they significantly reduce storm damages-many are required to sustain environmental resources or build landscapes away from population

centers. It does mean that priorities must be determined by multiple benefits more than has been the case in past planning.

4. **The near-term critical restoration features selected by Louisiana Coastal Area Ecosystem Restoration Study should be reexamined and prioritized to assure that they provide environmentally and economically sustainable approaches that advance both ecosystem restoration goals and support storm damage reduction.** While a truly integrated planning process has not yet been developed, there is sufficient understanding to prioritize near-term restoration features based on their likely contribution to the effectiveness of existing and intended storm damage reduction efforts, as well as advancing ecosystem restoration. Furthermore, long-term restoration strategies for the four geographic subprovinces should be refined by incorporating integrated objectives and framed around critical foundation features.
5. **Federal and State governments should engage scientists, economists, engineers, government officials, communities and stakeholders to develop a spatially explicit vision of a future coastal Louisiana that incorporates long-term challenges, opportunities and overarching goals.** As recently stressed by the National Research Council, such a vision should guide integrated, multiobjective management within geomorphic subprovinces and along the entire coast throughout the planning and project implementation process. Stakeholders should participate in formulating and evaluating alternatives that recognize the opportunities and limitations associated with maintaining the status quo under the perilous, urgent and changing circumstances. The vision should anticipate future changes that may affect options, for example energy scarcity, climate change and demographic shifts. As adaptations occur and new projects are realized, the vision for the coast can be revised in light of changing landscape and socioeconomic conditions, knowledge of the system, and social preferences.
6. The President and Congress have mandated studies of potential supplements to the existing but strengthened storm protection works. Particular attention is being given to a continuous peripheral coastal defense (a hurricane barrier) similar to that used in the Netherlands. Although the systematic approach of the Dutch is commendable, substantial differences between the Netherlands and south Louisiana limit the applicability of their model, including contrasts in human settlement patterns, land uses, geology, hydrodynamics and coastal ecology. Maintaining functioning estuarine ecosystems and self-sustaining wetlands inside and adjacent to such peripheral defenses would be extremely difficult, if not impossible, because extended levees and floodgates would obstruct key hydrological processes that maintain the coastal landscape. The relatively dispersed populations and low intensity of land use may make investment in such a barrier difficult to justify. Rather than simply adopting the Dutch approach, the plan for Louisiana should recognize the different Louisiana setting and take advantage of its characteristic coastal landscape. **Storm damage reduction should be achieved through a combination of stronger inner defenses around larger population centers; broader, self-sustaining wetland landscapes that reduce storm surge and wave fetch; restrictions along artificial channels to limit storm surge propagation; and maintaining barrier islands along selected areas of the coast.** This may include lower elevation, semi-porous barriers placed between the levees protecting population centers and the open coast that attenuate storm surge but allow tidal exchange. However, any such barriers should be compatible with sustainable coastal landscapes. To the extent possible, extensive wetland areas should not be enclosed by levee systems.

7. Navigation channels that cut across the coastal gradient have resulted in substantial degradation of wetland habitats, thus increasing hurricane surge vulnerability. **Future integrated planning and decision making should recognize, account for and mitigate the disruption of coastal landscape dynamics when formulating and evaluating navigation channel expansion, maintenance or abandonment.** One of these channels, the Mississippi River Gulf Outlet (MRGO), is likely to be decommissioned as a deep-draft navigation channel as a result of the risks it poses and its weak economic contribution. However, even if mostly closed it will remain a feature on the coastal landscape that has to be integrated into a coastal restoration and storm damage reduction strategy for the vulnerable east side of Greater New Orleans.
8. A new management framework requires improved organizational arrangements for coordinating and integrating planning, decision making, implementation and evaluation. **A joint Federal-State body should be given the responsibility and organizational and fiscal support for guiding the program.** The Corps, or another appropriate agency, would continue to have the responsibility to design, construct and, if authorized, operate and maintain projects. An integrated assessment group and an engineering and science program focused on reducing decision-relevant uncertainties (scientific and otherwise) would support decision making in an adaptive management process.
9. **Authorization and financing should be separated from the Water Resources Development Act process.** The integrated planning process, engineering and science program and smaller investment projects should be supported by a programmatic authorization and a more reliable appropriation stream. Funding for larger projects should be provided through a Congressionally-chartered coastal investment corporation.
10. **Project planning should rely on innovative decision-support analyses that engage stakeholders and responsible agencies in resolution of conflicts and in identifying and synergies among projects.** The analyses would formulate and evaluate project alternatives using performance measures derived from the policies, goals and objectives of the Nation and the region. Significant areas of risk and uncertainty will be highlighted for decision making, as well as for establishing monitoring and research priorities for the adaptive management program."

Expanded Hurricane Protection

As made clear by the President's announcement, initial efforts to improve hurricane protection will focus on strengthening existing levees and floodwalls protecting urban areas. An in-depth analysis of the feasibility and environmental consequences of expanded hurricane protection (EHP) is beyond the scope of the framework developed here. The Corps of Engineers is currently assessing the feasibility of such an expanded and enhanced protection system, the details of which are not yet in the public domain. Based on general information made available to the working group we discuss four possible protection strategies and their implications for restoration and conservation of coastal ecosystems:

Strategy 1: Protect only New Orleans and larger population centers by strengthening existing protection systems without providing additional flood protection farther out in the coastal zone. Restoration would focus on the same activities that were being planned before the hurricanes, but with more attention to the coastal landscapes adjacent to urban areas.

Strategy 2: Construct storm surge barriers along the inner coastal zone between population centers and the outer coast. Openings in the system for water management could provide potential opportunities for restoration and conservation but altered hydrologic conditions inside the barrier could also have potential negative impacts (e.g., changes in salinity and tidal regimes and reductions in soil accretion due to sediment starvation) that should be considered. Opportunities would still exist for restoration outside the barrier system.

Strategy 3: Establish a first line of defense along the existing coastline, e.g. by maintaining barrier islands, to dampen storm surges. This would potentially minimize the destructive impacts of hurricanes, but modeling should be conducted to quantify the likely benefits. These "speed bumps" would be far from the urban areas with extensive open water and wetlands behind them and, when overtopped, may not adequately reduce the storm surge to prevent extensive damage farther inland. A benefit of outer speed bumps is that they could provide opportunities for landward restoration and continue to allow for sediment deposition during storms. However, these barriers would be highly erosive features requiring long-term maintenance.

Strategy 4: Combine elements of strategies 2 and 3. This would provide the greatest opportunity for both protection of populations and conservation of coastal landscapes. The outer ring of speed bumps limits hydrologic impacts to existing wetlands and also provides opportunities for additional restoration in areas behind the features. The inner series of partial barriers (scenario 2) would provide the same opportunities as described above but synergy between the two protection systems would potentially allow for additional restoration opportunities outside of the inner ring of barriers."

Organization and Funding

The existing plans for strengthening storm damage reduction, initiating the LCA ecosystem restoration, and maintaining and improving navigation infrastructure provide a foundation for planning, but cannot be the only basis for future investments. As we have repeatedly stressed, future decisions on projects and their operations must be informed by an integrated assessment of contributions of these and other projects to the multiple economic, environmental, social and cultural objectives. Such integrated assessment will identify conflicts, synergies and opportunities for securing multiple purposes. The value of, and possibilities for, integrated assessment are illustrated by the preliminary analysis and evaluation included above. Importantly, a future integrated planning process should be structured and supported as an adaptive management program that recognizes and reduces uncertainties to improve the effectiveness of future decision making. Some of those decision-critical uncertainties have been highlighted earlier in this report.

A complex of state and federal agencies already exists with missions, budgets and authorities affecting planning, investment and implementation. However, improvements to the existing organizational, funding and planning structures will be needed to meet planning needs and expedite project implementation by the Corps and the State.

The organizational and funding barriers that have inhibited the adoption of an integrated planning and adaptive decision making process persist . Both new organization and funding reforms are needed to support coastal planning and project implementation by the Corps and the state. We recognize that there are many ways in which the government can organize to carry out integrated planning and decision making as long as the organization, funding and analytical needs for such a new process are served. To better illustrate these concepts, and organizational possibilities, the Working Group offers one such approach.

Maritime Transportation Planning

While the President and Congress have mandated the Corps to take actions and develop investment plans for hurricane protection and ecosystem restoration, they were silent on planning maritime transportation investments. Similarly, the scope of the Coastal Protection and Restoration Authority (CPRA) recently created by the Louisiana Legislature does not seem to encompass maritime transportation. However, a marine transportation network that will continue to be maintained and upgraded over time characterizes the Louisiana coast. Marine transportation interests are primarily concerned with: (1) the availability of a system of reliable channels; (2) transit time from to and from port to deep water; and (3) a minimization of cargo handling costs. These goals will continue to be advanced through new project proposals and maintenance of existing projects. As discussed earlier, some elements of the navigation network can be detrimental to hurricane protection and coastal landscapes. Moreover, innovatively conceived navigation realignments and utilization of existing channels could enhance sediment dispersal through the coastal wetlands or reduce storm damages. Therefore, consideration of plan formulation and evaluation for marine transportation investments should be incorporated into the more comprehensive study authorities and re-organization plans, such as those proposed below.

A New Framework for Coastal Louisiana

Federal Intragovernmental Coordination

At present, the Federal program for coastal planning is led by the Corps of Engineers, but it is not clear how the responsibilities of the other federal agencies will be represented going forward. The new integrated management framework would require tradeoffs that impact agency responsibilities and the streamlining of NEPA and other reviews. It requires the Federal government to speak with one voice. The Comprehensive Everglades Restoration Program (CERP) has been working to overcome interagency coordination barriers and may offer useful experiences, if not a model. The Corps is the lead agency for CERP, but there is extensive involvement by other federal agencies. The federal agencies have joined a Memorandum of Understanding (MOU) specifying a dispute resolution process and a time line for resolution. An interagency MOU, similar to that prepared for the CERP, should be signed by the federal agencies with significant participation in coastal Louisiana planning.

The Corps itself is organized along "business lines" including (a) navigation, (b) flood and storm and flood hazard management and (c) ecosystem restoration. The business line organization can create organizational barriers to integrated planning and evaluation. These organization barriers exist both at the districts and headquarters. Also, Corps planning and funding mechanisms are currently not well structured to meet the challenge of integrated and adaptive management. The Corps headquarters should create a unit, led by a Senior Executive, charged with fostering innovations in the planning and assessment approaches required for the integrated management of the Louisiana coastal area, as well as for CERP, Missouri, Upper Mississippi, the Columbia River and other areas where the multiple missions of the Corps can be best achieved through more integrated management.

Coastal Louisiana Authority

The Corps and the state, as well as partner federal agencies, have developed working relationships through the LCA, the CWPPRA, and as cost-share partners on local navigation and storm damage reduction projects. However, differences persist in viewpoint, ranging from cost-sharing responsibilities to project priorities. For example, project selection through the

CWPPRA Task Force sometimes led to individual agency advocacy and agreements that accommodated the different agencies demands, rather than true integration.

Louisiana has created a new Coastal Protection and Restoration Authority (CPRA) to centralize and integrate its coastal efforts and the Legislature will shortly be considering additional legislation for consolidation of the numerous levee districts. However, there is still a need in coastal Louisiana to clarify the federal-state responsibilities for planning, to make and implement joint decisions, and in so doing to expedite outcomes and ensure coordination with water resource and other activities of the federal and state governments. A Federal-State body, which we will for convenience refer to as the "Coastal Louisiana Authority" (it could alternately be a "board" or "commission"), should be established to fulfill this role. The CLA would be comprised of a small number of members with appointments made by the President and the Governor of Louisiana. The group would have a small administrative staff and an executive director, as necessary to execute its functions. Its authorization should be subject to periodic review and renewal by the Congress and the state. The CLA could report to the President and Governor or operate under the administrative jurisdiction and support of an appropriate federal agency to ensure coordination with the water resources and other activities of the federal government.

The CLA's responsibilities and powers would be limited to three areas. First, it would be responsible for leading the development of joint federal-state policies that govern an integrated investment and management program (discussed later in this section) and for revising those policies over time as new knowledge emerges, and social, economic and environmental conditions change. Second, the CLA would review and approve the use of the programmatic funds (see discussion of authorization and funding, below) allocated for adaptive management and the science and technology program, as well as other uses discussed below. Third, the CLA would direct, receive and use analyses of its Coastal Assessment Group (CAG) and, based on those analyses, stakeholder input and coordination with the Mississippi River Commission and the Louisiana CPRA, would make funding recommendations for significant investments (those that exceed a defined threshold). The recommendations of the CLA would be an affirmation that the proposed project has been formulated and evaluated in full consideration of the agreed policies. Based on such recommendations the Corps, or another appropriate agency, would have the responsibility to design, construct and, if authorized, operate and maintain the recommended project.

Coastal Assessment Group

The CLA would base its advice on analyses conducted under the direction of a Coastal Assessment Group (CAG). The CAG should have a professional staff with a full range of skills and perspectives (multiple purposes and multiple disciplines including natural science, social science, economics, and engineering). However, the staff would remain small, but could be expanded to address specific tasks with personnel from the state and federal agencies on temporary assignment.

The CAG would have two roles. First, the CAG would be responsible for executing the integrated assessment to assure that each proposed project investment in storm protection, navigation and coastal restoration takes advantage of synergies and avoids and mitigates conflicts among purposes. Also the CAG would report whether and to what extent different economic, environmental and social objectives are served. The integrated planning process would be led by the CAG, however detailed project design, basic data acquisition and modeling,

and other tasks contributing to project execution would be done in the existing agencies, principally the Corps and the state. Second, the CAG would be responsible for the direction and oversight of the Coastal Engineering and Science Program (CESP) in order to assure that the work of that program is targeted to the decision making needs of the CLA.

Coastal Engineering and Science Program

A Coastal Engineering and Science Program office would build on the concepts developed for the LCA Science and Technology Program ' but would be broadened to address storm damage reduction and maritime transportation, encompassing the natural science, engineering, social science and economics applications deemed relevant to the integrated management framework. In particular, it would be responsible and accountable for supporting adaptive management, including participatory decision making, and ensuring rigorous, independent peer review. A key responsibility of the managers of the CESP is to respond to the oversight of the CAG and assure that the scientific uncertainties deemed relevant to decision making are addressed through the program. The CESP would rely on scientists and engineers in agencies, universities and the private sector to perform most of the required research, modeling, and monitoring. Consequently, the office staff would remain small.

Programmatic Authorization and Funding

While the total composition and costs of the integrated planning and investment program can not be determined at present, it is necessary for the Administration and the Congress to make a significant and certain up-front commitment of funds and establish new procedures for expeditiously funding this program over time.

No less than two hundred million dollars per year, for a 10year period, should be authorized by the Congress to support the CLA and the CAG. Appropriations should follow that authorization. The agencies receiving the appropriations would manage those funds consistent with the guidance of the CLA for: (a) the integrated systems planning program; (b) the CESP research on decision-critical technical uncertainties, including funding pilot projects to test project design concepts; and (c) comprehensive post-implementation monitoring and assessment. Also, the CLA would be authorized to allocate funds for projects costing less than some threshold, e.g. \$25 million, with project execution being the responsibility of the Corps and the State. In the future, consideration should be given to administering the existing CWPPRA program through the CLA some time after the efficacy of the CLA has been established.

Programmatic funding would loosen the restrictions on adaptive management costs as a percentage of total project costs, as well as the requirements for separate authorization for each component project. With a certain funding stream there could be a continuity of programs and staff, an adequately funded and reasonably managed engineering and science support program, and accelerated planning for implementation of smaller projects.

Louisiana Coastal Investment Corporation. The CLA could recommend authorization and appropriations for Corps projects that exceed the thresholds in the programmatic authority, or for project maintenance, through the existing WRDA and appropriations processes. However, reliance on authorization through the uncertain WRDA process (the last WRDA was passed in 2000) seriously risks delay and programmatic incoherence. A more predictable and flexible alternative approach would be to legislatively create an entity, for convenience referred to as the Louisiana Coastal Investment Corporation 60 (LCIC), as an independent funding authority for new projects and their maintenance. The LCIC would receive recommendations from the CLA

and would fund projects meeting investment criteria established by Congress when it authorizes the LCIC policies. The corporation would be given the authorization to issue bonds with maturities of up to 50 years to finance investment projects to meet the three purposes of storm protection, marine transportation and coastal landscape restoration. An initial bonding authority of \$5- 10 billion appears to be justified by the extensive storm protection, navigation and restoration needs of the region.

The long-term bonding authority aligns the financing of the new investments with the long-term benefits they provide. The federal government would guarantee the bonds. In addition the Congress could set a financial limit on the bonding authority when the corporation is chartered. The Congress could review the LCIC on a five-year basis, could dissolve the corporation at those times or choose to raise or lower the bonding authority. The bonds could be repaid with a combination of funding sources that may include, but would not be limited to: future federal appropriations; fees on port, waterway or pipeline users; wetlands permitting fees; receipts from Outer Continental Shelf (OCS) mineral revenues; and non-federal cost sharing payments. Intergovernmental cost-sharing requirements would be established by a Congressional formula and a legally binding agreement to make payments that contribute to retiring the bonds would be required before issuing any bond.

Professional Staffing

An essential element in enhancing the credibility and soundness of planning and implementation is an agency's internal staff capabilities. The Corps of Engineers is facing a significant loss of staff numbers and capability through retirement, just at the time that the demands for its skills are increasing. Indeed, the integrated planning process will demand a wider array of skills from the engineering, hydrologic, geological, biological and social sciences than is currently available in the agency or in federal or state agencies generally. Also, the effectiveness of the long-term program requires the institutional memory that develops within a permanent and professional staff. This is not to suggest that all the work needs to be done by agency staff. However, if much of the work is done by contract, agency professionalism and competence are essential for comprehending advice from outside experts and translating it into useful information to support decision making. The Corps and the bodies recommended here must have the ability to recruit and the ability to retain talented personnel.

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