FLOODPLAIN MANAGEMENT 2050

A Report of the 2007 Assembly of the
Gilbert F. White National Flood Policy Forum
Washington, D.C.

About The Gilbert F. White National Flood Policy Forum

The ASFPM Foundation has established a periodic gathering of leading experts in flood policy and floodplain management to facilitate national discussion of important floodplain management issues. These Forums develop policy and research recommendations and establish an ongoing record of flood policy issues and directions for the future. The Forums have been named in honor of Gilbert F. White, the most influential floodplain management policy expert of the 20th century. The Forums are not only a tribute to his work, but also a recognition of the success of his deliberative approach to policy analysis and research.

Periodically the Forum explores one pressing national flood policy issue by assembling and facilitating a dialogue among topical experts who represent various stakeholders from government, industry, and academia. The goal of each Forum is to identify needed research and policies that will reduce the human casualties and economic losses associated with flooding, as well as protect and enhance the natural and beneficial functions of floodprone areas.

The discussions and recommendations for action and research formulated at each Forum are summarized and distributed as a report by the ASFPM Foundation. It is anticipated that policymakers and their constituent groups will review these reports to determine which actions could be undertaken to reduce flood losses in the nation. Furthermore, these reports are expected to provide the bases and priorities for conducting the research necessary to improve policy or program implementation.

The 2007 Assembly of the Forum

The second assembly of the Gilbert F. White National Flood Policy Forum was held November 6–7, 2007, at George Washington University in Washington, D.C. It addressed the question of the long-term future of floodplain management and its role in shaping the United States of 2050. The assembly comprised 92 nationally and internationally known experts, invited specifically for their knowledge and experience in resource management; engineering; economics; demography; land use; insurance; local, state, and federal government; environmental sciences; planning; risk analysis; the law; building and construction; emergency management; finance; communication; transportation; and policy analysis. They used their considerable wisdom to consider what the future of floodplain management could look like under both a business-as-usual scenario and also under an alternative scenario of carefully crafted and aggressive action. This report conveys the results of that dialogue.

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Report of the
Second Assembly
of the
Gilbert F. White National Flood Policy Forum

Marvin Center
George Washington University
Washington, D.C.
November 6–7, 2007

hosted by the
ASFPM Foundation

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The second Assembly of the Gilbert F. White National Flood Policy Forum, and this report of its deliberations, were the products of the dedication and diligence of numerous people and organizations.

The planning, background work, synthesis of the Forum, and this report were carried out by a team led by Doug Plasencia, Michael Baker, Inc., Chair of the Events Committee of the ASFPM Foundation, and made up of Bruce Baird, ASFPM; Diane Brown, ASFPM; Gerald Galloway, University of Maryland; Larry Larson, Executive Director of the ASFPM; Dale Lehman, URS Corporation; Jacquelyn Monday, JLM Associates, Inc.; Edward Thomas, Michael Baker, Inc.; and Pam Pogue, CFM, Rhode Island Emergency Management Agency.

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Generous sponsorship of the Forum was provided by AMEC Earth & Environmental; Black & Veatch; CDM; Dewberry; Greenhorne & O'Mara; H20 Partners; Mrs. J.W. Hershey; Michael Baker, Jr., Inc.; PBS&J; Reznick Group, P.C.; URS Corporation; Watershed Concepts; and The Widgeon Foundation.

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Finally, we pay tribute once again to Gilbert White's enduring influence and inspiration. The ASFPM Foundation appreciates the continued interest and support shown by his family in the Foundation's efforts to carry on his work after his death.

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EXECUTIVE SUMMARY

The participants in the Second Assembly of the Gilbert F. White National Flood Policy Forum agreed that the future that lies along our current trajectory is not a pretty sight.

In spite of heavy investments of public and private dollars and decades of management, up until 2007 we have not been able to keep pace with continually increasing flood losses in the United States. At the outset of the 21st century, unprecedented conditions—in the form of population growth and migration, changes in climate, and serious degradation of water-based resources—have entered the stage. They are colliding with the cumulative impacts of the last century's well-meaning but misguided policies—failure to provide for the maintenance of infrastructure, development at the expense of natural resources, overreliance on engineering solutions—to overwhelm current attempts to reduce flood losses and to protect water-based resources. Without dramatic shifts in our approaches and actions, by 2050 flood losses are likely to be far greater, ecosystems may well collapse, the nation's quality of life will be diminished, and all hope of sustainable communities will be lost.

A Visionary 2050

To counteract this grim prospect, during their assembly in early November 2007, the Forum experts devised alternative, visionary scenarios of a safe and sustainable United States in 2050, focusing on the main techniques used by our society to address flood hazards. These techniques, termed "adjustments" by Gilbert F. White in his groundbreaking 1942 dissertation, still frame the categories of measures in use today and served as analytical tools for the Forum discussion. For each adjustment, the experts created a visionary, optimal scenario of 2050 as a means of identifying both long-term objectives as well as those aspects of current approaches that would have to be changed in order to reach the envisioned future.

Human Adjustments to Flooding according to Gilbert F. White, 1942

- Land Use
- Flood Abatement (watershed management)
- Structural Alterations (building & development standards)
- Elevation of Land
- Insurance
- Relief
- Emergency Measures
- Structural Flood Protection

In the case of **land use**, by 2050 every state could have comprehensive land use planning that begins with a template of its land and water and related resources and hazards. Proposals for economic development, transportation, infrastructure, and other community concerns would be evaluated within the context of that template, with the objective of allowing no adverse impact on flooding, on other properties, or on the natural functions or resources. Many no-build zones—such as places subject to deep coastal storm surge, deep riverine floodplains, and other high-hazard or environmentally sensitive areas—would be in place, analogous to the floodways and coastal barrier resources system units of the 20th century. These no-build areas would be respected in order to sustain the natural benefits they provide to society, including high-quality water, appropriate habitat for fish, wildlife, and flora; groundwater recharge; recreation; and open spaces, in addition to flood damage abatement. Some communities would have been relocated in whole or in part. A significant proportion of paved areas would have been reclaimed as natural space.

Water resources management in 2050 could be based on Congressional passage of a national water resources and floodplain management policy, implemented through holistic techniques for ensuring both water quality and quantity and applied by state and local governments. The premise of the strategy could be that no unmitigated adverse impacts to locally designated values are permitted. The federal government would provide leadership through a body that coordinates and integrates all programs, policies, and disciplines that have to do with water resources. The agricultural sector and the floodplain management profession would be allies in preserving sensible uses of riparian areas.

Building and development standards in 2050 could be targeted toward completely AVOIDING construction in floodprone areas if at all possible—including residual risk areas behind levees and below dams—dramatically reducing the exposure of homes and infrastructure to flood damage. **Elevation** of the land surface through fill or elevating buildings to a specified level would no longer be automatically considered to be the best or safest solution. Stronger standards would be in place for siting, construction, and protection of critical facilities. The private sector would be the leader in planning and designing sustainable development. Federal grants, tax deductions, and funding programs would reward states, communities, and individuals that reduce flood risk to their existing buildings and facilities and minimize impacts on other properties. Those who take unwise action and exacerbate their flood risk would not be rewarded with federal benefits, nor would they be permitted to externalize the costs and consequences of flooding to the federal taxpayers.

In 2050, **flood insurance** could be part of all-hazards insurance coverage that is mandatory throughout the United States, including in residual risk areas. Through a government-backed framework involving private insurance companies, premium rates would be actuarially based, making the program self-supporting and providing incentives for proper siting, design, construction, mitigation, and retrofitting. Rate reductions in flood insurance would be available at the individual policyholder level, providing an incentive for individual actions that reduce risk.

In the visionary 2050, **flood disaster relief** would remain a viable back-up mechanism as one component of a comprehensive system of indemnification, but the public would be aware of its limits. Discrepancies among 20th century relief and mitigation policies and funding mechanisms would have been resolved so that the programs create strong incentives for wise local use of floodprone and coastal areas. The availability of indemnification for flood losses, including through litigation, would be contingent on community and state implementation of holistic water resource mitigation and preparedness measures. All communities would have robust pre-disaster mitigation plans that are followed religiously after a disaster to reduce future vulnerability. The private sector would be the vanguard of a system of indemnification, loss reduction, data collection, forecasting, warning, and other **emergency measures**.

Structural flood protection would be used in 2050 only to protect existing development, and then only as an option of last resort. Non-structural solutions to a flood "problem" would be considered first. Aging infrastructure from the late 20th century, such as dams, levees, and channels, would have been relocated or rehabilitated and, in some cases, removed. Citizens would understand that structures such as levees merely lessen risk from some events rather than eliminate it, and may worsen risk in extreme events. No flood protection structure would be built, rebuilt, or repaired unless funding for its maintenance were guaranteed up front.

By 2050, public **awareness and education** could have led gradually to a voluntary reduction in building in floodplains. The population of the United States could be a well-informed one that understands both the burdens and blessings of the flooding process. Households would

take responsibility for their own physical and financial safety and for the natural resources they consume or affect. They would have a plan for surviving and recovering from a flood disaster without waiting for government assistance. When development proposals are made, well-informed people would engage with elected officials, policymakers, investors, developers, and other influential parties to ensure that all potential impacts of the project are identified, that the property owners and taxpayers who will be affected by future flooding or will be paying for current and future damage have been notified and their concerns addressed, and the sustainability of the ecosystem in question has been ensured.

Steps to an Optimal 2050

Forum participants agreed that the optimal 2050 is within reach but that, because past policies and management approaches are partly responsible for the current dilemma, a range of changes—some large, some small—needs to be made. The steps are described in terms of White's still-robust human adjustment concept.

Additional Human Adjustments to Flooding

An analysis of the world in which floodplains are managed today—and will need to be managed tomorrow—suggests the need to add four adjustments to White's original list: (1) room for rivers, oceans, and adjacent land areas; (2) personal responsibility; (3) geographic interdependence; and (4) awareness and education.

Room for Rivers and Oceans

Implicit in White's analysis of ways for humans to adjust to flooding was the "no action" option, that is, to choose not to occupy the floodprone areas at all and thus both avoid the hazard as well as preclude any unintended adverse impacts on the ecosystem. Today, however, advances in engineering and technology along with increased material wealth have made possible human encroachment on even the most sensitive and hazardous sites—with dire consequences. It is now necessary to make explicit among our range of adjustments to flooding the option of routinely putting some distance between humans and our waterways and oceans.

Personal Responsibility

This is another adjustment that needs to be made explicit. Probably the most effective overall technique for living with floods would be for people to take personal responsibility for their own flood risk and for the sustainability of water (and other natural) resources. A cultural and behavioral shift to the assumption of more individual responsibility is in order to develop full societal understanding and acceptance of what is at stake.

Geographic Interdependence

Vulnerability to flood hazards is no longer limited to the floodplain or the ocean coast. With most aspects of our economy and society reliant on digital data and its easy transfer (including data, infrastructure, markets, and communications) we have introduced vulnerabilities that did not exist only a few decades ago. Flood damage to a town, business, or industry can have widespread ripple effects if digital linkages are broken. Adjusting by recognizing geographic interdependence means protecting these linkages—our 21st century critical facilities.

Awareness and Education

Today's public is accustomed to a continual flow of information, with instantaneous action and reaction by those "in charge." People who understand flooding processes are more likely to take action to reduce their vulnerability and to protect natural systems. Thus, active communication of information about the potential of flooding, hazards from hurricanes and storm surge, the ways in which human development alters and depletes water resources, and other water-related concerns is an important technique. This adjustment contemplates the use of thorough, well-targeted education strategies, outreach efforts, and risk communication vehicles to supply individuals, decisionmakers, influential groups, and professionals with information that will enable appropriate behavior.

A Different Mixture of Adjustments

In hindsight, overreliance on some adjustments has mired us deeper in our flood-loss crisis. Exclusive reliance on engineered structures was a wrong path that was followed for decades. Now it is becoming clear that allowing (even encouraging) development in the floodplain as long as it is elevated also has brought unanticipated consequences as projected flood levels rise. What is needed is a better grasp of the full range of adjustments, along with appropriate assistance and incentives to make wise choices from among them.

Improved Implementation

There is much room for improvement in the implementation of the programs and policies by which we carry out our adjustments to flooding. Suggested changes are grouped into four categories below.

Shifts in Governance Needed

There is a desperate need for clear and holistic national policies for treating land and water as important resources. Our twin goals must be to protect people and property from flooding while also protecting floodprone lands from people. We must take a broader view than we have in the past, and return to treating water and watersheds as the resources they are, with floods as an inextricable component. States and their localities can take the lead, by developing and tailoring programs and policies to match their own land and water issues. The federal level can provide incentives to build capability, and bring oversight and consistency so that the whole fits together in a sustainable approach. We need to adopt a much longer-term view, far beyond the 5- to 10-year planning horizons that are considered acceptable today.

Program Changes Needed

The nation's fragmented system of water resource management, disaster relief, mitigation, and insurance should be overhauled to incentivize conduct that will provide long-term benefits while eliminating disincentives and duplication and also minimizing costly and time-consuming litigation.

- Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands, need to be re-invigorated and strictly enforced.
- *De facto* no-build zones should be established for coastal areas, similar to floodway zones in riverine areas.

- Universal flood insurance coverage is highly desirable but will only come to pass if it is made mandatory. We must step up the pace of phasing out flood insurance premium subsidies and moving toward actuarial rates.
- Consideration should be given to shifting our flood hazard and resource protection approach from a regulatory basis to a strategy that is grounded in public/private partnerships, performance, and outcomes.
- More rapid movement is needed toward no adverse impact management strategies, with an eye towards environmental, economic, and social sustainability. Much of this can be led by non-governmental organizations and non-profit groups.
- We need to seize the opportunity presented by the fact that a significant proportion of existing infrastructure will be repaired or replaced over the next 50 years. New policies should specify removing infrastructure from the floodplains where possible, applying stricter standards for siting replacement facilities, retrofitting and strengthening during repair, and considering ecosystem needs in concert with human ones.
- We need to apply a much longer perspective to the design and siting of critical facilities, and widen that category to include other important systems and structures.

Research and Data Needs

Movement toward an optimal 2050 requires extensive, accurate, easily accessible data on every aspect of the resources and hazards inherent to our water and its adjacent lands. We must integrate data on our natural resources with our floodplain data.

- We need to upgrade the data on which floodplain management relies to incorporate reliable climate change data.
- We need to compile a national topographic data set, a flood loss data set, and a database of the elevation of every structure.
- Our stream gage data collection system needs to be restored, expanded, and made available to those many local, state, federal, and private-sector users from myriad disciplines.
- An independent, comprehensive review is needed of all federal water related programs, programs that subsidize or promote development decisionmaking, and all grant programs. These authorities need to be integrated, coordination and leadership put in place, and Congress's oversight of them consolidated.
- Accepted, reliable methods for quantifying the natural and beneficial functions of floodprone areas need to be established so that they can be incorporated into benefit/cost analyses.
- A major investment must be made in basic, regionally based climatological analyses to identify the major demographic, water resource, and ecosystem trends and their expected impacts on flooding and on riparian and coastal ecosystems. Based on that data, we need to develop scenario-based evaluations for the whole nation of alternative outcomes of alternative trends and actions.

Funding and Other Incentives Needed

Secure, ongoing funding must be found from any and all sources for floodplain management programs, infrastructure repair and maintenance, resource protection and restoration, flood map updates, and mitigating the repetitive flood loss problem. State and local action to mitigate floods and protect water-related resources should be rewarded by incentives, such as a sliding cost-share or other financial advantage. All funding programs should be zero-based, so that those who do take positive action benefit from them and those who take risky action pay their share of the costs.

The bases upon which eligibility for federal (and other) funding is determined need to be modified to incorporate the value of sustainability, of resource protection, of ecosystem resilience, of recreation, and a range of other benefits previously omitted or not quantified. New procedures must capture the annual average costs and benefits of flooding.

Change as an Opportunity

A final but overarching step to the future will be to take advantage of today's unprecedented circumstances. Public alarm about extreme weather and global warming can be transformed into individual and collective action to become better informed and shoulder more responsibility. The huge amount of new and replacement buildings and infrastructure that will be needed for the larger, wealthier population of the future can be sited and constructed to create safe and sustainable communities. The immense amount of expertise, energy, and capital held by the private sector can fill gaps in government services. The challenge will be to discover the potential in these and other circumstances and then develop it.

Action Guidelines

All the technical and programmatic steps essential to sustainable management of our water resources and related hazards described above can be condensed into six critical action guidelines. These guiding principles capsulize the new ways of thinking and operating that will be needed to achieve safe and sustainable relationships with our water resources. If decisionmakers, professionals in floodplain management, households, businesses, and others keep these guiding principles in mind, then our individual and collective actions will operate to remedy past errors and move the United States toward a safe and sustainable future.

1. **Make room for rivers, oceans, and adjacent lands.** These places are inherently both dangerous and environmentally sensitive. Avoiding them when contemplating future development or repairing or replacing infrastructure will be the most foolproof way to minimize flood losses and protect water-based resources. A gradual pattern of voluntary resettlement of people away from certain of these areas needs to be initiated.

2. **Reverse perverse incentives in government programs.** Too many federal—and corresponding state and local—public policies and activities for water-related resources and hazards operate at cross purposes and even foster activities that undermine safety and environmental quality. The culprits need to be identified and the varying objectives reconciled. Laws and policies that are already on the books need to be revived and enforced.

3. **Restore and enhance the natural, beneficial functions of riverine and coastal areas.** Even if these risky and environmentally sensitive areas are not subject to development in the future, past degradation of them needs to be remedied. It should be a national priority to reclaim lost riparian and coastal resources wherever possible, including dunes, bottomland forests,

estuaries, and marshes. This will help restore natural buffers to storms and floods, supply open space and recreational opportunities for a burgeoning population, and prevent some ecosystems from further deterioration.

4. **Generate a renaissance in water resources governance.** Too many decades have passed in which the nation has struggled to manage its water resources without a clear, integrated vision and policy. Both are essential and should include legislation establishing a national floodplain management policy and a national riparian and coastal areas policy, as well as consideration of an official shift to make SUSTAINABILITY of water resources our paramount concern, rather than DEVELOPMENT of them. National programs and investment decisions should be adapted quickly to account for expected trends and impacts associated with the collision of intensified human development and climate change.

5. **Identify risks and resources and communicate at public and individual levels.** Communication, education, and outreach efforts should be intensified immediately. Individuals, communities, and decisionmakers at the highest levels all need concrete, easy-to-understand information about flood risks and about environmental degradation. With computer modeling and digital technology it is possible to generate and depict nationwide scenario-based assessments of risk that take into consideration alternative conditions of climate, population density, sea level rise, infrastructure placement, and more.

6. **Assume personal and public responsibility.** We need to move quickly to revive our ancestral ethic of land and water stewardship. The nation needs a framework that will foster localized responsibility for flood risk, water-related resources, and wise use of floodprone lands. Incentives need to be institutionalized to ensure that individuals and communities that act responsibly receive benefits while those that do not manage their risks and resources wisely cannot externalize the resulting losses and costs to federal taxpayers. All properties should be covered by actuarially based, all-hazards insurance that has a strong loss-reduction (mitigation) component.

INTRODUCTION

Imagine the United States in 2050 if current social, environmental, technological, and political patterns persist. . . . Far more people are threatened and enormous amounts of development are vulnerable to flooding, coastal storms, erosion, and related hazards than was the case at the end of the 20th century. This, combined with more frequent flood disasters and changes in sea level, has caused annual flood losses to increase ten-fold to an average of $60 billion annually.[1] A large proportion of people and public and private property are not covered by flood insurance. Neither individuals nor localities have become demonstrably more self sufficient than they were in the 1990s. Heightened reliance on public disaster assistance places huge financial burdens on taxpayer dollars and transforms disaster recovery and rebuilding into formidable challenges. Yet there is public concern and outcry over the growing cost of covering disaster losses. Flood-related policies are driven more by litigation than by legislation as influential people and their attorneys succeed in carving out niches for special treatment and Congress still resists adopting a holistic framework for managing water and land resources. In 2050 flood losses represent a significant percentage of our gross domestic product. Flooding is more frequent and more severe and ecosystems that once provided natural protection and ameliorating functions have disappeared. All hope of sustainable, resilient communities has been lost, and the nation's quality of life diminished.

The future foreseen by the experts who participated in the Second Assembly of the Gilbert F. White National Flood Policy Forum was not a pretty sight. Up until 2007 we have not even kept pace with escalating flood damage, and new drivers of change and the accumulated impacts of past actions seem likely to overwhelm the approaches and programs that we believed had been slowing the increases in flood damage.

> Intensified development in high-risk areas accompanied by climate and weather changes will bring increased potential for frequent flood disasters, and for large, Katrina-like catastrophes as well.

A simple extrapolation from history may make this forecast seem extreme, but the problem is that the nation is moving into uncharted waters of rapid and nonlinear change—a future in which past experience and performance may well be nullified.

- Climate change could result in extreme variations in flood severity and frequency and coastal areas could face dramatically higher sea levels.
- The largest population increase ever seen by this nation will put intense pressure on both our natural and managed waterways and our flood protection systems.
- Estuaries and ecosystems that are at the brink of becoming unsustainable will reach the tipping point when exacerbated by climate change and population growth.

Why Consider Floodplain Management in 2050?

Public policy is shaped by incremental changes in condition, experience, and opinion as well as by somewhat more dramatic events that can change forever the way policy makers and the public view the world. Through this process, flood policy over the past century has evolved and at times been altered directly in response to world events, usually disastrous floods.

In the first half of the 1900s, the United States had a "floodplain management policy" that consisted almost entirely of a single-purpose program of federally based structural flood control. The nation was confident of its ability to use dams and levees to control nature. The ancillary functions and benefits provided by relatively pristine riverine and coastal ecosystems were taken for granted and, in any case, seemed abundant and vigorous enough to survive any impacts humans could impose. However, damaging and even catastrophic flooding continued to occur.

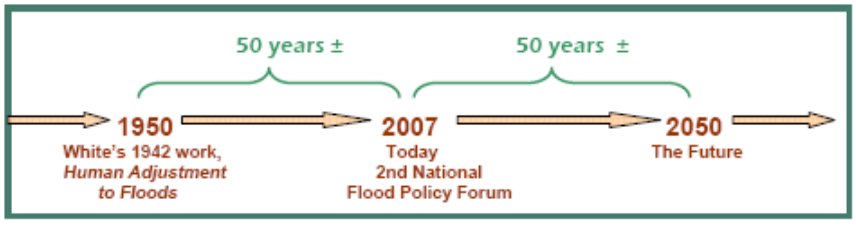
In the 1940s, Gilbert F. White penned an alternative approach to flood control in his ground-breaking dissertation, *Human Adjustment to Floods*.[2] The foundation of White's writing was the idea that it would be necessary for humans to adjust their activities to the natural phenomenon of flooding, rather than vice versa, if vulnerability to flood damage were to be reduced. Beginning in the 1950s many of White's concepts took root, and some states and federal agencies applied land use management strategies to address flood problems. With the passage of the National Flood Insurance Act of 1968, the nation commenced a decades-long, though not fully coordinated, effort to use a multi-faceted approach that combined ways to minimize floods, ways for people to adjust their behavior in the face of flooding, and ways to indemnify damage to property.

Over that same period the nation's flood damage curve flattened somewhat, but it continues to move upward today. In addition, there are several factors in play now, 50 years into our use of the human adjustment approach, that did not exist when we began our current efforts:

- Explosive population growth in the United States;
- Climate change and rising sea levels;
- Stressed environmental resources, specifically estuaries and riparian zones; and
- Declining discretionary budget capacity within the federal government at the same time that states and localities are struggling to fund needed public safety activities.

Will the human adjustment concept, and the techniques developed pursuant to it, serve us into a future shaped by these changes? Or are the adjustments in some manner dated or perhaps less relevant than they were when first postulated by White? Having applied the human adjustment concept for about 50 years, it is useful to ask what another five decades would bring.

"Floodplain Management 2050" thus was chosen as the topic for the second Gilbert F White National Flood Policy Forum, as an opportunity to evaluate our past and present while at the same time considering a future that will hold challenges little considered 50 or 100 years ago. The year 2050 provides a convenient mid-century milestone on which to center the discussion.



The Concept of Human Adjustment to Flooding

The idea that human beings can and should modify their behavior in various ways to acknowledge the hazards posed by the natural process of flooding was fairly revolutionary when introduced by White, but the idea underpins floodplain management even today. White listed eight ways in which it was possible for humans to "adjust" to flooding, and those eight approaches have endured as the building blocks of floodplain management for the last 50 years.

- **Elevation** of the land surface or a building;
- **Flood Abatement** or watershed management;
- **Flood Protection** with levees, channels, or other engineering devices;
- **Emergency Measures** to temporarily protect people and property;
- **Structural Alterations** to buildings and infrastructure, such as floodproofing or codes and standards;
- **Land Use** to arrange development in ways that lessen damage;
- **Relief** for victims, from private or public sources; and
- **Insurance** as a way to build up funds and indemnify those who suffer flood damage.

What makes this idea of human adjustment enduring is that it allows for broad thinking about what constitutes ways to mitigate flood hazards and their impacts and that, by its very design, it allows for evaluation over time. The adjustments for floodplain managers are analogous to a mechanic's set of tools or an array of essential ingredients for a chef. These tools and ingredients, guided by the right policy and effective implementation, can bring excellent results. However, they are not magic and, if out of date, used improperly, or unsuited to current or future needs, can be ineffective or even counterproductive.

The human adjustment concept framed the 2007 Assembly of the Forum in two fundamental ways. First, the main adjustments in use today served as a point of reference for discussing the validity of or needed modifications to floodplain management strategies. Second, the adjustment concept itself enabled the participants to step well back from floodplain management as we know it and think in more fundamental ways about how humans interact with both the hazards and benefits of their water-related environments. This perspective helped prevent the experts from confining themselves to narrow, program-related issues or short-term fixes to this year's problems.

What Is Floodplain Management?

Throughout this report, the ASFPM Foundation uses the term "floodplain management" to refer collectively to all the activities undertaken and decisions made both to reduce flood losses and to protect and restore the natural resources and functions of floodplains.

Floodplain management includes structural and non-structural measures, flood loss reduction efforts, education, warning, evacuation, insurance, flood mitigation, watershed-based planning and management, and many other approaches. The intent is to focus attention on improving many aspects of the relationship between human activity, the flood hazard, and the floodprone lands, rather than simply on minimizing property damage.

This definition is consistent with the Unified National Program's broad use of the term "floodplain management" as the process of working to achieve the "wise use of the nation's floodplains." [3]

PROCEDURES

for the 2007 Assembly of the

Gilbert F. White National Flood Policy Forum: Floodplain Management 2050

In the months before the Forum, over 40 of the invited experts prepared short papers giving their perspectives on "Floodplain Management 2050," covering anticipated changes related to flood risk by 2050; the question of human occupance of the floodplain and its relation to land use and to the natural and beneficial functions of floodplain lands; flood insurance and its economic implications; understanding, delineating, and communicating flood risk; elevation, building standards, infrastructure, and flood control; vulnerability reduction; and improving the mix of our adjustments to flooding. (The collection of papers has been released as *Experts look at Flooding and Water Resources in 2050*, as listed in the appendix.)

This background reading served to inform all the participants about each others' thinking in advance. At the Forum assembly, four invited speakers provided an overview of the principal changes taking place today that will influence how floodplain management will look in the future.

- Human Factors in 2050: Population Trends, Growth, and Urbanization
- Environmental Factors and Natural Resources in 2050: Climate Change, Ecosystem Degradation, Land Use
- Government and other Factors in 2050: Devolution Upwards and Downwards
- Scenario-based Planning to Guide Future Adjustments: The Foresight Flood and Coastal Defence Project of the United Kingdom.

Then, participants proceeded to facilitated, small-group discussions at which White's eight adjustments provided an analytic tool for discussion. The participants debated the relevance of each of the adjustments in today's world, how some have been molded by changing circumstances, whether any are no longer appropriate, and finally, whether additional adjustments, not foreseen by White, should be added to the list in order to strengthen the foundation of floodplain management and bring about an optimal 2050. Summaries of these discussions were reported back to the whole group. This procedure was repeated twice, and culminated in a list of needs, changes, priorities, and action items. Those professional judgments were assembled into this report.

PART I

REALITIES, TRENDS, AND INFLUENCES

The question of being on the right or wrong floodplain management course when moving towards 2050 will be made more pressing by anticipated increases in U.S. (and world) population, continued and possibly increased development in flood hazard areas, development that is at once denser and more extensive (bringing higher potential damage), isolated ecosystem collapse with the prospect of more, the specter of impacts from a changing climate, and socio-economic shifts that dictate a different approach. More and more, professionals and the public as well are coming to accept that the hazards and benefits of flooding are intertwined with water resources and other natural resources issues and cannot be effectively managed in isolation.

Some of these "drivers of change" were not in play 50 years ago, or were occurring but much more slowly than they are now. All of those discussed below will shape 2050 overall and will influence floodplain management needs and techniques.

Demographic Drivers on the Road to 2050

More People and More Development

Of all the countries on the planet, only India and Pakistan are growing faster than the United States. We can expect as many as 460 million U.S. residents by 2050, an increase of from 125 to 160 million people over the next several decades.[4]

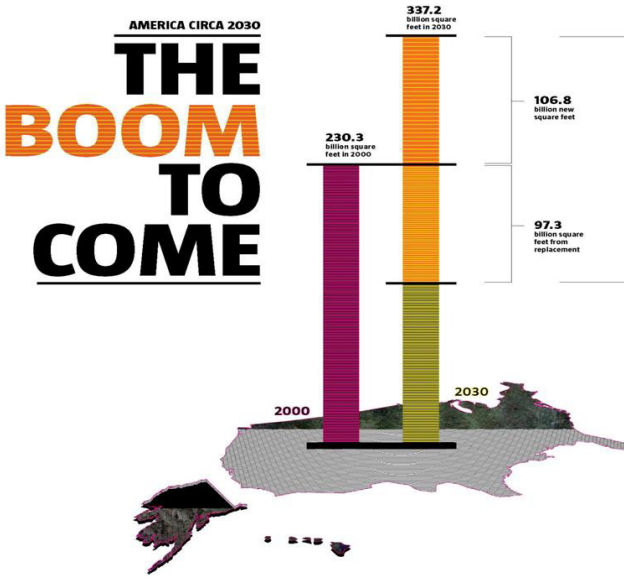
More people will mean more buildings of all kinds, and more infrastructure such as roads, bridges, parking lots, stormwater systems, and communications. The development will be extremely dense in some places, bringing more public health issues than in the past, and more safety and damage concerns when floods occur, along with concentrated pressures on water and related resources.

A Different Character

The income and wealth gap between the "haves" and the "have nots" is widening. The middle class is shrinking and the result is going to be more lower-income people. We can expect a larger proportion of households headed by one person instead of a couple and we are headed toward a nation in which there will be many more retirees and elderly people than today.[5] These latter groups—and there are other growing groups as well—tend to be more vulnerable to flood and other disaster losses. Thus the overall vulnerability of the nation is bound to increase.

A Pattern of Movement and Urbanization

The increase in population will lead to the geographic concentration of people (urbanization) over wider areas than at present. Existing metropolitan areas will become even larger and we can expect moderately sized urban areas to graduate to true megapolitan status.[6]



Graphic from http://www.architectmagazine.com.

In 2030, there will be 106.8 billion square feet of new development in the United States, about 46% more than existed in 2000—a remarkable amount of construction to occur within a generation.

Analysis by Arthur C. Nelson, Virginia Tech University, based on figures from the U.S. Census Bureau, U.S. Department of Energy, U.S. Department of Housing and Urban Development, Society of Industrial and Office Realtors, and the Council on Tall Buildings and Urban Habitat.

The population and urban areas of the future will not be evenly spread across the nation or its regions, because people are moving into the West, the South, and the coastal areas. As already evidenced, this migration is matching up with flood-related or other hazards such as hurricanes, earthquakes, and western wildfires. The combinations of these hazards in the face of increased population have the potential to make the situation even more serious.

Pressure on the availability of land and the rising cost of housing may well lead to the concentration of socially vulnerable people in high-hazard areas.[7]

Governance Drivers on the Road to 2050

Functions Devolve to Local Level and to Private Sector

We are already seeing a devolution of authority and responsibility from the federal to state and local levels of government. This devolution is the result of both finding more effective ways to implement certain functions and of a growing inability to continue to deliver a top-down model of government. At the same time, shrinking tax bases lead local governments to try to attract development and the accompanying tax revenues, regardless of long-term environmental and disaster costs and consequences.

The private sector is taking over some functions long held to be governmental responsibilities. The remarkable success that is possible through such devolution of function can be seen in the emergence of private trusts for land conservation. In the last five years alone, the private sector has doubled the acreage it has preserved nationwide, to 37 million acres.[8]

Specialized regional governments/districts will be more common in the future and there will be a proliferation of homeowner and voluntary associations. There is growing expectation of citizen involvement.

Existing Structure, Laws, and Entities Changing

The nation's perception of natural disasters and national security issues appears to be coalescing. There has been a tendency recently to view all threats as sinister and to adopt a battle mentality.

The balance among several factors in the management of floodprone lands and water resources is shifting. Along with the redistribution of responsibility among government agencies noted above, more and more jurisdictions and other authorities are developing partnerships to carry out their functions.

The relationship between government and science and technology appears to be shifting as well. Whereas at one time scientific expertise was a valued input to the political process, in recent years public policy affecting flooding and natural resources has tended to be established on other bases ranging from economic enhancement to moral imperatives. Ironically, this is occurring in an era in which many pressing national and global problems demand science-based solutions.

Changing Relationship between People and their Government

Compared to several decades ago, people now demand and expect more, more sophisticated, and more efficiently delivered services from their governments. At the same time, however, they are unwilling either to fund the very services they demand or to assume responsibility for obtaining them (or rendering them unnecessary) on their own. In the scramble to meet these growing demands, revenue-starved states and localities are making local land use and development decisions that will yield immediate local financial benefits. Sooner or later, however, the outcomes of these decisions will force huge costs onto federal taxpayers, produce suffering by disaster victims, and despoil the environment.

Paradoxically, there is also less confidence in all levels of government and public dissatisfaction with the large amounts of money the federal government spends on disaster response and recovery. The federal government appears to be all too willing to declare disasters and approve federal spending for response and recovery from them. Does the need to plow an unusually heavy snowfall constitute a disaster? Wouldn't the state or the county be the appropriate level of government to respond to a tornado? The range of differing demands, powerful special interests, and non-stop media scrutiny overwhelm political will to do the right thing, particularly if the benefits of a proper decision lie in the distant future.

Financial Pressures and Situations

By some projections, the federal budget of the future could be almost entirely consumed by entitlements and payment on the national debt, yet there is an abundance of private capital here and abroad.[9] The world of today and tomorrow is market-driven, and those markets are interrelated and react swiftly to external events and to each other.

Natural Resources/Environmental Drivers on the Road to 2050

We have already experienced degradation of natural resources and ecosystems and the loss of natural protective buffers; acceleration of this trend seems inevitable. As the climate changes and human impacts on the environment become more pronounced, there will be more, and more complicated, unintended environmental consequences.

At the same time, we are developing a more thorough scientific understanding of, and data on, water-related resources and also the interrelationships among development, runoff, snowpack, flooding, drought, wildfire, geomorphology, and societal relationships to the environment. Billions of dollars at last are being devoted to restoration of damaged ecosystems, with some success.

What has not been fully appreciated until recently is the significant role that our natural resource base plays in the nation's economy and well being. For too long the debate on environmental resources has focused primarily on the visual and recreational benefits they yield. Although these benefits are necessary and important they keep the debate focused on environmental resources as being "nice to have" rather than "indispensable."

Degradation or loss of essential estuaries, fisheries, and other habitats already has negatively affected local and regional economies that depended on these resources, but continued and broader degradation will ultimately strain wider economies through higher prices and limits on the availability of necessary products. New demands for resources from our floodplains—such as crops for ethanol as a substitute for petroleum-based fuels—will have as-yet unknown impacts. In the past, world-wide markets have provided a buffer for these consequences, but over-harvesting, changes in climate, and population growth will diminish the viability of these international resources.

Economic and Technological Drivers on the Road to 2050

The future will bring stronger connections to a global economy as opposed to national or even local production and markets. There is already growing reliance on foreign lending as baby boomers retire. Transnational and multinational corporations are multiplying.

The United States is generating a more highly educated public with higher expectations. The public demands instantaneous information of all types and on all topics. But oversaturation with information makes it even more difficult for citizens and communities to filter out what is unimportant and to really understand such issues as flood risk and ecosystem maintenance.

There is a rapidly expanding ability to conduct whole-system ecomodeling, characterize flood risk, and generate real-time forecasting. We are accumulating scientific data and methods necessary to apply economic values to natural resources and other costs and benefits previously considered unquantifiable. We also have more environmental monitoring than ever and this coverage will increase. Geographic information systems are proliferating and are becoming interconnected and accessible to the public.

Unfortunately, science and technology are tending to outstrip the ability of the public and policy makers to understand and make appropriate decisions about issues that should be underlain by science.

Other Factors Not in Play 50 Years Ago

Failure to Maintain and Upgrade Infrastructure

Over the last 50 years, the nation invested heavily in new infrastructure without making provisions for ongoing maintenance of it, and this omission is bearing bitter fruit at last. The majority of dams and levees are owned and operated by private parties or by local or state governments and the record of their maintenance of such structures has been dismal.[10] Shrinking state and federal budgets have made it difficult for states and even federal agencies such as the U.S. Army Corps of Engineers, Department of Transportation, and the Department of Agriculture to fix, rebuild, or relocate some critical pieces of infrastructure on which our society relies. As a result, today we are facing widespread decay not only of dams and levees but also of such infrastructure as bridges, surfaced roads, and stormwater and sewer systems.[11] This will be exacerbated by impacts from climate change that are expected to be felt in many of the nation's urban areas—the very locales in which infrastructure is concentrated.

Recognition of the Need to Save Open Space

We are facing the cumulative impacts of decades of land use decisions that were based on a perception of unlimited space and resources. Based on this perception, very few steps have been taken to protect space and resources, floodprone areas included. As land has become scarcer with the growth of the population and its material wealth, the price of property has risen. One result is that developers are less willing to set aside floodprone lands for open space. Another is that floodprone land is relatively less expensive, so developers see that their profit margins can be widened by using that land for development, as long as the costs of future consequences (flood damage and deterioration of the resource be) can be passed along to others in the community or to future generations of taxpayers. Finally, communities continue to insist that their floodplains are the only options for development. Altogether, these factors generate a new imperative for the deliberate protection and, where possible, reclamation of floodprone lands as open spaces, for multiple purposes.

Interdependencies

We live in a society that is and likely will continue to become more specialized and also be increasingly interdependent geographically. Instantaneous communications, efficient transport, and other factors have combined to enhance efficiency in business that, in turn, has created a "just in time" mentality. Consequently, the loss of a key service, manufacturing capability, resource, or product distribution network now can create significant ripple effects on businesses and consumers hundreds or even thousands of miles from an area affected by a flood or other extreme event.

PART II

TWO VIEWS OF THE FUTURE

There is a sense among professionals today—borne out by available data—that some progress has been made in combating flood losses and in slowing the deterioration of water-related natural systems.[12] However, there is an equally strong sense that we are moving far too slowly, particularly as external events occur faster than ever, carrying with them the potential to override any gains that have been made. In addition, after five decades we are finally beginning to discern the accumulated negative impacts of some of the floodplain management approaches that we believed would be solutions to the problem.

> "To what extent is it that . . . the best efforts have simply been overwhelmed by the scale and speed of the processes that lead to increased vulnerability: . . . population growth, economic expansion, and greater material wealth . . .?"
>
> —Gilbert F. White[13]

At this point then, halfway between the origins of "modern" floodplain management 50 years ago and a future 50 years ahead, Forum participants devised two alternative plausible outcomes for floodplain management in 2050.

One "bookend" scenario assumes the continued application of an incrementalist, "muddling-through" approach. In this case, tweaks continue to be made to existing programs and policies for flood and water resources management, much as they have been in the past, while the drivers of change described in the previous section push success further and further out of reach. Forum experts concurred that this scenario likely would not play out exactly as described below, because escalating problems would force at least some action. But this business-as-usual scenario may well be a fairly realistic outcome given the slow pace at which the nation has moved to modernize its policies over the years.

The opposite bookend is a scenario that encompasses more aggressive action, in which the nation anticipates the impacts of the drivers of change and modifies human actions to avoid or minimize those impacts before irreversible or excessively costly decisions are made. Under this scenario, the nation also takes advantage of the opportunities that demographic, environmental, and other drivers may bring. Such a change in course is within our capabilities now but apparently not forthcoming unless significant shifts occur and actions are mobilized.

The alternate views of the future described by the Forum experts are presented below, organized roughly according to the major adjustment strategies in place today: (1) land use management; (2) water resources management; (3) building and development standards; (4) flood insurance; (5) flood disaster relief and recovery; (6) structural flood protection; and (7) awareness and education.

Land Use and Management

Using land use to adjust to flooding simply means arranging human occupance on the land with an eye toward using that arrangement to minimize vulnerability to the flood hazard and/or to maximize the natural functions of the watershed or coastal area.

Bookend 1—Where Current Land Use will Take Us

In 2050, we can see that the pattern of land use across the United States is much the same as it was at the turn of the 21st century. However, more land area is taken up by human development, and developed areas are far denser. We see now that planning horizons used in 2007 and before were far too short, and that our ancestral perception of endless open spaces on the continent was wrong. For one thing, reliance on the automobile and the sprawling suburban housing styles that began in the post-World War II era have consumed and otherwise disturbed large amounts of land area, a good portion of which was once productive agricultural land. Drainage patterns and habitat within watersheds have been disrupted by this development style as well. There are even more impervious surfaces than ever before. The accumulated changes to the ground surface resulting from extensive fill for development have contributed to increased and faster runoff and other alterations to the local and regional hydrology.

To account for a larger population, by 2050 much development has taken place inside the nation's floodplains and, to make matters worse, it has been built to yesterday's flood level, rather than to tomorrow's or even today's. Further, places just outside the special flood hazard areas designated in the late 20th century have long since become densely developed. Flood levels have risen, so these structures and land areas are even more vulnerable than would have been anticipated. At the turn of the century, about 33% of historical flood claims paid through the NFIP were for properties that, for one reason or another, were not identified as being located within special flood hazard areas.[14] In 2050, that number is much larger.

Local governments, whose responsibility and prerogative it has always been to manage land uses within their jurisdictions, for the most part still take a narrow view that ignores the interdependent nature of fluvial processes within a defined geographic area. They have been spurred in this by federal approaches to regulation and flood insurance, which zeroed in on a community-based (rather than watershed-wide) approach in the 1960s and never deviated from it. This encouraged local staff and officials to develop an attitude that is still prevalent in 2050: "I do not care what happens outside my mapped floodplain or upstream or downstream—what matters is what is inside the mapped floodplain and within my community, and only for today's flood, not anything that might happen in the future."

With diminishing state and federal funding, local elected officials are attempting to find ways to raise revenue to support the services their constituents demand. But in 2050 the number and sophistication of the needed services are larger than at any time in U.S. history. There is overwhelming demand for potable water; infrastructure; stormwater systems; and transportation. In their struggle to guarantee themselves sources of tax revenue, localities naturally have tended to allow development in areas that perhaps could have been put to more sustainable use and also have hesitated to impose restrictions that would ensure wise and sustainable development. Local implementation of strict land use and development regulations to address flood hazard and natural functions and resources also has been hindered by periodic legal challenges (successful or not) to land use regulations. Land use decisions are influenced heavily by court decisions.

Bookend 2—A Vision of Land Use in 2050

On the other hand, it is possible that by 2050 every state will have comprehensive land use planning that begins with a template of that state's land and water and related resources and hazards. In the visionary 2050 the template is overlain with risk analysis information, critical areas for protection, and with the appropriate mitigation strategies such as warning, evacuation, rebuilding/recovery, and property acquisition. Plans and proposals for economic development,

transportation, infrastructure, and other community concerns are evaluated within the context of the land/water/resources/hazards template, with the objective of allowing no adverse impacts on flooding, on other properties, or on the natural functions or resources. Communities apply a "no adverse impact" standard to whatever values they consider critical to their long-term survival and their economic, social, and environmental resilience.

There is a stronger trend in 2050 toward higher-density development, clustering, in-filling of urban areas, and planning for green infrastructure. The full range of flooding events is taken into account in planning, including low-probability, high-consequence storms. Many no-build zones—such as deep coastal storm surge zones, deep riverine floodplains, and other high-hazard or environmentally sensitive areas—are in place, analogous to the floodways and coastal barrier resources system units of the 20th century. These no-build areas are respected in order to sustain the natural benefits they provide to society, including high-quality water, appropriate habitat for fish, wildlife, and flora; groundwater recharge; recreation; and open spaces, in addition to flood damage abatement. Some communities have been relocated in whole or in part. A significant proportion of paved areas have been reclaimed as natural spaces. These land use policies allow everybody a choice of safe and livable areas.

By 2050, massive buyouts to mitigate flood hazards have been underway for several decades, not just for houses and businesses but also for entire parcels of land that are better used as natural open space to meet the needs of the ecosystem and those of a large, urban-based population. Some buyout areas are planted in damage-resistant non-row crops that can easily withstand flooding, provide the input for alternative energy sources, and/or sequester carbon or perform other natural functions.

The old-style single-purpose, community-based agencies for flood hazard mitigation, resource protection, and stormwater management have been merged into state and regional entities with a holistic, watershed-wide focus. This, in turn, has enabled and encouraged local governments to adopt a broader perspective in managing the development and use of their land.

In managing flood hazards, future conditions are accounted for, green infrastructure is encouraged all the way up to the source waters of the watershed, and a water/land stewardship like that developed in the United Kingdom has been fostered. In 2050, no adverse impact is a widely used planning and management principle. Preserving natural riparian and coastal areas has become paramount, and when large disasters occur, certain pre-identified areas are not rebuilt. For example, planned retreat is underway from high-hazard areas, particularly those along the coast that are experiencing significant increases in flood levels and are losing protective natural resources as a result of climate change. Communities use their land use authority and work with all sectors to incorporate important natural areas into their comprehensive plans and thereby achieve livable and sustainable communities. Ecological functions are a central basis for planning. Remote sensing is used for regulatory monitoring.

Management of Water and Related Resources

One way for humans to co-exist with the hazards and benefits of flooding is to apply techniques and decisionmaking processes that will preserve necessary natural functions of the hydrologic cycle. This means giving appropriate attention to both land and water, to both the quality and quantity of water, to associated habitats and recharge areas, and a range of ecosystem processes and attributes.

Bookend 1—Where Current Water Resources Management will Take Us

At the federal level, which is mirrored among most states, water-related programs in 2050 remain stovepiped as they were in 2007, with program coordination and cooperation occurring only on an *ad hoc* basis. Programs for flood management, water quality, habitat maintenance, dam safety, levee safety, stormwater, fisheries, watershed protection, and others are not integrated even though they are all based on the same inseparable land and water resources. Wasteful duplication of effort takes place across the board. In 2050 there still is a pressing need for strong federal leadership on the integration of water-related issues and programs within and among the levels of government and the private sector.

Because federal policy at the end of the 20th century treated land and water as though they were infinite, expendable resources, by 2050 we have experienced many decades of continual degradation of these and related resources. Some estuarine ecosystems have collapsed. Vast acreages of coastal marshes have disappeared.

There has been a notable increase in severe, localized water crises. Periodically, stormwater runoff in some urban areas is almost unmanageable. Groundwater supplies have diminished and/or been degraded. Localized droughts are common. The shortage of fresh water has become a matter of serious concern. There is widespread demand for government action to respond to these circumstances, which people attribute largely to climate change.

In 2050 competition for land and its related water resources is fierce. The U.S. and world populations have grown to the point that land is critical to food production. However, national security interests have succeeded in converting much of that farmland (as well as some land areas sensitive or critical to ecosystem health) to biofuels production to minimize reliance on foreign petroleum supplies. At the same time, public demand for recreational open space, especially space with a water component, is many times what it was at the turn of the 20th century.

Bookend 2—A Vision of Water Resource Management in 2050

Instead, imagine an integrated hazard/ecosystem management approach to water and land resources, based on a National Water Resources and Floodplain Management Policy Act, passed by Congress in 2019. Through a nationwide strategy, state and local governments apply holistic techniques for sustaining our water quantity and quality, managing drought, and achieving related multiple objectives. The strategy is ecologically sensitive and is based on the premise that no unmitigated adverse impacts to locally designated values are permitted. The federal government provides leadership through a coordinating and integrating body for all programs, policies, and disciplines that have to do with resources. The United States collaborates with other countries to improve management and conservation techniques for the world's river basins.

In the visionary 2050, ecosystem services sustain populations; investment in the maintenance of healthy ecological status is accepted. The value of natural resources and functions of floodprone areas to society, in the form of habitat, recreational opportunities, filtration, storm buffering, carbon sequestration, and others, are always taken into account in decisionmaking.

Private philanthropy plays a major role in water resources and ecosystem management. Stormwater is used as a resource; nutrients are recycled. Accurate economic modeling reveals the true costs of floodplain development, and changes in old benefit/cost analysis procedures have resulted in appropriate weight's being given to the natural functions and resources of water-related resources. The agricultural sector and the floodplain management profession are allied in preserving sensible uses of riparian areas. Standards for instream flow help sustain ecosystems.

Standards for Development, Buildings, and Critical Facilities

This adjustment groups together the ideas of elevating buildings above flood levels, applying construction and development standards to make buildings safer, and differentiating between human uses of floodprone areas that need extra protection because of their importance to society.

Bookend 1—Where Existing Building Standards will Take Us

The urbanization of watersheds that has occurred continuously since the 1900s, along with impacts of climate change felt in the decades since, have resulted in the higher projected (and actual) flood levels we are seeing in 2050 in many locations throughout the United States. Millions of homes and other buildings that were constructed to projected 100-year flood levels that were based on earlier circumstances are now below that level—sometimes far below. The idea, so prominent at the end of the 20th century, of elevating buildings to a "safe" level has proved to be a futile goal. Whether elevated on fill or on piers or foundations, homes have been repeatedly isolated from the outside world (including emergency services) during times of high water—memorably during the disastrous flooding when several levees protecting large residential areas in the West failed during the winter of 2034 and spring of 2035. During those floods, rescue workers, and fire and police personnel were put at risk when tens of thousands of elevated structures were rendered inaccessible for almost two months. The added cost of providing protection from fires, looting, and other dangers during those circumstances added enormous financial burdens to the already-stricken local and state governments.

In 2050, numerous coastal buildings previously thought to be "safe" have been particularly hard hit by rising flood levels, reflecting the unwillingness of individuals and governments to engage in strategic retreat from the shoreline and instead rely on engineered designs and construction standards that purported to ensure safety.

Although federal agencies had been directed in 1977, through Executive Order 11988, to consider the flood hazard in siting or funding projects, in the more than seven decades since then there has been inadequate enforcement of the order's provisions. Without adherence to the mandated standards or procedures, federally supported facilities, licenses, and infrastructure have encouraged a proliferation of development in and near floodprone areas.

Even in 2050 there are still no consistently applied standards for selecting safer locations or requiring mitigation measures for such critical facilities as public buildings, roads, hospitals, fire and police stations, communications systems, power plants, and water and wastewater treatment facilities. The standards that do exist are unevenly implemented. Certain facilities, such as water treatment plants, too often have been located in floodprone areas, precipitating subsequent arguments that flood control structures are needed to protect them. Facilities that in earlier years were considered not prone to flood hazard now are exposed, both because of the rising flood levels brought by urbanization and changes in climate and because of more accurate estimates of flood levels.

In 2050 we need far more infrastructure and public facilities to serve our higher-density development, but planning and designing the facilities is more complicated than before because of changes in the flood hazard, concentration of people, and the need to account for evacuation of large populations. In the absence of clear, well-enforced, and amply funded programs for maintenance, infrastructure that was already aging in 2007 has long since deteriorated and the threat posed by its condition is exacerbated by the increased potential for flooding.

Bookend 2—A Vision of Building Standards in 2050

Alternatively, federal and state governments could well be using future conditions as the basis of flood modeling and mapping in 2050. In this way, flood risk is analyzed based on trends in long-term development, climate, and population change. The design, planning, and construction standards for new development are correlated to flood risk (that is, probability multiplied by consequences) and vary from 100-year flood for low-risk, low-value land uses or buildings, to some considerably higher level of risk reduction for critical facilities or for areas behind levees that are already built up or planned for development. The cost of flood insurance is based on the risk (including a factor for the future if risk levels are clearly changing), providing incentives for applying appropriate building-by-building mitigation measures.

Instead of allowing construction in flood hazard areas as long as the buildings are elevated, the national focus in 2050 is on completely avoiding construction in floodprone areas—including residual risk areas—if at all possible. This dramatically reduces the exposure of homes and infrastructure to flood damage. When there are no alternatives to using a floodprone site, development is only permitted if it is done in a manner that minimizes putting people at risk and causes no unmitigated adverse impacts to natural flooding functions or other community values. In no case, however, are critical facilities, such as residences, hospitals, nursing homes, water and sewer treatment plants, or emergency operations centers, built within 500-year flood zones, or if avoidance is impossible, all of them are protected to and accessible during 500-year floods. Building levees around vacant land in order to create new "developable" areas is no longer acceptable.

Grants, tax deductions, and other sources of federal funds have a sliding cost share that rewards those communities and individuals who do the most to reduce flood risk to their existing buildings and facilities and minimize impacts on other properties.

In the visionary 2050, we have a very long-term focus for the planning and siting of critical facilities. Federal incentives are provided to move and keep such structures out of the floodplain, and federal guidelines put more weight on safe locations in decisionmaking. Federal policies and programs reward states and localities that reduce future damage and impacts by encouraging mitigation and relocation. In addition,

- There is universal adherence to Executive Orders 11988 and 11990, which were re-issued in invigorated forms in 2011.
- Stronger standards are in place for siting, construction, and protection of critical facilities.
- Certain high-hazard or environmentally sensitive areas and facilities, such as wetlands known to filter large volumes of water, deep riverine floodplains, or designated ecological restoration areas, have been declared ineligible for development-fostering federal support in the form of disaster assistance, grants, loans, tax deductions including the casualty loss deduction, charitable donation contributions, and the like.
- The private sector leads in planning and designing sustainable development, using no adverse impact approaches that increase its marketability.

Flood Insurance

In the market-based U.S. economy, where private property is highly valued, insurance against flood damage is an appropriate and potentially effective way to adjust to flooding. In addition, this mechanism can encourage appropriate actions in the face of flood hazard and require payment for inappropriate ones.

Bookend 1—Where Today's Approach to Flood Insurance will Take Us

In the absence of insurance rate and program reform, in 2050 there are many more millions of at-risk people and structures without flood insurance, because people continue to misunderstand both the flood hazard and the insurance mechanism. Because flood insurance remains voluntary, those who do purchase it tend to be those with the highest risk, making for an unbalanced policy base, and driving premium rates higher. Because of the lack of effective long-term mitigation, the numbers and costs of repetitive flood-loss properties have continued to rise and that category of structures still represents a disproportionately high cost to the NFIP. High levels of overall annual flood losses persist as well. Unfortunately, Congress still hastens to provide disaster relief and exempt structures with high and residual risk from purchasing flood insurance—all while continuing the debate over the best ways to indemnify individual losses, minimize risk, and be fiscally responsible. Lawmakers still ponder whether the federal government should be involved in flood insurance at all, or should instead turn it over to the private sector because flood and hurricane disasters repeatedly deplete federal financial resources.

Bookend 2—A Vision of Flood Insurance in 2050

Imagine instead, that in 2050, multi-hazard insurance that includes flood coverage is mandatory throughout the United States, including residual risk areas. Through a shared framework involving private insurance companies and government backing, premium rates are truly actuarially based. This makes the program of coverage self-supporting and also provides incentives for wise land use decisions by local governments, including proper siting, design, construction, mitigation, and retrofitting. The system is modeled after the procedures 20th century insurance companies used to credit communities that maintained excellent fire fighting capability, enforced strong building codes, and encouraged home alarms to reduce the potential for break-ins or unobserved fires. The government-backed framework for flood/multi-hazard insurance has built-in sliding cost-share incentives tied to disaster relief programs and other federal funding mechanisms. With these incentives, a larger portion of federal funds are available to localities and states that have taken action to reduce flood damage and/or protect natural floodplain functions.

In the visionary 2050, rate reductions in flood insurance are available at the individual policyholder level, providing an incentive for individual actions that reduce vulnerability. Subsidies and grandfathering have been eliminated. Digital maps depicting flood risks, insurance zones, land uses, habitat, resources, and other factors are integrated into digital geographic information systems that are freely accessible to everyone.

Flood Disaster Relief and Recovery

Disaster relief and recovery are human adjustments that work to help individuals, households, businesses, and government entities resume normal functioning after being damaged by a flood. This help can take the form of hands-on emergency assistance, financial contributions or loans, technical support, or other means.

Bookend 1—Where Current Disaster Relief Policies will Take Us

In 2050 there still is persistent misunderstanding about what financial compensation will be forthcoming after a flood from homeowners' insurance, flood insurance, and federal disaster relief. Since the late 20th century, the media has intensified its tendency to dramatize extreme events and to cast blame. Even though public safety has always been the clear responsibility and primary function of local government, since the 1990s federal agencies have been highly visible in the media after disastrous floods and hurricanes, leading the public to believe that the federal government should and always will be on the spot, and that taking care of flooding is its job. In that environment, it is no wonder that federal officials have continued to promise to deliver assistance and even pledge to make people "whole" again, even though the latter is neither possible nor their legal or financial responsibility.

The availability of federal relief after a disaster, especially in the form of public assistance to local governments, has seriously undermined the cost-sharing arrangement required for taking mitigation action. Thus, those communities who did the least to reduce flood damage and flood risk to their citizens over the decades were rewarded with federal relief dollars while those communities that wanted to take action struggled to find funding. As a result, in 2050 relatively few localities and states have managed to implement comprehensive flood mitigation measures.

Now, in 2050, people always look first to the federal government for compensation for their losses after a flood. In the absence of adequate compensation from that source, filing a lawsuit against localities, engineers, designers, builders, and others has become a commonplace avenue of redress. The long and costly litigation process ties up the legal system, directs resources to attorneys, courts, expert witnesses, and others instead of those who were damaged by flooding, and favors those who can afford it, leaving economically disadvantaged parties without recourse.[15]

Bookend 2—A Vision of Disaster Relief in 2050

If techniques for coping with flooding are applied effectively for several decades, by 2050 emergency measures and disaster response and recovery will not be needed as frequently as they were in the 20th century. However, higher flood levels and more intense storms combined with a larger and densely concentrated and more diverse population have made emergency measures, especially evacuation, critically important when floods do threaten.

In this visionary 2050, disaster relief remains as a viable back-up adjustment as part of a large system of indemnification, but considerable education has been done to make the public aware of its limits. The complex patchwork of indemnification processes, including the federal disaster relief programs and policies that were embodied in the Stafford Act of 1988 and its 2000 amendments, was re-designed early in the 21st century to reconcile discrepancies among relief and mitigation policies and funding mechanisms. Now federal policies create strong incentives for wise local management of floodprone and coastal areas. The availability of indemnification for flood losses, including through litigation, is contingent on community and state adoption and implementation of broad and far-reaching holistic water resource mitigation and preparedness measures. This requirement serves both as an incentive and as a statement to the public about what is expected.

- All communities have robust pre-disaster mitigation plans that are followed religiously after a disaster to truly reduce future vulnerability.
- The processes for collecting data on precipitation, streamflow, groundwater, water quality, habitat, and other resources and functions have been greatly enhanced and

modernized since the 20th century. Up-to-date information, often in real time, is available on all critical systems.

- In the visionary 2050, highly accurate and real-time forecasting and warnings are distributed in various formats, including visualization techniques, combining data from all agencies and private entities.
- Emergency action plans exist for all critical facilities and are practiced regularly.
- Sheltering in place is planned and designed for in selected appropriate locations, preventing traffic snarls during mass evacuations.
- Areas with residual flood risk have been identified and people within the areas are aware of that designation. Flood warning plans for these residual risk areas are in place and are regularly exercised, with annual notification to affected property owners.
- The private sector leads the way in a system of indemnification, loss reduction, data collection, forecasting, warnings, and other emergency measures.

Structural Flood Protection

Flood protection structures include dams, levees, floodwalls, channelization, and other engineered techniques. Once known as "structural flood control," these measures were for many decades the preferred approach to coping with flood hazards and, particularly in the case of stormwater management and already urbanized areas, remain necessary in many places.

Bookend 1—Where Reliance on Structural Protection will Take Us

Unless things change, in 2050 we will see clearly that most of our structural flood control measures like levees, floodwalls, dams, and artificial channels are being overwhelmed by increasingly larger events. In some cases, development has resulted in more runoff and flooding that outpaced the structures' design levels. In others, maintenance procedures were faulty. In many places floods and storms increased in intensity, catastrophic events damaged the structures, or their useful design life simply passed.

The single-purpose structural solutions preferred by many residents and communities in past decades have brought drawbacks that often outweigh their benefits. These drawbacks include residual risk, the non-stop expense and diligence of maintenance, and the virtually assured liability that will ensue should the facility's design be exceeded or fail. Lawsuits over flood damage stemming from structural flood control measures have proliferated. As technology and knowledge increase our ability to predict the cause and degree of flooding, owners of structures are less likely to escape liability by offering an "act of God" defense.

Unfortunately, more urbanization has brought increased pressure at the local level to apply a quick fix to problems of water supply and flooding. More reservoirs have been built to meet the demand for water.

Bookend 2—A Vision of Structural Protection in 2050

Or, consider a 2050 in which the nation has an integrated framework for sustainable water resources that carefully brings together consideration of all uses for water. Professional floodplain managers of 2050 still realize that structural protection can be of tactical value in some

circumstances, but structural flood protection measures are considered a last resort for mitigating flood hazards. Aging infrastructure, such as dams, levees, and channels from the late 20th century has been relocated or rehabilitated and, in some cases, removed. Instead of relying solely on structures, we analyze local and regional risk to determine whether, in the long run, it would be better to relocate households and businesses away from hazard areas now protected by structural systems than spend the money to continuously upgrade and maintain these structural elements.

In this visionary 2050, citizens understand the concept of residual risk and realize that structures such as levees merely lessen risk from some events rather than eliminate it, and may worsen risk in extreme events. Where it is unavoidable, such residual risk is managed effectively through a system of planning for the future that facilitates automatic mitigation, such as removal or elevation of buildings and purchasing and keeping flood insurance. When relocation is proposed, issues of social equity are carefully considered and resolved among all the stakeholders.

- Flood damage reduction structures are used only to protect existing development, and then only as an option of last resort.
- Levees are never built to protect vacant land for human development, because that only encourages at-risk housing and commercial structures.
- Non-structural solutions to a flood "problem" are examined first.
- Second priority goes to hybrid systems—a mix of nonstructural and structures.
- All structures are natural. Urban "hardened" channels constructed in earlier decades have been rehabilitated to provide natural functions and benefits.
- No flood protection structure is built unless funding for its maintenance is guaranteed up front.
- The federal government no longer builds flood protection projects, although it assists in the rehabilitation of older ones and provides technical assistance in bottom-up evaluations of mitigation options. When flood protection structures are built, the private industries or communities that benefit from them provide the funding for design, construction, and maintenance.

Awareness and Education

This adjustment is an ongoing and diverse one through which individuals, organizations, businesses, and decisionmakers become aware of and comprehend the processes, benefits, resources, and hazards of flooding. It is based on the assumption that, armed with knowledge, people will make appropriate choices about risks and resources.

Bookend 1—Where Today's Floodplain Awareness will Take Us

By 2050, the spread of urbanization, the scarcity of unspoiled natural areas, and the proliferation of entertainment-related technology has created an even wider disconnect between people and their environment than existed at the turn of the century. In addition, because they tend to move several times during their lifetimes, most people do not develop an intimate understanding of or sense of stewardship for their natural surroundings. The vast majority of coastal dwellers, for instance, are relatively new to the hazards, extreme weather, and fragile ecosystems of that region. The ill-conceived "100-year" and 1% flood and storm designators of

earlier years are still in use, and still misunderstood. Insurance risk zone maps are interpreted by the public to mean that the areas outside the identified hazard zone are guaranteed to be safe.

Just as it was in the late 20th century, public lack of comprehension about water-related hazards and resources still is exploited—inadvertently or not—by those who stand to benefit economically from development of floodprone areas. Because people do not understand the risks, or the resources that are at stake, or that some adverse impacts will not be realized for years, they do not participate in the decisionmaking processes.

Bookend 2—A Vision of Floodplain Awareness in 2050

Perhaps, though, the population of the United States in 2050 will be a well-informed one that understands both the burdens and blessings of the flooding process. In this visionary 2050 people have a healthy respect for floods and other natural hazards and they appreciate the natural functions and resources inherent to riverine corridors, estuaries, coastlines, and other floodprone lands. This awareness has gradually led to voluntary reduction in building in floodplains. Children have been taught to have an appreciation of all natural hazards, including floods, just as they came to accept seat belts late in the 20th century.

People understand the connection between healthy waterways and food, have an awareness of ecosystem services, and demand that natural areas be protected. Households take responsibility for their own physical and financial safety and for the natural resources they consume or affect. Families are knowledgeable about self-reliance, including rescue and survival, and have a plan for a flood disaster that includes ways to store or acquire necessities without waiting for government assistance.

At last, in 2050 this deep and broad appreciation is reflected in the actions of elected officials, policymakers, investors, developers, and other influential parties. Public and private policies have been devised and are implemented to protect shared land and water resources and functions and to help people protect themselves.

Decisions about community development are made only after all impacts of the proposed activity are identified, the property owners and taxpayers who will be affected by future flooding or will be paying for current and future damage have been notified and their concerns addressed, and the sustainability of the ecosystem in question has been ensured. All current and future adverse impacts and costs are mitigated before development proceeds.

PART III

A FUTURE WE COULD REACH—STEPS TO AN OPTIMAL 2050

In the alternative 2050 . . . in spite of rapidly growing populations and a changing climate, both flood risk and land and water resources are being managed towards more sustainable outcomes. The nation views land and water as precious resources, and therefore protects the natural and beneficial functions of floodplains, wetlands, and coastal areas. Because these areas have been preserved—and in some cases, restored—a maximum amount of natural mitigation of flooding takes place continually. Integrated water management is an accepted practice. All new development is designed and built so that it has no adverse impact on flood levels, sedimentation, erosion, riparian or coastal habitat, or other community-designated values. The market strongly favors sustainable development, which means that floodprone construction rarely occurs. Private and public losses due to floods are indemnified through a government-backed but private system of universal insurance coverage that encourages mitigation. Floodplain management programs are funded from fees charged for development impacts, a highway trust fund, or other secure sources. Risk communication through all levels of government has become advanced enough that local decisionmaking is well informed; policy decisions are based on sound science.

Is the visionary 2050 merely a dream? The Forum participants did not think so. Even though we are in a critical situation with regard to our escalating national flood losses and our diminishing water-related resources, the experts agreed that the better future is within our grasp. We can reach it by taking on clarified and holistic goals and by deliberately and aggressively applying what we have learned in the last 50 years. With the technology and science at our disposal today, we have a realistic expectation of achieving a comprehensive and sustainable relationship between humans and natural flooding processes.

The management approaches we have been using for the last several decades are partly to blame for the situation in which we find ourselves. Accordingly, the Forum experts identified numerous shifts that will be needed in order to escape undesirable outcomes and reach an optimal future instead. These changes include shifts in thinking and philosophy, many improvements to practice and programs, clarifications of policy, targeted scientific research, better application of new technology, and many more. These recommendations and ideas are organized under four steps that floodplain management professionals and policymakers need to take, and are described more fully in the rest of this section.

(1) Apply new ways by which humans can adjust to flooding.

(2) Alter the mixture of adjustments that we are using today to de-emphasize those that are not proving effective and rely more heavily on those that will be more successful in the long term.

(3) Significantly modify the implementation strategies for the adjustments we use today so that they will be more effective.

(4) Use the drivers of change (population growth and urbanization, climate change, etc.) as opportunities.

Cultivate additional Human Adjustments to Flooding

Certain themes run through the scenarios of an optimal future—themes that are missing from our current course. Although White's original eight adjustments will remain fundamental as we move through the coming century, there was consensus among the Forum experts that in 2050 floodplain management will have to be based on a broadened range of adjustments. Our changed and rapidly changing world makes four additional adjustments critical to effective floodplain management.

Room for Rivers and Oceans

White's original adjustments were based on a premise that we seem to have forgotten, i.e., that humans have the choice of NOT occupying river floodplains or coastal areas at all. This premise was not made explicit, perhaps because at the time White offered his initial adjustments, the perception was that the United States had an excess of "environmental" resources and, because of the smaller population, open spaces appeared abundant. Society was focused on improving life via technology. The need to conserve and protect natural lands and their functions was less evident and, for that matter, society gladly exchanged those resources for growth and development.

Since then our land, water, riparian, coastal, and associated resources have been gradually used up, altered, and degraded—ironically to enable two of the very trends (population growth, denser development) that now are further threatening them. Today in some areas fisheries of international renown are gone, water supply has reemerged as a pressing, nationwide problem, and we are on the brink of losing resources such as the Louisiana coastal marshes that, besides being culturally iconic, are economically important, and serve flood protection and natural resource needs.[16]

The specter of a rising sea level brings home as never before the risks of locating development too close to the coastline. Just a slight increase in sea level will cause widespread significant negative impacts on large and heavily populated portions of the United States, including the Chesapeake Bay region, much of Florida and the Gulf Coast, and other areas. Secondary impacts will reverberate through the economy and ecosystems.[17]

As the population expands and density increases, the choices we make about land uses will become absolutely critical. Choosing not to occupy floodplain lands would profoundly improve natural functions. Our thinking needs to be brought back around to considering human adjustment to floods and the benefits to society of natural flooding functions, not just to flood HAZARDS. The fragility of our water resources and the hydrologic/ecologic system upon which we rely must be recognized and accommodated.

For an optimal future we must acknowledge that degradation of natural resources is an inevitable byproduct of our occupance of the land (floodprone or not), and carefully consider how to avoid causing that impact. We need to introduce an adjustment tied to benefiting these ecosystems and natural resources and to ensuring their viability over the long term. Europeans call this adjustment "making room for the river" or making room for water.

We need to begin a pattern of gradual and voluntary relocation or strategic retreat from the highest-risk and most ecologically sensitive areas, with climate change and long-term sustainability both in mind. State mitigation plans could incorporate strategies for vacating certain areas and converting them to safer, more natural uses; no federal dollars would be spent on development in these areas. More funds will be needed for removal of structures.

Personal Responsibility

This is another premise that likely underlay White's writing but that, for one reason or another, has receded into the background. Society in the last few generations has seemed to glamourize victimhood, take for granted that financial or other compensation is owed to those victims from some vague source, and search for someone or something to blame for every mishap. Probably the most effective overall technique for living with floods is for people to take personal responsibility for their own flood risk and for the sustainability of water (and other natural) resources. A cultural and behavioral shift is called for to develop full societal understanding and acceptance of what is at stake. Water resources, flood problems, impending climatic impacts, and natural resource degradation are interlinked and should not be stovepiped—we need a whole society that embraces human relationships to the planet.

Human Adjustments to Flooding, 2007

- Space for Rivers and Oceans*
- Awareness and Education*
- Personal Responsibility*
- Land Use
- Watershed Management
- Development & Building Standards
- Insurance
- Geographic Interdependence*
- Emergency Measures
- Disaster Relief
- Structural Flood Protection
- Elevation of Land or Buildings

**proposed new adjustment*

Geographic Interdependence

With reliance on digital data and its easy transfer for most aspects of the economy and society (including data, infrastructure, markets, and communications) we have introduced vulnerabilities that did not exist in 1945—some related to national security, some related to global economies, and others related to individual livelihoods. The economic consequences of damage/failure of these facilities and linkages could range from ripples to major losses. Flood damage to an industry is no longer a relatively isolated event; instead, it can be felt hundreds if not thousands of miles away. In short, vulnerability to flood hazards is no longer limited to the floodplain or the ocean coast.

The private sector is the logical leader in the implementation of this new adjustment. For example, business plans will need to account for the vulnerability of that business if a flood or coastal storm damages one of its suppliers or interrupts a vital digital linkage. Adjusting by recognizing geographic interdependence means protecting these linkages—our 21st century critical facilities. This does not mean building walls around them, but rather making it a high priority to consider the flood hazard and multiple ways to mitigate the threat it poses to these critical facilities, networks, and intangible linkages.

Awareness and Education

Communicating the information about the potential of flooding, the hazards of hurricanes and storm surge, the ways in which human development alters and depletes water resources, and other water-related concerns is more important than ever. Not only are people drawn to ever-riskier areas, but the hazards in some places are increasing. People have the financial resources to build over-sized and expensive structures in flood hazard areas, thus significantly increasing national vulnerability to flooding.

The public is now accustomed to a continual flow of information, with instantaneous reactions by those "in charge." A populace that is well-informed about the risks it poses to our

water resources through carelessness, waste, or overconsumption is a populace that can take myriad individual actions to avoid causing harm. By the same token, people who understand why and how flooding is likely to occur and what they can do about it are an important weapon in society's arsenal against flood damage. The longstanding misperceptions about flood insurance and flood risk zones are good examples of how easily misinformation can be transferred and how long it can persist.

We need to apply thorough, well-targeted, well-funded education strategies, awareness and outreach efforts, and sophisticated risk communication vehicles that will actually change behavior and induce knowledge-based adaptation. We also need to recognize that education and communication will not succeed unless some of the disincentives to wise development are removed or changed.

Perhaps more important, public decisionmakers at all levels, leaders of influential industries like homebuilding, insurance, and banking; and professional groups all must be supplied with information and data that will arm them with the understanding to make decisions that will be wise for the long term. Also, specific ways in which each profession, interest group, business, and others affects the long-term vulnerability of both people and the environment will need to be spelled out in indisputable terms, and safeguards and remedies identified and applied.

Alter the Mixture of Adjustments that are Used

In hindsight, overreliance on certain adjustments to flooding has mired us deeper in our increasing-flood-losses crisis. It has been abundantly clear for some time that exclusive reliance on engineered structures was the wrong path, although the legacy of that thinking will linger for many decades. A subtler and newer example is that the minimum requirements of the National Flood Insurance Program, which have become the *de facto* standards in most of the nation, have tended to emphasize "safe" ways to build in flood hazard areas, rather than ways to make decisions about whether that land should be used for development at all. This has generated an underlying sense that building in flood zones is acceptable, as long as the building is elevated high enough, sufficiently anchored, or otherwise protected. Now that we see flood levels rising as a result of urbanization, we realize that encouraging development in flood hazard areas, even with widespread elevation of floodplain structures, is not the best answer.

What is needed is a better grasp of the full range of adjustments, along with appropriate assistance and incentives to make wise choices.

Improve Implementation of Existing Adjustments

All of the adjustments White identified are still in use in one form or another today, and Forum experts concluded that none of them should be abandoned. However, there is much room for improvement in how we implement the programs and policies by which we carry out the adjustments. Suggested changes are grouped into four categories below.

Shifts in Governance Needed

There is a desperate need for clear and holistic national goals for treating land and water as the vital resources that they are. Our twin goals must be to protect people and property from flooding while also protecting floodprone lands from people. Further, we can no longer afford to isolate these activities from the closely related national interest in preserving supplies of fresh

water and keeping water quality high. We must take a broader view than we have in the past, and return to treating water and watersheds like resources and flooding as an inextricably linked component. States and their localities can take the lead, by developing and tailoring programs and policies to match their own land and water resources and hazards. The federal level can provide incentives to build capability, and bring oversight and consistency, so that the whole fits together in a sustainable approach. We need to adopt a much longer-term view, far beyond the 5- to 10-year planning horizons that are considered acceptable today.

We need strong policies, programs, and funding that embrace and support a holistic water resources concept, with hazards management as an underpinning. This should include an effective national floodplain management policy. A high-level oversight or coordinating mechanism is needed to implement water-related activities, possibly a new federal department or agency whose sole concerns are the resources found in our water, our coastal areas and riparian zones, desalinization, aquifer recharge, wetlands, estuaries, and other related issues.

The Forum suggests that Congress formally establish twin national goals: (1) reduce the vulnerability of our population to flood damage, and (2) improve our stewardship of the natural and beneficial functions of our floodprone areas. Water legislation at state and federal levels must be aligned and programs seamlessly integrated and coordinated for these dual purposes. Legislation clearly stating our water and floodplain management policy should be passed. Congressional oversight of water-related programs now is scattered among many committees and subcommittees, which grossly inhibits progress.

In addition, a decisive statement is needed that it is U.S. policy to achieve and maintain environmental, social, and economic sustainability. Restoring and enhancing our green infrastructure—riparian areas, vegetative cover, water bodies, habitat—should be a national priority.

We need a fully integrated and modeled scenario of flood hazards and resources so that society can fully understand the consequences of taking any given action. The British have demonstrated, with their Foresight Flood and Coastal Defence project, that this can be done on a very large scale and be based on projections of conditions many decades into the future.

For any nationwide approach to be successful, we must have a framework that enables Congress to make wise choices and still retain political support. An appropriate analogy may be that of the closing of domestic military bases during the 1990s, in which Congress adopted a set procedure by which the hard decisions about closures were made in a fair and open fashion, and the far-reaching local and regional implications in terms of jobs, land use, and economic impacts were addressed up front.

Foresight Flood—
The United Kingdom Shapes its own Future

With £200 billion of assets vulnerable to flooding in and around British rivers and coasts, and with flood risks set to rise over the next century due to changes in climate and society, HM Treasury ordered a massive scientific study of the best options by which both government and the private sector could respond to the future challenges.

The Foresight Flood and Coastal Defence Project developed four different scenarios of the future to analyze anticipated risks of flooding and coastal erosion. They incorporated alternative government actions, changes in climate, socioeconomic outcomes, greenhouse gas emissions, and other variables.

The results of the unprecedented, nationwide models make it clear that continuing with existing policies is not an option. According to Sir David King, Chief Scientific Adviser to HM Government, "in virtually every scenario considered, the risks grow to unacceptable levels."

See http://www.foresight.gov.uk/Our Work/CompletedProjects/Flood/index.asp.

In addition, a work group may be needed to analyze the gaps in technical and scientific information that must be filled to conduct a meaningful nationwide vulnerability assessment for the United States. For example, we may need stronger topographic data, or centralized, accessible databases of damage potential, or other kinds of information.

Past policy and program mistakes can be avoided in the future if it is accepted that funds must be set aside to periodically review existing programs to see if they work and if any unintended consequences result.

Program Changes Needed

While more sweeping change is being crafted, improvements still can be made to existing policies to bring them more in line with the bigger shifts in governance (noted above) that are needed for the long term.

The nation's fragmented system of water resource management, disaster relief, mitigation, and insurance should be amended to promote a unified program to protect and manage water as a resource.[18] The whole patchwork system of indemnification for disaster losses should be overhauled to incentivize conduct that will provide long-term benefits while also eliminating disincentives and duplication and minimizing costly and time-consuming litigation.[19]

- The concept of identifying certain critical resources areas for federal protection and no-build zones, analogous to the thinking underlying the Coastal Barrier Resources Act, should be explored for possible application to other water-related resources.
- Executive Orders 11988, Floodplain Management, and 11990, Protection of Wetlands, need to be invigorated and enforcement of them intensified.
- Properly administered, support for water resources including tax incentives, federal and state grants, as well as flood insurance should encourage appropriate actions and require payment for inappropriate ones. It seems clear that universal flood insurance coverage is highly desirable but will only come to pass if such coverage is made mandatory. We must step up the pace of phasing out flood insurance premium subsidies and moving toward actuarial rates.
- *De facto* no-build zones should be established for coastal areas, similar to floodway zones along rivers and streams. The privatization of flood insurance bears consideration. All mapping should be based on future conditions.
- We need to adopt a much longer perspective on the design and siting of our critical facilities.
- Consideration should be given to shifting our flood hazard and resource protection approach from a regulatory basis to a strategy that is grounded more in public/private partnerships, performance, and outcomes.[20]
- More rapid movement is needed toward no adverse impact management strategies, with an eye towards environmental, economic, and social sustainability. Much of this can be led by non-governmental organizations and non-profit groups.
- We need to seize the opportunity presented by the fact that a significant proportion of existing infrastructure will be repaired or replaced over the next 50 years. New policies are needed to specify removing infrastructure from the floodplains where possible;

applying stricter standards for siting replacement facilities, retrofitting, and strengthening during repair; considering ecosystem needs in concert with human ones; and accounting for the reality that "where infrastructure goes, so goes future development."

Research and Data Needs

Movement toward an optimal 2050 will require extensive, accurate, easily accessible data on every aspect of the resources and hazards inherent to water and its adjacent land areas. We must integrate data on our natural resources with our floodplain data.

- We need to upgrade the data on which floodplain management depends to incorporate reliable climate change data.[21]
- We need to compile a national topographic data set, a flood loss data set, and a database of the elevation of every structure.
- Our stream gage data collection system needs to be restored, expanded, and made available to its many local, state, federal, and private-sector users.
- An independent, comprehensive review is needed of all federal water related programs, programs that subsidize or promote development decisionmaking, and all grant programs. It should answer such questions as, What are the barriers to the integration of these authorities? How can Congress's duplicative jurisdiction and oversight be consolidated? What federal legislation and policies are needed? What coordination and leadership is missing?
- We need to reach consensus on the general trends we expect to see associated with climate change and sea level rise, particularly geographically specific impacts on flood severity and frequency, as well as impacts on riparian and coastal zone ecosystems. Based on these expected trends, the pertinent national programs should be adapted quickly to account for changed conditions, especially those likely to be most severe.
- The natural and beneficial functions of floodprone areas need to be acknowledged as worthy of protection, restoration, and enhancement throughout all federal, state, and local programs. We need to immediately establish accepted, reliable methods for quantifying these resources and ecological services so that they can be incorporated into benefit/cost analyses and other decisionmaking tools. A federal task force or other leadership on natural and beneficial functions may be needed. Data on the resources is just as important as that on flood hazards. A work group could identify data and collection methods for valuation of floodplain related information.
- There is a need to map the original adjustments crafted by White along with the four new adjustments offered by the Forum against the policies and programs that are deemed to support the realization of each adjustment. This will serve to evaluate the breadth of activities within each adjustment and also serve as a gap analysis.
- We need to make a major investment in basic climatological trend analysis on a regional basis. Data is needed that focuses on major urban areas and their surroundings to capture the anticipated impacts of climate change. As a first step, leading subject matter experts could be brought together to lock down, on a geographic basis, what the major demographic, water resource, and ecosystem trends are, along with their

expected impacts. Second, based on that data and those projects, we need to do scenario-based evaluations that provide data to support outcomes from both altered and unaltered trends. Finally, we must consider how we map economics and flood risk into the long-range scenario based plans.

Funding and Other Incentives Needed

Secure funding sources—such as service fees or earmarked tax revenues—must be established for floodplain management programs, infrastructure maintenance, resource protection, flood map updates, and mitigating the repetitive flood loss problem. The science arms of federal agencies need funding levels adequate to meet the expanded future need for science-based information and models.

State and local action to mitigate floods and protect water-related resources should be rewarded by incentives, such as a dramatically sliding cost-shares or other financial advantage. Funding programs should be zero-based, so that those who do take positive action benefit and those not acting appropriately pay their share of the costs of risky action.

The bases upon which eligibility for federal (and other) funding is determined need to be modified to incorporate the value of sustainability, resource protection, ecosystem resilience, recreation, and a range of other benefits previously omitted or not quantified. New procedures must capture the annual average costs and benefits of flooding. The new benefit/cost policies and procedures need to be applied universally and not vary from agency to agency.

We need to reconcile all programs that subsidize development decisions with our programs for mitigation funding so that they reinforce instead of undermine each other. This includes the programs and policies of the Departments of Agriculture, Energy, Housing and Urban Development, Interior, and Transportation; the Economic Development Administration; the Environmental Protection Agency; the Federal Emergency Management Agency; the Tennessee Valley Authority; the U.S. Army Corps of Engineers, and others.

The United States needs to make a serious investment in the inspection, repair, redesign, rehabilitation, and maintenance of its aging infrastructure, including highways, roads, bridges, dams, and levees.

Use Drivers of Change as Opportunities

Finally, to reach an optimal 2050 we are going to have to take advantage of impending circumstances. The unprecedented drivers of change described in Part I can overwhelm us and our efforts, or they can help us shift to a mixture of adjustments to flooding that will be more successful for the future.

Exploding population growth and urbanization are upon us, but we can shape impending growth to help achieve floodplain management objectives. For example, existing local zoning and related codes were based on templates developed decades ago that catered to families with children, which accounted for 48% of the population in 1960. We have inherited this spread-out landscape and associated development patterns that do not match housing needs of the future, when, for example, it is anticipated that only 25-35% of households will have children and other demographic differences will be in place.

The good news is that impending development trends are presenting us with ample opportunity to create safer and more sustainable housing and commercial structures and infrastructure. Over half the commercial and residential structures that will be needed in 2050 do not exist today. If we start now to build, rebuild, repair, and retrofit both buildings and infrastructure in ways that will closely meet future needs instead of following outdated patterns, about two-thirds of all development in place by 2030 could be safe and sustainable.[22]

Another opportunity is that some traditional government functions are already devolving to state and local governments, to the private sector, and to nonprofit groups. For example, non-profit land trusts successfully establish and operate conservation reserves, parks, and nature centers. International foundations fund water-quality and sustainable development initiatives. Rather than heralding a loss of governmental leadership or services, this process can present an opportunity if we craft an orderly, creative transition. We need to anticipate those activities that can best be conducted by nongovernmental entities and move to set them up properly. The creativity and economic efficiency that the private sector can bring to bear on human adjustments to flooding can be a huge contribution.

Although there is disturbing—and growing—evidence of the deterioration of some ecosystems, and scientific consensus that climate is changing more swiftly now than in recent history, these danger signs have an up side too. Certain aspects of the crisis have captured the public's interest and "being green" is reflected in a vast number of modifications in consumer goods and in consumer behavior. This awakening could be channeled into a second wave of landmark initiatives to further environmental protection. While the earlier, 1960s and 1970s array focused on single-purpose legislation like the Clean Water Act, the Endangered Species Act, the Wild and Scenic Rivers Act, the National Environmental Policy Act, and others, public enthusiasm and support could now be channeled into groundbreaking sustainability legislation, a national vision for land and water policy, and an ethic of stewardship.

A Final Word

The 2007 Forum was characterized by a sense of urgency. Professionals from every field related to floodplain and coastal management, along with policymakers and the public as well, remain seriously dissatisfied with the limited progress we have made in addressing flood losses and in managing our water resources. Now, with the impending increases likely in both the flood hazard and the human development with which it interacts, the future of our nation, our resources, and our quality of life are themselves in question. But the Forum experts also exhibited ambitious determination to avert potential calamities and a strong belief that many of their visions can become reality. With a handful of bold brushstrokes now, the United States can paint a safe and sustainable future for its water resources.

PART IV

ACTION GUIDELINES

Floodplain management professionals and other experts gathered at the Second Assembly of the Gilbert F. White National Flood Policy Forum agreed that sweeping change is urgently needed to avoid the dismal future that awaits if the present course of scattered, short-sighted water-related policies and activities continues. All the essential technical and programmatic steps described in the previous section can be condensed into six action guidelines. These guiding principles capsulize the new ways of thinking and operating that will be needed to achieve safe and sustainable relationships with our water resources. If decisionmakers, professionals in floodplain management, households, businesses, and others keep these guiding principles in mind, then our individual and collective actions will operate to remedy past errors and move the United States toward a safe and sustainable future.

1. Make room for rivers, oceans, and adjacent lands.

- Beginning now, AVOIDANCE of floodprone and/or ecologically sensitive areas should be axiomatic in planning new development. Although a strategy of avoidance cannot erase unwise existing development, it will minimize the cumulative damage, losses, and degradation that otherwise will be felt sorely by 2050.

- We need to begin a pattern of gradual and voluntary resettlement of those portions of communities that already have been located in the highest-risk or most ecologically sensitive areas, including areas behind levees and within the downstream influence of dams. At least four lines of attack should be employed in this strategy. First, as we repair and replace infrastructure anywhere in the nation, it should be removed from the floodplain if at all possible or, at a minimum, be brought up to higher standards of safety and environmental protection. Second, states should incorporate into their hazard mitigation plans (and localities into their comprehensive and mitigation plans) strategies to make significant changes to the land uses in certain dangerous or environmentally critical areas. Third, from now on, no state, local, or federal funds (including any type of subsidy in the tax code) should be spent that could foster development or infrastructure in high-risk and/or environmentally sensitive areas or would otherwise conflict with the provisions of Executive Orders 11988 and 11990. Fourth, new and replacement levees should be set farther back from the edges of waterways, which not only will allow more storage space for flood water but also will gradually shift existing and potential development into less hazardous areas.

- No adverse impact principles should be applied in all land use and development decisionmaking. The standard of "not causing harm," coupled with the use of future conditions as the basis for hazard and resource identification (as noted below), will result in the protection of people, property, and natural resources and functions now and into the future.

- We need widespread measurement of cumulative future conditions in terms of flood flows, flood levels, riverine and coastal erosion, sedimentation, barrier and shoreline

migration, sea level rise, subsidence, and other attributes. Then we must establish a policy that limits human actions in watersheds and coastal zones that would alter any of these attributes. This will result in preserving floodplain functions as well as reducing future losses.

2. Reverse perverse incentives in government programs.

- An independent, comprehensive review is needed of all federal programs that fund, subsidize, license, or promote development or redevelopment (including disaster relief, the tax code, housing grants, small business loans, and many others). All of these programs should be reformed to eliminate the incentives they unwittingly provide for making unwise decisions and taking inappropriate action with regard to our water resources. In their place, we must create positive incentives for appropriate action anywhere in the watershed, but especially in areas that are floodprone and/or ecologically sensitive.

- Federal agencies should adhere closely to E.O. 11988 and 11990 and thereby eliminate federal projects, funding, licenses, permits, loans, grants, or other incentives that foster new or replacement development in floodplains that exposes people, property, and taxpayers to added risk and costs. Public facilities such as causeways, bridges, evacuation routes, and water treatment plants should be treated as additional "critical facilities" under the terms of the Executive Orders.

- A sunset date should be established for subsidized and grandfathered flood insurance premium rates, because subsidized rates encourage development in hazardous areas. Exemptions to the flood insurance purchase requirement must be eliminated. We should be moving toward mandatory actuarially based flood insurance (or all-hazards insurance) for all homeowners[23] that drives mitigation and also has a pooling mechanism for coping with catastrophic losses.

3. Restore and enhance the natural, beneficial functions of riverine and coastal areas.

- We must make it a national priority to reclaim, over time, our lost riparian and coastal resources wherever possible, including dunes, bottomland forests, estuaries, and marshes. This will help restore natural buffers to storms and floods, supply open space and recreational opportunities for a burgeoning population, and slow the further deterioration of some ecosystems. Generous funding must be sought from all possible sources for this effort. For example, the potential for generating revenue by trading carbon credits should be considered.

- Recognition and respect for the natural and beneficial functions of floodprone areas, including the coast, must be incorporated into the programs of all federal, state, and local agencies. The value of these functions has been acknowledged officially and repeatedly because they prevent harm to people, the environment, and the public good; therefore they are worthy of protection, restoration, and enhancement.

4. Generate a renaissance in water resources governance.

- A nationwide vision and policy for water resources sustainability and flood loss reduction are essential. This would require legislation incorporating both a national floodplain management policy and a national riparian and coastal areas policy. The act should establish unequivocally both the value to the nation of these resource areas and their natural functions, as well as their inherent hazards. This policy needs to be supported with a comprehensive legislative package to be coordinated with and implemented through states, local governments, tribes, governors, and others. We need to draw on the leaders and experts of the nation to craft and agree on outcomes and metrics for the year 2050, including how we measure success and failure.

- A high-level, central point of coordination and implementation is needed to ensure that water-related laws and programs at all levels are seamlessly aligned and integrated. This could be a new federal agency or other entity but it should be dedicated solely to water-related issues. The wasteful and counterproductive fragmentation and stovepiping of federal (and state) water-related programs and of Congressional oversight of them must be eliminated.

- We must consider carefully the central question of whether a national policy of water resources "development" is still relevant for 2050 and beyond or whether a policy of water resources "sustainability" that balances human and ecosystem needs is a wiser approach.

- The National Water Assessment, last conducted in 1976, needs to be updated.[24] Up-to-date data on streamflow, reservoirs, groundwater, and withdrawals are critical to crafting nationwide policy that is both far-seeing and grounded in science.

- National programs and investment decisions should be adapted quickly to account for expected trends and impacts associated with the collision of intensified human development and climate change. Particular attention should be given to those parts of the nation where the impacts on the frequency and intensity of flooding are likely to be most severe, and on the ecosystems of our riparian and coastal zones.

5. Identify risks and resources and communicate at public and individual levels.

- A thorough, nationwide examination of our water-resources-related risks is the critical first step to understanding and resolving our present and future dilemma. Britain's Foresight Flood and Coastal Defence Project has shown that a scenario-based, comprehensive assessment of risks and resources is feasible even on a very large scale. What is more, the scenarios have proven invaluable in driving home the seriousness of the situation, in fleshing out alternatives, and in communicating with policymakers. Such an assessment should be commenced for the United States at once.

- All identification of flood risks and resources should be based on future conditions. In some locales, fully built-out watersheds already are anticipated in comprehensive

planning, but the increases in flood risk and the resource depletion that this level of development will bring are not considered in mapping or other management activities. Decisionmaking about all aspects of water resources and water-related hazards must be based on much longer time horizons than are being applied today.

- Communication, education, and outreach efforts must be intensified immediately. We need to identify the specific behaviors that must be changed to reduce vulnerability and protect resources. Then we need to work through schools, the media, watershed councils and other local groups, and use any other available means to bring about changes in those behaviors. A communications tool kit for local opinion leaders, industry representatives, homeowners, and others will be a good start.

- We must capitalize on technological advances in communication to help people understand flood hazards, the exposure and vulnerability of people to those hazards, and the fragility of water resources. We need to use visual depictions of the impacts of development on flooding and also of the adverse impact of different development scenarios on all properties and on natural resources in the watershed. These should be disseminated digitally to keep pace with other web-based attractions.

- Nationwide data on many factors is absolutely critical to determining what the most efficient course will be and when progress is being made. We need to find out who is at risk from flooding and why. We need an inventory of nation's floodprone structures and risk. Existing data feeds need to be monitored so we can determine the impacts of climate change as soon as possible.

- Intelligible scenario-based models are needed to help communities grasp and plan for climate change and work towards sustainability of their resources. National databases should be accessible to local governments to assist their decisionmaking.

6. Assume personal and public responsibility.

- Actuarially based, all-hazards insurance must become mandatory for all properties, nationwide. The coverage should include a strong loss-reduction (mitigation) component. This will foster individual understanding of risk and acceptance of personal responsibility. If an all-hazards insurance program cannot be developed, then flood insurance under the existing mechanisms should be mandatory for all properties.

- Our ethic of land and water stewardship must be revived. We need to provide a framework that will foster local responsibility for dealing with flood risk, sustaining water-related resources, and making wise use of floodprone lands. Incentives need to be institutionalized to ensure that communities that are doing a good job receive benefits related to their efforts and, in contrast, those that do not manage their risks and resources wisely are not allowed to externalize the resulting losses and costs onto the federal taxpayers. These incentives could include a sliding scale for the non-federal share of the cost of disaster relief and recovery; and preference for federal grants and loans given to communities that act to mitigate risks and protect or restore resources.

ENDNOTES

1. This is a mid-range of several projections. Between 1955 and 1999 floods were estimated to have caused $270 billion in losses, or an average of about $6 billion each year (1999 dollars). The decades were punctuated by single years of severe storms with catastrophic losses: the 1973 flooding from Hurricane Agnes resulted in damage that exceeded $30 billion; another $22 billion occurred during the 1993 floods on the Mississippi River. Since the turn of the millennium the pattern appears to have been worsening: in 2005 alone, over $150 billion in flood and hurricane losses were recorded (NFIP Evaluation Final Report Working Group, 2006, *The Evaluation of the National Flood Insurance Program: Final Report,* Washington, D.C.: American Institutes for Research).

2. White, Gilbert F., 1942, *Human Adjustment to Floods*. Ph.D. Dissertation. Department of Geography. Chicago: University of Chicago.

3. Federal Interagency Floodplain Management Task Force, 1994, *A Unified National Program for Floodplain Management*. Washington, D.C.: Federal Emergency Management Agency.

4. Projections of future population differ, depending on the methods used and the underlying assumptions of rates of births, deaths, and net migration, but these figures are on the conservative side of a range of credible sources. For example, the U.S. Census projections for our 2050 population range from 313 to 552 million (Hollmann, Frederick W., Tammany J. Mulder, and Jeffrey E. Kallan, 2000, *Methodology and Assumptions for the Population Projections of the United States: 1999 to 2100*. Population Division Working Paper No. 38. Washington, D.C.: U.S. Census Bureau, available at http://www.census.gov/population/www/documentation/twps0038.pdf). The Pew Research Center projects 438 million by 2050 (Passel, Jeffrey S., and D'Vera Cohn, 2008, *U.S. Population Projections: 2005-2050.* Washington, D.C.: Pew Research Center, p. 1). Robert Lang expects 400 million by 2050 (Robert E. Lang, 2008, "U.S. Population Trends: Demographic and Spatial Distribution," Fulbright lecture presented at the École Normale Supérieure, Paris). Another analysis predicts 460 million (Nelson, Arthur C., 2007, "Human Factors in 2050: Population Trends, Growth, and Urbanization," presentation at the Second Assembly of the Gilbert F. White National Flood Policy Forum, November 7, Washington, D.C., available at http://www.floods.org/Foundation/Forum.asp).

5. One study concludes that the nation's elderly population will more than double in size from 2005 through 2050, as the baby boom generation reaches traditional retirement years (Passel, Jeffrey S., and D'Vera Cohn, 2008, *U.S. Population Projections: 2005-2050. Washington, D.C.:* Pew Research Center, p. 20). The U.S. Census projects a similar trend, from an elderly (over 65 years of age) population of about 37 million in 2005 to a projected 86 million by 2050 (U.S. Census Bureau, 2004, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin," available at http://www.census.gov/ipc/www/usinterimproj/).

6. A megapolitan area consists of at least two existing metropolitan areas but may contain many more; has at least 10 million projected residents by 2040, and has other characteristics as defined by Robert E. Land and Dawn Dhavale, 2005, "American's Megapolitan Areas," *Land Lines* 17 (13, July) available at http://www.lincolninst.edu/pubs/PubDetail.aspx?pubid=1039.

7. The National Research Council has pointed out that research is needed to determine the extent to which socially vulnerable segments of the population may tend to be "pushed" into high hazard areas (Committee on Disaster Research in the Social Sciences, National Research Council, 2006, *Facing Hazards and Disasters: Understanding Human Dimensions*, Washington, D.C.: National Academies Press, available at http://www.nap.edu/catalog.php?record_id=11671#description). For a

discussion on this phenomenon in an international context, see Blaikie, Piers M., Terry Cannon, Ian Davis, Ben Wisner, 2004, *At Risk: Natural Hazards, People's Vulnerability and Disasters*, 2nd edition, New York: Routledge.

8. Mehan, Tracy G. III, 2007, "Devolution: Government and other Factors in 2050." Presentation at the Second Gilbert F. White National Flood Policy Forum, November 6-7, Washington, D.C., available at http://www.floods.org/Foundation/Files/2007_GFW_Forum_Mehan.pdf.

9. Mehan, Tracy G. III, 2007, "Devolution: Government and other Factors in 2050." Presentation at the Second Gilbert F. White National Flood Policy Forum, November 6-7, Washington, D.C., available at http://www.floods.org/Foundation/Files/2007_GFW_Forum_Mehan.pdf.

10. For example, the Corps of Engineers released in January 2007 a list of 146 levees in 29 states and territories that pose an unacceptable risk of failing during a flood. The levees are of varying sizes, types, and purposes: some protect populated areas while others are in more rural areas and were built to minimize flood damage to agriculture or to facilities such as water treatment plant. The report was a result of heightened emphasis on inspection as ordered by Congress after Hurricane Katrina. Most of the substandard levee conditions are result of inadequate maintenance, which is the responsibility of the levee owner—in most cases a local government—even if the levee was initially constructed by a federal agency. See http://www.hq.usace.army.mil/cepa/releases/leveesafety.htm and http://www.hq.usace.army.mil/cepa/releases/leveelist.pdf.

11. The American Society of Civil Engineers estimates that over $1.6 trillion will be needed over the next five years to bring the nation's infrastructure up to "good" condition. Of the 15 categories of infrastructure rated in its 2005 "Report on America's Infrastructure," not one received a grade as high as "B" ("good"), and only four received scores of "C" ("mediocre"). See http://www.asce.org/reportcard/2005/index2005.cfm.

12. See, for example, Doyle, Martin W., Emily H. Stanley, David G. Havlick, Mark J. Kaiser, George Steinbach, William L. Graf, Gerald E. Galloway, and J. Adam Riggsbee, 2008, "Aging Infrastructure and Ecosystem Restoration," *Science* 319 (January):286-287. As another example, the U.S. Department of Agriculture's Conservation Reserve Program estimated that, by 2004, it had restored over 1.8 million acres of wetlands and wetland buffers nationwide (see http://www.fsa.usda.gov/Internet/FSA_File/nonfloodwet04.pdf). An estimated 9,000 square miles of the nation's most floodprone and ecologically sensitive riverine lands have been protected from development by virtue of having been designated as floodways under the National Flood Insurance Program (Task Force on the Natural and Beneficial Functions of the Floodplain, 2002, *The Natural &Beneficial Functions of Floodplains: Reducing Flood Losses by Protecting and Restoring the Floodplain Environment*. A Report for Congress. FEMA 409. Washington, D.C.: Federal Emergency Management Agency, at p. A-2).

13. White, Gilbert F., Robert W. Kates, and Ian Burton, 2001, "Knowing Better and Losing Even More: The Use of Knowledge in Hazards Management," *Environmental Hazards* 3 (3-4): 81-92, at 89.

14. Claims data from FEMA support this proportion, and FEMA's insurance information materials confirm that "last year, about one-third of all claims paid by the NFIP were for policies in low-risk" areas [meaning outside the mapped 100-year flood hazard area] (http://www.floodsmart.gov/floodsmart/pages/flood_facts.jsp). Also, see the analysis of damage from floods exceeding the 100-year level at p. 67 and at p. 151 in Galloway, Gerald E., Gregory B. Baecher, Douglas Plasencia, Kevin G. Coulton, Jerry Louthain, Mohamed Bagha, and Antonio R. Levy, 2006, *Assessing the Adequacy of the National Flood Insurance Program's 1 Percent Flood Standard*. Washington, D.C.: American Institutes for Research.

15. See Thomas, Ed, 2007, "Recovery Following Hurricane Katrina: Will Litigation and Uncertainty Today make for an Improved Tomorrow?" *National Wetlands Newsletter* 25 (5 August-Sept). 30-32.

16. Extensive analysis and documentation of this problem for just one area—coastal Louisiana—can be found in U.S. Army Corps of Engineers, New Orleans District, 2004, *Ecosystem Restoration Study: Coastal Louisiana*, available at http://www.lca.gov/main_report.aspx.

17. Published scientific bases for forecasting, analyzing, and modeling the possible impacts of a changing climate are plentiful. Among the more rigorous are those released by the National Academies Press, listed at http://www.nap.edu/topics.php?topic=331&offset=10. One very recent study focused solely on impacts to U.S. transportation systems (Transportation Research Board, National Research Council, 2008, *Potential Impacts of Climate Change on U.S. Transportation*, TRB Special Report 290. Washington, D.C.: National Academies Press, available at http://www.trb.org).

18. Among federal laws needing such revision are the Stafford Act, the National Flood Insurance Act, and the Water Resources Development Act. The Unified National Program for Floodplain Management also needs to be updated and strengthened.

19. Edward A. Thomas, 2007, "The Patchwork Quilt as a Creative Strategy for Safe Post-disaster Rebuilding," Draft paper available at http://www.floods.org/PDF/Post_Disaster_Reconstruction_Patchwork_Quilt_ET.pdf.

20. See Association of State Floodplain Managers, 2006, *National Flood Programs and Policies in Review 2007*. Madison, WI: ASFPM, available at http://www.floods.org/Publications/NFPPR_2007.asp; and ASFPM Foundation, 2005. *Reducing Flood Losses: Is the 1% Chance Flood Standard Sufficient?* Madison, WI: ASFPM, available at http://www.floods.org/Foundation/Forum_2004.asp.

21. For example, the 1982 *Guidelines for Determining Flood Flow Frequency* (Bulletin 17B of the U.S. Geological Survey's Hydrology Subcommittee) should be updated with this in mind, and also to indicate that a 50% confidence level is insufficient for the design of critical facilities, including levees.

22. Nelson, Arthur C., 2007, "Human Factors in 2050: Population Trends, Growth, and Urbanization," presentation at the Second Assembly of the Gilbert F. White National Flood Policy Forum, November 7, Washington, D.C., available at http://www.floods.org/Foundation/Forum.asp.

23. Flood coverage is included in standard homeowners insurance policies in the United Kingdom. According to the Association of British Insurers, "The UK is unique in offering flood cover as a standard feature of household and most business policies. Unlike much of Europe and worldwide, cover is widely available to the UK's 23.5 million householders . . . more than 2 million homes are at risk from coastal or inland flooding." See http://www.abi.org.uk. For a recent analysis of the impact of severe flooding on the availability of flood coverage in the United Kingdom, see Lamond, J.E., and D.G. Proverbs, 2008, "Flood Insurance in the UK—A Survey of the Experience of Floodplain Residents," pp. 325-334 in *Flood Recovery, Innovation and Response*, edited by D Proverbs, C.A. Brebbia, and E. Penning-Rowsell. Volume 118 of *WIT Transactions on Ecology and the Environment.* Southampton, UK: WIT Press. http://library.witpress.com/pages/PaperInfo.asp?PaperID=19312.

24. U.S. Water Resources Council, 1978. *The Nation's Water Resources 1975–2000, Second National Water Assessment*. Washington, D.C.: U.S. Government Printing Office.

APPENDICES

Appendix A. Participants in the 2007 Assembly

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National Association of Home Builders

Wallace A. Wilson
W. A. Wilson Consulting Services

Back

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Participants in the 2007 Assembly of the Gilbert F. White National Flood Policy Forum

Standing in back:—Lynda Hall, Jon Kusler, David Greenwood, Matt Miller, Bill Brown, Chad Berginnis, Matt Watkins, Dan Accurti
Row 8—Pam Pogue, David Maurstad, Mary Jo Vrem, Meredith Inderfurth, Dan Lawson
Row 7—George Riedel, Michael Moye, Larry Buss, Makoto Kutsukake, Dale Lehman, Kevin Coulton, Natalie Love, Fran McCarthy
Row 6—Robert Mason, Cheryl Small, Ed Hecker, Jack Davis, Vince DiCamillo, Firas Makarem, Claire Reiss, Colin Thorne, Clive Goodwin
Row 5—John McShane, Jim Murphy, Pete Rabbon, Wally Wilson, P.G. de Sousa Costa, Grant Smith, Jim Fiedler, Scott Edelman, Tim Cohn
Row 4—Aaron Naas, Craig Anderson, Doug Marcy, Victor Hom, Robert Detlefsen, Fernando Pasqual, Sam Riley Medlock, Deborah Mills
Row 3—JoAnn Howard, Will Meyer, Burrell Montz, Graham Tobin, James Van Hemert, Sally McConkey, Doug Bellomo, David Conrad
Row 2—Laurel Lacy, Bill Cumming, Michael Armstrong, Neal Gruber, Ricardo Pineda, David Ford, Kevin Houck, Michael DePue
Row 1—Edward Thomas, Gerry Galloway, Larry Larson, Larry Olinger, Doug Plasencia, Jacquelyn Monday

Appendix B. Agenda of the 2007 Assembly

2007 ASSEMBLY OF THE
GILBERT F. WHITE NATIONAL FLOOD POLICY FORUM
Marvin Center, George Washington University

A G E N D A

Tuesday, November 6, 2007

1:00-1:45 pm **Welcome and Introductions – 3rd floor amphitheatre**
Larry Olinger, President, ASFPM Foundation, Dewberry
Participants (brief self-introductions)

1:45-2:15 pm **The Forum Topic and Process: Applying Gilbert White's Adjustment Concept to Address Floodplain Management in 2050.** Taking the eight human adjustments delineated in Gilbert White's 1945 dissertation as a starting point, the Forum will try to determine what similar—or new—adjustments will be needed to manage floodplains effectively in 2050.
Larry Larson, Executive Director, Association of State Floodplain Managers

2:15-4:15 pm **What Factors could be Driving the Management of Floodplains in 2050?** Three speakers will set the stage by describing key factors that are likely to shape a future in which floodplain resources and flood losses may need to be addressed with adjustments that differ from those of today. Questions and discussion by the Assembly.

*2:15-3:00 p*m **Human Factors in 2050: Population Trends, Growth, Urbanization**
Dr. Arthur C. "Chris" Nelson, Virginia Tech-Alexandria Campus

3:00-3:15 pm **Break**

3:15-3:45 pm **Environmental Factors and Natural Resources in 2050: Climate Change, Ecosystem Degradation, Land Use**
Dr. Margaret Davidson, Coastal Services Center, National Oceanic and Atmospheric Administration

3:45-4:15 pm **Government and Other Factors in 2050: Devolution Upwards and Downwards**
G. Tracy Mehan, III, Principal, The Cadmus Group, Inc., Former Assistant Administrator for Water, U.S. Environmental Protection Agency

4:15-5:00 pm **Challenges to Floodplain Management as we move towards 2050** Through facilitated discussion, the Assembly will list the broad changes expected by 2050 that will present challenges to floodplain management, and the scenarios that could evolve from those changes.
Dr. Gerald Galloway, University of Maryland
Doug Plasencia, Michael Baker, Inc.

5:00-7:00 pm: Reception

Wednesday, November 7, 2007

8:30-9:00 am **The Use of Scenario Based Planning to Guide Future Adjustments.** This example of scenario-based planning was done in the United Kingdom with considerations through the year 2080. Should the Untied States consider doing a similar effort?
Colin Thorne, Professor and Chair of Physical Geography, University of Nottingham

9:00-10:45 am **Session One (Break-out): What Human Adjustments will be Needed by 2050?**
The Assembly will divide into three groups; each group will devise a list of adjustments that it believes will be effective in managing floodplains in 2050. Groups will start with White's eight adjustments and add, subtract, or alter them as needed.

10:45-11:00 am **Break and transition to amphitheatre for feedback session**

11:00-11:30 am **Session One (Feedback):** A spokesperson from each group will present a "revised" list of human adjustments that will be needed to meet the floodplain management challenges of 2050. Discussion by the Assembly, combination of lists.
Gerry Galloway, Doug Plasencia, facilitators

11:30-1:00 pm **Lunch** *(participants' choice)*

1:00-2:45 pm **Session Two (Break-out): What Changes are needed so that Appropriate Adjustments will be Available and Effective by 2050?**
Three small groups will discuss what shifts in program, policy, funding, etc. will have to take place in order to implement appropriate adjustments by 2050.

2:45-3:00 pm **Break and transition to amphitheatre for feedback session**

3:00-3:30 pm **Session Two (Feedback):** A spokesperson from each group will summarize that group's ideas about shifts in program, policy, and other matters. Discussion by the Assembly and combination of lists.
Gerry Galloway, Doug Plasencia, facilitators

3:30-4:10 pm **Session Three (Plenary): An Action Plan for Floodplain Management in 2050**. The Assembly will catalog its recommended modifications to programs and policies, along with needs for data, research, and funding.
Gerry Galloway, facilitator

4:10-4:30 pm **Wrap Up** Next steps to be taken by the ASFPM Foundation, the ASFPM, and others to advance the recommendations made by the Assembly. Discussion of possible topics for the next Assembly of the Forum.
Larry Olinger and Larry Larson

4:30 pm **Adjourn**

Appendix C. Supplemental Materials Published Separately

Background papers for the 2007 Forum

ASFPM Foundation, 2007. *Experts Look at Floodplain Management in 2050*: Background Reading for the Second Assembly of the Gilbert F. White National Flood Policy Forum, November 6-7, 2007. Available at http://www.floods.org/Foundation/Files/2007_GFW_Forum_Background_Reading.pdf.

Presentations at the 2007 Forum

"Applying Gilbert White's Adjustment Concept to Address Floodplain Management in 2050" (PowerPoint) - *Larry Larson, Executive Director, Association of State Floodplain Managers.* Available at http://www.floods.org/Foundation/Files/2007_GFW_Forum_Larson.ppt

"Human Factors in 2050: Population Trends, Growth, Urbanization" (PowerPoint) - *Dr. Arthur C. "Chris" Nelson, Virginia Tech - Alexandria Campus.* Available at http://www.floods.org/Foundation/Files/2007_GFW_Forum_Nelson.ppt

"Government and Other Factors in 2050: Devolution Upwards and Downwards" (Paper). *G. Tracy Mehan III, Principal, The Cadmus Group, Inc., Former Assistant Administrator for Water, U.S. Environmental Protection Agency.* Available at http://www.floods.org/Foundation/Files/2007_GFW_Forum_Mehan.pdf

"The Use of Scenario Based Planning to Guide Future Adjustments" (PowerPoint). *Colin Thorne, Professor and Chair of Physical Geography, University of Nottingham, Nottingham, UK.* Available at http://www.floods.org/Foundation/Files/2007_GFW_Forum_Thorne.ppt

Other Resources

Larson, Larry A. and Doug Plasencia, 2001. "No Adverse Impact: A New Direction in Floodplain Management Policy." *Natural Hazards Review* 2 (4)(November): 167-181. Available at http://www.floods.org/NoAdverseImpact/NAIjournal.pdf.

Thomas, Edward A. 2008. *Protecting the Property Rights of All: No Adverse Impact Floodplain and Stormwater Management*. Rocky Mountain Land Use Institute. Available at http://www.floods.org/PDF/NAI%20_No%20Adverse%20Impact%20Floodplain%20and%20Stormwater%20Management.pdf

Kusler, Jon A. 2007. *Professional Liability for Construction in Flood Hazard Areas*. Madison, WI: Association of State Floodplain Managers Foundation. Available at http://www.floods.org/PDF/ASFPM_Professional_Liability_Construction.pdf.