Cross Training

Light the Torch

Proceedings of the Seventeenth Annual Conference of the Association of State Floodplain Managers

March 16-18, 1993
Atlanta, Georgia
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Preface

The annual conference of the Association of State Floodplain Managers is the premier floodplain management event in this country. This conference is also the highlight of the year for the Association. Our 17th annual conference theme, "Cross Training: Light the Torch," and logo incorporated the spirit of athletics along with the educational element of learning about new ideas, as we met in Atlanta, the host city for the 1996 Summer Olympic Games.

Our host this year was the Georgia Department of Natural Resources, and through the Conference Director, Alexis Harris, we experienced southern hospitality at its finest. This was accomplished in the face of extreme adversity—this year's attendees will never forget enduring "The Storm of the Century." As the snow began on the Friday before the conference and continued through the day on Saturday, we early arrivals had some doubts as to how it would all turn out. Although some last-minute changes had to be made, by Monday over 300 enthusiastic people had shown up, somewhat shaken and late, and many filled with personal stories of travel troubles.

Papers presented at this year's conference were on more diverse topics than in past years, in keeping with the cross-training theme, and emphasized the technical, educational, and institutional diversity in the current world of floodplain management. Conference attendees were challenged on the first day to meet new people, to learn about the breadth of the field, and to attend sessions on topics about which they had limited knowledge.

Additional features of this conference were the lessons learned and future directions set for emergency managers and floodplain managers after the catastrophic 1992 hurricanes. Speakers relayed to conference participants their experiences with all aspects of the hurricanes, along with ideas about how to lessen future impacts.

The papers in these proceedings constitute a very concise summary of the happenings at the conference. For those of you who were fortunate enough to participate, these proceedings will provide a review and future reference. For those who were not present, we hope that this proceedings volume will be useful and will provide an incentive to join us at future conferences beginning next year in Tulsa.

Jerry Louthain
Chair, Association of State Floodplain Managers
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Acknowledgements

The conference is over and we are now in our respective offices, focusing on the work that is our everyday realm. Looking back on the 1993 gathering, we sigh with a bit of relief. It was a unique conference. Mother Nature reinforced the innovation of the program and intrigue of the location by snowing—not just a little, but a blizzard, and not just anywhere, but in Atlanta, Georgia. Despite her, it went off by the willingness of the membership to fill in, pitch in, and persevere in showing up.

This was a conference for which many people deserve thanks. From the onset, the Conference Director and Program Chair challenged the Board of Directors and Administrative Council to do things a new way. They listened, provided good advice, and then gave a number of approaches a try. Key among the Board, our Executive Director, Larry Larson and (now) former Chair, Jerry Louthain, deserve recognition for their contributions. No Association conference could go right without the big-hearted, generous efforts of Diane Watson. The Association is fortunate to have her administrative talents. The true driving force, the man behind the scenes, the person who so diplomatically gave the proverbial boot in the rear (at least to the Program Chair, where it was most needed), Tim Keptner, Standing Conference Committee Chair, deserves special thanks, not to mention a gold medal.

Then there were people who volunteered their time and talents long before we got there: the moderators, the speakers, the field trip leaders, the staff from Georgia, Connecticut, and Pennsylvania, who supported and worked with the idealists in their offices who agreed to be the Conference Director, Program Chair, and Exhibits Chair, respectively. The Association is always appreciative of our corporate sponsors, who prepared the conference signs, but this year we must thank the firm of Michael Baker, Jr., Inc. for the special effort of preparing our conference theme sign: the football player in a tutu, lighting an olympic torch. Among those who agreed to assist with moderating, Alan Wald of the State of Washington deserves special mention. After arranging for several sessions on geographical information systems, including the cross-training course, he was unable to attend. But he then made sure that everything was covered so no one else was inconvenienced. Besides preparing a course and moderating a session, Steve Randolph also deserves accolades for his leadership in organizing technical field trips. Beverly Rhea was instrumental in putting together both spouse tours and one of the technical field trips. Katie Hayden designed the conference logo, and in addition to her general support, can be credited with making the first-ever Flood Olympics happen. In the end, Chris Abbett got un-snowbound from the mountains of Tennessee in time to conduct his much-acclaimed post conference tour.

Some did not volunteer, but responded to the request of the Program Chair. Janie Douglass, Rebecca Quinn, Steve Randolph, Lou Sidell, French Wetmore, and Andrew Reese deserve a special expression of praise for putting
together the cross-training basic courses. These sessions were the foundation of the conference and the embodiment of its theme.

Big thanks go to those who volunteered on the spot. Next year’s conference chair got first-hand experience when he ran the registration desk. We all appreciated the efforts of Jack Page and Frank Spring, of his staff. It was greatly appreciated when Jennie Larson and Donna Louthain volunteered their otherwise free time. Brian Hyde, Alan Luloff, and Thomas Morrissey stepped in for moderators who could not make it. Brad Loar, our sign man, relieved the rest of us of that concern. A big thank you goes to our new Chair, Doug Plasencia, for filling in for the opening speaker, who had to manage storm damages at home. And there are always numerous friends who come to the rescue in some immediate crisis. They are too many to mention, but we thank them all.

We hope that it was the best conference you have attended to date. We also wish lots of luck to the conference team for 1994. If they get half the support and help that we did, they cannot miss. Thank you all.

Alexis Harris, Conference Director
Jay O. Northrup, Program Chair
Dante C. Accurti, Exhibits Chair
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Part One

Plenary Addresses
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Gone are the days of self-explanatory conference themes. Cross Training: Light the Torch! I'll bet that half of you shook your heads at that one. Just what do we mean by that? Well, there are really two distinct elements.

We will begin with the end. "Lighting the torch" is an act that implies a beginning, and is borrowed from the Olympics (to be held here in Atlanta in 1996). We wanted it to be a more individual beginning. Past themes have referred to local programs and partnerships. Thus, our second element: cross training is a term commonly used by athletes, such as those in the Olympics. It refers to the technique in which individual athletes practice for events other than their own, in order to improve performance.

My sport is swimming, so I'll use it as an example. Swimming tones muscle but doesn't build it too much. But today, swimmers look like weight lifters. That is because in order to get muscles they lift weights; thus, cross training. However, my favorite example brings me to the drawing some of you may have seen outside the conference office yesterday. It is a football player in a tutu. Why, might you ask? Did you know that some football players take ballet in order to improve their agility and muscle control? Now that is an example of cross training that you won't soon forget! This football player has no intention of becoming a ballet dancer, but every intention of improving skills that his sport does not provide to the degree necessary to compete today.

Like everything else in this world, floodplain management is changing and evolving. No whole can be greater than the sum of the parts, therefore we are each more important than we may think. Trends such as multi-objective management, multiple hazard insurance, and the greater integration of natural and beneficial values require a broader base of understanding—outside our traditional academic education and professional training. We floodplain managers are in a uniquely advantageous position, because as a group we have no single training of origin. We are planners, engineers, insurance professionals, computer guru—you name it. Therefore we can teach each other enough to have the ability to communicate and bridge professional and institutional gaps. So I challenge you to "light the torch" by attending at least one session on something about which you honestly feel ignorant; and in so doing, begin your own cross training for the future.

Our program is intended to make it easy for you. There are specific cross-training courses on floodplain management, GIS, stormwater, utilizing volunteers, and influencing decisionmakers. As we used to say when I was in college, "Go for it!"
On August 24, 1992, Hurricane Andrew made landfall in southern Dade County, Florida. While the country’s initial reaction was a sense of relief—greater Miami’s most populated areas had been spared the full brunt of the storm—officials eventually realized that an area encompassing about 250,000 people had suffered a major disaster.

After crossing Florida, Hurricane Andrew made landfall again, wreaking havoc in southwestern Louisiana. When the storm subsided, it was clear that Andrew would prove to be the nation’s most costly natural disaster. It also became increasingly evident that the governmental response, particularly in south Florida, had fallen short. The immediate needs of the disaster victims, as well as the general public’s need for a competent presence in the midst of such destruction, went largely unmet.

In response to a Congressional mandate, a panel of the National Academy of Public Administration conducted a study of capacities of the federal, state, and local governments to respond promptly and effectively to major natural disasters occurring in the United States.

The panel judged that it could make a unique contribution by reviewing and analyzing the entire structure of the disaster response system. This includes all levels of government—federal, state, and local—as well as private and non-profit organizations and individuals. Moreover, the panel determined that it could not examine the response to natural disasters in isolation from all emergency management functions: mitigation, preparedness, response, and recovery. This paper presents the panel’s observations, conclusions, and recommendations.

Enduring Problems of Emergency Management

There are some problems associated with emergency management that are unique in their intensity and in their enduring nature. They endure because they are rooted in human nature, American attitudes toward long-range planning, the
dynamics of power in the Executive Branch, and the short-term perspective of the American political process. Emergencies and disasters are easily dismissed as something that is unlikely to happen, going to happen to someone else, or going to happen on "someone else's watch."

Americans have never seemed to value long-range planning and training. Although they have come to accept the necessity of these things in the military in order to protect citizens from threats from abroad, they have not yet developed an appreciation for their need in protecting citizens from hazards that can befall them "at home." As a result, emergency management agencies are generally underfunded for planning, training, and exercises even though these activities are every bit as essential for their effectiveness as they are for military organizations.

Emergency management requires coordination of a wide range of organizations and activities, public and private. Everyone acknowledges the need for such coordination in an emergency, but in fact no one wants to be "coordinated," nor is it clear what the term means in practice. Statutory authority is not readily transformed into legitimate political authority, and emergency management agencies are very seldom given anything but statutory authority to "coordinate" in the event of an emergency or disaster that everyone prefers to believe is unlikely. Statutory power is a necessary but insufficient condition for real power to coordinate.

Finally, emergency management has almost no natural constituency base until an emergency or disaster occurs. Except for those persons and agencies with responsibilities in emergency management, which are modest in number and influence, the function has no generally attentive, supportive set of constituents or clients, which is so important to the survival and effectiveness of public agencies.

**Need for an Effective Emergency Management System**

Every year the United States is hit by numerous disasters, both large and small. The nation needs a well-organized, effective emergency management system; the panel found it does not have one. All levels of government as well as private, nonprofit, and business organizations are involved. In the aftermath of Hurricane Andrew, few of the parties involved, whether public or private, could claim a flawless performance. The blame for the extensive dislocation and misery the victims experienced after the storm must be widely shared.

**Strengthening the Federal Role**

At the national level, the President and numerous federal agencies are responsible for providing assistance to disaster victims. For crises overseas, the National Security Council coordinates policy for the President. No counterpart
exists on the domestic side. The President should have a Domestic Crisis Monitoring Unit to assure that the federal responses to catastrophic events are timely, effective, and well coordinated.

The Federal Emergency Management Agency (FEMA) was created in 1979 to provide a new, integrated approach to emergency management. However, the panel found that few of the goals set for that organization 14 years ago have been realized.

Currently, FEMA is like a patient in triage. The President and Congress must decide whether to treat it or let it die. And though the tendency is to focus principally on FEMA, the present time and circumstances provide a unique opportunity to improve the way all those involved in emergency management respond to disasters and catastrophic events.

The panel has concluded that a small independent agency could coordinate the federal response to major natural disasters, as well as integrate other emergency management functions, but only if the White House and Congress take significant steps to make it a viable institution. FEMA has been ill-served by Congressional and White House neglect, a fragmented statutory charter, irregular funding, and the uneven quality of its political executives appointed by past presidents. In short, the agency remains an institution not yet built.

The President, Congress, and strong, competent FEMA leadership could create the conditions necessary to build FEMA or a successor into a highly respected agency that coordinates—and thus leads—other federal agencies as well as state and local governments. These essential conditions are:

(1) Reduction of political appointees to a director and deputy director, development of a competent, professional career staff, and appointment of a career executive director.

(2) Access to, and support of, the President through the creation of a Domestic Crisis Monitoring Unit in the White House.

(3) Integration of FEMA’s subunits into a cohesive institution through the development of a common mission, vision, and values; an integrated development program for career executives; and effective management systems.

(4) Development of structure, strategy, and management systems to give agency leadership the means to direct the agency.

(5) A new statutory charter centered on integrated mitigation, preparation, response, and recovery from emergencies and disasters of all types.
(6) Joint assessment teams and a gradated response scale for more timely and effective responses to disasters, including catastrophic.

(7) Development of functional headquarters-field relationships.

Regarding item (3), FEMA has experienced widespread and persistent problems with internal communications and coordination that were intensified by classification restrictions on its national security emergency preparedness programs under the National Preparedness Directorate. These problems could be mitigated by (1) reducing the number of security clearances and the impact of classification, (2) transferring certain program responsibilities and limited program staff to DOD, (3) improving the integration of NP assets into domestic emergency response, and (4) reevaluating the placement of some FEMA programs under the national security budget function.

Some additional funding in the near term may be required to meet these conditions, but the panel believes that the longer run result will be improved efficiency and program effectiveness that also reduce costs. Given the current government-wide budget stringencies, FEMA must do everything possible to economize and make best use of existing resources.

If, after a reasonable period, it is clear that these changes are beyond reach, the President should consider and take action on a more drastic option, such as (1) abolishing FEMA and returning its component parts to their agencies of origin or placing them elsewhere, or (2) transferring most functions intact to an existing federal department.

If FEMA were abolished, a small office in the Executive Office of the President would be needed to coordinate the federal response. Because this was the unfortunate condition which caused FEMA to be created in the first place, this is a useful option only if no other is available. No other department or agency provides an ideal home for the emergency management function and all have other priorities and problems. Because changes in law would be required, Congress also would have to act.

Role of the Military and the Federal Government as First Responders

The panel does not recommend that the disaster response function be transferred to the Defense Department. The time has come to shift the emphasis from national security to domestic emergency management using an all-hazards approach. Making this function a routine part of the defense mission would further complicate larger issues of the Armed Forces’ peacetime roles. Their primary mission is to prepare for war and to fight if necessary.

The panel recognizes that the Armed Forces have repeatedly demonstrated valuable capabilities in responding to major disasters, including Andrew, but it
holds that they should be tasked by civil authority—promptly when necessary—in the case of a domestic catastrophe. The problem should be addressed by improving procedures that enable civilian authorities to call upon the capabilities of the Armed Forces in a timely fashion in those relatively rare circumstances that require response capabilities of a magnitude only they can provide.

Nor can the federal government become the nation's "911" first responder. The nation's constitutional structure, rooted in the values of federalism, is fundamentally "bottom-heavy." Although the federal role has expanded over two centuries, governing in American generally occurs within the broad, general "police" powers reserved to the states by the Constitution and delegated in turn to local governments. There are tens of thousands of emergencies each year. Most emergencies—even most disasters—are met by state and local governments. This layered system of disaster response can be improved without altering federalism.

Joint federal-state-local emergency response teams, which include relevant military and civilian agencies, should be trained to enter a disaster site immediately to assess damages as well as life support needs. They would issue recommendations to the governors of affected states and the President. Team members should train and conduct regular exercises together and draw upon the unique mobile communications that FEMA has available. Joint decision making by government leaders, plus full cost coverage by the federal government during the initial response period after a catastrophe, would facilitate prompt and sufficient action to meet victims' life support needs.

**The Role of States and Localities**

State and local governments must be able to successfully manage small and medium-sized disasters on their own, and they must be able to function effectively as part of an intergovernmental team when an event warrants a Presidential disaster declaration and federal intervention. At the state and local levels, emergency management suffers from:

1. A lack of clear and measurable objectives, adequate resources, public concern, and official commitments.
2. Low levels of public concern and support for events of low probability but potentially high impact.
3. Local sensitivity surrounding building code enforcement and land-use planning, both essential elements in planning and implementing mitigation measures and prominent in recovery efforts.
(4) Fragmented decision making and strained intergovernmental relations. For example, prior to Hurricane Andrew, relations between the independent cities in Dade County and the county government were poor, as were those between the county and the state of Florida. After the disaster, these relations did not improve, which impeded response and recovery efforts.

(5) Inconsistency of federal support and involvement.

(6) A lack of knowledge and competence in emergency management.

(7) A lack of commitment to and funding for emergency management.

The federal government needs to do more to help enhance the capacity and consistency of emergency management efforts at the state and local levels, especially in areas vulnerable to catastrophic events. Possible measures include: targeting upgrades of state and local government capacity; using financial incentives strategically to reward effort and competent performance; improving training and education; increasing research and its application; and fostering peer exchanges and mutual aid agreements.

Congress' Role and Responsibility

Congress plays a leading role in developing policies for emergency management and the federal response to natural disasters. Jurisdiction over these functions and FEMA is so splintered, however, that no single authorizing committee has the ability or interest to examine either one in their totality. This splintered jurisdiction also reinforces fragmentation within the agency, as well as programmatic authorizations tied to specific kinds of disasters, such as earthquakes or radiological hazards. In addition, FEMA’s relations with Congress are needlessly time-consuming, complex, and contentious.

As a result, FEMA has been reluctant to propose a restructuring of its authorizing statutes. Several laws apply to emergency management programs, some with competing objectives and overlapping provisions. The results is a hodge-podge of statutory authorizations providing sometimes conflicting and outdated guidance, which, in the panel’s judgment, hampers the integration of emergency management functions and slows, as well as materially complicates, the federal response to natural disasters.

Emergency management and FEMA are overseen by too many Congressional committees, none of which has either the interest or a comprehensive overview of the topic to assure that coherent federal policy is developed and implemented. A preoccupation with constituent interests, while
laudable in times of great need after disasters, makes it very difficult to achieve a balance between cost and service.

The panel believes the Congress' attention ought to shift from a preoccupation with shortcomings in the federal response, to support for improved management of FEMA and for the development of a national emergency management system based on intergovernmental cooperation. FEMA or a successor agency needs a more coherent legislative charter, greater funding flexibility, and sustained support for building an effective agency and a national emergency management system.

The Need for a Galvanizing Event

The panel is making numerous recommendations to strengthen the nation's emergency management system. Changes of this magnitude will require strong, sustained White House and Congressional attention and support. Given the nation's economic and social problems and the foreign policy challenges likely to occupy its political leadership, the panel believes a galvanizing event may be needed before the states can reach a new agreement with the federal government on how the nation will prepared for and respond to emergencies, and who will pay the cost.

Such an event could be a White house or governors' conference on emergency management, a summit meeting between the President and the governors, or a national commission chartered by Congress or appointed by the President. Without bold action, America's frustration with the timeliness and quality of the governmental response to natural disasters will very likely continue.
SUBSTANTIALLY DAMAGED BUILDINGS: 
A NATIONAL MITIGATION DILEMMA

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Background

In the fall of 1992, after the unprecedented wind and flood damages caused by Hurricanes Andrew (Dade County, Florida) and Iniki (Kauai County, Hawaii), the Federal Insurance Administration (FIA) greatly expanded the scope of its normal damage assessment and post-disaster activities. This included forming and activating Building Performance Assessment Teams (hereinafter "Assessment Teams") composed of experts in wind- and flood-damage-resistant design and construction.

In light of lessons learned from these Assessment Teams, this paper discusses an unrecognized, or at least an under-appreciated national mitigation dilemma: the required repair and retrofitting of buildings located in floodplains that are substantially damaged during catastrophic events, whether the damage is from wind, fire, flood, earthquake, or other causes.

Companion papers included in these proceedings describe (1) the concept of the Assessment Team (Davison, Oliver, and Gambel); (2) the causes of and techniques to mitigate damage suffered during Hurricanes Iniki and Andrew (Davison, Bornman, and Pendley) (Gambel et al.); and (3) innovative measures employed by the Federal Emergency Management Agency (FEMA) in Dade County to provide technical assistance on flood-resistant construction to owners of substantially damaged buildings (Oliver and Romano).

NFIP Requirements for Substantially Damaged Buildings

Buildings in flood hazard areas are often exposed to other hazards such as wind (hurricanes and tornados), earthquakes, and fire. For example, in Dade and Kauai counties, the majority of the damaged buildings located in floodplains were damaged by wind. Under requirements of the National Flood Insurance Program (NFIP), participating communities must regulate the reconstruction of buildings located in the floodplain that are "substantially damaged," regardless of the cause of the damage. In Dade and Kauai counties, this requirement means that thousands of buildings located in the floodplain that were substantially damaged by wind and/or flood must be brought into conformance with flood elevation requirements if they are rebuilt.
After severe damage, mitigation requirements (retrofit construction) for non-conforming buildings in hazardous areas are not only prudent, but also logical because (1) a considerable investment is being made in the repair of damage incurred, (2) it is normally more economic to retrofit while undertaking repairs, and (3) frequently, the owner has relocated temporarily and there is no additional personal inconvenience.

**Regulating versus Funding Post-Disaster Mitigation**

Despite the logic and prudence of retrofitting buildings in the post-disaster environment, Hurricanes Andrew and Iniki clearly demonstrated that funding sources available to offset the increased cost associated with meeting floodplain management requirements are limited. Few property insurance policies pay the additional cost associated with retrofitting a building located in a floodplain that is substantially damaged. Even in the case of substantial damage caused by flooding where flood insurance is carried, the NFIP, by statute, can only pay claims for physical damage incurred by the property. The NFIP cannot fund the additional cost necessary to bring buildings into conformance with floodplain management requirements. As a result, in Dade and Kauai counties, as many as 5,000 homeowners may ultimately bear the full responsibility for funding the required flood mitigation actions for reconstruction (average cost per residence = $25,000–$40,000).

Because of the functional offset between regulations and funding sources, required flood hazard mitigation has been difficult for local officials to enforce and has triggered tremendous public and political pressure to waive these mitigation requirements. As exemplified by the tremendous reconstruction demands after Hurricanes Andrew and Iniki, local government agencies that administer building code and floodplain management requirements are ill-prepared to respond to the needs of their citizens in terms of staffing and technical expertise. As a result, two innovative measures were used to assist citizens and ease the burden on local government.

**Innovative Methods for Technical Assistance**

Experience from Dade and Kauai counties demonstrates the need to develop new strategies for establishing coordinated reconstruction efforts after catastrophic damage events where the technical and staffing capabilities of local governments are overwhelmed.

In Dade County, thousands of substantially damaged slab-on-grade buildings must be elevated, but little technical expertise was available for citizens on design and cost considerations. Therefore, a Reconstruction Information Center (RIC), staffed by a cadre of technical support staff, was
conceived and established by FEMA. The RIC provided homeowners ready access to technical assistance on building designs and local building code requirements. The RIC also offered counseling to homeowners on funding sources from FEMA and the Small Business Administration for retrofitting substantially damaged homes and advice from the Internal Revenue Service on casualty loss deductions. Over 1,300 homeowners were counseled at the RIC.

In Kauai County, overwhelming demands for the issuance of building permits for reconstruction were placed on a rural government with limited resources. Therefore, FEMA funded the operation of an Office of Emergency Permitting (OEP). The intent was to centralize and expedite the permit process, while ensuring that prudent reconstruction practices were employed to the greatest extent possible. At the OEP, technical assistance on every aspect of the building permit process, from floodplain regulations, to health codes, to requirements for historic structures, was provided.

The goal of both the RIC and the OEP was to assist and educate owners of damaged buildings concerning mitigation requirements and how to best meet them in the least costly and fastest way possible.

Conclusions

In flood hazard areas, catastrophic wind, earthquake, and fire events, in addition to flooding, can cause substantial damage to large numbers of buildings, which must meet floodplain management requirements when rebuilt. Based on activities of the Assessment Teams, the following conclusions can be drawn:

- Communities are ill-prepared to adequately administer reconstruction and mitigation requirements for substantially damaged buildings in a post-catastrophe setting.

- Federal, state, and local mitigation requirements are incongruous with available funding for the implementation of these requirements.

Recommendations

To address these issues, the following recommendations are offered:

- To ensure successful mitigation, there is a need for an explicit reconstruction plan/strategy parallel to or as an addendum to the Federal Response Plan. Mitigation issues must be adequately addressed in the pre-event and immediate post-event stages, even when life, health, and safety issues are normally an overriding priority.
• There is a need for FEMA, in cooperation with state and local
government, the property insurance industry, national model building
code organizations, and the building industry, to develop and
implement strategies for providing technical assistance concerning
flood-, wind-, and seismic-resistant construction to communities most
prone to major disasters from these forces.

• Nationwide, there is a need to provide communities with incentives
such as pre-funding to plan for massive post-catastrophe
reconstruction in flood hazard areas.

• Pre-disaster preparation should include developing a GIS-based
inventory of vulnerable buildings in flood hazard areas and specific
design and construction guidance for the repair and retrofitting of
these buildings. In addition to recovery after flooding, this guidance
should include recovery after earthquake, wind, and fire disasters.

• The NFIP should be revised to insure for payment of the increased
cost associated with bringing substantially damaged insured buildings
into conformance with NFIP requirements, thereby pre-funding
mitigation costs.

• Lessons learned from the RIC (Dade County) and the OEP (Kauai
County) should be used to formulate strategies for establishing
coordinated reconstruction efforts after catastrophic damage events
where the technical and staffing capabilities of local governments are
overwhelmed.
THE DEVELOPMENT OF TECHNICAL GUIDANCE MATERIALS: ELEVATING SUBSTANTIALLY DAMAGED BUILDINGS IN DADE COUNTY, FLORIDA, IN RESPONSE TO HURRICANE ANDREW

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Background

In the aftermath of Hurricane Andrew, south Dade County, Florida, was left in a state of devastation and confusion. Homeowners desperately sought information for repairing their storm ravaged homes. One issue that quickly rose to the attention of the public and the media was Dade County's floodplain management regulations on substantially damaged residential buildings. One of the requirements under the regulations stipulated that substantially damaged residential buildings be reconstructed so that the lowest floor is at or above the base flood elevation (BFE). This requirement is stated in the county's floodplain management ordinance and is mandated under the National Flood Insurance Program (NFIP).

During the late 1960s and early 1970s, in response to a growing demand for housing in the south Florida area, thousands of new homes were built within south Dade County. The typical residential structure built in that area was constructed using slab-on-grade, masonry construction. The vast majority of south Dade County is located within the 100-year floodplain. With ground elevations averaging between seven and eight feet above the National Geodetic Vertical Datum (NGVD), and the BFEs ranging from nine to eleven feet above NGVD, many of the homes in south Dade County are two to four feet below the BFE.

A post-Andrew field assessment by the Metropolitan Dade County Government indicated that as many as 3,500 substantially damaged residential buildings are located within the floodprone areas regulated under the county's floodplain management ordinance. This large number of substantially damaged homes presented the Federal Emergency Management Agency (FEMA) and Dade County with the difficult task of disseminating needed information to the residents of the county in a rapid and comprehensive manner. Many residents of south Dade County expressed the need for obtaining specific information concerning the county's and the NFIP's regulatory requirements for rebuilding substantially damaged homes and the availability of financial assistance to
homeowners. To meet this public need, the federal Disaster Field Office (DFO) in Miami, Florida, established a temporary "Reconstruction Information Center" (RIC). The RIC was situated in south Dade County and functioned as a clearinghouse for information on the availability of federal disaster assistance from FEMA, low-interest loans from the Small Business Administration, Internal Revenue Service assistance on taxes, county assistance on building codes and floodplain management regulations, and technical assistance from FEMA on compliant elevation techniques for substantially damaged homes. The temporary RIC was fully operational from early October 1992 to the end of January 1993. During that period, over 1,300 residents received assistance.

This paper focuses on the process employed by FEMA and one of its technical support contractors, Greenhorne & O'Mara, Inc. (G&O), for the rapid development and dissemination (through the RIC) of technical information on the various available techniques for elevating residential buildings in south Dade County.

FEMA, through the Federal Insurance Administration (FIA), administers the NFIP. FIA was called upon to identify and develop engineering and cost guidance for elevating substantially damaged buildings. In an intensive 12-day continuous effort, staff from FIA as well as expert consultants (under contract to G&O) developed a profile of the typical residential building to be elevated, identified several alternative elevation techniques and assessed their technical feasibility, and estimated the costs of each feasible alternative. A series of technical illustrations and cost estimating guidance materials were then developed. These materials were assembled in a document entitled "Technical Information on Elevating Substantially Damaged Residential Buildings in Dade County, Florida" (FEMA, 1993).

Composition of the Technical Information Development Team

The development and dissemination of engineering and cost guidance at the RIC was accomplished through a team of experts in residential construction. After identifying the need to rapidly develop technical information on elevating residential structures, FIA and G&O promptly took the necessary actions to assemble the required team of professionals. The team consisted of a residential architect, two structural engineers, two civil engineers, a geotechnical engineer, two building construction/restoration estimators, and a building relocation/elevation contractor. The residential architect and the civil, geotechnical, and structural engineers were all licensed in the State of Florida and each had specific experience and expertise in residential construction and renovation in the south Dade County area. Similarly, the building construction/restoration and relocation/elevation contractors were experienced
in residential construction, including both cost estimating and preparing technical guidance documents for the public.

Each member of the team served a specific function in the development of the engineering and cost guidance information. The residential architect and the structural and civil engineers provided technical expertise on residential construction and restoration, including design considerations for roofing systems (trusses, sheathing, materials), foundation systems, structural loading requirements, local building code requirements, grading and site development requirements, permit requirements, feasibility and applicability of the various elevation techniques considered for a typical residential structure in south Dade County, and preparation of computer-generated drawings and illustrations. The geotechnical engineer conducted an analysis of the soil conditions at specific sites and provided technical assistance, including the evaluation of the various elevation techniques. The building construction/restoration contractors provided cost estimating expertise for repairing or restoring substantially damaged residential buildings. They also provided technical assistance in the evaluation of cost-effective techniques for retrofitting damaged structures. Similarly, the building relocation/elevation contractor provided the technical support for assessing the feasibility, applicability, and cost-effectiveness of the various elevation techniques being considered for the affected residential structures. This contractor was highly experienced in conducting relocation/elevation projects in Florida and was intimately familiar with the technical challenges associated with the various techniques considered.

Developing the Engineering and Cost Guidance Documents

After surveying the damaged areas, the team developed a typical profile of the building types and methods of construction. The typical residence was profiled as being a one-story, masonry, slab-on-grade structure with a wood truss roof framing system and an area of about 2,000 square feet. The typical structure was also considered to have incurred considerable interior damage from flooding and/or high winds, thus requiring "gutting." The technical and cost considerations that were subsequently developed by the team were based on this typical building profile.

Elevation techniques were identified from techniques that had been employed at various locations throughout the United States and from original ideas proposed by team members and other interested parties. The techniques identified ranged from technically sophisticated methods that required specialty contractors to simple techniques that do not require special trades or skills.

Detailed cost estimates were developed using standard construction costing methods. After the cost estimates for each technique were prepared, the pricing
structure for each method was converted into simple calculations (using square footage) that homeowners could easily perform. All the cost estimating procedures developed by the team were then provided on "user-friendly" cost estimating work sheets for homeowners (FEMA, 1993).

### Elevation Techniques Identified

In all, five major elevation techniques (with variations) were identified by the team as being technically feasible for the south Dade County area. The five alternatives ranged from raising the existing building with the slab intact to altering the existing building by raising the roof system, extending the existing walls upward, and installing an elevated floor system within the existing walls. Specifically, the five techniques and variations identified by the team are as follows:

- Raising slab-on-grade masonry structures with the slab intact;
- Raising slab-on-grade masonry structures without the slab (proposed first floor: concrete slab or wood truss);
- Installing an elevated concrete slab or wood-frame floor system within an existing masonry structure and raising the roof;
- Creating a new second-story masonry or wood-frame living area on top of an existing one-story masonry structure; and
- Demolishing the existing masonry structure prior to constructing a new elevated structure.

All of these techniques were identified as being compliant with the NFIP requirements as well as state and local building codes. In fact, three of the five techniques recommended by the team have been or are now being used (with some modifications) by local contractors to raise the lowest floor of substantially damaged residential buildings in the community. One of the recommended techniques, "installing an elevated concrete slab or wood-frame floor system within an existing masonry structure," is depicted in Figures 1 and 2. Figure 1 illustrates the type of technical materials (drawings and wall section details) provided to homeowners for each of the proposed techniques. Figure 2 is a photograph showing one of the residential structures in south Dade County that was elevated using this recommended technique. Note that the structure shown in Figure 2 was elevated by removing the existing windows and roof system, installing a new concrete floor slab, extending the masonry walls upward,
Installation of an Elevated Concrete Slab Within an Existing Masonry Structure

1. **EXISTING RESIDENCE**
2. **EXISTING CONCRETE SLAB**
3. **EXISTING FOOTING**

1. **REMOVE EXISTING ROOF SYSTEM**
2. **REMOVE WINDOWS**
3. **REMOVE INTERIORS AND PARTITIONS**

- Remove all elements of the residence except the exterior masonry walls and floor slab and salvage roof system and windows, if possible.

3. **NEW CONCRETE FLOOR SLAB**
4. **NEW CONCRETE FLOOR SLAB**
5. **NEW CONCRETE FLOOR SLAB**
6. **NEW CONCRETE FLOOR SLAB**
7. **NEW CONCRETE FLOOR SLAB**
8. **NEW CONCRETE FLOOR SLAB**
9. **NEW CONCRETE FLOOR SLAB**

- Existing openings block closed.
- Install a floating concrete slab.
- Construct new masonry with tie beam on top of existing beam.
- Reinstall salvaged roof system and new roofing.
- Relocate utility and mechanical equipment above flood level.

4. **NEW RESIDENCE WALLS**
5. **NEW ROOFING**
6. **NEW ROOFING**
7. **NEW ROOFING**
8. **NEW ROOFING**
9. **NEW ROOFING**

Figure 1. Illustrations of a technique for elevating a residential structure in south Dade County, Florida.
reinstalling the windows and roof system, and raising utility and mechanical equipment to the BFE.

**Information Dissemination to Homeowners**

The information developed by the team was disseminated to the RIC technical staff, which consisted of FEMA regional office staff and local FEMA-hired architects and engineers. This information was used at the RIC in one-on-one counseling sessions with homeowners. To assist homeowners in determining which method was best suited for bringing their homes into compliance with the NFIP, FEMA provided each homeowner with an information package that contained the drawings and cost estimates developed by the team, as well as FEMA and U.S. Army Corps of Engineers publications on elevating buildings.

Furthermore, in an effort to reach out to the land development community, FEMA and the National Association of Home Builders, in cooperation with the

![Figure 2. Example of a residential masonry structure (slab-on-grade) elevated using removal of roof system and extension of wall technique (as shown in Figure 1).](image)
South Florida Builders Association, sponsored a two-day seminar on hurricane-resistant construction techniques in October 1992. The information developed by the team was again used as part of a presentation to approximately 300 contractors, architects, and engineers involved in the reconstruction efforts in south Florida.

Current Reconstruction Activities in South Florida

As the reconstruction of south Dade County continues, contractors have begun to elevate buildings to bring them into compliance with the NFIP and local ordinances. Many elevation techniques, such as those recommended by the team or some variations thereof, are currently being used by local contractors. These techniques include (1) lifting (one full story height) a slab-on-grade masonry structure with the slab intact; (2) installing an elevated concrete slab within an existing masonry structure, raising the floor level and consequently the roof (the existing roof system was lifted off in its entirety for later re-installation once a new tie-beam is poured at the top of the existing masonry walls); and (3) raising an interior floor approximately four feet by installing a wood floor and wood framing system above the existing concrete slab.

Conclusions

The rapid deployment of the RIC, training of the RIC staff, and the development of technical and cost guidance materials for elevating substantially damaged structures were well received by the affected homeowners. The opportunity for homeowners, local engineers, and contractors to interact directly with RIC engineering and architectural staff was valuable to FEMA, Dade County, and the affected public. FEMA was given the opportunity to identify, discuss, and disseminate technical and cost guidance to the affected homeowners on a one-on-one basis. Such a direct exchange of information allowed local residents to receive a clearer and more comprehensive understanding of the compliant rebuilding options that were available to them. The following conclusions can be drawn from FEMA's experience with the RIC process:

- Elevating substantially damaged structures is technically feasible;
- Expertise exists at the local and national levels in the design of elevated residential structures;
- Technical information can be readily transferred on a one-on-one basis with homeowners and other interested entities; and
Federal, local, and private governments working in a partnership, are able to support the needs of homeowners as well as the local community.

References

Federal Insurance Administration
Part Two

Flood Hazard Mitigation
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POST-DISASTER SURVEY OF HURRICANE ANDREW DAMAGE IN LOUISIANA

John G. Burian
Michael Baker, Jr., Inc.

Introduction

On August 26, 1993, shortly after midnight, Hurricane Andrew struck the coast of Louisiana. When Hurricane Andrew struck Louisiana, its central pressure depression was approximately 970 mb and rising rapidly. Sustained wind speeds were 80 knots, with gusts in excess of 90 knots. The distance from the eye of the storm to its peak winds was 13 statute miles. Moving forward at approximately 30 miles per hour, the hurricane traveled in a north between the major communities of Lafayette, Morgan City, Houma, and Baton Rouge. By 5 a.m. on the same day, the hurricane had crossed into Mississippi and had been downgraded to a tropical storm, with wind speeds of less than 65 knots.

Visual Investigations

On September 2, one week after Hurricane Andrew hit Louisiana, Michael Baker, Jr., Inc., flew a team of engineers to Louisiana to survey those areas most severely affected by the hurricane. The purpose of our survey was to obtain information on the scope and type of damage associated with the storm. From this information, we hoped to estimate the recurrence interval of this event, examine what types of structures withstood the storm, and reach a better understanding of what could be expected when a 100-year event does hit this portion of the Louisiana coast.

We established our base of operations in Lafayette, Louisiana, just west of the storm’s path. The most populated and highly developed area within the storm’s 45-mile-wide path is along U.S. Highway 90, which stretches between Lafayette and New Orleans (see Figure 1). U.S. Highway 90 parallels the Louisiana coastline and is the closest major highway to the coast.

Along U.S. Highway 90, between New Orleans and Houma, the only evidence that a storm had hit the area were bent trees and scattered debris along the roadside. However, between Amelia and Lafayette, we observed extensive wind damage in the following communities: Baldwin, Bayou Vista, Berwick, Centerville, Charenton, Cyremort, Franklin, Garden City, Jeanerette, Lydia, Morgan City, New Iberia, Patterson, and St. Martinsville.

In those communities, the damage ranged from downed power lines and telephone poles to bent signs and fallen trees to destroyed wood-frame houses and overturned mobile homes.
Figure 1. The south Louisiana study area.
Much of the damage to the utility poles can be attributed to the soil’s poor foundation qualities and the area’s high water table. We estimated that 50% of the downed power lines were the result of poles falling because of wind stress. Moreover, the hurricane’s winds snapped off the higher portions of many of the remaining poles.

The damage to trees was extensive. Small, as well as large, trees were either uprooted or had branches snapped off. The more flexible younger trees seemed to weather the storm better than older trees.

Most disheartening was the damage inflicted on residential and commercial structures. In every community in the storm’s path that we visited, we witnessed extensive damage to roofs—from missing shingles to roofs that had been completely blown off. As might be expected, mobile homes and wood-frame structures suffered considerably more damage than brick buildings. We saw numerous overturned trailers and wood-frame structures that had been completely destroyed.

From our vantage point, the path of the storm left no discernable pattern. It was not unusual to see a completely destroyed trailer only yards away from a similar structure with considerably less damage.

**Recorded High Water Levels Compared to 100-Year Still Water Flood Elevations**

In its capacity as administrator of the National Flood Insurance Program (NFIP), the Federal Emergency Management Agency (FEMA) has developed still water flood elevations associated with various recurrence intervals for storms. The standard for determining special flood hazard areas and base flood elevations is the 1% (100-year) flood event. In coastal areas, FEMA has determined 100-year still water elevations associated with the hurricane storm surge in Louisiana.

For some of the areas struck by Hurricane Andrew, the National Hurricane Center obtained estimated and actual high water marks. High water marks ranged from 3.5 to 8.0 feet above the National Geodetic Vertical Datum (NGVD).

Comparing the elevations provided in the effective Flood Insurance Study reports to the high water marks observed indicates that Hurricane Andrew produced still water elevations that were between the 10- and 50-year recurrence interval. This is consistent with interviews conducted with local residents who reported little flooding damage. Table 1 presents the high water and still water elevations for some of the communities that we surveyed.
Table 1. High water and still water elevations of selected communities.

<table>
<thead>
<tr>
<th>Location</th>
<th>High Water Elevations (NGVD)</th>
<th>Still Water Elevations (NGVD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-year</td>
<td>50-year</td>
</tr>
<tr>
<td>Cocodrie</td>
<td>8.0*</td>
<td>5.2</td>
</tr>
<tr>
<td>Grand Isle</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Delcambre</td>
<td>—</td>
<td>5.2</td>
</tr>
<tr>
<td>Franklin</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Houma</td>
<td>—</td>
<td>3.3</td>
</tr>
<tr>
<td>Morgan City</td>
<td>—</td>
<td>4.0</td>
</tr>
<tr>
<td>Cypremort Point</td>
<td>—</td>
<td>6.2</td>
</tr>
<tr>
<td>South Bend</td>
<td>—</td>
<td>5.8</td>
</tr>
<tr>
<td>(Yellow Bayou)</td>
<td>—</td>
<td>5.8</td>
</tr>
</tbody>
</table>

* Estimated

Conclusions

In comparison to the wind and flood devastation experienced in Florida, the residents of Louisiana experienced considerably less devastation because of Hurricane Andrew. Although the storm surge recorded was far less than that predicted for the 100-year standard (generally between the 10- and 50-year storm event), the damage created by the high winds was considerable and no less a burden to Louisiana residents.

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Burian

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Federal Emergency Management Agency

Federal Emergency Management Agency

Federal Emergency Management Agency

Federal Emergency Management Agency

Michael Baker, Jr. Inc.

National Hurricane Center
A PLANNING AND OPERATIONS GUIDE, CONNECTICUT'S FLOOD WARNING SYSTEM

Alphonse J. Letendre and Douglas Glowacki
Connecticut Department of Environmental Protection

The Automated Statewide Evaluation in Real Time (ASERT) system is an early flood warning system. The automated rainfall and river gages which make up the ASERT flood warning system monitor rainfall and river levels state-wide, and transmit their data via VHF radio signals to a pair of computer base stations.

The base stations are located at the National Weather Service Northeast River Forecast Center (NERFC) in Bloomfield, and at the State Office Building within the offices of the Department of Environmental Protection (DEP), Inland Water Resources Division (IWRD) in Hartford. Once received, the precipitation and river data are stored in the base station computers. Special software is used to analyze the data and alert staff of potential flooding conditions before they occur. The ASERT system also provides rainfall data to the DEP forestry fire monitoring program. In addition to the ASERT system there is the Automated Local Evaluation in Real Time (ALERT) system. Four towns which suffer from repeated flooding have installed ALERT systems to increase their flood warning and response time. The DEP has dedicated two full-time staff positions to the ASERT/ALERT flood warning systems. Individual towns wishing to join the state-wide system by installing a local system, will receive financial and technical assistance from the DEP and the federal government.

The Benefits of an Automated Flood Warning System

If your community suffers from repeated damage caused by the flash flooding of small rivers and streams, an automated flood warning system can increase your warning time, and provide your emergency personnel with an invaluable tool for responding to flooding emergencies. An automated flood warning system allows emergency personnel to view heavy rainfall and river levels in real time (live), and take actions immediately.

In Connecticut, homes and businesses within the 100-year floodplain of selected rivers are surveyed. These surveys are used to prepare a flood audit for each building. The flood audit contains information on floodproofing and prevention techniques, and an emergency action plan which provides the homeowner or business with detailed emergency actions to take in case of flooding. For a relatively small cost (systems average around $40,000), towns can save several times over the cost of unnecessarily fielding an entire public works department, or failing to evacuate persons prior to flooding.
Connecticut's System

The first phase of the design involved the installation of 14 automated precipitation gauges evenly spread across the state. Five radio repeaters were installed to relay data transmissions from the gauges to the base stations. Six fully automated weather stations were also installed as part of this phase. Sensors on these weather stations collect and transmit rainfall, temperature, soil moisture, wind speed/direction, and relative humidity data to the base stations via the radio repeaters. Together the 14 precipitation gauges and weather stations make up the ASERT system.

The second phase of installation called for two ALERT systems to be installed in the communities of Southington and Norwich. Each of these ALERT systems consists of four precipitation gauges, one river gauge, a computer base station and a radio repeater.

National Weather Service

The National Weather Service (NWS) is responsible for preparing flash flood watches and warnings which are broadcast throughout Connecticut. The Weather Service Forecast Office (WSFO) in Boston, Massachusetts, is the main forecast office for southern New England. The Northeast River Forecast Center (NERFC) in Bloomfield, Connecticut, is responsible for preparing river stage forecasts, headwater guidance, and flash flood guidance for all of New England and much of New York. The NERFC also issues flood warnings and river statements for gauged rivers in Connecticut. Coordination between the WSFO Boston and the NERFC take place by telephone, and by their AFOS (Automation of Field Operations and Services) computer network. ASERT/ALERT rainfall and river data from Connecticut’s flood warning system get transmitted from the NERFC ASERT computer into the AFOS computer and are received by all NWS facilities in southern New England.

Emergency Operations

The NERFC and WSFO in Boston will take the lead. Since flood watches are issued for the most part by the WSFO in Boston, coordination between offices will take place. In the most rapid of situations, NERFC will issue forecasts and warnings for ALERT river basins and coordinate with the DEP and the Office of Emergency Management (OEM). In many situations, the DEP will contact ALERT base stations and Emergency Operations Centers (EOCs) directly to relay the latest warnings. Personnel at the local EOCs have the ability to contact persons living in the floodplains by phone, and inform them of the latest river stage forecast. Individuals should then begin moving the
possessions listed in their Flood Audit Emergency Operations Plans out of basements and flood-prone areas.

Towns with ALERT Base Station computers also have the capability to monitor rainfall and river levels in their own area. The local computer base stations are equipped with an antenna which receives the rainfall and river data at the same time it is transmitted to the NWS. This gives the local authorities the ability to respond quickly and independently to the sudden rise of a local river, or locally heavy rains.

The river forecasts will contain forecasted rainfall for the next few hours. This provides users of the forecasts with an "if/then" scenario. If, for example, an additional inch of rain falls during the next hour, then the user can expect the river to rise to a certain stage.

The Flood Audit Program

The flood audit program was developed by the U.S. Soil Conservation Service (SCS) and the Connecticut Department of Environmental Protection to help reduce flood damage to contents and building components. This program is performed in conjunction with the installation of municipal ALERT flood warning and response systems. The flood audit provides homeowners and small businesses with information on flood warning levels and the relationship of the flood levels to their structures. When a flood warning level is actually forecasted for the area, the individual takes the actions listed in the flood audit for the corresponding level.

Flood audit data are also loaded into the local community's flood warning system database to produce a computer display. The structures are listed in order of water entry height. To date, approximately 420 flood audits have been performed in five major river basins (Connecticut, Yantic, Quinnipiac, Wepawaug, and Rippowam).

Determining the Flood Potential in your Community

The design and installation of an automated flood warning system requires detailed research and planning well before any equipment can be installed. Please remember that the planning and design process, when actually undertaken, is far more detailed than described here. The State of Connecticut has prepared detailed specifications and planning procedures to guarantee that new ALERT systems are installed using high quality equipment which is compatible with existing software at the NERFC and DEP base stations.


History of Flooding

As a first step to installing a flood warning and response system, the flood history of the damage area should be determined. If you don’t know of any single flooding event which caused considerable damage within your community, then you should contact other agencies. The Corps of Engineers (Corps), or the SCS may have already performed a study to determine your community’s flood damage potential.

Another good source of flooding information is the Flood Insurance Study (FIS), prepared by the National Flood Insurance Program (NFIP) for your community. The FIS contains inundation maps showing the 100-year floodplain for all major streams and rivers within a community.

Figuring Flood Damage in Dollars

Flood Insurance Studies may contain actual estimates on the amount of damage (in dollars) caused by different frequencies of flooding within a community. The following formula can be used to convert the frequency and corresponding damage estimates into a mean annual damage from flooding.

$$\frac{1}{\text{Frequency}} \times \text{Damage } \$ = \text{Mean Annual Damage (Non-Structural 100 Year)}$$

The formula should be applied to the 2, 5, 10, 25, 50, and 100 year storms. The sum of the mean annual damages for each frequency will provide an acceptable mean annual damage estimate for your town. For example, as shown in Table 1, if the City of Milford suffers the following non-structural damages, for storms with frequencies of 2, 5, 10, 25, 50, and 100 years, then to calculate mean annual damages, multiply the reciprocal of the frequency times the damage in dollars for each frequency.

The category of non-structural damage is used because most avoidable flood damages consist of materials or vehicles that can be moved quickly above the flood waters. In a later section, Available Funding Sources, the amount of average damages is used to help towns qualify for grants to help fund flood warning systems.

Table 2 shows how a benefit-to-cost ratio can be calculated using the sum of mean annual damages which were calculated in Table 1. Column 1 depicts a 10-year life expectancy for an automated flood warning system. The expected yearly cost of installing and maintaining the flood warning system is shown in column 2.
Table 1. Damage estimation by flood frequency.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Frequency X</th>
<th>Damage (1,000's of $)</th>
<th>Mean Annual Damage (Thousands of $)</th>
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<tbody>
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<td>100</td>
<td>.01</td>
<td>565</td>
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Sum of Mean Annual Damages = 16.33

Table 2. Figuring the benefit-to-cost ratio.

<table>
<thead>
<tr>
<th>Years Since Initiation, Renewal, or Expansion</th>
<th>Expected Cost (1)</th>
<th>Expected Yearly Benefit (2)</th>
<th>Present Value Discount Yearly Factor for 10 Percent (3)</th>
<th>Present Value Column (2) × Column (4) (4)</th>
<th>Present Value Column (3) × Column (4) (5)</th>
<th>Present Value Benefit (6)</th>
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<td>0.909</td>
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<td>0.386</td>
<td>772</td>
<td>6,303</td>
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Present Value Cost: $40,766

Present Value Benefits: $100,329

Present Value Net Benefit = $100,329 - $40,766 = $59,563

Benefit to Cost Ratio = $100,329 / $40,766 = 2.46

Designing a Table Top Model

Before any field investigation, it's a good idea to set up a table-top model of your planned flood warning system. This section discusses, in roughly chronological order, information gathering and construction of the model.

Layout of River Basin

Using a USGS drainage basin map (scale 1:125,000), locate your desired river basin. Outline the basin and be sure to include all tributaries which flow
into the main stem of the river. Outline the known areas where flood damages occur within the river basin. Use the basin list on the left hand side of the map to find your basin and all tributaries. Add together the basin area in square miles upstream of where you intend to place the river gauge. A good rule of thumb: If the river basin is less than 30 square miles, use three precipitation gauges, and one additional precipitation gauge for each additional 40 square miles of basin area.

If a river basin and its tributaries cover less than 15 square miles, the river may rise too rapidly and unpredictably to warrant the use of an automated flood warning system. If, on the other hand, your basin is greater than 1,000 square miles, the NWS would probably be able to provide timely flood forecasts with a conventional non-automated system.

**Locating Gauges**

Precipitation gauges should be located on high ground within the river basin, upstream of the river gauge. Be sure the site is accessible by car. High ground is preferred to provide as good a radio path as possible to your base station. But, even the highest locations will not guarantee a good path. Although high ground is preferred, if a good path exists from a lower elevation, the site should be used. Field testing of the radio path is absolutely necessary prior to installation.

It is okay to place precipitation gauges just outside the boundaries of your basin if a suitable site is unavailable within the basin, but you must place the gauge as close as possible to the basin boundary, to provide an accurate rainfall record for the basin. For legal and maintenance reasons, it is advisable that gauges be placed on state or municipally owned land.

River gauges should be located just upstream of the most flood prone areas and away from large obstructions such as narrow culverts or low bridges, to avoid being placed in a backwater condition.

Gauge locations should be selected to prevent vandalism. Either remote, but accessible locations, or very visible areas with large clearings, such as public parks, airports and schools are used successfully.

**Base Station Location**

The base station should be located in a building which is occupied 24 hours a day, and has a backup power generator. Police or fire departments are the best choice because they often meet both of these criteria. It is critical that a trained person be available during emergencies to operate the computer base station.
Table Top Radio Path Survey

A radio path survey is necessary to determine if the data transmissions from the gauges will reach the base stations uninterrupted. ALERT gaging stations transmit data in the 168-172 Mhz frequency range. Radio waves in this frequency range travel in roughly straight lines. Obstacles such as hills and very large buildings can block the radio waves. Once you have a good idea of where to place your gauges, mark the gauge locations, and base station location(s), on a USGS 7.5-minute quadrangle map with 10' or less contour intervals. Also it's a good idea to mark down a number of alternative sites for each gauge. Draw a line between each gauge site and the base station. Draw hash marks at 1/2" (approximately 1,000 feet) intervals along each line, and record the ground elevation at each hash mark.

Using graph paper, plot out the distance and height of each point on the line. Through experience, radio engineers have determined average distances a radio can be used under fixed conditions. As an example, for a receiver antenna height of 100 ft. and a transmit antenna height of 10 ft. above average terrain, the maximum usable distance of a 10 watt transmitter operating in the VHF hydrological band is about 15 miles. This distance was found to be an average when transmitting over hilly terrain. If you lower the receive antenna to 50 ft., the path shortens to 10 miles.

To verify a path, construct a graph with the height of the terrain on the Y axis and the distance from the transmitter on the X axis. Include the height of the antennas on the Y axis. Draw a line from the transmit antenna to the receive antenna. If the line that represents the path is well above the terrain over the entire length of the path, you have exceeded the conditions of the general range rule and your path could be longer than 15 miles. If the line just touches but does not pass through the terrain then you have met the conditions of the range rule and will get a distance of about 15 miles. If the line goes below the terrain at any point the range will be less than stated above.

The river gauge will be the toughest to place since the sites are limited to low areas located near historically damaged areas, since the river itself is always the lowest point in the basin. One way to solve a bad path problem is to purchase a radio repeater ($8,000) to relay the signals to the base station. For statewide systems, especially in the northeast United States, you may find that an average of one repeater is required for every 10 gauges.

On-Site Radio Path Survey

Once you have selected your potential sites for the gauges and base station within your flood warning system, you should verify the radio paths to assure that the data transmissions from the gauges will reach your base station. If it becomes necessary to install a repeater, or a series of repeaters, you may want
to have the manufacturer perform the tests and supply you with the results. Be sure that the manufacturer will guarantee the reliability of the radio path. Radio path testing should be conducted only when there is foliage on trees. Radio signals are dampened by the effects of leaves on trees. Radio paths which are tested during the winter may become unreliable when foliage returns to the trees.

Available Funding Sources

Several funding sources are currently available to Connecticut towns that plan to install an automated flood warning system. The two most often utilized funding sources are: State of Connecticut Assistance Grants, and Federal Hazard Mitigation Grants.

The State of Connecticut may provide up to 66.6% of the cost of the purchase and installation of new automated flood warning systems in Connecticut. The municipality must share the remaining 33.3% of the cost of purchasing and installing a new system and base station receiving computer. All new systems installed in Connecticut will be maintained by the state, and must meet the state specifications.

When funding is available from the Federal Emergency Management Agency (FEMA), under the Stafford Disaster Assistance and Relief Act, Section 404, Part 206, subpart N (P.L. 93-288 as amended by P.L. 100-707), it is provided for post-disaster hazard mitigation projects. Automated flood warning systems qualify for funding under the Stafford Act, but funding is competitive, limited, and is only available after a Presidentially declared disaster.
FLOOD HAZARD IDENTIFICATION OF PUBLIC SCHOOLS

Rebecca C. Quinn
Maryland Water Resources Administration

Introduction

One of the first steps in a successful mitigation effort is awareness and assessment of vulnerability, and the single most attention-getting awareness mechanism is getting flooded. There is little to question about a facility's vulnerability to flood when it is under water. Vulnerability assessment can lead to a number of effective, low-cost, high-benefit results.

Potomac River Flood of 1985

In 1985, the Potomac River experienced another in a long series of floods. Luckily for Maryland, long reaches of the Potomac’s floodplain are in federal ownership and are managed by the C & O National Historic Park. However, along the upper river, there are numerous pockets of development that have flooded in the past. The presence of the U.S. Army Corps of Engineers' Bloomington Lake has modified the floodplain somewhat, but its effects become insignificant less than 50 miles downstream.

The 1985 flood included a highly unusual aspect involving the South Branch Potomac River, a tributary which joins the main river just below the community of Oldtown, Allegany County. Exceptionally high tributary discharges resulted in blocking mainstem flow, and produced a confusing situation for river observers in Oldtown. The Potomac River appeared to flow "back river." As a result of the blockage, the water rose very rapidly and inundated several homes and the Oldtown School with nearly eight feet of water. Local residents and the fire department reported that the confusion delayed efforts to remove valuable items from the school.

Presidential declarations were made for many communities in Virginia and West Virginia after the floods of 1985. Maryland sought a declaration, but failed to qualify even for Small Business Administration assistance. Many small creeks and streams came out of bank and caused severe flooding of a small number of individuals, but the numbers were below federal thresholds. At least one victim leveled a complaint that he was not able to get financial assistance because Maryland and its communities had done such a good job keeping development out of the floodplain!

Despite the relatively few private homes involved, damage to the Oldtown School was sufficient to prompt the state to negotiate with the Federal Emergency Management Agency (FEMA) and the U.S. Department of Education. To date, this school remains the only Presidentially declared disaster
for a single building in FEMA history. Unfortunately, the haggling has continued and the Department of Education still has not provided all of the anticipated funding.

**Hazard Mitigation Plan**

The State of Maryland committed to developing a hazard mitigation plan as a condition of the Federal-State Agreement. After discussion with FEMA Region III, it was decided that a 15-day report would not be prepared. The State Hazard Mitigation Officer was faced with a valuable opportunity and decided to use the plan requirement to broaden the state's awareness and assessment of vulnerability of flood hazards. The final plan focuses very little on Oldtown School itself. Rather, it addresses the question of the flood risk of all existing public schools and the procedures by which local school boards select sites for future buildings.

**Site Selection for Future Construction**

The most effective flood mitigation is to avoid building in the most susceptible places. This concept held the most immediate promise since all public school sites are purchased with partial state funding provided by the Public School Construction Committee. The state Department of Natural Resources Water Resources Administration (DNR-WRA) worked with committee personnel to revise site-selection criteria to assure adequate identification of floodplains and wetlands. The guidelines allow for purchase of land if unused portions, or areas scheduled for minimal use, are within the floodplain. However, comments from the National Flood Insurance Program State Coordinator are obtained prior to commitment of funds.

On at least two occasions in the past few years, state funding was denied for the purchase of land that was constrained by floodplain and wetlands. In these instances, significant encroachment into the floodplain would have been necessary.

**Identification of Vulnerable Existing Schools**

The State Hazard Mitigation Officer met with the state's organization of school superintendents to brief them on the situation at Oldtown, and the task of determining if any other public schools were subject to flooding. The superintendents committed their own staff resources to assist with the effort, and agreed to direct each county's facilities planner to work with DNR-WRA staff.

A complete set of Flood Insurance Rate Maps (FIRM) for each county and the incorporated municipalities within each county was mailed to the facilities
planner. Detailed instructions for using the maps were provided along with a data sheet. If a building appeared to be in the 100-year floodplain depicted on the FIRM, detailed data were requested, for example, when it was built, if there was any record of previous flooding, and if plans were available showing the elevation of the lowest enclosed area, elevation of lowest point of entry, and elevation of the main entrance.

A total of 18 schools were identified as having some level of flood risk. Six buildings are expected to be marginally affected by the 100-year flood or will be surrounded by flood waters. Of the remaining 12, seven are considered to have flood risks ranging from moderate to severe. Several others have flood-prone athletic fields or access routes, but these conditions are not considered to be severe.

Within Allegany County, three schools that prompted concern were identified: (1) Oldtown School is the state’s most severely flood-prone school; (2) Westernport Elementary is exposed to flooding from the Potomac River and from George’s Creek; and (3) Flintstone Elementary is only marginally flood-prone but is situated less than five feet from the top of an eroding streambank. Follow-up activities for these schools are detailed below.

**Emergency Procedures for Schools**

A few years after the flood of 1985, the Maryland Emergency Management Agency assisted with a revision of guidelines used by public schools during emergencies. In consultation with the State Hazard Mitigation Officer, emergency procedures for school bus drivers were amended. The old guidelines advised drivers to proceed with caution when driving through floodwaters. This was amended to direct bus drivers to become familiar with the susceptibility of bridges along their routes and urge them to consult with local planning offices to review the flood maps. Further, the guidelines were substantially changed to prohibit driving through high water, regardless of the apparent shallow depth.

**Follow-Up Activities**

**Flood Insurance**

All counties were provided copies of the identification report and urged to investigate whether their existing insurance provided adequate protection. The constraints imposed by the Stafford Act, reduction in federal disaster assistance if a public building is flood-damaged, were explained to local school boards. The Allegany County Board of Education purchased flood insurance on its flood-prone schools, and includes flood insurance premiums in its annual budget.
Oldtown School

The Board of Education and the Allegany County Office of Civil Defense and Emergency Services developed a plan of action. The plan includes specific parameters for observing the rise of the river, who will be responsible for initiating evacuation, relocation of computer equipment and current office records to the second floor, and where students will be taken and how they will be cared for until safely home.

As part of the initial identification of measures to reduce exposure, the Oldtown School determined that long-term storage of vital records would be relocated from the main office to a second floor room. It was also recommended that cabinets, shelving, restroom partitions, etc., be replaced with water-resistant materials. Unfortunately, the last communication to the State Hazard Mitigation Officer indicated the Department of Education determined that the additional expense was ineligible for funding.

Perhaps one of the more interesting ramifications was discussion of the way that all exit doors open outward from the building, a requirement of state fire codes so that rapid evacuation is not hampered by inward-opening doors. However, it was found that the two or three adults who were the last to leave Oldtown after the water was several feet deep had been unable to open the doors due to pressure. After considerable distress, they discovered one door in the building’s physical plant that opened inward, and were able to escape. The Oldtown School’s emergency procedures, which are provided to all staff, now clearly explain how to exit the building if floodwaters prevent opening of the main doors.

Flintstone Elementary School

At the request of the State Public School Construction Committee and the Allegany County Board of Education, DNR prepared an analysis of flood conditions and a recommended design for gabion protection of the eroding streambank. Due to budget constraints, the project has not gone forward. However, the county’s school facilities planner performs an annual visit to assess whether erosion appears to be worsening. In addition, school personnel have been instructed to check the streambank after all highwater events, even if they are not considered to be floods.

Westernport Elementary School

A few years ago this school was scheduled for closing. However, due to local protest, the state and the Allegany County Board of Education decided to undertake major renovations and the addition of a gymnasium facility. Due to its presence in the floodplain, both local and state requirements for substantial improvement were applicable. Therefore, the existing building had to be
floodproofed and the gymnasium addition had to be elevated. The county applied for and received a grant of $100,000 from the Maryland Flood Management Grant Program designed to assist local governments with flood mitigation capital projects.

The school building is masonry, and is composed of the main building and at least two additions. The possibility of retrofitting floodproof measures was investigated. The State Hazard Mitigation Officer requested and received assistance from the U.S. Army Corps of Engineers through the Flood Plain Management Services Program. A team visited the site and conducted a floodproofing evaluation which was summarized in a written report.

Due to questions about the floodplain depicted on the FIRM and the relative magnitude of flooding from both sources (Potomac River and George's Creek), DNR performed a floodplain study to determine the appropriate 100-year flood elevation. This information was valuable in the subsequent design of floodproofing and in efforts to develop a warning and response plan.

The end product is a floodproofed school building. To be effective, sufficient warning is required to place a total of eight flood shields. The shields are clearly marked and stored for easy access. School personnel thoroughly investigated the opportunities for flood warning, and ended up with a combination of basinwide alerts for George's Creek, and predictions of crest from the National Weather Service River Forecast Center. There are also a number of volunteer observers in the area who have been part of the county's flood watch network for many years.

**Conclusions**

The statewide mitigation efforts undertaken as a result of the 1985 flooding of the Oldtown School were low cost and not staff intensive. At each step, there were always two or more partners working with the same objective. The benefits are summarized below:

- Flood risk at all public schools is known,
- School children are more protected from flood risk while attending school or in transit on buses,
- Bus drivers have revised flood emergency procedures,
- More flood-prone public buildings have financial protection provided by flood insurance,
• Procedures for new school site selection preclude construction in floodplains and wetlands,

• Oldtown School has reduced flood risk and developed a warning and response plan, and

• Westernport Elementary School is floodproofed and has a warning and response plan.
HAZARD MITIGATION GRANT PROGRAM: 
THE EVALUATION REPORT OF THE 
JOINT TASK FORCE ON HAZARD MITIGATION

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Introduction

Anyone directly involved in natural hazard mitigation is painfully aware of the need for cross training. This awareness was heightened by surveys conducted last year by a task force composed of the Association of State Floodplain Managers (ASFPM), the National Emergency Management Association (NEMA), and the Federal Emergency Management Agency (FEMA). The surveys, one a questionnaire and the other an instrument that collected information on projects funded by FEMA’s Hazard Mitigation Grant Program (HMGP), demonstrated that current processes do not readily identify projects after disaster declarations (HMGP funds are available only in declared disaster areas). Indeed, the task force concluded on the basis of the surveys that mitigation will simply not occur unless the staff of hazard mitigation programs finds a way to learn from each other. Note, as you read the recommendations of the joint task force below, that the overriding call is for cross training, networking, and coordination.

Scope of the Task Force Report

The task force studied the application process of the HMGP. That process is a series of tasks that identifies and selects projects that contribute to hazard mitigation objectives. These tasks include state hazard mitigation planning, eligibility assessment, and environmental scrutiny. According to task force findings, technical assistance, which includes training, plays a very large role in identifying and selecting hazard mitigation projects.

Task Force Recommendations

Each task force recommendation calls for cross training or some interactive forum that produces the level of awareness so sorely needed for successful hazard mitigation projects. The principal recommendations of the task force are:

(1) States should create teams of state agency representatives that would prepare hazard mitigation plans and, with the assistance of local
agencies, oversee the implementation of HMGP projects following a disaster declaration.

(2) For each disaster declaration, a hazard mitigation strategy should be developed and endorsed jointly by federal, state, and local representatives.

(3) Priority should be given to providing technical assistance for the identification of hazard mitigation projects, assessments of cost-effectiveness, and the eligibility of projects under the HMGP.

(4) There should be a concerted effort to convey the concept of hazard mitigation planning to all federal, state and local agencies, the private sector, and professional organizations.

These recommendations and the supporting recommendations listed below are based on survey findings and task force interpretations of those findings. The surveys contributed to a thorough evaluation of the HMGP application process. Otherwise the task force might not have learned, for example, that the most successful HMGP projects are the result of non-traditional alliances among government agencies and cooperative work relationships among people with different backgrounds and expertise. Most task force recommendations focus on building such alliances and relationships.

**Task Force Surveys**

The survey questionnaire asked about HMGP matters and the project survey collected data on projects submitted to FEMA regional offices for HMGP funding over the past four years (the program was authorized in 1988). Under direction of the task force, the questionnaire focused on four major issues: (1) the application process; (2) coordination among local, state, and federal agencies; (3) hazard mitigation planning; and (4) technical assistance. Questionnaire responses confirmed the validity of the issues identified by the task force. It was sent to members of the ASFPM and NEMA and FEMA regional hazard mitigation staff.

The questionnaire also validated "concerns" grouped under each major issue. For example, questions about training, written guidance, and the quality of expert assistance were subsumed under "technical assistance." Similarly, questions about planning, project identification, and interagency team reporting were subsumed under "coordination" among government agencies. Survey respondents agreed with the task force on these concerns as well.
Questionnaire Findings

The task force found that hazard mitigation projects are difficult to identify whenever one or more of the following situations arise: (1) when partnerships among experts is lacking; (2) when hazard mitigation planning is intermittent, erratic, and disjointed instead of continual, consistent, and coherent; (3) when technical assistance is lacking in cost-effectiveness assessments and environmental analysis; and (4) when the HMGP application form and substance are not clearly understood.

The task force also learned that the administrative apparatus that permits the identification and selection of hazard mitigation projects in the aftermath of a disaster is only beginning to materialize. It appears that the key to the process of identifying projects is the provision of a forum that simultaneously fosters education and planning. Education is important because the task force learned that a major impediment to project identification is that hazard mitigation has different meanings to different kinds of people whose cooperation is vitally important to program implementation and success—emergency managers, public works directors, planners, natural hazards specialists, economic or community development staff, and elected officials. Second, the timing of HMGP implementation, which is triggered by a disaster declaration, is a problem. In the aftermath of a disaster, sufficient technical expertise, coordination, and work hours are hard to come by.

Project Survey Findings

The project survey found that HMGP projects define seven categories. Beginning with the largest concentration of projects, the categories are (1) drainage projects, (2) acquisition and relocation projects, (3) education and training projects, (4) equipment purchase projects, (5) public and private facility projects, (6) planning projects, and (7) land improvement projects. Although drainage projects account for the largest number of projects, public and private facilities lead HMGP grants for all types of hazards. Public and private facilities include such things as roads and bridges, schools, government office buildings, and the buildings of non-profit organizations.

Approximately $52 million in HMGP funds have been obligated since January 1989. The rank-order of obligations among project categories is (1) public and private facilities (58%), (2) drainage projects (14%), (3) equipment purchases (12%), (4) relocation and acquisition projects (11%), (5) planning programs (3%), (6) education and training (1%), and (7) land improvements (1%).
Supporting Recommendations

The task force rounded out its recommendations with 11 supporting recommendations. The recommendations fall within four general categories: agency coordination, technical assistance, administration, and evaluation.

**Recommendations for Agency Coordination**

1. Create state teams to respond to disaster declarations, modeling them on the Federal Interagency Hazard Mitigation Team (IHMT).

2. Develop and endorse a federal-state hazard mitigation strategy after each disaster declaration to identify mitigation opportunities presented by the disaster.

3. Reinforce the need to prepare and/or update state hazard mitigation plans through the Federal-State Agreement.

**Recommendations for Technical Assistance**

4. Initiate a major effort to strengthen all technical assistance activities, including training and handbooks, for hazard mitigation purposes.

5. Improve guidance on project identification, eligibility under the HMGP, and the environmental review process as applied to hazard mitigation projects.

6. Establish a linkage among current research findings and technical assistance and training on the techniques of hazard mitigation.

**Recommendations for Administration**

7. Adopt a standard HMGP project application form and checklist.

8. Initiate a marketing and public awareness program on the benefits of hazard mitigation.

9. Reevaluate the non-federal share for hazard mitigation projects in the interest of establishing consistent cost sharing among disaster assistance programs.
**Recommendations for Evaluation**

(10) Develop a strategy for measuring the impact of hazard mitigation projects on reduction of disaster damages.

(11) Establish a permanent advisory council on hazard mitigation to coordinate the resolution of hazard mitigation administrative issues.

**Achieving Recommendations**

Many organizations are carrying out recommendations of the task force. For example, several states either have established or are in the process of establishing hazard mitigation teams, including Colorado, Kentucky, Texas, and Ohio. A methodology that assesses the cost-effectiveness of hazard mitigation projects has been developed, and FEMA regional offices are testing it. Three new hazard mitigation training courses, including environmental training, are available. In addition, guidance on HMGP project eligibility and the application process is under revision. Underlying each task is cross training, networking, and coordination among people who have the wherewithal to make hazard mitigation happen.

**Post Script**

Alert floodplain managers can obtain HMGP funds to reduce future flood damages. The HMGP provides funds for all natural hazard projects. Moreover, project eligibility is not limited to the hazard that produced a disaster declaration. For example, a flood project is eligible for HMGP funds in a disaster area if an earthquake caused the disaster declaration.
VARIATIONS IN RESIDENTIAL
DEPTH-DAMAGE FUNCTIONS USED BY THE
U.S. ARMY CORPS OF ENGINEERS IN
FLOOD DAMAGE ESTIMATION

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Introduction

This paper examines the variations in residential depth-damage functions used by U.S. Army Corps of Engineers (Corps) planners. These differences include how the curves are derived, how structure and content values and damages are determined, and variations in building types and flooding characteristics. The paper should help other analysts who perform flood damage estimates to better understand the depth-damage functions used by the Corps and perhaps to carefully reconsider their existing damage functions. A broader application would be the benefit to community floodplain officials from considering the extent and kind of damage that might result from various levels of flooding.

A depth-damage function is the mathematical relationship between the depth of flood inundation above and below the first floor of a building and the damage attributable to that flooding. In tables and graphs illustrating damage as a function of water depth, the first floor elevation is equivalent to 0 water height; positive numbers indicate heights above, and negative numbers heights below the first floor threshold. Depth-damage relationships are computed separately for structures and contents. They are generally expressed with content damage as a percentage of content value, and structure damage as a percentage of structure value, for each foot of inundation.

The depth-damage relationship is based on the premise that the level of flood inundation is the critical variable in determining the expected damage to buildings and their contents. While many other factors affect the amount of damages, including velocity and duration of flooding, sediment load, and warning time, the depth-damage function, based solely on water height, is the primary relationship used by the Corps in flood damage estimation (IWR, 1988). Thus, the development and selection of a depth-damage curve has a substantial impact on estimating the benefits of flood damage reduction projects.

The Corps applies depth-damage functions to individual properties. Each property is surveyed to determine a structure classification, structure value, content value, and first floor elevation. Information on the inventoried properties are aggregated over a small, homogeneous geographic area known as
a damage reach to determine an elevation-damage relationship, which expresses the monetary value of physical damages by elevation of flooding. The elevation-damage relationship is then combined with the hydrologic and hydraulic frequency-discharge and stage-discharge relationships to determine the expected annual flood loss for each reach. Expected annual damage indicates the average yearly monetary value of physical loss based on the magnitude and probability of losses from all possible flood events. Expected annual flood loss with and without flood mitigation is the major component in determining the benefits of flood damage reduction. The objective of federal involvement is to formulate a flood mitigation plan that maximizes all net benefits (i.e., National Economic Development benefits minus costs) and which is feasible from an engineering standpoint, environmentally sound, and publicly acceptable (USACE, 1990).

Variations in Depth-Damage Functions

Often, the greatest variations in depth-damage functions used by Corps analysts are determined by their source. Of the 38 Corps offices performing flood damage reduction studies, no less than 18 different sets of depth-damage curves are employed (IWR, 1992). There are four principal sources for these damage functions: (1) direct application of existing depth-damage functions, such as the Flood Insurance Administration (FIA) rate review tables; (2) adaptation of an existing depth-damage function to a local or regional situation; (3) relationships derived from post-flood surveys of recent flood victims; and (4) synthetic estimates of the damage that would occur in a hypothetical flood situation. The advantages and disadvantages of each of these sources are discussed below.

Federal Insurance Administration

The primary source of residential depth-damage functions used by the Corps is the FIA, an organization within the Federal Emergency Management Agency (FEMA). Twenty-four of the 38 Corps offices surveyed use some form of the FIA depth-damage functions, including the original damage functions developed in 1970, a set of "theoretical" base curves generated in 1973, the FIA's annual rate review (a synthesis of both annually updated claims data and the 1973 curves), and direct use of raw FIA claims data to calculate new damage functions (IWR, 1992).

The initial 1970 FIA depth-damage functions were based on data from several Corps of Engineers post-flood surveys. These were adjusted in 1973 based on additional Corps surveys, initial flood insurance damage claims information, and the collective judgment of experts on a National Flood Insurance Program (NFIP) actuarial committee. These 1973 depth-damage relationships, referred to as theoretical base tables, are now updated annually by
the FIA with the total damage information obtained during claims adjusting procedures, or "rate reviews." The rate review tables have thus changed slightly over the years as additional claims are added to the database.

The original FIA curves were computed separately for structure and contents for seven different structure types: single floor with and without basement, two or more floors with and without basement, split level with and without basement, and mobile home. Annual FIA curves still include six housing types for structures (two or more floors with basement has been discontinued) and three curves for contents (first floor only, first floor and above, and mobile home).

A major advantage of the FIA depth-damage functions is that they contain the most exhaustive database of damage claims and represent the only set of national curves. Whether these curves are applicable everywhere across the country is another issue. Their standardized nature precludes variations except between building types. A major disadvantage may be that the FIA curves are too heavily relied upon, at least within the Corps. The wide acceptance of these national curves has taken away much of the stimulus for research at the local level. And, although updated annually, the FIA damage functions are still heavily weighted by the 1973 theoretical base tables. The Corps' Institute for Water Resources (IWR) is currently exploring the possibility of using FIA's massive claims database in the computation of regional damage functions. Further information on FIA data is available in two Corps reports (IWR, 1992) (IWR, 1993).

**Adaptation of Existing Depth-Damage Functions**

A common practice among Corps districts offices is to use depth-damage functions adapted from either the FIA or other districts. While little guidance on the adaption of existing curves is available, four steps are recommended by the Corps (IWR, 1992). These include (1) identify the predominate structure types by number of stories, presence of basements, foundation type, and building materials; (2) identify the flood characteristics of the study area, such as typical flood velocities, durations, warning lead times, and other factors that may affect the extent of flood damage; (3) review other flood damage functions and determine the comparability of structure categories and flood hazard characteristics between local and source damage functions; and (4) determine the adjustment factors for each curve. Adjustments to a compatible set of depth-damage functions are influenced by the water height at which damages begin, the shape of damage functions, inflection points, and the magnitude of damages.

Adaptation of existing depth-damage functions is the least expensive and least time-consuming method of establishing depth-damage functions. This practice is a potentially efficient way to build on previous work, while allowing the incorporation and consideration of localized flood conditions and building
Post-Flood Surveys

Conducting a post-flood survey is the most precise method of gathering residential depth-damage information. Recent flood victims are interviewed about damages incurred. During the interview, damages are also estimated for elevations above and below the first floor level of a structure (IWR, 1991). There are several advantages to post-flood surveys. First, they provide the only method of obtaining real data on the susceptibility of building materials, mechanical equipment, and household contents to actual flooding. Second, the analyst can determine the age and pre-flood condition of all contents and depreciate them based on a pre-determined depreciation schedule. Third, items included in the property and damage inventories are documented, benefiting future users of the depth-damage curves. Finally, post-flood surveys are also useful as supporting information in constructing synthetic damage functions and in adjusting previously existing depth-damage functions. In terms of disadvantages, the lack of financial resources is obviously the major constraint to post-flood surveys. The surveys are also dependent on a recent flood occurrence.

Synthetic Damage Estimates

Synthetic damage functions are constructed by estimating the percentage of a structure or contents damaged at hypothetical flood levels. Interviews similar to those for post-flood surveys are conducted. Damages can be estimated by questioning floodplain residents regarding the damages that might occur at various flood elevations. Accuracy is improved by having the interviews conducted by individuals experienced with flood claims adjustments or damage estimation.

A major advantage of this method is that it is expedient, relatively inexpensive, and does not require a recent flood event. The major disadvantage is the hypothetical nature of the assumptions. Guidelines such as those developed for the Corps New York office by URS Consultants (URS, 1988) provide damage susceptibility and unit costs of repair and replacement that are invaluable in making synthetic damage estimates.

Structure and Contents Definition and Value Determination

Variations in depth-damage functions may also result from differences in how structures and contents are defined and how their values are estimated. A structure is usually defined as a permanent building and everything attached to
it. Current Corps regulations prescribe the evaluation of building values as an estimate of depreciated replacement value of the structure, but other measures, such as market value, have been used in the past as surrogates (USACE, 1990). Household contents are usually defined as everything within the house that is not permanently installed. The standard depth-damage relationships applied to residential property often incorporate content-to-structure value ratios. While ratios used by Corps district offices have ranged from 25 to 75%, the ratio is now limited subject to a local survey.

**Variations in Building Types and Types of Flooding**

Standard depth-damage relationships are common for residential structures because residential property is considered to be fairly homogeneous in susceptibility and layout of contents, and in types of building material used. Because of the popularity and widespread use of FIA curves, the six FIA building type categories are used by nearly all Corps district offices to some extent (IWR, 1992). Some regional variations occur, however, especially when geographic or cultural conditions influence the predominate building types in a region. For example, the Memphis, Vicksburg, Little Rock, Albuquerque, and Walla Walla districts differentiate between various building materials; the Galveston and Wilmington offices include a high-raised structure category; several offices, such as New Orleans, Galveston, and Jacksonville, do not include building categories with basements; and the New York and New England offices use different curves for various styles of houses, including cape cod, colonial, ranch, and seasonal (IWR, 1992).

Depth-damage curves may also vary regionally because of the type of flooding characteristic of an area. For example, the New Orleans and Vicksburg offices employ both freshwater and salt water damage functions to reflect differences in damage resulting from inland flooding or coastal storms. Similarly, the curves developed by Huntington district and used by the Pittsburgh and Vicksburg offices distinguish between tributary and main stem riverine flooding to incorporate differences in velocity and duration of flooding.

**Application to State and Local Floodplain Managers**

It has been estimated that over 20,000 communities in the United States experience flooding problems of varying severity, character, and frequency (NSF, 1980). In most of these locations at least some kind of local flood protection has been or is being considered. Regardless of the size of the project, the communities considering such projects should apply an economic analysis to determine whether flood protection is an efficient expenditure, the optimal mix of components, and the proper scale of the project to be
undertaken. Depth-damage functions are an essential tool in making damage estimates. It is just as important for a local or state government to have appropriate depth-damage functions for estimating benefits of local flood protection projects as it is for the Corps. The Corps can supply important depth-damage information to state and local governments.

State and local governments are also the sponsors of Corps projects. Sponsors are no longer silent partners in the planning process. Not only have the stakes been raised in the sponsor's financial commitment toward project implementation, but sponsors now have a 50-50 cost-sharing responsibility on feasibility reports. Part of that responsibility is greater in-kind participation, a larger role in decision-making, and the need to have a better understanding of depth-damage functions, a primary variable in the computation of flood damage reduction benefits.

The technology transfer runs both ways. The Corps benefits substantially from information supplied by the state and local agencies that sponsor its projects. These agencies supply data on flood characteristics, building attributes, property values, warning time, and occasionally, depth-damage functions. Flood damage analysis is one area that should continue to provide opportunities for cross-fertilization.

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U.S. Army Corps of Engineers Institute for Water Resources

URS Consultants
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Part Three

Multi-objective Management
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History of the Upper Trinity River Basin

The word "vision" can be simply defined as foresight; however, "vision" implies more than that; having "vision" allows goals and dreams to be blended into reality. For many years, the Trinity River was envisioned as a barge canal to create an inland commercial port in the north-central Texas area. In 1981, when this concept of the river was officially abandoned by the Fort Worth District of the U.S. Army Corps of Engineers (USACE) and the local governments in the Dallas/Fort Worth area, new ideas emerged. Throughout the eighties, development pressures from differing interests competed to shape the river for different roles.

Since the abandoning of the barge concept, the USACE realized that the level of floodplain development activity occurring in the Trinity corridor was a dangerous trend. The level of development activity and the lack of a comprehensive floodplain model for the Trinity River made the USACE's ability to make sound permit decisions very difficult. The USACE initiated a regional environmental impact statement (REIS) for the Upper Trinity River basin to determine the potential impacts from such widespread floodplain development. The REIS was completed in 1987 and demonstrated that uncontrolled development in the Trinity floodplain would significantly increase the flood potential in the corridor and the resulting damages would be devastating. The 1987 REIS Record of Decision significantly altered the USACE permitting requirements due to the anticipated loss of critical valley storage in the Trinity corridor resulting from the current local development policies in the floodplain. Simply stated, the USACE's permit requirements became more stringent and the local governments took notice.

Numerous significant and dangerous flood events were observed during the 1980s, resulting in policymakers acknowledging the danger of haphazard development patterns in the floodplain and recognizing the regional nature of the Trinity River. Since the mid 1980s, the North Central Texas Council of Governments (NCTCOG) has been serving as the facilitator of local governments in pursuit of a COMMON VISION for the Trinity River corridor. A steering committee and staff-level task force of elected officials and senior local government staff, respectively, was assembled to guide the interjurisdictional program. The Trinity Corridor Steering Committee consists of elected officials representing nine cities (Arlington, Carrollton, Coppell,
Dallas, Farmers Branch, Fort Worth, Grand Prairie, Irving, and Lewisville), three counties (Dallas, Denton, and Tarrant), and two special districts (Tarrant County Water Control and Improvement District Number 1, and the Trinity River Authority), and is responsible for providing policy direction to the regional effort. The Flood Management Task Force consists of senior engineering staff and floodplain managers that are responsible for the deliberation and resolution of technical issues arising in the program.

In 1989, the Trinity Corridor Steering Committee adopted a regional policy position statement that says, "Until a major flood control program can be completed . . . development of the floodplain must be managed in the most practical and equitable manner possible to at least stabilize current levels of flooding risk. Attention must also be placed on meeting water and other environmental quality goals and implementing desired regional public facilities." The corridor communities recognized that maintenance of safe and effective drainage, protection of water quality and the unique cultural, recreational, and environmental resources of the river were important to the entire region. The new "vision" for the Trinity River had begun to be forged and the region is now poised to make significant progress towards making the common vision a reality.

After the completion of the REIS, the Upper Trinity River Reconnaissance Study was released in March 1990. NCTCOG, representing the Trinity River Corridor Interjurisdictional Management Program participants, was actively involved in the reconnaissance study process. The study recommended 13 structural projects for further evaluation during the feasibility study phase of the USACE formal planning process. However, in order to enter the next step in this planning process, local governments were expected to cost-share in a feasibility study on a 50/50 basis. Because of the regional scope of the study, the cost-sharing by the participants would require a new and innovative approach.

The feasibility study represents an excellent example of an innovative funding technique. In this study, 25% of the funds are provided by the participating local governments in cash and in-kind services, 25% by the Texas Water Development Board (TWDB) through a grant program, and the remaining 50% by the federal government. Thus far, the multi-jurisdictional funding arrangement has proven to be an efficient means of funding one of the most unique cooperative public projects in north-central Texas.

Upper Trinity River Feasibility Study Background

The Trinity River COMMON VISION Program entered an important phase on September 1, 1990. Acting on behalf of 14 local governments and agencies, NCTCOG and the USACE began the five-year, $8-million Upper Trinity River Feasibility Study, focusing on the Trinity River through portions
of Dallas, Denton, and Tarrant Counties and the major tributaries within the standard project flood (SPF) floodplain boundaries of the Trinity River. This is the largest cooperatively cost-shared flood control effort the USACE has ever undertaken. The feasibility study will build upon the research and evaluation performed and documented in the USACE reconnaissance report for the Upper Trinity River basin. This report identified both the need for added flood control in the Upper Trinity River basin and the Trinity River communities to further investigate various flood damage reduction alternatives. It is important to note that in addition to flood damage reduction, other equal study purposes were identified in the Congressional legislation authorizing the feasibility study. These include "environmental enhancement, water quality, recreation, and other allied purposes."

As the enabling legislation indicates, this study requires a comprehensive evaluation of the Trinity River corridor. Basically, a viable plan for the sound management of the entire floodplain corridor that adequately provides solutions that address local and regional needs for flood damage reduction, improved water quality, environmental enhancement, and additional recreation and open space opportunities must be developed. Regional facilities of importance that maintain the economic health and quality of life of the region must also be considered for implementation through a comprehensive integration process.

The Upper Trinity River corridor is made up of nearly 240 square miles of SPF floodplain land. The sheer size of this area makes our task very difficult and challenging. Recent flooding events have demonstrated just how important this project is to the Dallas/Fort Worth (DFW) area. The storm events of 1989, 1990, and 1991 were significant. The 1990 flooding resulted in metropolitan area damages of approximately $300 million and the estimated flow at the Dallas gage was 81,000 cfs, the fourth largest volume ever. Yet most of the trigger storm events observed in these floods have been less than 50-year flood frequency storms. Thus, there is significant regional concern about the alarming trend of cumulative flood events causing significant damages. It has become apparent that existing floodplain management policies must be re-examined. The continuation of traditional views regarding floodplain management may eventually bankrupt government at all levels.

To put things into perspective for the DFW area, the Upper Trinity River Reconnaissance Study estimated that a standard project flood event could cause damages that would exceed $4 billion. This also assumed that the Dallas and Fort Worth levee systems remained intact—an assumption that is not very reassuring, since the 1990 event produced peak flood elevations in the Dallas floodway that were approximately four feet below the levee crest. Should these levee systems fail, the term "catastrophic" would not be inappropriate since much of downtown Dallas and Fort Worth would be inundated. This report also indicated that this damage value could approach over $11 billion if current
development trends continue. As shown, the DFW area is facing a serious threat that must be resolved and will require the cooperation and resources of the local, state, and federal governments to address appropriately. We believe that the Upper Trinity River Feasibility Study effort will accomplish this mission and it has already produced some positive results.

Feasibility Study Strategies

The ability to meet the lofty goals of the COMMON VISION is dependent on how well the program can be "sold" locally and the chosen method of conducting the study. Traditional approaches in plan formulation activities have been hierarchical. However, traditional studies and approaches would not work because of the complexities and varied interests in the Trinity corridor. In order to tackle these challenges, the NCTCOG and the USACE determined that the use of a multiple objective management (MOM) approach in this study is our only real choice. MOM is a process that is driven by local needs, involves all interested parties, and results in a strategy or plan that incorporates and balances the requirements of all user groups while maintaining or protecting and, it is hoped, restoring the floodplain environment. Simply put, this process means compromise among all interested parties. MOM also provides an excellent opportunity to broaden and combine the forces of various interests groups that might not have previously occurred.

It is important to state that the process of utilizing MOM has many pitfalls. A successful MOM project effort involves many critical elements that must be addressed and completed. The following elements are essential to insure a successful MOM project is developed.

- Projects should be locally driven. The local community needs must be met and as discussed before, they are expected to fund a significant portion of the project. "You can't sell what people don't want."

- Bring all viewpoints to the table. Interest groups make better allies than enemies. Get them involved so they "own" the project as well.

- Public involvement is a must. Start these efforts early and insure a thorough job is done. This will help insure that the consensus building and public "ownership" efforts are successful. Without it, the project is guaranteed to fail.

- The efforts should focus on the production of an action plan. Avoid the creation of only a huge report that must be dissected in order to
be understood. If this cannot be avoided, then the report should contain an action plan section that clearly and concisely presents the findings and recommendations.

- The process should be action oriented. Make sure that efforts are focused on producing a project that will be implemented. This should be a pre-requisite for any public involvement activities.

- Seek and implement innovative solutions. This sounds difficult but it really is the underlying purpose behind the MOM process. Compromise requires innovation.

- Anticipate conflicts and be prepared. This task is quite difficult. Interested "publics" will not usually welcome different views openly and motives will be questioned. The project success depends on this ability to anticipate and respond to these concerns.

- Develop flexible projects and programs. The key to success is to meet the needs of the diverse publics. This requires flexibility, innovation, and compromise. Developing a project priority ranking system can be a useful tool in this regard.

- Base solutions on sound science and technology. This is a must, especially since most floodplain programs will involve significant amounts of environmental concerns. There seems to be an alarming tendency to avoid the use of sound science in this regard these days. Environmental issues are political at most levels of government; however, do not assume that these concerns are the top priority of local politicians. Environmental mandates are usually seen as financial burdens at the local level at a time when cities are struggling to maintain existing service levels to their citizens. The use of sound science and technology will insure that all interested publics have been fairly represented. If not, the funding for project implementation may not be there.

- Develop a wide range of alternative solutions through the collection of information. This involves spending adequate time listening to interested "publics" and openly receiving information from them. It also involves responding in a timely manner when appropriate. Any appearance of a closed process will become a major hurdle to overcome. This type of process can be viewed as a "comfort" planning effort. As this implies, it is important to collect the
pertinent information and insure that everyone understands the process and the local and regional priorities. As alternative solutions are identified, screened, refined and evaluated, the process must be performed openly and thoroughly.

- Pay attention to operation and maintenance concerns and costs. As described previously, the local governments will be paying the bills for project implementation. Therefore, solutions that have low operation and maintenance (O&M) responsibilities must be identified. Also, all alternative solutions should clearly identify and describe O&M concerns and costs as these are formulated and evaluated.

The use of the MOM technique in the feasibility study requires that the region conduct a thorough self examination of its prior decisions, priorities, and needs for the corridor. NCTCOG has attempted to maintain a high profile public involvement process throughout the first two years of this study. NCTCOG produces a quarterly publication called *Reflections on the Trinity* that provides general progress reports on this study and is distributed widely to the public. Since current study efforts are focusing on the generation of alternative solutions, more aggressive public involvement activities are planned. These efforts will be patterned after the eight public workshops held last November and will again involve multiple workshop sessions around the region. Also beginning in March, NCTCOG and USACE staff will be meeting with each participant for the purpose of collecting information, resolving conflicts and improving communications. The local government staff from all departments with an interest in the corridor are requested to participate in these meetings.

Through these efforts during 1993, problems and opportunities in the corridor are being identified in a systematic way. From there, reasonable alternatives to address these issues will be developed. Naturally, by evaluating multiple objectives in the corridor at the same time, compromise solutions will come forward. As the "key" points to a successful MOM approach describe, the process is challenging and difficult. The ability to balance the competing public and private interests in the corridor will directly affect the final outcome of this effort.

**MOM and the Feasibility Study**

One important component of this cooperative regional program using the MOM approach is the Corridor Development Certificate (CDC) process. The CDC process was developed to stabilize the existing level of flooding risks in the corridor. Participating federal, state, and local governments worked together for several years to develop this process which outlined a uniform and more
restrictive common engineering criteria for development along the river. The CDC process development produced a set of reference floodplain boundary maps, an engineering criteria manual, and a development review process. A development certification or permit includes the review and comment on potential development in the corridor by all participating governments. Information collected from this permit process will be used to modify and update sophisticated computer hydraulic and hydrologic models being developed based on the detailed basemapping being created in the study. Coordination of this process with other state and federal regulatory programs can ensure consistent review at all governmental levels. Currently, the CDC process is being implemented by the feasibility study participants.

Other key components of the feasibility study and associated programs include the integration of hydrologic, hydraulic, and economic models with geographic information system (GIS) technology, the identification and evaluation of other alternatives consistent with the study purposes and the reevaluation of structural and nonstructural flood damage reduction alternatives to develop selected individual alternative work plans for implementation. The creation of the detailed basemapping information alluded to above is the foundation from which this study effort builds. This data has been captured in a GIS format, thus providing the analytical engine to support all of the major work elements in this study. Some examples include the development of the new USACE models and the alternatives formulation process with the local governments. The use of GIS allows us to systematically approach difficult study tasks and invest more time in the production of appropriate alternatives and action plans. The inherent analytical abilities of GIS supports the MOM approach beautifully.

Conclusion

The ultimate goal of the COMMON VISION is to manage development along the river to provide safe and efficient flood drainage, while maximizing the Trinity's inherent recreational, cultural, and environmental values. The study is in its third year and the progress has been consistent. The major task of creating the digital basemapping of the corridor is nearly completed. The arduous task of constructing the new models and formulating viable alternative solutions for consideration is underway. The remaining years of this study will be challenging and represent the true test of the ability to conduct a MOM approach in a study of this size. Fortunately, reflecting on the progress so far, it looks promising that the study will be very successful. As it is completed and the implementation of these alternatives begins, regional acceptance and support of the COMMON VISION will be assured.
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Introduction

With the 1996 Olympics coming to Atlanta, the Southeast can expect a large influx of visitors from other parts of the nation and the world. Communities throughout the region have the opportunity to showcase their significant historical identity, cultural amenities, and natural features, providing opportunities for visitors to enjoy local and regional outdoor recreation and tourism sites and, in general, to use the Olympics to strengthen and develop local economies based on tourism.

In anticipation of the Olympic Games, the Rivers, Trails, and Conservation Assistance (RTCA) program of the National Park Service has been helping five communities within a day's drive of Atlanta focus local community activism on developing multi-use trails and greenways: linear protected areas that conserve and connect valuable community resources. The five are Huntsville, Alabama; Chattanooga, Tennessee; Columbia, South Carolina; Augusta, Georgia; and Savannah, Georgia (Figure 1). These five local greenway efforts serve not only as successful models of creative multiple objective planning for river corridors and floodplains, but also as excellent models of creative public/private partnerships developed through extensive citizen involvement and empowerment.

Methodology

While each community chose to approach its planning opportunities differently, all five projects share certain basic elements that characterize the work accomplished nationally through the involvement of the Rivers, Trails and Conservation Assistance program.

First, these efforts were and are all client-driven. RTCA staff have responded to requests from these communities to help organize local interests around planning for the protection of particular resources, help these citizens identify what they want to accomplish for their community resources, and identify realistic strategies for their long-term protection. RTCA staff never come into a community with their own plan of how best to protect these resources: they work with and listen to local citizens, and help these citizens develop strategies that will accomplish the protection of these resources.
Figure 1. Location of the five cities with local greenway plans.
Second, these projects are all cooperative. While the Park Service provides staff and technical know-how to help local efforts, local cooperators—municipal, state and federal agencies, non-profit organizations, interested citizens—fully share in all aspects of a project. RTCA staff act as catalysts, helping the community develop a realistic vision and establish strategies for the attaining it. The success of any local greenway, trail, or river corridor protection project lies in the ability to develop broad-based, active public/private partnerships, formed through mutual interests and shared visions.

Third, projects are cost-shared. Often the local cooperator share is in-kind: staff, facilities, local experts, and communications networks. An early stage in each project is determination of roles and responsibilities of all cooperators, including the Park Service.

Fourth, the RTCA program is results-oriented. A paper plan, no matter how beautifully written and illustrated, means little if there is no commitment to on-the-ground results: a new trail, greenway, or restored floodplain area. Often, a new organization or intergovernmental entity is formed to ensure project implementation after the Park Service has completed its one-to-three-year commitment.

Finally, all these projects follow a comprehensive and proven methodology that includes early meetings with potential cooperators to scope out the project, setting project goals, identifying potential local concerns and issues, developing and implementing a public participation plan, engaging all interests, assessing significant local resources, developing protection alternatives, and finally, developing an action plan. This process is vital to positive results through citizen empowerment and coalition building to encompass all project interests. Variations on this approach abound, but following at least these steps, provides a framework for developing maximum public involvement and buy-in, while also accomplishing needed local resource protection.

**Huntsville, Alabama**

Since the late 1980s, the city of Huntsville has sought to develop a multi-modal transportation system—pedestrian sidewalks, on-road hiking routes, multi-use of off-road trails, adequate surface streets, and a van-based mass transit system—that would provide opportunities for citizens to use either motorized or non-motorized modes of transportation to travel throughout the city. In the early 1990s, this vision evolved into local discussion of and support for a community-wide network of greenways and trails that would provide not just alternate transportation, but also opportunities for active and passive recreational pursuits such as walking and hiking; conservation; interpretation of the region’s unique cultural, historical, and natural resources; and protection and restoration of the community’s floodplains and wetland resources.
In 1991, the city asked the National Park Service for assistance in developing this city-wide greenways system. RTCA staff helped the Huntsville Planning Department, local conservation organizations, and interested citizens identify important community corridors that could be protected as greenways and develop a strategy for developing this community greenways network. The plan identified a series of greenways along streams, ridges, and other linear corridors that would link the citizens of Huntsville to the Tennessee River, historic Monte Sano Mountain and numerous parks and tourist facilities in the community. Huntsville is now developing its first greenway along Aldridge Creek and is well on its way to having Alabama's first community greenways system.

**Chattanooga, Tennessee**

The National Park Service began a long and profitable relationship with the city of Chattanooga in 1989. After helping to plan for and implement the first segment of the community's initial greenway, North Chickamauga Creek Greenway, RTCA staff worked with the city's Parks Department, Planning Commission, and the Chattanooga Greenway Advisory Board to help establish a county-wide system of greenways using the Tennessee River corridor as the spine of the system. The leader throughout the Southeast, the city and Hamilton County are developing the Tennessee Riverpark along a 20-mile-long portion of the river through Chattanooga. The focal point of this river park is the new Tennessee Aquarium that interprets the natural history of the Tennessee River and other freshwater systems throughout the world.

RTCA staff, local resource experts, and citizens identified a network of more than 30 suitable greenway corridors located primarily along county streams and ridgelines. The potential greenways were prioritized and now numerous citizens' groups are working to implement several of them, along such local streams as South Chickamauga Creek, Lookout Creek, and Chattanooga Creek, and along local mountains and ridges like Lookout Mountain and Hawkins Ridge.

**Augusta, Georgia**

The Park Service was asked in 1992 by the Augusta Canal Authority and city of Augusta to join in developing a Historic Canal Corridor Plan as well as a more comprehensive interconnected system of greenways for the region. While the Authority had already hired a consultant, Park Service assistance was needed to develop effective ways to bring in the public and also to expand the planning to include such federal agencies as the U.S. Forest Service, the Army Corps of Engineers, and the state of South Carolina.
The Savannah River corridor includes a diversity of important values, including historic sites and landmarks, fish and wildlife resources, and recreational opportunities. With a diverse community near the river and canal corridors, it offers great potential for wildlife habitat and recreation. Despite major upstream dams, flooding has remained a significant issue for the city and in fact an early and major component of a greenway system is a river walk utilizing the existing levee.

An unusual cooperator on the project has been the Georgia Department of Transportation (DOT). With new direction and funding from the 1991 federal highway bill, the DOT has made $130,000 available from federal highway funds under the ISTEA program.

Savannah, Georgia

The city of Savannah—Georgia's birthplace—has always been a rare resource that combines the best of our nation's history and her magnificent natural beauty. Savannah was chosen as the site for a majority of the 1996 Olympics water-based events, and has worked even harder recently to improve its already outstanding image as a major destination for vacationers from around the globe.

In the late 1980s, Jim Golden, Chatham County Parks Director, realized that the community had an opportunity, provided both by Olympic and other tourism, to transform the community into an even more popular destination for environmentally-minded and historically-inclined tourists. He and other city leaders, working with staff from the Fort Pulaski Nation Monument, helped develop a vision for converting an abandoned railroad along the salt marshes between the city and Tybee Island into a multi-use trail for outdoor recreation, environmental education, and historical interpretation. The first segment of this six-mile corridor has been developed into a nature trail and is open for local and visitor use.

To help provide other recreational and educational opportunities in other portions of the community, the Parks Department is helping locals develop a trail along an old canal—the Savannah and Ogeechee Canal—near downtown. This project is well underway and will surely provide numerous opportunities for national and international Olympic visitors to sample the history and beauty of Savannah.

Columbia, South Carolina

After working with National Park Service to complete the South Carolina Rivers Assessment in 1988, the state Water Resources Commission and Department of Parks, Recreation, and Tourism moved ahead to develop plans
for a significant stream highlighted in the Assessment: the Saluda River (which becomes the Congaree River within the city limits of Columbia). The Saluda has rich natural flora and fauna and many historic sites but has also been subject to repeated proposals for damming for hydroelectric development.

A Lower Saluda River Task Force was formed, which involved over 100 agency staff and citizens working through eight committees. They completed a detailed assessment of the river corridor resources and developed recommendations for resources protection, access and user safety, law enforcement, and tourism promotion. Once again, a diverse array of state and local agency partners, which included law enforcement personnel and commercial interests as well as scientists and recreation specialists, led to the creation of a multi-faceted plan.

In anticipation of the 1996 Olympics, the state and city expect to have completed both Hope Ferry Regional Park and Twelvemile Creek Park, with various trail linkages. Overall, the region will have a system of inter-jurisdictional agreements to insure protection of land resources, visitor access, safety, and connections between sites.

**Conclusion**

None of these five greenway projects is yet completed and the 1996 Summer Olympics are still three years off. So the success of these project in generating tourist dollars and providing high quality experiences in the southeast is untested. Nevertheless, using the examples from a National Park Service publication, *The Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors*, as an indicator, all of these communities will realize at least modest economic benefits. At the same time, they will have established for all time new river, trail, and park amenities for their own citizens. Through the assistance of the Rivers, Trails, and Conservation Assistance program, communities all across the country that value their resources and have active local constituencies can achieve significant conservation results.

For additional information and for Park Service staff in your area, contact the Rivers, Trails, and Conservation Assistance Program, National Park Service, P.O. Box 37127, Washington, D.C. 20013, (202) 343-3780.
CONCEPTUAL DESIGN TO IMPLEMENT THE LAKE ROUSSEAU OPERATIONS AND MANAGEMENT PLAN ON THE FORMER CROSS FLORIDA BARGE CANAL AT INGLIS, FLORIDA

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Funding Source for the Study

The Southwest Florida Water Management District (SWFWMD) contracted with Greiner, Inc. to perform a study on the feasibility of constructing modifications to the existing water management system of Lake Rousseau and the lower Withlacoochee River. The required completion date was controlled by requirements of the legislation resulting in the deauthorization of the Cross Florida Barge Canal. A short contract period of 45 calendar days was allotted for the work.

Project History

Lake Rousseau is an artificial impoundment (circa 1909) on the Withlacoochee River near the towns of Inglis and Dunellon, Florida (see Figure 1). It was originally constructed as a hydropower generation site. The works were modified to become a part of the Cross Florida Barge Canal (CFBC) which was intended to provide a commerce route across Florida through the use of artificial canals, existing rivers, and artificial lakes. The CFBC continued construction until 1970, but the works were not completed due to environmental concerns. In 1990, the Florida Legislature passed a law creating the Cross Florida Greenbelt State Recreation and Conservation Area contingent upon the deauthorization of the CFBC project by Congress. In November 1990 the CFBC was deauthorized. The CFBC is now the "Cross Florida Greenbelt."

The facilities constructed on the west end of the CFBC include the barge canal, Inglis Lock, Inglis Dam, and the Inglis bypass channel and spillway. The barge canal was constructed on a linear alignment which crossed the Withlacoochee River downstream of Lake Rousseau. The barge canal was separated from the Lower Withlacoochee River by a rock dam. Flows to the Lower Withlacoochee River were provided by the Inglis bypass channel and spillway. Flood flows were routed to the barge canal through the larger capacity spillway at the Inglis Dam.
Figure 1. Water management of Lake Rousseau area.
Lake Rousseau Operations and Management Plan

The Southwest Florida Water Management District staff completed a detailed engineering, hydrologic, and environmental study in February 1989 entitled, "Lake Rousseau Operations and Management Study." The study documented the need to maintain flows in the lower Withlacoochee River and enhance channel flushing in the reach which passes through the towns of Inglis and Yankeetown, Florida. A design concept was formulated although not investigated in detail. Additional benefits were anticipated by changing the Lake Rousseau management schedule to allow for periodic lake drawdowns to expose and oxidize bottom sediments and control aquatic weeds.

Project Issues Requiring Resolution

The following is a brief listing of the major concerns associated with the project.

- **Flood protection**: development had occurred on the lower Withlacoochee River along the banks of the river. Flood protection was being provided by the barge canal and became a concern after the abandonment of the CFBC.

- **Navigation**: navigation was requested from the Gulf through Lake Rousseau to the Withlacoochee River.

- **Maintenance of flow**: flow requirements to the Lower Withlacoochee River were to be maintained during lake drawdowns to prevent a change in the salinity gradient of the river.

- **Water quality**: the environmental quality of the Lower Withlacoochee River could be improved by flushing the river with flows similar to historic amounts.

- **Water quantity**: structural improvements should be capable of discharging historic flows to the Lower Withlacoochee River while controlling flood flows.

- **Fluctuation range**: structural improvements should be able to discharge historic flows while the lake is at minimum operating level. Larger flows for flushing should be available when the lake is at its normal operating level.
Operation and maintenance costs: such costs should be greatly reduced from the costs associated with operating the existing facilities.

Construction costs: improvements should be limited to the relative range of feasible construction projects associated with the operating budget.

Public acceptance: benefits to the public must be clearly shown since funding is associated with local taxing.

Techniques Used to Design the Plan

The client was involved with the development of the plan through interactive project meetings. Since the schedule was tight, weekly project meetings were held on Monday mornings to discuss project issues. Decisions on techniques, calculation methods, preferences, and ideas could be addressed in a timely manner.

A HEC-2 hydraulic analysis was used to determine the capacity of the Lower Withlacoochee River. Flood profiles were plotted. Areas identified from aerial topographic maps as susceptible to flooding were used to determine the maximum flushing flows for the river.

The level of detail required that only a spreadsheet calculation be used to calculate the new spillway. A graph of various spillway lengths and head conditions allowed the selection of an optimal condition.

Alternatives were developed to meet the requirements of the study. The alternatives with fatal flaws were eliminated. The remaining alternatives were ranked using an evaluation matrix. The matrix listed each alternative and assessed points (1–5) dependent upon how the alternative addressed the project issues.

The highest ranking concept included the abandonment of the Inglis Lock, abandonment of the Inglis bypass channel, construction of a new spillway to the Lower Withlacoochee River, construction of an earthen dam within the barge canal, and excavation of a connection from the barge canal to the Lower Withlacoochee River. The estimated implementation cost of this alternative was $7,422,000 for a two-year phased construction project. A significant savings of approximately $600,000 in reduced operation and maintenance costs per year would be accomplished by this alternative.
Project Management Techniques

This project incorporated several modifications to project management processes which proved successful, as discussed below.

Work Plan

The Project Work Plan is a bound document that includes the (1) project purpose and work product definition; (2) individual tasks and activities; (3) staff commitments and responsibilities, including the project directory; (4) project schedule; (5) labor and expense budgets; (6) quality assurance procedures; (7) monitoring and reporting procedures; (8) mini-drawings and report mock-ups; and (9) project kick-off meeting notes. The Project Work Plan document was given to all consultant staff and to the client’s project manager. Sharing the Project Work Plan with the client was an important test of mutual understanding of project goals and objectives. The client participated in the consultant’s internal staff kick-off meeting, which improved communications by introducing each staff to the other and ensuring that the project goals were understood by all.

Participatory Environment

Weekly project review meetings were held which included the key staff members of both the client’s and consultant’s staff. To control cost, they were held at the consultant’s office. Other staff were available during the scheduled meeting time by telephone. The meetings were working review sessions that considered the previous week’s activities.

Calendar Scheduling System

While it is typical to define projects using a work breakdown system and to schedule using a network diagram or bar chart, the successful completion of this project required processes that (1) acquired data from a previous process; (2) processed that data; and (3) passed the processed data to a subsequent process. It was more convenient, and obvious, to use a planning calendar to schedule processing and data transfer milestones. All possible data transfer milestones were incorporated in the schedule, especially public meetings and meetings of interested agencies.

Advantages of This Approach

The advantages can very simply be listed as follows:
Minimal changes or redo work is required due to client involvement;

Review times are greatly shortened. Information can be passed back and forth at regularly scheduled meetings;

Enhanced understanding of the project due to direct participation;

Excellent control over budget and schedule.
INTEGRATION BETWEEN FLOODPLAIN MANAGEMENT, WETLAND RESTORATION, AND DEVELOPMENT

Elliot Silverston, James A. Harned, and Robert F. Permenter
Greiner, Inc.

Background

The Savannah Airport Commission is currently expanding its existing airport facilities to meet the projected enplanement/deplanement needs for the year 2007. The first phase of the expansion includes a new terminal building, apron, taxiways, support facilities, access roads, and I-95 interchange. Future phases will include a new runway, terminal expansion, terminal support, and commercial development.

The approximately 2,000-acre site is located in low-lying coastal Georgia, which is typically drained by a system of creeks, artificial canals, and rivers. A majority of the site contributes to Pipemakers Canal, which outfalls to the Savannah River. Pipemakers Canal, the major drainage system for the cities of Pooler and Bloomingdale in Chatham County, Georgia, traverses and borders the site for approximately 10,000 feet. The canal frequently floods portions of the southern section of the site. It is also a regulated floodway.

The challenge of this project is to maximize development and provide airport safety without significant adverse impacts on the Pipemakers Canal floodplain and floodway. This task is further complicated because the on-site floodplain is comprised of hardwood wetlands. The trees have recently been harvested and the wetland is overdrained due to gully erosion along the canal banks. Restoration of the hardwood wetlands was a key component of the wetland mitigation plans included in the Corps of Engineers 404 permit obtained for the project.

Project Integration

The success of this project required a learning process by the client, regulatory agencies, and the design team. It was important that the design team be composed of airport/transportation engineers, hydrologists, and biologists because each of these disciplines provided the expertise to move the project from the planning stage to construction. A balance was required between airport layout and safety, stormwater and floodplain management, and wetland and wildlife management. The overall concept was first presented to the client as a feasible, cost-effective project and then to the regulatory agencies such as the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S.
Fish and Wildlife Service, City of Savannah, Chatham County, and the State of Georgia. The project was reviewed in depth by each of these groups. Some of the specific issues and solutions follow.

**Issue**

Pipemakers Canal is a regulatory floodway. As such, construction activities cannot encroach into the floodway and cause adverse floodplain impacts.

**Solution**

Water control structures are used to regulate discharges to the floodway from the airport. Multi-stage non-operating structures are placed in the existing spoil berms, at existing discharge locations, to detain water in airport wetlands during flood events. The water control structures allow two-way flow so that when surface water elevations are high in Pipemakers Canal, the water will spread into the adjacent airport floodplains, as occurs today. Three existing separate drainage systems are used to attenuate discharges from the site to the floodway. Two of these systems are separated by an on-site berm and the third utilizes an artificial channel to convey water from interconnected borrow pits (ponds) along I-95 on the west side of the site to Pipemakers Canal. To maintain the existing storage along Pipemakers Canal, airport planners and the client minimized improvements in this area. A further measure required airport planners and the client to keep airport improvements from encroaching into the floodway.

Hardwood wetland floodplains adjacent to Pipemakers Canal are encroached upon by new construction and the roadway system. The volume and rate of flow to the floodplains are also increased as a result of development in upland areas. To minimize adverse floodplain impacts, a system of berms and water control structures are used to attenuate off-site discharges. The borrow pits adjacent to I-95 are also utilized in the stormwater plan for attenuation.

To minimize wetland impacts, the berms separating attenuation areas serve a dual role. First, the berms are actually the roadway system for the airport, and second, the berms are used for water control. The control structures at each berm are designed both to control peak discharges and to maintain hydroperiods in adjacent wetlands. The structures have been placed along the roadway to distribute flows throughout the wetlands. Graded ditches have been constructed on the upstream side and spreader swales on the downstream side of the berms to assist in maintaining adequate water movement between structures.
Issue

Airport safety is an important factor that has been considered in the design. Bird strikes and animals crossing taxiways and runways must be minimized.

Solution

Minimum safe distances, as defined by the Federal Aviation Administration, have been adhered to in keeping open water bodies away from active air transportation areas. Ponding is excluded, where possible, at the end of and along present and future runway locations.

A compromise has been attained in evaluating wildlife impacts. A viable wetland must maintain adequate wildlife corridors yet allow the proposed roadway crossings. Animal crossings are included in the project design at each roadway berm to allow small animals to cross from one side to the other. However, larger mammals, such as deer, were precluded to minimize their access to taxiways and runways.

Issue

Water quality, erosion and sediment control measures are necessary aspects in the design of stormwater facilities during and after construction to minimize impacts on on-site wetlands and to Pipemakers Canal.

Solution

Oil water separators, skimmers, spill prevention plans, and other best-management practices will be in place during airport operations. Retention/detention ponds, grassed channel side slopes, riprap, and flexible liners are used to prevent erosion and trap sediments from reaching environmentally sensitive areas. Repair and reinforcement of breaks in the existing maintenance berm on the north side of Pipemakers Canal are planned to reduce sediment loading to Pipemakers Canal. Water control structures will be used to detain discharges and allow removal of sediments that presently directly discharge to the canal during heavy rains. During construction, an extensive erosion control plan utilizing silt fences, hay bales, turbidity barriers, watering of exposed earth for dust prevention, and temporary ditch blocks are being used to control erosion of disturbed areas.

Conclusions

A multi-disciplinary design team of engineers, biologists, and planners developed strategies for maximizing airport development, while minimizing
wetland and wildlife impacts, maintaining airport safety, and avoiding significant adverse floodplain impacts to Pipemakers Canal or adjoining property. These tasks were accomplished through a learning process by team members of the needs and goals in each category and applying the teamwork necessary to integrate these ideas. Once the team understood the process, the client and regulatory agencies were involved so that a win/win project could be constructed. Construction is ongoing for the first phase and is expected to be completed by November 1993.
TURTLE CREEK:
A FLOODPLAIN MANAGER’S DREAM OR NIGHTMARE

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Introduction

Turtle Creek is one of the best-known urban greenbelts in north Texas. The greenbelt is the product of some of the earliest floodplain management efforts in the Southwest. In 1910, pioneer urban planner George Kessler proposed a linear system of parkways and open spaces throughout Dallas. Turtle Creek and Mill Creek, an adjacent watershed, were included in this plan.

However, some problems common to many urban streams are occurring on Turtle Creek. Therefore, in 1992, the City of Dallas undertook a floodplain management study to address them. A multidisciplinary team of engineers, scientists, and planners was assembled to tackle the problems. Public involvement was solicited through a series of public meetings.

The problems range from engineering to logistical and include

• Evaluating land use and redevelopment effects in the watershed,

• Increasing capacity of historic structures,

• Siltation,

• Correlating original flood insurance study (FIS) results to new stream hydraulics, and

• Evaluation of existing dams.

This paper presents the problems and the recommended solutions. We also describe the public involvement and attempt to address the future of floodplain management on Turtle Creek in particular and Dallas in general.
City of Dallas Floodplain Management

Since commissioning its first study in 1968, the City of Dallas has completed floodplain management plans for 25 of 30 major stream basins. The studies to date have:

- Delineated the 100-year floodplain;
- Investigated the adequacy of existing storm water system elements, such as creeks, channels, bridges, and storm sewers;
- Identified existing and future flood problem areas;
- Provided alternative solutions to flooding problems;
- Identified areas worthy of preservation as open space; and
- Identified land suitable for active recreation (athletic fields, pedestrian trails, etc.).

A side benefit of the program has been the development of several new technologies to reduce labor and increase accuracy of floodplain delineation, especially for the larger studies. These include

- Automatic data input from three-dimensional digital mapping;
- Establishment of monumentation (horizontal and vertical control) using Global Positioning Systems methods in conjunction with National Geodetic Survey information;
- Determination of percentage imperviousness and urbanization through establishment of a geographic information system (GIS), utilizing remote sensing and the Earth Resources Data Analysis System (ERDAS) image-processing software; and
- Delineation of final floodplains and profiles by computer-generated CADD techniques.

Implementation

Implementation of Dallas' floodplain management plans has been difficult. For example, a management plan was developed for the Fivemile Creek basin in 1976. This plan included structural flood control features such as regional
detention and some channelization to remove a serious flooding threat to 390 homes. In May of 1989, a severe storm struck the basin. Although two of the detention basins had been funded, no flood control features had been constructed and many homes were severely damaged. One person was drowned at the Marsalis Bridge, which was scheduled for conveyance improvements in the management plan.

On the other hand, a floodplain management report for Lower Peaks Branch has been successfully implemented. In this area, some 400 homes were periodically flooded, some on an annual basis. As a result of a floodplain management study and several public meetings, a structural solution was proposed. Between 1982 and 1988, some 8,000 linear feet of existing drainage channel was lined and widened and a 8,400 linear-foot relief storm sewer (double 12’ x 12’ box culvert) was constructed at a cost of $12 million. As a result, the floods of 1989, 1990, and 1991 caused little damage along lower Peaks Branch.

**Turtle Creek**

Turtle Creek, one of the most beautiful of all Dallas’ streams, is one of the last watersheds in the city for which a management plan is being developed. Its central location and natural beauty have attracted expensive high-rise apartments along with beautiful, large- and medium-sized homes and prime office buildings. Out of the total of 2.8 miles of corridor, 0.8 miles are owned by either homeowners associations or the City of Dallas, and occupied by beautiful parks. The remaining 2.0 miles are privately owned commercial and residential properties platted to the centerline of the creek. Several significant pieces of sculpture are within these parks, which include a 2.3-mile-long walking and jogging path and the Dallas Theater Center’s Frank Lloyd Wright Theater, which lies along the stream’s east side between Blackburn Street and Lemmon Avenue.

Turtle Creek historically flowed directly into the Trinity River until the lower reaches were altered by flood-control engineering works for the construction of the Dallas floodway levees. Currently, the end of the natural stream is in Reverchon Park along Interstate Highway 35E. Below this point, Turtle Creek flows into the sump of Dallas River Levee Operations Pump Station B. At the pump station, the water is discharged into the Trinity River through a gravity sluice or pumped over the levees. Above Fairmont Street (± 1 mile upstream), a weir guides the water into an 18.5-foot-diameter, 9,200-foot-long horseshoe pressure sewer that discharges the water directly into the Trinity River. The water that flows in the stream below Fairmont Street is the weir overflow when the capacity of the pressure sewer is exceeded and the storm water falling on the drainage area below the weir.
This Turtle Creek Floodplain Management Study begins at the pressure sewer continuing 1.6 miles upstream to the Dallas/HIGHLAND PARK city limits at Fitzhugh Avenue (see Figure 1). The total drainage at the pressure sewer is approximately 5,400 acres including 1,200 acres of the Mill Creek drainage basin. Mill Creek was diverted into Turtle Creek in the early 1950s by an eight-foot-diameter horseshoe tunnel that enters from the east between Blackburn Street and Lemmon Avenue just west of the Frank Lloyd Wright Theater. This diversion includes drainage from Central Expressway from Cambrick up to Lovers Lane. The expansion of Central Expressway required major upsizing of the storm drainage system. A 218-acre-foot underground detention basin is currently being installed under Cole Park to receive storm water for all storms exceeding five years in frequency, the capacity of the Mill Creek diversion sewer. This system will provide improved drainage for Central Expressway without increasing flooding problems on Turtle Creek.

Although Turtle Creek travels through one of the oldest developed areas of Dallas, there are only three residential or commercial buildings in the regulatory floodplain. Of these three structures, two have finished floor elevations only 0.30 feet below the computed 100-year water surface elevation. The other residential structure would be inundated by over three feet, but it is protected by a flood wall for low frequency events. In comparison, of the 11 road crossings within this reach, only Lemmon Avenue and Avondale Street are not overtopped by the 100-year flood. Several of these crossings, such as Stonebridge Drive, are considered historic structures which can not be raised without destroying the beauty and history of the existing structure. Turtle Creek Boulevard, the parkway system recommended by George Kessler, which parallels Turtle Creek along the west side, is also overtopped in several areas by approximately one foot.

There are also four dams in this reach of Turtle Creek, which create linear channel ponds. A siltation study was performed on three of these ponds in the summer of 1992. The purpose of the study was to determine the volume of silt in the ponds and to recommend a method of silt removal to the City of Dallas. The following quantities of silt deposition were determined by direct observation, depth meter, or soundings:

- Hall Street Pond, 8,000 cubic yards of silt (±2 feet),
- Blackburn Street Pond, 7,000 cubic yards (±1.3 feet),
- Stonebridge Street Pond, 4,500 cubic yards (±1.4 feet).
Figure 1. Turtle Creek floodplain management study area, Dallas, Texas.
The silt removal study recommends draining the three ponds separately and removing the silt with conventional excavation equipment. This method is believed to be the most efficient and cost-effective option.

**Conclusion**

In general, it was found that early floodplain management efforts along Turtle Creek have been successful. All of the flooded buildings are along the east side of the creek where homes abut the floodplain. Turtle Creek Boulevard along the west side of the creek provides a prime example of how a parkway system should work. The buffer zone created by this parkway has resulted in controlling additional encroachment into the floodplain and minimizing flooding along this side of the creek.

The principal flood control improvements proposed will include modifications to several of the bridge structures with minimal channel work to preserve the natural beauty of the channel and floodplain. The historic structures will be preserved with bypass or relief structures to reduce flooding depths. An overall management plan is currently being prepared to address these flooding issues, erosion control, and maintenance of the existing scenic and environmental assets of the Turtle Creek greenbelt.
Part Four

Geographic Information Systems and Other Digital Tools
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The North Central Texas Council of Governments (NCTCOG) represents over 200 local governments in the 16-county north-central Texas region and includes the Dallas/Fort Worth metropolitan area. NCTCOG has been using Geographic Information Systems (GIS) for over four years. NCTCOG uses the ESRI ARC/INFO GIS software in many of its regional programs. ARC/INFO is used primarily for the analyzing, processing, distributing, and managing of Census, environmental, transportation, land use, and other regional data of interest to NCTCOG and its member local governments. U.S. Geological Survey Digital Line Graph (DLG) and 1990 TIGER line files are the primary basemapping data used at this time. New database structures and source file options for regional basemap files are being pursued through the execution of current work programs in the agency. Currently, NCTCOG is pursuing the development of a hybrid regional basemap that will be used for all of the basic regional planning projects and programs in the agency. NCTCOG existing coverages are being rectified to SPOT Panchromatic imagery (10 meter data) which is relatively inexpensive and readily updated. Since this effort is just getting underway, this paper will not cover this GIS effort in any great detail. Instead, the paper focuses on another very important regional program and the role GIS is playing in that effort.

The Upper Trinity Feasibility Study Mapping Project

In August 1990, the U.S. Army Corps of Engineers (USACE) and NCTCOG, representing nine cities, three counties, and two special districts, entered into an agreement to conduct an $8 million dollar feasibility study of the Upper Trinity River Basin. An important goal of this cooperative effort was to develop modeling tools that would automate floodplain study processes, allowing more time and resources to be devoted to the formulation and evaluation of alternatives. GIS was logically seen as the primary analytical tool to achieve this goal.

One of the most significant and costly elements of the feasibility study involved the development of accurate basemapping information of the Trinity River corridor. This detailed basemapping effort of the corridor covers more than 237 square miles (approximately 153,000 acres) of area in the heart of the
Dallas-Fort Worth metropolitan area. Greenhome and O'Mara, Inc. (G&O) of Maryland was selected to produce the new digital basemap of the corridor.

Mapping work began in February 1991 and involved establishing a consistent survey control datum, delivery of digital topographic mapping files in Intergraph IGDS and ARC/INFO file formats, and the generation of digital cross-sections to be used in the hydraulic modeling. Several important items should be mentioned regarding this digital mapping contract. NCTCOG, the USACE, and G&O committed the necessary time to insure that open communications were established between all parties. This also included clearly identifying party responsibilities for various technical elements requiring review. This resulted in the USACE being responsible for the survey control, final mapping accuracy, topographical features, and compliance with the USACE's Intergraph standards. NCTCOG was responsible for the additional review of topographical features and the overall topological data structure review. For the GIS database design, G&O submitted a data dictionary design for this contract which went through several iterations and testing prior to the full production of the digital mapping. These pre-production efforts included the performance of a pilot or prototype mapping project. Based on the results of the pilot, the database design was revised and G&O altered their quality control and production methodologies. These efforts were the two greatest factors in the overall success of this project.

The creation and availability of this digital basemapping is critical to the success of the study. This topographical data will provide the hydraulic and hydrologic engineers as well as the economists with highly accurate and consistent information so that accurate floodplain and flood damage assessment models are developed for this study. The following sections describe in more detail the specific contractual elements of the digital basemapping project.

**Mapping Control**

G&O established 36 permanent first order horizontal and vertical control points in the NAD 83 State Plane Coordinate System and the National Geodetic Vertical Datum (NGVD) of 1929 using Global Positioning System (GPS) surveys. The mapping control also incorporated 13 existing NAD 83 monuments in the area. In all, the total number of control points utilized in this digital mapping effort exceeded 700. The aerial photography was flown during February 1991 at an altitude of 800 feet. It was very fortunate that the contractor was able to complete all of the aerial photography in two days, since the vegetation in the corridor began coming out about five days later. The finished basemapping product was required to meet National Map Accuracy Standards. The results have exceeded these mapping standards and produced horizontal accuracies of ±four feet and vertical accuracies of ±one foot at a scale of 1" = 200'.
Mapping Features

Virtually all desirable planimetric elements have been identified and captured in this mapping project, including two-foot contours. An extensive list of point, line, and polygon features were captured creating a 16-layer GIS database. As an example of the complexity of this GIS mapping project, the contour data coverages in ARC/INFO required the generation of continuous contour lines. This is no small feat considering the dual delivery requirements in CADD and GIS formats. Because of this complexity, 13 distinct contour feature codes were defined in the GIS contour coverage. Also included in this project was the capture of over 990 valley cross-sections suitable for HEC-2 modeling and 80 miles of levee centerline data.

Basemapping Status

G&O is nearing completion of this digital mapping effort. Due to the dual file format delivery requirements, G&O was required to deliver the Intergraph files first to the USACE for review and comment. Once G&O corrected these CADD files, the data was translated into the ARC/INFO format for final editing to complete the GIS requirements of the contract and submitted to NCTCOG for the topological review of the data. The USACE has just received the last delivery on digital data and approximately 80% of the GIS data has been submitted to NCTCOG to date. The final completion and acceptance of the basemapping data is expected in April 1993.

Managing GIS Mapping Projects

The performance of the mapping contractor, G&O, has been excellent. We have had our troubles along the way, but having maintained open lines of communications, we were able to resolve them quickly. When undertaking a GIS mapping project of this magnitude, it is important to commit adequate resources to the preparation of the specifications. The specifications must be written clearly. This type of large-scale mapping project is not at all common, especially in the GIS field. Everyone involved must be able to communicate openly if you want to avoid pitfalls.

The key elements to a successful GIS database design are understanding the fundamentals of the GIS system, clearly defining the anticipated GIS applications of the database, and communications. It is not easy forecasting or anticipating the types of uses for a GIS database, but it must be done. The GIS mapping database should be designed to be as flexible as possible because, it is hoped, the investment you are making today will prove to be useful 10 to 20 years from now.
The Role of GIS

As previously noted, the use of GIS technology is very important to the study partners. Increased utilization of GIS technology for fundamental study elements is being pursued. Since the study began, specific computer methodologies that will be utilized during the feasibility study have been documented. This was accomplished by conducting a prototype methodology study that was completed in December 1991 which explored methodology options and "debugged" technological and data integration problems. The prototype methodology study demonstrated that a GIS could be used for the generation of hydrologic data developed in a directly usable form for input into the hydraulic model (HEC-2); the results from the HEC-2 model could be ported to the GIS and the results delineated or mapped.

The economic evaluation process could be automated using GIS analytical tools once the structure valuations were added to the database. This methodology effort also examined other types of GIS applications, including a natural resource management application for use in plan formulation activities. The results of this methodology study were good but these GIS application tools will continue to be refined further. Currently, the efforts in this regard include additional evaluation of the economic analyses and the generation of floodplain delineations in vector GIS formats.

What's Next?

As this study proceeds, new opportunities to utilize GIS technology will continue to be found that are very exciting but tremendously challenging. NCTCOG is presently developing a comprehensive set of GIS standards for this basemapping as well as standards for more traditional types of planning-scale base maps for use throughout the region. Until recently there was no national GIS standards for data exchange. Fortunately, through the guidance established by the Spatial Data Transfer Standard (SDTS), some of the data-sharing problems of the past in GIS may go away. However, there are many new problems to take their place. These problems will generally center on the establishment of true mapping standards for GIS data and it is not clear whether or not a standard could ever be developed. The reason for this is simple: a standard requires consistent use of the information and a fundamental purpose of a GIS is to promote new uses of information. Basically, the standards could never catch up. NCTCOG has established its version of GIS basemapping standards for this project and hopes that some reasonable level of consistency will be achieved in the region.

The biggest concern currently facing us is "now that we have it, how do we maintain it in a timely fashion?" NCTCOG is developing a regional policy
to address this issue through a formal committee structure. Currently, five programmatic elements that the regional policy should address have been identified. These elements are as follows and include discussions concerning possible strategies.

**Dissemination of Data to Sponsoring Communities**

Data generated as part of the feasibility study can be disseminated to communities. NCTCOG is distributing a questionnaire to the region and study participants to determine their spatial data requirements, including software (CADD or GIS), hardware platforms, preferred exchange formats and media, frequency of request for data, and volume of requests. From this information, NCTCOG will develop a data management policy for review and approval through our committee structures.

**Expansion and Densification of Control Network**

The network established as part of the feasibility study can be expanded. NCTCOG is proposing a survey densification program within the existing control network for the mapping area. Information distribution methods and marketing strategies for this survey data are being formulated.

**Ongoing Database Maintenance and Updates**

Several options are being considered in this regard. One option is to require digital "as builts" for permitted projects in the corridor. It is doubtful that a process like this would be very successful. Other options can include more traditional methods such as periodic reflying of areas impacted by development, or reflying the entire mapping area and comparing the new aerial photography with the original aerial images to identify the altered areas.

**Expansion of Existing Database**

NCTCOG is considering the possibility of expanding the area of mapping. A significant amount of additional data could be captured immediately due to the excess aerial photography and mapping control beyond the study limits which defined the contractual mapping extent. NCTCOG is soliciting interested parties in the pursuit of this additional mapping area.

**Development/Automation of Quality Control**

Procedures for updates, maintenance, and expansion need to be established. NCTCOG is developing a comprehensive management program for this data. Included in this program is the creation of quality control processes
for the maintenance and expansion of the database. The establishment of a common GIS database dictionary for use in the region is critical. Naming conventions and tiling schemes are also very important to establish. Again, questionnaires may be employed to help in this regard.

**Conclusion**

NCTCOG believes that by addressing these important programmatic elements, a sound regional policy for the long-term management of this mapping database resource will be developed and implemented. Again, the level of communication established between NCTCOG and interested parties throughout the region will dictate the success of this endeavor. Significant progress towards the long-term management of this digital basemapping data is anticipated. A formal NCTCOG policy is expected to be finalized during the fall of 1993. This mapping effort has been very successful and through continued hard work, it will provide valuable information to the region for many years to come. It is clear that maintaining the full functionality and usefulness of this information into the future will provide us with the greatest challenges of all.

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DATA MANAGEMENT FOR MULTI-OBJECTIVE PLANNING

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Introduction

In recent years there has been a paradigm shift towards dealing with development issues from an ecosystem planning perspective. Development pressures are becoming increasingly focused in areas of environmental, political, and economic significance. To facilitate effective and meaningful evaluation of alternative scenarios for the most acceptable development proposal, data management must be efficient, consistent, and complete. The sources of information forming the database for investigations will be varied, and range from digital base mapping to 35 mm photographs to paper reports to aquatic/terrestrial inventories.

This information, along with additional data gathered throughout any study process, will ultimately provide the framework upon which solutions to problems can be structured. Traditionally, study team members would be required to review the base information and utilize the data in their analyses. The diversity and scope of the information base is usually significant, which complicates the sub-assemblage of interrelated data for analysis. The results of the analysis are essential in the formulation and implementation of the proposed watershed plan as a prerequisite step in the process of land use planning. Without a comprehensive approach, incomplete and/or out-of-date databases could be used, which would likely lead to the potential for unsound decisions at the land use planning stage and development proposals with limited sustainability.

This paper describes the development of such an AutoCAD®-based environmental data management system for the Sheldon Creek watershed for the City of Burlington, Ontario, Canada.

In the southern Ontario area, it is only in exceptional situations that planned development does not impact on a watercourse. In the past, the watercourse has been regarded as a convenient means of conveying any and all stormwater away from the development site. This simplistic view of the watercourse required only limited analysis. Drainage infrastructure was set in place to maximize the developability of the site and the receiving stream was valued as an outfall.

As development pressures have increased over time, impacts of upstream development on flooding and erosion have become quantifiable. As a result, the analyst has been prompted to expand the extent of the analysis to encompass downstream areas, but still focused at expediting the runoff mechanism from the proposed development site. Data requirements to facilitate this type of analysis
were still limited to a few topographic maps and some land use and ground cover data.

In recent years, the watercourse and more generically the river corridor, is now recognized as a key component of the watershed ecosystem. This revelation has sparked the requirement of analysts to take a more comprehensive approach to investigations focused at development issues.

The ecosystem approach (similarly the multiobjective planning approach) in part, as described in Watershed, the August 1990 Interim Report of the Royal Commission on the Future of the Toronto Waterfront

- focuses on the system as a whole and the interrelationships of the individual elements,

- recognizes the dynamic nature of the ecosystem, and

- incorporates natural, physical, economic, social, and cultural elements as components parts of the environment.

The ecosystem approach to watershed management demands a sound appreciation of the environmental characteristics of a watershed. As well, the requirements for effective integration of these characteristics into the framework process for land use planning is vital for responsible and sustainable development.

Data Sources

The ecosystem approach to development planning requires that the analyses encompass not only the gamut of environmental components but also the range of other considerations. The varied sources of information (typically federal, provincial/state, regional and local/municipal agencies and other interested parties) will supply digital base mapping at various scales; paper maps and drawings; previous reports and other documents/letters; 35 mm type photographs as well as air photos; hydrologic, hydrogeologic and hydraulic information; flood and erosion information; present and future land use information; development plans (Draft Plans, Secondary Plans, etc.); land cover information; soils data; parcel information; assessment information; environmental information (flora/fauna inventories); air quality information; transportation information; noise information; public comment; and other miscellaneous data.

Considering the scope and quantity of data involved, the most appropriate means of dealing with this requirement for effective data management is an Information Management System (IMS).
Sheldon Creek Master Watershed Plan Study

The purpose of this undertaking was to develop a comprehensive stormwater management plan for the Sheldon Creek watershed and a tributary of the Bronte Creek. The plan was intended to provide a planning framework against which the municipalities of Burlington and Oakville, the Halton Region Conservation Authority, the Ministry of Natural Resources, the Ministry of Transportation, and the Ministry of the Environment would administer their respective mandates particularly in relation to drainage from future development within the study watershed areas to guide sustainable development.

The Sheldon Creek (17.6 ± km²) and Bronte Creek tributary (3.8 km²) watersheds straddle the municipal boundary between the City of Burlington (population 120,000 ±) and Town of Oakville (population 100,000 ±) and outlet into Lake Ontario. The watersheds are currently predominantly agricultural with existing residential development clustered near the lakefront zone downstream of the Q.E.W. Highway. Significant development over pressures are being exerted on these lands, which represent the primary development opportunity in the Burlington/Oakville area.

This Master Watershed Study defined drainage constraints to future development within the study area in the context of the physical, social, and cultural environment. The potential impact of future land use on drainage was assessed in terms of water quantity and quality, and mitigative measures were evaluated and recommended for implementation.

This study resulted in

- Identification of the location, areal extent, significance and sensitivity of the existing natural environment within the study area and establishment of their stormwater-related dependencies. This will include an assessment of topography and soils, surface water, ground water, watercourses, valleys and flood plains, vegetative communities and woodlots, and fisheries and wildlife;

- Establishment of lands not suitable for development (i.e., constraint mapping);

- Assessment of the impact of post-development stormwater runoff on the existing natural resources, based on current land use planning information; and

- Establishment of appropriate structural and non-structural stormwater management measures required to mitigate any adverse impacts to the
natural environment resulting from post-development stormwater runoff.

Development of a Watershed Inventory Management System

The basic requirements for the Information Management System (IMS) included provision of

- Complete coverage over the entire study area for all data (topographic basemapping and 'baseline' inventory);
- Flexible access to and management of any component of the database; and
- A minimal learning curve to provide for effective data management beyond the Sheldon Creek study.

The IMS solution adopted for information management on this project is based on an AutoCAD® spatial data management system (SDMS).

The AutoCAD® SDMS is an integrated set of programs for managing spatial information. In this context, spatial information refers to anything which has a location in space, and/or can be defined in terms of its own geometry.

AutoCAD®, the graphics engine for the SDMS, provides a transparent and consistent "window" into existing tabular databases through the AutoCAD® SQL interface and the SDMS spatial database, which contains a continuous, seamless map of the entire study area.

The basic components of the IMS are

Base Mapping
Community Boundaries
Parcel Data
Floodplain Mapping Data
Stream Morphology Data
Land Use Data
Study Boundary Limits
Hydrologic Modelling Data
Hydrogeologic Data
Woodlots/Wildlife Data.

The IMS that has been developed embodies 70 ± pre-defined graphical queries of the 10 categories of baseline inventory information assembled through
field work and library research. Queries are activated from within the AutoCAD® graphics "window" via pulldown menu. Specific data items or multiple "layers" of information can be retrieved from the IMS databases for user interrogation.

Summary

From a study team perspective, "central management" of the inventory data in a CAD-based information system has allowed for consistent representation of the complex data relationships throughout the duration of the study. This baseline inventory of data (engineering, planning, environmental, and geotechnical) and the nature of the expandable, adaptable, PC-based, menu-driven system provides easy access to the comprehensive database for graphically based queries and production of on-demand presentation graphics (drawings, maps, figures) as well as providing for more effective and coherent presentation tools for public meetings and formal hearings.
WINNEBAGO COUNTY
FLOODPLAIN REDELINEATION PROJECT

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The Federal Insurance Administration (FIA) of the Federal Emergency Management Agency (FEMA) is the governmental entity administering the National Flood Insurance Program (NFIP). The NFIP has published 80,000 individual map panels called Flood Insurance Rate Maps (FIRMs), which depict flood hazards in communities nationwide. Currently the NFIP is undertaking a 10-year project to convert these hard-copy maps to a digital format using geographic information system (GIS) technology. Standards for digital FIRMs were developed in October 1992.

Floodplain mapping provides the basis for local floodplain zoning that prevents development in floodprone areas and identifies structures that need flood insurance. The accuracy of the floodplain mapping directly affects how well the zoning is accepted and enforced and how well the flood insurance costs are accepted by affected homeowners. Accurate floodplain mapping results in less resistance to floodplain zoning. Local communities are more willing to enforce floodplain zoning requirements, resulting in fewer structures constructed in the floodplain.

Legislation in Wisconsin was passed in 1989 establishing the Wisconsin Land Information Program to improve land information systems. Approximately $6 million in funding is generated annually through increased document recording fees. Two thirds of the money stays in the county while the other one third goes to a Wisconsin Land Information Program board which administers a grant program for land information program projects. The legislation identified zoning mapping as one of a number of "foundational elements" that must be addressed to be eligible to receive funding. As a result, while automating tax parcel information is the initial emphasis, some Wisconsin communities are in the process of digitizing floodplain zoning maps as part of their program to automate land information data.

Winnebago County is developing an automated Land Information System (LIS). This two-year, $4-million project also includes the five incorporated communities in the county. When completed in August 1993, the county's LIS will include parcels, political boundaries, transportation networks, building footprints, hydrology, soils, wetlands, floodplains, and two-foot contour mapping. The contour mapping, being developed at a cost of approximately $300,000, is the most significant component for floodplain mapping. In
December 1991, the county conducted a pilot project in which the various associated maps were automated in a five-square-mile area that included a portion of the City of Oshkosh.

What's Wrong With This Picture?

The FIRM was one of the maps included in this pilot project. Figure 1 is an example of the resulting overlay when that digital FIRM was "blown up" to match Winnebago County's larger-scale base map. It was obvious to the County Zoning Administrator that he was not going to be able to use this digital FIRM in the Winnebago County LIS to help make land use permit decisions.

Why Don't the DFIRMs Fit?

The FIRM for Wisconsin were prepared using topographic mapping available at the time of the engineering analysis (generally USGS 7½ minute quadrangle maps at a scale of 1:24,000 which is equivalent to 1"=2,000'). Winnebago County is developing base mapping at a scale of 1"=200'. A digital FIRM developed at the same scale as the present hard copy FIRM will not match this larger scale base mapping. This becomes especially apparent when comparing the floodplain boundaries from the FIRM (developed from 10-foot contour maps) with the county's new two-foot contour mapping.

Figure 1. DFIRM over larger-scale base map.
However, improved topographic mapping also provides a means to redelineate the floodplain boundary to better fit the larger scale base mapping. In October 1992, a cooperative project was initiated with FEMA, the Wisconsin Department of Natural Resources, and Winnebago County to determine how to develop DFIRMs that better "fit" improved topographic and base mapping. We felt that this project was achievable because a two-foot contour Digital Elevation Model (DEM) is available, hydrologic and hydraulic data is available, and the analytical capabilities of GIS software can assist in floodplain delineations.

Objectives

The overall purpose of this project is to determine if new floodplain boundaries can be delineated using the GIS tools of ARC/INFO. The specific objectives are to establish standards and procedures for digital floodplain mapping in Wisconsin that will "fit" improved topographic and base mapping, and to establish the contract language and review process necessary to ensure counties receive an approvable set of digital FIRMs.

Basic Procedures

(1) Create ARC/INFO coverages. The first step in this project was to obtain Winnebago County's base mapping with particular attention to the two-foot contour mapping, hydrology, political boundaries, transportation, building footprints, and parcel data. The files received were in Intergraph's DGN format, which we converted to ARC/INFO coverages. We then obtained work maps to determine the location of the cross sections. We found this preferable to digitizing the cross sections from the FIRMs for two reasons: first there were substantial cartographic modifications to the cross sections during the map production process, and second, the work maps were USGS 7½ minute quadrangles and therefore had horizontal control (which the FIRMs do not). We also reviewed the hydraulic models for cross section information.

(2) Create GRID of the area around the stream. The TIN (Triangular Irregular Network) or DEM (Digital Elevation Model) was created using the contour data. ARC/INFO accepts contour data as direct input for TIN generation. Weed tolerance was set to one foot and proximity tolerance was set to 0.000. The TIN has two purposes: it serves as an input to GRID which will be used to create the new floodplain, and it is also used to create a cross section graph to compare to the cross sections that were input for the hydraulic model. Also included in the TIN creation process was the spot height file to provide additional accuracy of the TIN. This TIN was then converted to a GRID using the command Tinlattice. The cell size was set to two feet and the quintic method was used in this conversion. GRID is a raster data model. This method
was used because it is much easier to create a surface which is a function of two other surfaces using this model.

(3) Create a GRID of the flood water surface. The elevation of the flood water surface is derived at each cross section by the hydraulic model. The 100-year elevations were added as attributes to the cross section coverage. The spline command (cell size = two feet) was used to create a GRID of the water surface from the cross section coverage. This GRID represents an interpretation of the water surface associated with the 100 year-flood.

(4) Delineate the floodplain boundary. We created a GRID that reflects areas in which the water surface is greater than the water surface. GRID map algebra makes this straightforward: "floodplain = (flood surface > ground surface)." A polygon coverage was created from the floodplain grid using the ARC/INFO command Gridpoly.

**Evaluation**

We were fortunate that a stream in the county (Sawyer Creek) had been recently restudied. The study contractor had the new two-foot contour map available when they delineated the floodplain boundary. Therefore, we were able to compare the manually delineated floodplain boundary with a floodplain boundary delineated using GIS software. Figure 2 is an overlay that allowed us

![Figure 2. GIS vs. manual delineation.](image-url)
to compare the results. It appeared that using GIS software was indeed an acceptable method to delineate floodplain boundaries.

Next Steps in the Project

We must still establish procedures to map floodways and to redelineate floodplain boundaries in approximate areas (unnumbered A zones). In addition, we must provide a DFIRM in accordance with FEMA standards. The project is scheduled to be completed in October 1993.

Conclusions

We were able to redelineate the floodplain boundary by digitizing cross sections, adding base flood elevations as attributes to the cross sections, and interfacing this data with the DEM for Winnebago County. The most difficult part of the process was establishing the proper location of the cross sections. The most useful source of information was the original study contractor work maps.
GIS AND FLOODPLAIN MANAGEMENT: BEYOND THE FIRMs

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National Flood Insurance Program/GIS Background

The Federal Insurance Administration's (FIA) National Flood Insurance Program (NFIP) is engaged in a 10-year program to automate flood risk assessment and digitize the Flood Insurance Rate Maps (FIRMs). Applying the high technology of digital mapping and integrating the digital FIRMs into state and local geographic information systems (GIS), will dramatically change all steps in the process—from the initial engineering phase of the studies to the distribution of the final map product on CD-ROM. Recognizing the changes an effort like this involves and the complexity of the task, FEMA is working with state, county, and local governments to digitize the FIRMs.

Application of the Technology

At the outset of the project, it was determined that a prototype was necessary to test the concept. Five counties with high flood frequency, a sizeable FIA policy count, and representing different areas of the country were selected for the initial testbed to be digitized, incorporated with software developed for the project, and placed onto a CD-ROM. One of the counties selected was Dade County, Florida.

Dade County, in south Florida, stretches from North Miami Beach down to Key Largo. It is primarily urban with a population of 1.9 million people, rich in cultural diversity, a busy area of government, tourism, sports activities, neighborhoods, retirement communities, and beautiful ocean beaches. At about 5:00 on the morning of August 24, 1992, Dade County received the brutal force of Hurricane Andrew. With winds recorded in excess of 185 miles per hour, Andrew was classified as a category four hurricane. Passing over the southern portion of Dade County, Hurricane Andrew left destruction of extraordinary proportions in its wake. Incredibly, loss of life in a storm this size was minimal. But property loss, now calculated in the billions of dollars, and the upheaval to human life and order sapped the vitality of many of the citizens of Dade County.

When the storm had passed, Dade County residents surveyed the devastation in stunned disbelief. Trees, cars, mobile homes, furniture, roofs, refrigerators, and boats were all blown into massive piles of twisted metal and material. Neighborhoods were unrecognizable to long-time residents, children could no longer find their schoolyards, all utilities and communication were out. Food and drinking water were at a premium.
County and state resources were quickly exhausted and assistance was called for. Relief from federal and state agencies and private donors began to pour in. Trouble was, with a devastated infrastructure, delivery of needed goods to those in need was virtually impossible. The immediate concern for food, water, medical attention, and other disaster assistance was growing.

Not surprisingly, many thought to implement GIS to sort out the chaos. On day two, at Florida City, in the lobby of the local motel, the only substantial structure left in town, a jury-rigged system of MacIntosh computers operated by a few dedicated emergency managers soon became the emergency operations center (EOC). Florida City, incidentally, was so devastated it had the distinction of rising from the fourth-poorest city in the nation to the poorest overnight. This EOC, staffed 24 hours a day for seven weeks following the storm became an effective information center for the Florida City area. Map production, a prominent feature of the EOC, was soon known throughout the area. Hundreds of maps were provided to responders from neighboring communities and to the military for use in search and for damage assessments. Hundreds more were distributed to residents of the area containing disaster-specific information: where to obtain food, potable water, and medical assistance.

In Miami, at the disaster field office, volunteers from Digital Matrix Services (DMS) of Dade County arrived on September 4, 1992, and installed the InFoCAD Geographic Information System software on two workstations. The database contained information on county segments with street name, address range, and zip code. This commercial product, containing the initial street network developed out of TIGER files, was donated by a private firm of California. Within a week the system grew to 10 workstations and the Metro-Dade GIS street network database (more refined but also from the original TIGER files) was imported.

From these two efforts grew data acquisition, query and analytical capabilities, and production of thematic maps relevant to the response. Maps were produced daily for the military with updated information on the need for delivery or pick up of supplies, tents, and sanitary facilities. For the situation rooms in Miami and Washington, D.C., maps reported overall operations and progress. The U.S. Army Corps of Engineers, with its own GIS, performed cost saving analyses, tracking, and mapping for their biggest task, debris removal. In addition, other state and federal agencies needed information about the conditions in Dade County: the U.S. Centers for Disease Control, Housing and Urban Development, the Department of Agriculture, and the Bureau of the Census, to name a few.

An innovative approach to disaster assistance began to emerge. Dade County has an extensive governmental system, and each entity within the system tracks its clients and responsibilities with a database. The blending of the data
contained therein with databases from federal agencies and the private sector into a comprehensive information system might yield the overall information necessary to, in part, manage the response now and the recovery efforts later. This would require close cooperation and exchange of data, and coordination to facilitate disaster assistance by FEMA, the U.S. Army Corps of Engineers, and Dade County. The Dade County floodplain vector data, with U.S. Bureau of the Census TIGER files on the FIA prototype CD-ROM, was a piece of this complex puzzle. These data in combination with the Dade County Tax Assessor's database provided serviceable information on housing units including property value, flood zones, tax keys, address, insurance, and ownership.

Now, six months after Hurricane Andrew stormed across south Florida, these efforts continue. Housing has become the main issue. Associated problems are the need for housing units, the hundreds of homeless still in Dade County, rats, vermin, and disease. Rebuilding, repairing, elevating, and demolition of uninhabitable structures are the daily activities in Dade County. The Florida City emergency managers, DMS, and the U.S. Army Corps of Engineers are still involved in the recovery phase of Hurricane Andrew, and still solving problems with GIS. Floodplain managers and planners are taking an active role in this process to insure proper recovery and enforcement of the South Florida Building Code. Here is an example of "cross training" at its best.

**Conclusion**

GIS as management and analytic support to the recovery effort cannot be denied. An unmistakable and irreversible impression of GIS as a tool in emergency management has occurred. A maturing of the process and a refinement of problem solving is taking place. It is further understood that aggressively embracing this technology at the mitigation stage by maintaining quality databases that share a common standard, and truly being prepared will lessen the problems and pain of response and recovery in future disasters. Planning and preparation are ongoing activities, and disasters happen in their own time. Planning and preparation we can control; disasters we can expect.
CREATING DIGITAL BASE MAPS AS A COMPONENT OF DFIRMS

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Introduction

Creating a digital base map on a real-world coordinate system, as part of producing a Digital Flood Insurance Rate Map (DFIRM), requires the integration of the best available horizontally controlled data for the county and communities. This includes county base mapping, USGS 1:24,000 scale quadrangles, and the U.S. Census Bureau’s Topologically Integrated Geographic Encoding and Referencing (TIGER) data. These sources are integrated, resulting in an end product of a street centerline vector file with street names for the entire county.

Community Data

A DFIRM is a Flood Insurance Rate Map (FIRM) produced by digital methods with supporting digital data files. At the outset of DFIRM production, the county being converted from the manual environment to digital format is contacted to determine what, if any, digital data are available. If the county, or any of the incorporated communities within the county, has a digital land base, additional research is performed to determine its usefulness. For the centerline data needed for the DFIRM base, the key questions are

- What is the positional accuracy of the data?
- In what format are the data available?
- Is there a data base with street names?

Once it has been determined that the available data will meet the requirements for the DFIRM land base, the data are requested.

The data, once obtained, will typically require translation to the production system. ARC/INFO, DXF, and MicroStation are the most common formats encountered and present little translation difficulty. The translation process also involves bringing along the street name data base. This is invaluable in the subsequent production process where the streets and roads are to be labeled on the final product. Without the digital data base of street names, the street
labeling process would require research to determine the name of each road as well as the typing of each name by the production operator for placement.

The last step in the incorporation of a community land base in the DFIRM is the coordinate transformation to the UTM system. Although the data may be provided in UTM coordinates, State Plane Coordinates, which convert easily, are more commonly used.

A primary advantage in using county-furnished data is the resulting overlay compatibility of the DFIRM data with the county base map data in a geographic information system (GIS) environment, enabling the community to perform spatial analysis with the flood data.

USGS and TIGER Data

If no data are available from the community, the TIGER data will be used for the centerlines, with the USGS quadrangles providing the controlled base. This approach is attractive because both TIGER and USGS data sources are available for all areas in the United States. TIGER linework also has the street names associated with each street segment, a distinct advantage over the USGS's digital line graph data.

Regular, paper USGS quads provide the horizontal control needed, not only for the land base, but also for the entire DFIRM production process. The procedure begins with the creation of a USGS quad index based on the latitude and longitude of the corners. These are mathematically placed in a file. A paper copy of each quad is optically scanned and the resulting raster data adjusted to fit into the proper four-corner location in the index. This is accomplished by identifying the visual corner of the quad using the raster data followed by the mathematical or exact corner using the index. The raster quad data are then transformed to fit their true location. This process is repeated for each quad until the base map is complete for the county.

The TIGER data contains several categories of information including transportation (roads, railroads, and airports); pipelines and powerlines; hydrography; and political boundaries. In addition, there is a data base which contains information such as feature names, address ranges, and zip codes. The roads, railroads, and their associated feature names are the only elements used for the DFIRM land base from TIGER; other sources are used for the political boundaries and hydrography.

The TIGER data has been released on compact discs and is available only as complete counties. To facilitate production, these full county data sets are subdivided into files called "shifted quads," covering 7.5 minutes of latitude and longitude. The corners are offset 3.75 minutes of latitude and longitude from the published USGS quads to minimize the number of centerline files needed to cover the flood data quad file in production. Because the entire county data set
can be over 100 megabytes, this method of subdivision is especially advantageous because the files are manageable in size and only four files are needed at any one time.

Each of these "shifted quads" is then displayed with the raster quad data, which have been adjusted to the mathematical index. The TIGER centerlines will not normally overlay the USGS quad location for the road. As a result, an adjustment of the centerline data is required. This is called "warping." This adjustment begins with the selection of points common to TIGER and the quad centerline files. This is a digitizing function performed by a production operator who locates an intersection in the vector data and then locates the same intersection in the raster data. Because the TIGER centerlines have been found to be irregular in their correlation to the quad roads, the majority of the intersections are used as monuments, including dense areas in cities and towns. This results in a significantly better adjustment of TIGER to the quad.

Once all monuments have been selected and digitized, the shifted quads of centerline data are "warped," file by file. However, the results of this batch process are not accepted as is. The centerline files are visually checked by graphic display of the data, searching for gross errors that would have been caused by mislocating an intersection monument. Following this cursory review, each centerline vector file is plotted with the corresponding raster quad files for a thorough visual inspection. The first phase of the visual inspection checks for alignment of the centerlines within the road shown on the quad. Misalignments are marked on the plot for revision. These misalignments fall into three major categories:

- Misplaced street intersections,
- Insufficient shape points (vertices) on a street segment, and
- Incorrectly placed shape points on a street segment.

Misplaced intersections are corrected by simply moving the intersection (all coincident endpoints) to the correct location. A street segment with an insufficient number of shape points is corrected by inserting vertices in the graphic element to better represent the form of the road. Incorrect shape points are revised by modifying the location of the appropriate vertices.

It should be noted at this point that the purpose of this base map is not as a general use map but as a base for DFIRM production. Therefore, the primary areas of interest are the floodprone areas and the area immediately adjacent to them. In areas outside the floodplain, the location of the centerlines is not as significant and is, therefore, not given the same scrutiny.
The second phase of the visual inspection is to identify roads that appear on the USGS quad but not in the TIGER centerline data. If the quads indicate new construction or development, these roads are digitized into the centerline file. However, attribute data, such as address ranges, are not obtained for the data base. Because the needed product is a base map with street centerlines and their names, the lack of this additional data does not affect production of the DFIRM.

**Effective FIRM Data**

The final step in creating the land base for the DFIRM is to add to and/or revise the centerline file based on the county's effective FIRMs. The effective FIRMs are optically scanned, and the raster data scaled according to the published scale of the FIRM. This raster data is then manipulated by moving and rotating the image to be displayed with the centerlines. Further addition and alignment revisions are made to the TIGER centerlines to maintain the data in accordance with the data on the effective FIRMs.

**Conclusion**

The base map on which the digital FIRM data is published is a vital component of the product. A significant research effort is required to ensure that the best available data is obtained. By building the DFIRM on a horizontally controlled land base with digital centerline locations, the further use of the digital FIRM flood data in a community GIS system is greatly enhanced.
AUTOMATING THE REVISION PROCESS USING DFIRMs

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Introduction

The creation of Digital Flood Insurance Rate Maps (DFIRMs) provides the opportunity to expedite the revision of Flood Insurance Rate Maps (FIRMs). The benefits will be realized in two areas. First, by allowing the needed revisions to be made quickly and efficiently by a technician at a graphics workstation, the time-consuming manual scribing process is bypassed. Second, and potentially of greater benefit, will be the capability of incorporating the study contractor's data directly into the DFIRM, eliminating redundancy of effort.

What Is a DFIRM?

Before discussing the revision process, some background on what a DFIRM is and how it is created would be appropriate. A DFIRM is a FIRM produced by digital methods using digital line graph (DLG) files. These data consist of four themes: (1) flood hazard zones, (2) hydrography, (3) political areas, and (4) map panels covering a single 7.5-minute USGS quadrangle. The flood, hydrography, and political themes were created by digitizing the appropriate data from the effective FIRMs. This data was then digitally "fit" to a land base composed of raster images of USGS quadrangles that have been adjusted to their mathematically placed corners and a vector centerline file, overlaid on the quads. The "fitted" data has been reviewed by engineering to resolve any mismatches between panels and communities. The data is then sewn together and output, by quad, as continuous data for an entire county.

The second component of a DFIRM is the digitally printed map. This product resembles the manually produced FIRM as closely as possible with respect to line thicknesses, text fonts and sizes, and shading. The DLG data is input to the map generation process and using geographic information system technology, a finished map product is produced. Operator participation is required for text placement and other aesthetic issues.

Revisions To Data

After a county has been converted to a DFIRM in county-wide format, future revisions that may be necessary can and will be done in a digital environment. There are three scenarios under which these revisions will occur:
- Study received in hard-copy form,
- Study received as digital data, and
- Study done interactively.

Each of these will require different approaches to incorporate the changes.

When a study is received in hard-copy form, the paper and/or mylar documents must first be optically scanned so that the data can be displayed with the digital data. Once scanned, the image will be scaled, rotated, and moved to locate it horizontally in its true position. With the study located, the currently effective data can be viewed simultaneously with the new updates. This review will readily show the differences. To incorporate revisions, a production operator will digitize the changes into the file used to generate the DLG. This file will have all current data "frozen" or locked prior to the digitizing. The purpose is to prevent modifying data which has not changed. It also enables the generation of a "change detection plot" which shows all revisions in red and all unmodified data in black. This DLG will then be input to the same map generation process that produced the original DFIRM, and a new map will be produced. As with the original DFIRM, some operator participation is required for aesthetics.

The second way a study can be received is as digital data. These data, in order to be used, must first be translated to the production system format. ARC/INFO, AutoCAD (DWG and DXF), and MicroStation are common formats and present little translation difficulty. Once in the production system format, the file structure must be revised to match the file structure in use. This most likely will require layer/level changes as well as color and weight changes. The final step required to bring the digital data in line with the production system is the coordinate transformation to the UTM system. Although the data may be provided in UTM coordinates, State Plane Coordinates, which convert easily, are more commonly used.

The data sets from the study and from the DFIRM/DLG can now be viewed together. At this point, the differences become apparent. As in the previous scenario, the existing data is locked and the new data, which in this case does not need to be digitized, are simply merged. A change detection plot will be generated and a new DLG file created for input to the map generation process. A production operator can then make aesthetic revisions.

The third method for revising a DFIRM is to complete the delineation interactively. The processes that the engineer normally performs on the board can be replicated at a graphics station. By loading all necessary data, including base maps, by either of the two methods previously described, an engineer can
perform the delineation on the screen directly compatible with the file formats used to produce the DFIRM/DLG files. The software used to do the delineation would be the same as that used to perform the initial data capture during the conversion from manual to digital. As in the two previous scenarios, the existing data is locked and the new data will show in red on the change detection plot. A new DLG is always required, reflecting the changes.

Conclusion

Today's technology provides the means for producing maps in a more timely fashion than is possible by manual methods. As study contractors embrace the technology, the redundancy of steps in the map production process will be eliminated. In the future, a digital library containing the data sets for FIRMs can exist, and the data can be kept more current as the technology shortens the revision cycle.
Part Five

Stormwater Management
COORDINATING FOR EFFECTIVE POLICY MANAGEMENT: 
THE TEN MILE CREEK INTERJURISDICTIONAL 
WATERSHED MANAGEMENT PROGRAM

Chris Brooks and Jack Tidwell 
North Central Texas Council of Governments

Introduction

The Ten Mile Creek Interjurisdictional Watershed Management Program (Program) began in the fall of 1990 and addresses flooding and other related watershed management issues on a regional watershed basis. This paper documents the efforts of the local governments participating in the Program. It also outlines the potential strategies that the North Central Texas Council of Governments (NCTCOG) has developed for the participating local governments to pursue. The Program demonstrates the commitment of all of the participants to plan for the preservation of the watershed, to implement policies to increase public safety by minimizing flooding hazards, and to maximize the environmental, recreational, and open space benefits for all of the communities in the watershed. The Program provides an important forum in which the goals and objectives of all the communities participating can be planned for and attained.

Watershed Description

The Ten Mile Creek watershed is marked by stark contrasts. The area was once the location of small rural communities that outlined the southern boundary of the rapidly growing City of Dallas. Now the communities in the watershed are well-established cities in their own right. The entire length of Ten Mile Creek, which was once surrounded by primarily agricultural activity, is now bordered and impacted by increasing amounts of urban development. However, it is important to note that even as the amount of storm water runoff from urban land uses has increased, the creek has still retained many of the unique natural characteristics of a rural stream. The 1990 Dallas County Open Space Plan estimated that population density by census tracts in the study area reached 3,000 to 4,500 persons per square mile.

In many ways, this program is a result of the tremendous development of the communities of southern Dallas County. This area has become a vital portion of the expanding Metroplex. The communities of the area have steadily transformed into large cities which support thriving high-tech industries and modern residential and commercial centers. These rapidly growing municipal governments have expanded the delivery of public services necessary to support
their dynamic communities. Of the services the communities provide, the provision of storm water drainage, flood control and watershed management have been unassuming, yet increasingly important responsibilities of the local governments.

**Watershed Management Approach**

The availability of water and adequate drainage have historically been two critical factors of development in Texas. It was important that new towns be located near creeks and rivers because of the need for water for irrigation, domestic uses, and the drainage of storm water and wastewater. As progress moved on, sophisticated public works projects were designed and built to replace natural streams for many of these roles. Therefore several of the most visible benefits of a creek to a community were diminished. The primary problems of a creek in a growing community centered around providing adequate drainage for new developments and whether subdivisions could be designed to maximize their value on the land area on which they were located. As a result, a creek’s role of providing drainage was now in competition with its role as a boundary to, or an amenity of, urban development. Drainage related problems of a community were once treated as the unavoidable results of development. Watershed management evolved from this background.

The Program has been developed around a core theme of comprehensive watershed management. This approach involves three interrelated activities; flood management, open space planning, and environmental quality management. A comprehensive program of floodplain and watershed management includes a balanced consideration of each of the three elements. The interrelated nature of the elements can be accurately described as a triad, especially when considering the impact of any one element on the other two.

**Flood Management**

As noted before, flood management and flood control activities have been a traditional focus of watershed management. Historically, structural controls and, to a limited extent, non-structural controls have been used to react to flooding problems in a community. This emphasis sometimes created significant problems of increased erosive velocities and decreased water quality. Structural controls can be thought of as physical projects that control, divert, or exclude the flow of excess storm water from flood prone areas. They are justified by the need to reduce damages to property, hazards to public safety, and economic losses. Non-structural controls are reactive as well. They attempt to avoid flood damages by exclusion or removal of damageable property from flood prone areas. Controlled land use, flood warning and evacuation, flood proofing or retrofitting, and relocation are good examples of how existing flood control
problems can be dealt with nonstructurally. Many of the nonstructural techniques can also be used to avoid future flood-related problems. Controlled land use planning and development standards are good examples of this more proactive approach. Watershed management has evolved and now includes planning to proactively prevent problems associated with storm water.

**Open Space Planning**

Open space planning plays an important role in the watershed management triad. This type of planning acknowledges the value that undisturbed or landscaped areas have in a healthy community. Traditionally, the goals and objectives of open space planning have included the protection of environmentally critical areas, the creation of recreational opportunities, and the maintenance of divisional "buffering areas" between potentially conflicting land use activities. Additionally, these areas can be a very useful tool in flood damage reduction. Significant amounts of rainfall can be effectively detained and absorbed by the soil and vegetation of an undeveloped area. Thus open space planning provides an important method to address how land areas that currently absorb rainfall and runoff will be affected by future development. It should be noted that several communities in the watershed area have already adopted landscape ordinances that deal with the shielding and buffering properties of appropriately designed developments.

**Environmental Quality Element**

The third element of the watershed management model is environmental quality. In recent years, environmental quality has become a priority at all levels of government. Because of emerging federal and state regulations, it is now necessary to measure the impact of a flood control project on the surrounding environment, and to mitigate the adverse impacts of flood control projects, e.g., the loss of wetland habitat. In the same way, several flood control methods can often enhance the environment. As an example, the soil and vegetation of an open space can act as a filter that enhances the water quality of a watershed while retarding and absorbing a portion of the flow of water from a storm event. In this manner, a vegetated open space area actually aids in reducing peak discharges of a stream. By removing sediment and other particulates from runoff, the quality of water entering into the Trinity River can be significantly enhanced.

**Summary of Interjurisdictional Approach**

The cities along Ten Mile Creek recognized the dramatic changes in the character of the creek and that a interjurisdictional approach to watershed
management was needed. In 1990, Dallas County and the cities of Cedar Hill, Dallas, DeSoto, Duncanville, and Lancaster embarked upon a cooperative effort to jointly apply advances in comprehensive storm water management to the Ten Mile Creek watershed. As a result, the Program was initiated. The Program receives direction from a two-level committee structure including a staff task force group of staff-level floodplain managers, planners, and city management officials to provide technical direction. The second group is made up of elected officials from each community to provide policy direction and final approval of Program recommendations.

Through the cooperative effort of this Program, the Ten Mile Creek participants have the ability to move forward in the creation of common watershed policies. Items that have been addressed to date include; past, current, and ultimate land use conditions; current floodplain management policies in force throughout the watershed; and significant state and federal flood damage reduction and environmental activities. A series of interviews has been held with representatives of the communities and NCTCOG staff to identify the common challenges and opportunities faced in the watershed. These interviews and committee meetings have produced an action plan of recommended policies for the communities to explore, discuss, and ultimately implement. The discussions thus far have been extremely enlightening to all concerned. City officials now recognize that their approach to floodplain management can not be considered totally independent of other jurisdictions. Instead, they recognize that their efforts are improved if their individual actions are coordinated with upstream and downstream neighbors. NCTCOG encourages the Ten Mile Creek participants to proceed cooperatively with further detailed studies in this watershed.

**Recommended Action Plan**

During the past several meetings of the staff task force and steering committee, all of the challenges and opportunities faced by the watershed were discussed at length. From these discussions NCTCOG staff developed the "triad" elements: flood control, open space planning, and environmental quality. NCTCOG is recommending that the participants investigate the following actions for official adoption and implementation in the watershed.

1. A watershed-wide base flood elevation (BFE) based on the 100-year floodplain of a fully developed watershed Land Use should be used for planning and permitting purposes.

2. Floodplain reclamation policies should allow no significant rise in BFE.
(3) Velocity controls should be developed that establish maximum allowable flow rates for specific channel, bed, and bank treatments.

(4) Development criteria should state that development shall not increase runoff rates above pre-construction conditions. The policy would be implemented through either on-site detention or a financial contribution to a watershed-wide solution.

(5) No alteration of undeveloped areas along the Ten Mile Creek channel or its major tributaries (except where required for safety and public welfare) should be permitted.

(6) Evaluation of specific development standards should be jointly pursued to insure adequate flood control and water quality protection in the Ten Mile Creek watershed.

(7) Policies requiring any floodplain remaining after final reclamation should be deeded or dedicated to the participating jurisdiction to prevent further encroachment and provide for adequate drainage maintenance along Ten Mile Creek. Cooperation between program participants should be encouraged in the creation of linear parks and use of open space along the Ten Mile Creek corridor.

(8) Participants should require the use of parallel streets and greenbelts to ensure access to the creek and to provide a buffer area between the floodplain and development.

(9) Cooperative stream maintenance should be pursued to maximize drainage efficiency and the natural values of the creek. Creative funding mechanisms should be investigated to finance a continuing effort of this sort.

(10) Established lines of communication should remain to ensure that the unique regional drainage and environmental characteristics of Ten Mile Creek are preserved.

Conclusion

By participating in a cooperative program, the local governments are working not only to avoid deterioration of the watershed, but also to enhance the unique attributes of the creek. Further evaluation and discussion of specific development standards, such as detention policies and minimum floor slab
elevations are the next items to be jointly pursued to insure adequate water quality protection and flood water control. The benefits of participating in a program such as the Community Rating System can be maximized for each individual entity by cooperation on a watershed-wide basis in federal program formulation and implementation. The participants acknowledge the importance of providing safe drainage and maintaining the creek's environmental, aesthetic, and recreational assets. With the commitment of the local governments, the stream will remain an unspoiled feature of the watershed that will attract residents and quality developments to this area of southern Dallas County.

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U.S. Fish and Wildlife Service
Introduction

Record rainfall and flooding during 1989, 1990, and 1991 brought havoc and death to a widespread portion of Texas, especially the Trinity River basin. These massive floods produced significant damages to homes, businesses, farms, parks, streets, bridges, and other public and private facilities. Millions of dollars in flood damages occurred and a number of lives were lost.

In response, the Texas Legislature allocated funds for flood related studies in Senate Bill 1543. Subsequently, the Texas Water Commission and the Trinity River Authority retained Albert H. Halff Associates to study alternative system-wide reservoir operation schemes, and to develop the key technical elements of a real-time flood forecasting system for the Trinity River basin.

Specific study objectives as developed from Senate Bill 1543 were as follows:

(1) Develop programs to minimize basin-wide flooding.

(2) Provide the framework for a basin-wide water release program.

(3) Develop the technical elements and procedures for a basin-wide real-time flood forecasting and operation system and flood warning program.

(4) Provide an analysis of proposed reservoir operating procedures to exercise emergency pre-release programs for non-flood control reservoirs.

The final report, *Flood Prevention and Control for the Trinity River Basin (SB 1543)*, was published in August 1992. The results were also included in a publication by the Texas Water Commission, entitled *Trinity River Flood Plain Study*, dated September 1992.
Reservoir Operation Study

The objectives of the reservoir operation study were to prepare a basin-wide reservoir simulation model for existing reservoir operating conditions, verify the model with observed historical reservoir operation data, and evaluate the effectiveness of several basin-wide operation scenarios for controlling flooding in the Trinity River basin. The HEC-5 reservoir simulation program, originally developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC), was used to accomplish these objectives. The Eichert Engineering version of HEC-5, with some improvements, was actually used in this study. Computed single-event flood damages for four historical floods (1990, 1989, 1979, and 1973) were used as the basis of comparison between existing conditions and four alternative reservoir operational scenarios.

The reservoir operation study included development of a basin-wide daily time interval reservoir operation model, calibrated to the four historical floods, and used to analyze both existing reservoir operation procedures, as well as variations of four operational scenarios:

1. Pre-Release from Lake Livingston (Lower Basin)
2. Pre-Release from Richland-Chambers/Cedar Creek Reservoirs (Mid-Basin)
3. Pre-Release from Lake Bridgeport/Eagle Mountain Lake (Upper Basin)
4. Storage Reallocation in Eight Major Water Supply Reservoirs

The reservoir operation scenario evaluations and comparisons for this study were based on computed flood damages for 20 damage centers located throughout the Trinity basin.

Real-Time System Study

The real-time system study involved development of an integrated network of flood data acquisition components and computer models, intended to facilitate the forecasting of basin-wide flood flows during a flood event. Several HEC computer programs were selected to perform the necessary real-time computer modeling tasks, including the PRECIP rainfall processing program, the HEC-IF runoff forecast model, and the HEC-5 (Eichert Engineering version) reservoir simulation model. The HEC Data Storage System (HECDSS) was utilized for the storage and retrieval of all real-time flood data. A user-friendly menu-
driven computer interface was also developed as part of this study to facilitate execution of the required computer programs, and to automate the tabulation and plotting of observed and computed rainfall and streamflow data.

This study included the development of an overall watershed rainfall-runoff response model, calibrated to the 1989-1990 floods and then converted to a real-time flood forecasting model. The real-time study also utilized a modified version of the HEC-5 reservoir regulation model from the planning study to make up the complete real-time flood forecasting/operation system. Verification of the system was made using actual hourly data from the 1989-90 floods.

To develop the Trinity River real-time model, four subsystems were used:

1. Data Collection, Transmission, and Retrieval Sub-System
2. Data Processing and Filing Sub-System
3. Rainfall Estimation and Runoff Forecasting Sub-System
4. Reservoir System Simulation Sub-System

The software sub-systems were integrated in two ways. The first was through the data filing sub-system, HEC-DSS. In addition to using HEC-DSS to process and file raw data, it was the mechanism for linking the analysis tools. For example, HEC-1F retrieves rainfall data from HEC-DSS, forecasts catchment runoff, and files this unregulated-flow forecast with the HEC-DSS. HEC-5 retrieves this forecast from HEC-DSS, simulates operation, and files the regulated-flow forecast with HEC-DSS. The user then can tabulate or plot forecasted flows and water levels with HEC-DSS utility programs, and can take appropriate action.

The programs are integrated also through a character-based program manager with pull-down menus, dialogue boxes, radio buttons, and all the PC-program features users have come to expect. This program manager, designated TRACE (Trinity River Advanced Computing Environment), serves also as a file manager, input processor, and database interface. TRACE is used to systematically execute the various utility programs such as PREFOR and PREOP (to create or modify HEC-1F and HEC-5 input, respectively), PRECIP, EXTRCT, DSPLAY, and DWINDO (to tabulate and edit data).
Study Findings and Conclusions

The following is a list of some of the more significant results from the study. Table 1 is a summary of the economic findings for the reservoir operations study.

- The 17 major reservoirs in the Trinity River basin are presently making major reductions in flooding (over $3.6 billion in reduced flood damages for four floods).
- Pre-release operations can create as well as reduce flood problems.
- Significant interdependency exists between the reservoirs in the basin.
- Analysis of upper basin pre-release operations were generally inconclusive.
- Only the storage reallocation scenario made consistent basin-wide flood damage reductions ($95.6 million damage reductions for four floods).

Table 1. Basin-wide summary of computed flood damages.

<table>
<thead>
<tr>
<th>Historical Floods</th>
<th>Total Computed Flood Damages (in Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990</td>
</tr>
<tr>
<td>Pre-Projects (i.e. no lakes)</td>
<td>3172.4</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>960.1</td>
</tr>
<tr>
<td>Exist w/Start at Top of Conservation Pool</td>
<td>952.8</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>954.3</td>
</tr>
<tr>
<td>Pre-Release from Lake Livingston</td>
<td>967.0</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>894.8</td>
</tr>
<tr>
<td>Pre-Release from Lake Bridgeport and Eagle Mountain Lake</td>
<td></td>
</tr>
<tr>
<td>Storage Reallocation in 8 Major Water Supply Reservoirs</td>
<td>894.8</td>
</tr>
</tbody>
</table>
Recommendations from Report

1. Reservoir owners/operators should implement a basin-wide operation policy that considers a coordinated pre-release program.

2. Reservoir owners/operators should coordinate the collection of flood data.

3. The state should authorize and fund an agency to further develop, test, maintain, and operate the real-time flood management system.

4. Design and implement a data acquisition system, and increase the number of Trinity River automatic reporting rainfall/stream flow gages.

5. Incorporate NEXRAD precipitation data into the proposed system.

Texas Water Commission Recommendations

From this study and other activities initiated by S.B. 1543, the Texas Water Commission developed several significant recommendations.

1. Create a comprehensive, coordinated, and enforceable state-wide program for flood hazard management.

2. Designate an agency to operate the Trinity River Management Model.

3. Develop flood management computer models for coordinated reservoir releases in other Texas river basins.

4. Provide support to Corps of Engineers flood control studies and implementation of preventative measures.

References

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Eichert Engineering

Texas Water Commission

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U.S. Army Corps of Engineers, Hydrologic Engineering Center

U.S. Army Corps of Engineers, Hydrologic Engineering Center

U.S. Army Corps of Engineers, Hydrologic Engineering Center
UNDERSTANDING STORM WATER MANAGEMENT

Andrew J. Reese
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Introduction

A number of communities are now developing storm water quality management programs in response to the mandates of Environmental Protection Agency (EPA) storm water regulations. Other communities are facing growing storm water flooding and infrastructure maintenance problems. Some are developing or quantifying their storm water programs in response to the National Flood Insurance Program Community Rating System. In these communities one major difficulty is understanding just what the term "storm water management" really means, how it works, and how to explain it to political and other staff leadership who may not have the technical background necessary to understand the finer points of flood and pollution control—and their part in it.

This paper presents an easy way to explain these topics using a popular total quality management (TQM) approach which asks five levels of "why" questions. Once problems are understood solutions become readily apparent.

The TQM Analysis

Storm water management is often distinguished from floodplain management in terms of the "direction" in which flood waters enter a structure or property. If the water is on its way to a major stream when it floods a property it is "storm water." If the water is rising up from a stream it is "flood water". Regardless, the property is damaged and help is sought from the same people: the municipal staff and political leadership.

It is vitally important to understand the linkage between physical problems and deeper institutional root causes of those problems. Many municipalities have not understood this linkage and, as a result, wrestle continuously with the same problems, never coming to final solutions. Figure 1 illustrates the dynamics of this technical-institutional relationship using the "five whys" methodology of a TQM consideration of storm water management.

Typically, a storm water administrator, public works engineer, or political leader gets a drainage complaint call: "I have a flooding problem and I want you to fix it." This is level 1: the complaint. The complaint could just as easily have been an erosion or pollution complaint. Following the same methodology of asking "why?" would eventually lead to the same conclusions about pollution and erosion problems.
With the question, "why is there a flooding problem?" (level 2), there is usually one of (or a combination of) four reasons: (1) obstructed or damaged structures; (2) high risk residence location; (3) undersized structures; or (4) more flow due to the impacts of urban development. A fifth reason is that the

Figure 1. A Total Quality Management analysis of storm water management.
flood simply exceeded the design of the system, though for smaller systems that is a very hard response both to quantify and explain to wet residents. The typical solution is to go out and fix the problem or, more commonly, to tell the resident that the problem is not the municipality's responsibility.

However, if the level 3 question is asked: "why did this flooding problem (and ones like it) occur in the first place?" a matching set of four more foundational reasons is uncovered.

Structures are obstructed or damaged because they are not inspected and maintained. Municipalities typically maintain very little of the drainage system. Most maintenance that is done is in response to complaints and performed within the street right-of-way only. Much of it is done only to protect streets or public property. The 50–80% of the drainage system closest to private houses and other structures is rarely or never inspected or maintained. This is true despite the fact that much of the water carried in these drainage systems is derived from public streets and is, in some sense, therefore, "public water." Over years of neglect pipes and channels inevitably begin to fill with debris and sediment, structures begin to weather or are damaged, and erosion eats away at culvert headwalls and tail sections. Drainage systems work flawlessly when it is not raining. Finally the system is tested and overwhelmed by a storm whose intensity is often less than the system was designed to carry. Homes are flooded, roads are overtopped, damage is incurred, complaints flood in.

Homes are located too close to streams because no one properly regulates the location. Because of the demands of the National Flood Insurance Program, most municipalities control the location and elevation of new construction within regulated flood plains. However, the vast number of complaints are received from residents remote from regulated flood plains in locations where there is no such control. Municipalities which would not consider allowing development within the 100-year floodplain below the mandatory flood protection elevation daily approve plans for developments where a number of homes, unwittingly located within unregulated flood plains, would be inundated by a smaller more localized 100-year floods.

Structures are undersized because of poor or inappropriate methodology and incomplete data. Most municipalities allow drainage structures to be sized using the Rational Method. While this is not wrong, per se, the limits of this method are rarely understood by designers and plans reviewers. In cases where backwater effects predominate or under other special circumstances such methods may give non-conservative results. Additionally, many municipalities have little data on actual rainfall values, inlet capacities, tidal influences or the actual expected future maintenance-related condition of structures. Without this information designers may produce inferior designs unknowingly.

Upstream development floods downstream development because it is not accounted for in the design of the downstream structures and/or it does not
account for itself far enough downstream in the drainage system. Few municipalities require designers to account for either their own flow-related impacts or for the flow increases from expected development located upstream. Higher and faster peaks, greater flow volumes, increased velocities, warmer and dirtier water and lower base flow are all the result of urban development. Those cities that do account for impacts with a detention ordinance or policy rarely assess the impacts beyond the site boundaries. Therefore the mitigative effect of the detention basin is not felt very far downstream; and the accumulative consequences of development even with detention results in growing systemic flooding problems.

If again the "why" question (level 4) is asked, three basic causative factors emerge. Cities do not require appropriate levels of technical analysis because they are not sure what to require and how to implement these requirements. In spite of the wealth of computer software for drainage system analysis and the ability to remotely collect rainfall and runoff information, most municipalities have not had the time nor the knowledge to investigate and invest in such solutions. Programs are often staffed on a day-to-day basis by junior or mid-level engineers without the authority or experience to make such changes. Their superiors have multiple other pressing duties and responsibilities and, without prompting and education, do not see storm water as having the same importance or the same clear solutions.

Cities do not impose certain flood mitigation measures, development controls or maintain off the public right-of-way because there is no legal authority to do so. And there is little impetus to establish such authority. To extend control of development beyond federal mandates or to extend maintenance beyond the bare minimums requires gaining the support of political leaders, key staff members, and "stakeholders." It is often difficult to stimulate such desires when so few of these individuals have anything clear to gain by doing so. EPA mandates, local citizen groups, and/or a big flood event are often the necessary catalysts to action.

Even if these last two factors were solved the bottom line is that there is no stable, adequate and equitable funding source for storm water management. Storm water usually cannot compete effectively with such things as solid waste and street repair for general tax-based funds. Therefore a shift toward dedicated funding is occurring throughout the country. This can take the form of such things as sales taxes, ear-marked tax revenues and user fee systems.

The more basic factors emerge with the fifth "why" question (level 5). Even when key storm water staff understand the problems they must ask: who else is aware that flooding, erosion or pollution problems exist? Who supports a growth in storm water management? Who must support it for a successful program to be established? The public is usually little aware of flooding problems and municipal staff have little long-term political support to solve such
problems. If actions are not taken and decisions not made within a month or two after a flood, support quickly dries up. Memories fade. Other pressing demands thrust aside flooding, erosion, and surface water pollution problems. And the problem remains, largely invisible, until the next time a large storm moves through the area. Building and maintaining consensus and support for the storm water program is necessary for its establishment and survival.

Level 6 describes the real foundational reason most municipal storm water programs fail. There is no focus on and vision for storm water. Historically most programs managed storm water as an additional duty for a street superintendent or as an add-on for the water and sewer department. This dispersed authority led to poor coordination, conflicts, overlaps, and gaps in storm water administration. In successful programs the storm water system is seen as a "public system" and a public responsibility, in every way equal to the waste water collection or water distribution systems. In order for this to be accomplished successfully three types of champion are needed: (1) a staff person with sufficient authority to make changes and impact political leaders but low enough in the organization to care about drainage; (2) a political leader with the insight and drive to see a program through its formative and growth stages; and (3) a citizens group or strong individual to marshall public influence when the inevitable cost or regulatory increases occur.

Notice that the first levels of assessment contain primarily physical and technical problems for which structural technical solutions are often appropriate. Water is impacted by some physical means—an enlarged channel, a cleaned sewer system, etc. However, when the later levels are considered, the problems and the solutions are institutional, programmatic, and non-structural in nature. People are impacted by administrative means. These foundational problems allow or generate the more visible physical problems. If the root institutional problems are not eventually solved there will be a continual need to respond to an overwhelming number of flooding, erosion, and pollution complaints. And the basic philosophy will continue to be that damage must be suffered before corrective action can be taken rather than taking preemptive action to avoid problems. Successful municipal storm water management programs account for and deal with both the technical and institutional aspects.
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Part Six

Codes, Construction Standards, and Building Performance
THE SBCCI DEEMED-TO-COMPLY STANDARD FOR SINGLE AND MULTIFAMILY DWELLINGS IN HIGH WIND REGIONS AS A VALUABLE ADDITION TO COASTAL FLOOD MANAGEMENT IN HAZARD MITIGATION

William W. Arnold, Jr.
Southern Building Code Congress International

Wind damage to constructed facilities exceeds $3 billion annually, and this figure is expected to rise with accelerated coastal development and the migration of people to hurricane-prone coastlines. Much of this damage can be attributed to inadequate resistance of nonengineered buildings to high winds. The SBCCI Deemed-to-Comply Standard provides prescriptive construction details intended to ensure structural integrity of single- and multi-family dwellings designed within certain specifications in building geometry, materials, and wind climate.

Hurricane Hugo in 1989 and Hurricane Andrew in 1992 dramatically demonstrated the effects of both wind and water on the built environment. These events have increased public awareness of the need for adequate construction in coastal areas. There is great need for coastal residential hazard mitigation in relation to high winds as well as to damaging water.

Since its inception in 1945, the Standard Building Code has recognized wind loads as a force to be considered in building design and construction. Over the years as wind disasters have occurred, continuing studies of the effects of high winds on structures have resulted in greater understanding of construction needs and in a series of significant building code changes. This concern was greatly expanded in the 1980s and generated a number of detailed and complex code requirements for both high-rise and low-rise buildings, including simple residential buildings.

Traditionally, registered professional designers have not been required by law for construction of single-family houses. Seldom has any consideration been given to wind-load protection for simple residential structures beyond rudimentary hurricane straps. With additional code emphasis on wind conditions has come realization that code requirements apply to all buildings, including nonengineered single-family houses. This impact applies not only to owners and builders, but also to designers, inspectors, and other code enforcement officials. It even affects housing-related fields such as the insurance industry and influences hazard mitigation professionals such as floodplain managers.

Recognizing the difficulties of understanding the increasingly complex design, construction, and inspection requirements of the evolving code concepts, a number of Southern Building Code Congress members determined that a simplified solution was needed for nonengineered residences and other simple residential buildings. Accordingly, a committee was formed representing all
these facets of the construction industry. The product of several years of work was published in late 1990 as the "Deemed-to-Comply Standard for Single and Multifamily Dwellings in High Wind Regions". The Standard provides a pre-engineered prescriptive method of solving the performance requirements of the code and has been deemed by SBCCI's Board of Directors to comply with the intent of the code's wind-load provisions.

The Deemed-to-Comply Standard may be used for all one- and two-story residential buildings having gabled or hipped roofs. The building width must be between 12 and 60 feet. Ceiling height may not exceed 20 feet; maximum eave height is 30 feet. Roof slope must be between 10 and 30 degrees; and maximum eave overhang is one foot at gables, four feet elsewhere. Specific requirements for building components are given for three maximum wind speed zones: 90 mph, 100 mph, and 110 mph, as determined by the standard wind speed map for a 50-year mean recurrence interval.

The Standard recognizes two basic kinds of building construction: (1) exterior walls of masonry and (2) exterior walls of wood frame. Interior partitions may be of any reasonable construction. Requirements are given for pile, stem wall, or slab-on-grade foundations; for concrete slab-on-grade, suspended concrete, or wood framed floors; and for roof framing of pre-engineered trusses or conventional rafter/ceiling joist construction. The Standard does not yet include specific requirements for roofing, siding, or opening protection other than those already covered by the code.

The Deemed-to-Comply Standard assumes that all gravity loads, both dead and live loads, have been accommodated by normal construction practices. It then addresses the two main conditions caused by high wind forces: uplift loads and horizontal loads. Each of these loads varies with wind speed.

Uplift is overcome by carefully connecting all load-bearing parts and pieces from the roof ridge to the foundation. Each construction member and each connecting device is carefully selected to transfer its share of the load. If any one piece fails under load, the entire building may be lost. The ultimate uplift load resistance is the combined and connected dead weight of all the structural components.

Horizontal wind loading resistance also requires a connected series of structural components. The exterior walls must resist bending stresses and transfer the load to the ground and to horizontal resisting elements of the construction. Floors, ceilings, and roofs act as very thin laterally loaded beams called diaphragms. These diaphragms must collect the applied loads and transfer them to shear walls at their ends. Shear walls must be built to transmit these loads in the plane of the wall, without racking, all the way into the foundations and ultimately into the ground. Again, strength of each component and each connection is essential to the chain of the load path.
All buildings, including simple single-family houses, must be designed and built to withstand the high winds as well as the high water to be expected in hurricane conditions. Building codes have addressed this problem. But effective implementation is dependent on the awareness, understanding, and attitude of a long list of people: architects, engineers, other designers, builders, construction workers, manufacturers, material suppliers, inspectors, plan reviewers, other code officials, property owners, property insurers, politicians, planners, developers, and even hazard mitigation specialists.

During 1992 a series of 22 two-day hurricane-resistant construction seminars were presented along the southeastern coastline from Brownsville, Texas, to Ocean City, Maryland. These courses were sponsored jointly by the Federal Emergency Management Agency, NCPI, and SBCCI, and were attended by approximately 600 students representing all areas of the construction industry. The seminars dealt with hurricane action, the effects of both water and wind on buildings, FEMA's requirements for residences in V zones and A zones, and an in-depth study of the use of the Deemed-to-Comply Standard, which included an SBCCI-produced video on the subject. In 1993, FEMA and NCPI have agreed to underwrite eight additional basic seminars and advanced study courses.

The validity of the Standard is proven through this endorsement by FEMA and NCPI and was further enhanced when FEMA agreed to allow its use in lieu of architect or engineer certification of wind load design in the V zone. Reception of the Standard by designers, code enforcement officials, and property insurers has been overwhelmingly positive. The reaction of builders has ranged all the way from enthusiastic acceptance to misunderstood rejection. Further education is needed.

SBCCI has developed the Deemed-to-Comply Standard as an effective tool for wind resistance in simple residential buildings. In those areas where it is accepted and used, tragic loss of life and property can be avoided at very little extra construction expense and without expensive engineering costs.
Introduction

On September 22, 1992, at the request of the Mayor of Kauai County, the Federal Coordinating Officer for the Iniki disaster tasked the Federal Insurance Administration (FIA) to assemble a team of experts to assess the performance of buildings. The team assembled by FIA included staff from the Federal Emergency Management Agency Headquarters and Region IX, representatives of the State of Hawaii Office of Civil Defense and Kauai County, and registered professional engineers and architects from both Kauai and Oahu. The team's task was to survey the performance of primarily residential structures under wind and flood forces generated during Hurricane Iniki. The goal of this effort was to provide guidance and offer recommendations for reducing damage from future hurricanes. This goal was best met through learning from both failures and successes of building performance.

During the field assessment, the team investigated primary structural systems. For all buildings, the performance of exterior architectural systems, such as roofing, windows, and doors, was analyzed. The analysis also included the effects of windborne and waterborne debris and the quality of construction and materials. The majority of building types observed were one- and two-story, wood-frame, single-family and multi-family residential structures. However, pre-engineered steel commercial and industrial buildings, as well as resort hotels and condominiums constructed of reinforced concrete and masonry, were also examined.

Wind Forces

Noteworthy examples of adequately engineered and constructed buildings were observed in Kauai County. Almost without exception, successful performance resulted from clearly defined and continuous load transfer paths from the roof to the foundation. A well-designed load transfer path depends primarily on the proper type, size, and attachment of connections between the critical components of a building (for example, between the roof and walls and between the walls and foundation). Where connections, such as hurricane clips
and metal straps on wood-frame structures, were adequately sized and correctly applied, buildings performed relatively well.

Incomplete design and construction for load transfer and improper connections, especially between the roof and walls, were found to be the most important factors causing structural failure of buildings due to uplift wind forces. Consistently, a building’s structural integrity was compromised through the action of uplift forces on insufficiently designed and connected roof and wall systems. Loss of roof cladding (e.g., shingles), roof sheathing (e.g., plywood), and other building components provided a source of airborne projectiles that contributed to the overall damage. In many instances, loss of glazing (e.g., glass doors and windows), either from direct wind pressure or from debris impact, resulted in a breach of the building envelope, subsequent uncontrolled internal direct wind pressures, and progressive structural failure.

Much of the damage to structures caused by wind forces resulted from incomplete design, reliance on outdated methods of construction, and/or misapplication of various building materials. Many of these problems can be addressed by training and education programs that promote prudent building design and construction practices throughout Kauai County. This is especially true for buildings in bluff and oceanfront areas exposed to accelerated wind forces.

Flood Forces

In coastal floodplains and coastal high hazard areas, the obvious primary cause of building failure was direct wave impact (hydrodynamic forces) on buildings whose lowest floors had been constructed directly on the ground surface. Low-lying oceanfront buildings situated somewhat landward of the shoreline and having lowest floors elevated above the flood hazard fared much better than ground-level buildings immediately adjacent to the shoreline. Waterborne debris, such as lava boulders and debris from damaged non-elevated buildings, increased damage to adjacent buildings.

Recommendations

The Building Performance Assessment Team’s recommendations, examples of which are provided as Figures 1, 2, and 3, are presented in Building Performance: Hurricane Iniki in Hawaii. The team’s recommendations can be summarized as follows:

- Design all architectural elements to resist the same wind forces as the primary structural systems.
Figure 1. Post on concrete bearing pad.

Figure 2. Post on concrete bearing pad in flood prone areas subject to scour. Bottom of concrete socketed into lava rock for increased lateral resistance.
Figure 3. Construction methods for galvanized roofing for reducing wind damage.
- Provide adequate means and methods to ensure the structural integrity of a building by constructing properly engineered buildings which consider the continuous load transfer path of a structure from roof to foundation. To ensure the integrity of the load transfer path for wood-frame construction, metal fasteners ("hurricane clips") and straps must be adequately sized and properly installed.

- Construct and properly engineer buildings such that they protect, or contain adequately designed, glasswork in exposed areas; adhere to nailing and attachment requirements for roof sheathing, roof cladding, and windows and doors; and provide routine maintenance of building components, including repair and replacement of damaged elements.

- In areas subject to flooding, elevate buildings above predicted flood heights on properly designed and constructed foundations. Minimize the sources of future debris by appropriately designing and locating site improvements such as stone walls.

- Provide a program of training and continuous education to code enforcement officials, plan reviewers, inspectors, supervisors, and others who are charged with implementing the recommendations noted above. Provide companion training and education programs for homeowners, building contractors, and design professionals in the proper construction techniques for mitigation of wind and flood hazards.

- Building trade associations, labor associations, etc., should provide continuing education programs for updating their members concerning revisions to building codes under which they are performing their trades.

For copies of *Building Performance: Hurricane Iniki in Hawaii*, contact:
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HURRICANE ANDREW, DADE COUNTY, FLORIDA
BUILDING PERFORMANCE ASSESSMENT TEAM

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Introduction

On August 24, 1992, Hurricane Andrew struck southern Dade County, Florida, generating high winds over a vast area of the county. Although the storm produced high winds and high storm surge, the effects of storm surge and wave action were limited to a relatively small area of the coastal floodplain. It was evident from the extensive damage caused by wind, however, that wind speeds were significant and widespread.

In September 1992, the Federal Insurance Administration (FIA), at the request of the Federal Emergency Management Agency (FEMA) Disaster Field Office staff, assembled a Building Performance Assessment Team (hereinafter "Assessment Team") composed of FEMA Headquarters and Regional staff, professional consulting engineers, and a Metro Dade County building official. Its task was to survey the performance of residential buildings in the storm’s path and to provide findings and recommendations to both the Interagency Hazard Mitigation Team and the Dade County Building Code Task Force. The team invested over 1,500 hours conducting the site survey, preparing documentation, and assessing damages. Documentation of findings of ground level and aerial surveys included field notes, photographs, and videotapes.

Wind Forces

The Assessment Team investigated primary structural systems of buildings, i.e., systems that support the building against all lateral and vertical loads. The building types observed were one- and two-story light wood-frame; masonry wall; combination masonry first floor with light wood-frame second floor; wood-frame modular; and manufactured homes. In general, masonry buildings and wood-frame modular buildings performed well.

In addition, the performance of the exterior architectural systems, such as roofing, windows, and doors, was analyzed. The analysis included the effects of debris and the quality of construction workmanship. The breaching of the building envelope by failure of openings (e.g., doors, windows) due to debris impact and direct wind pressure was a significant factor in the damage to many buildings. These failures allowed a buildup of internal air pressure that resulted
Figure 1. Primary wood framing systems: walls, roof diaphragm, and floor diaphragm.
Figure 2. Typical installation of plywood openings protection for wood-frame building to reduce damage from windborne projectiles.
in further deterioration of the building's integrity. Failure of manufactured homes and other metal-clad buildings generated significant debris. Numerous accessory structures, such as light metal porch and pool enclosures, carports, and sheds, were destroyed by the wind and further added to the debris.

The loss of roof material and roof sheathing and the failure of windows and doors exposed interiors of buildings to further damage from wind and rain. The result was significant damage to building interiors and contents that rendered many buildings uninhabitable.

Field observations concluded that the loss of roof cladding was the most pervasive type of damage to buildings in southern Dade County. To varying degrees, all of the different roofing types observed suffered damage due to the failure of the method of attachment and/or material, inadequate design, inadequate workmanship, and missile (debris) impact.

Much of the damage to the primary structural systems of residential buildings was considered to be a result of inadequate design, substandard workmanship, and/or misapplication of various building materials. Inadequate load transfer was a major cause of the observed structural failures of buildings. In adequately designed and constructed buildings, the load transfer path is clearly made. Proper connections between critical components allow for the safe transfer of loads that is required for structural stability. Where high-quality workmanship was observed, building performance was significantly improved.

Inadequate county review of construction permit documents, county organizational deficiencies, such as a shortage of inspectors and inspection supervisors, and the inadequate training of the inspectors and supervisors are factors that may have contributed to the poor-quality construction observed.

**Recommendations**

The Assessment Team developed recommendations for reducing future hurricane damage such as that resulting from Hurricane Andrew. The recommendations, which are presented in *Building Performance: Hurricane Andrew in Florida*, addressed building materials, construction techniques, code compliance, quality of construction, plan review, inspection, and reconstruction/retrofit efforts. Examples of the level of technical guidance provided in these recommendations are shown in Figures 1 and 2. Such recommendations may also have application in other communities in Florida.

For copies of *Building Performance: Hurricane Andrew in Florida*, contact:

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Part Seven

Administrative Techniques
PRIORITIZATION METHOD FOR SHOAL REMOVAL PROJECTS*

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Introduction

The South Florida Water Management District (District) operates and maintains a regional system of canals and structures for flood control and water supply. Most of this canal network was designed and constructed by the U.S. Army Corps of Engineers (Corps) as the Central and Southern Florida Flood Control project. The District operates and maintains these canals according to criteria established by the Corps. Although shoal removal operations are normally handled as a routine function of the District’s maintenance program, a prioritization procedure is necessary to determine the order of urgency for implementation of remedial shoal removal projects outside the scope of regular in-house District forces. A prioritization scheme was developed and tested for this purpose. While the focus of our work was on shoal removal projects, the general principles employed in developing and testing the prioritization method may be applicable to other types of projects.

Objectives

The primary objective of this effort was to develop a defensible prioritization method which can be easily understood by policy makers and readily applied by operation and maintenance personnel. In addition, in order to ensure the usability of the method, care was taken to restrict data requirements to those which are readily available or easily acquired.

Methodology

The prioritization methodology employs a two-step scheme. The selection step acts as a filter to isolate, from a large number of shoals, those that are

*The authors thank the many people who reviewed and made comments on this method. Special thanks to the Canal Conveyance Capacity Task Force Members (John Adams, Jim Lane, Robert Laura, John Leslie, Victor Powell, Joe Schweigart, Robbie Speers, and Carl Zeis) and the District’s Operation and Maintenance personnel, whose experience and expertise formed the basis for calibrating the method, and to Joel VanArman for his help in putting the document together.
significant enough to warrant remedial action. The prioritization step determines the order in which shoals will be addressed, based on a number of criteria. A high-priority shoal requires immediate action, while a low-priority shoal may be addressed later. The primary advantage of this two-step approach is the ability to narrow the range of projects for consideration through the selection process, by discarding shoals which are deemed insignificant. This reduces data collection and analysis and simplifies the prioritization process.

**Selection Step**

This step distinguishes between projects which will be done and those which will not, based exclusively on hydraulic characteristics. Because of south Florida's flat topography, channel flows are predominantly low velocity and subcritical. When subcritical flow in an open channel encounters shoaling, the flow area is reduced, creating higher flow velocities and a backwater effect upstream of the shoal. Because the resulting increases in water surface elevation may reduce rates of inflow from secondary canals and may cause canals to flow out of bank, increases in water surface profile from shoaling are used as selection criteria, to identify significant shoals for removal.

Rigorous calculation of water surface profiles requires extensive survey data and a complete hydraulic analysis. Since available hydraulic data were generally limited to longitudinal canal bottom profiles and canal design characteristics, a number of simplifying assumptions were necessary. Canal reaches with constant design characteristics (e.g., cross-section, flows, and roughness) and roughly constant depths of shoaling were isolated and analyzed independently of any other shoals in the channel. The canal cross-section downstream of the shoal was assumed to be the same as the design cross-section. This was designated the control cross-section because flow is subcritical. The cross-sections impacted by shoaling were represented by the design cross-section with a shoal of uniform depth deposited on the bottom. Since the canal bottom slopes in this region are very small and often equal to zero, all isolated canal reaches were assumed to be flat.

Water depths were computed by trial and error, upstream and downstream of each shoal using the one-dimensional energy equation for steady, incompressible flow. Figure 1 illustrates this analysis, where cross-section (1) depicts a downstream cross-section and cross-sections (2) and (3) depict shoals. These computations were encoded in a spreadsheet for easy application. Figure 2 shows the input and output display from the spreadsheet. IWS represents the increase in water surface elevation between design conditions at cross-section (1) and shoal conditions at cross-section (3). Increased water surface elevation, expressed as a percentage of design depth of flow (ISP) is also computed. Two additional parameters, KCONV and EXL, are provided. KCONV represents the
Branscome and Guardo

Figure 1. Schematic of Hydraulic Calculations for Selection Step

\[
\begin{align*}
\text{Energy Gradient} \quad \text{Hydraulic Gradient} \\
\frac{v_3^2}{2g} \quad \frac{v_1^2}{2g}
\end{align*}
\]

(1) \[ y_1 + \frac{v_1^2}{2g} + K\text{EXP} \cdot \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g} \] (solve for \( y_2 \))

(2) \[ y_2 + \frac{v_2^2}{2g} + HF + K\text{CON} \cdot \frac{v_3^2}{2g} = y_3 + \frac{v_3^2}{2g} \] (solve for \( y_3 \))

(ISP = 2.67 %) (IWS = 0.64 feet)

Figure 2. Input/Output Display from Spreadsheet Program for Selection Step.
ratio of design conveyance to existing (shoal) conveyance and EXL is the excess energy loss created by the shoal. Sample calculations for shoals in the C-7 canal, Dade County, Florida, are presented in Table 1. Canal selections are based on IWS values; other parameters are provided as background information.

Table 1. Sample calculations for shoals in the C-7 canal, Dade County, Florida.

<table>
<thead>
<tr>
<th>Canal Reach (Stations)</th>
<th>BW (ft)</th>
<th>Design Bottom Elev. (ft NVD)</th>
<th>Design Water Elev. (ft NVD)</th>
<th>DD (ft)</th>
<th>z</th>
<th>n</th>
<th>L shoal length (ft)</th>
<th>YS ave. shoal depth (ft)</th>
<th>YS/ DD</th>
<th>KCON</th>
<th>KEXP</th>
<th>O</th>
<th>ISP (%)</th>
<th>IWS (ft)</th>
<th>EXL (ft)</th>
<th>KCON</th>
</tr>
</thead>
<tbody>
<tr>
<td>67+00· 84+00</td>
<td>40</td>
<td>-22.0</td>
<td>2.00</td>
<td>24.00</td>
<td>0.25</td>
<td>0.035</td>
<td>1700</td>
<td>4.0</td>
<td>0.17</td>
<td>0.3</td>
<td>0.5</td>
<td>3710</td>
<td>2.67</td>
<td>0.64</td>
<td>0.33</td>
<td>1.22</td>
</tr>
<tr>
<td>84+00· 98+00</td>
<td>40</td>
<td>-22.0</td>
<td>2.40</td>
<td>24.40</td>
<td>0.25</td>
<td>0.035</td>
<td>1400</td>
<td>4.9</td>
<td>0.20</td>
<td>0.3</td>
<td>0.5</td>
<td>3585</td>
<td>2.17</td>
<td>0.53</td>
<td>0.32</td>
<td>1.28</td>
</tr>
<tr>
<td>98+00· 114+70</td>
<td>40</td>
<td>-22.0</td>
<td>2.85</td>
<td>24.85</td>
<td>0.25</td>
<td>0.035</td>
<td>1670</td>
<td>3.3</td>
<td>0.13</td>
<td>0.2</td>
<td>0.4</td>
<td>2410</td>
<td>1.69</td>
<td>0.42</td>
<td>0.19</td>
<td>1.17</td>
</tr>
<tr>
<td>116+00· 148+00</td>
<td>40</td>
<td>-22.0</td>
<td>3.66</td>
<td>25.66</td>
<td>0.25</td>
<td>0.035</td>
<td>2700</td>
<td>4.4</td>
<td>0.17</td>
<td>0.3</td>
<td>0.5</td>
<td>3140</td>
<td>2.22</td>
<td>0.57</td>
<td>0.27</td>
<td>1.23</td>
</tr>
<tr>
<td>141+00· 210+00</td>
<td>40</td>
<td>-22.0</td>
<td>3.98</td>
<td>25.98</td>
<td>0.25</td>
<td>0.035</td>
<td>6700</td>
<td>4.6</td>
<td>0.18</td>
<td>0.3</td>
<td>0.5</td>
<td>2660</td>
<td>3.54</td>
<td>0.92</td>
<td>0.25</td>
<td>1.22</td>
</tr>
<tr>
<td>210+00· 230+00</td>
<td>40</td>
<td>-22.0</td>
<td>4.30</td>
<td>26.30</td>
<td>0.25</td>
<td>0.035</td>
<td>2000</td>
<td>2.7</td>
<td>0.10</td>
<td>0.2</td>
<td>0.4</td>
<td>2420</td>
<td>0.72</td>
<td>0.19</td>
<td>0.07</td>
<td>1.13</td>
</tr>
<tr>
<td>263+00· 304+00</td>
<td>40</td>
<td>-15.0</td>
<td>4.85</td>
<td>19.85</td>
<td>2</td>
<td>0.035</td>
<td>2100</td>
<td>2.5</td>
<td>0.13</td>
<td>0.2</td>
<td>0.4</td>
<td>2110</td>
<td>0.96</td>
<td>0.19</td>
<td>0.05</td>
<td>1.07</td>
</tr>
<tr>
<td>304+00· 335+00</td>
<td>40</td>
<td>-14.0</td>
<td>4.92</td>
<td>19.82</td>
<td>2</td>
<td>0.035</td>
<td>5100</td>
<td>2.5</td>
<td>0.13</td>
<td>0.2</td>
<td>0.4</td>
<td>1910</td>
<td>1.82</td>
<td>0.36</td>
<td>0.06</td>
<td>1.06</td>
</tr>
<tr>
<td>335+00· 340+00</td>
<td>40</td>
<td>-14.0</td>
<td>5.16</td>
<td>19.16</td>
<td>2</td>
<td>0.035</td>
<td>500</td>
<td>2.0</td>
<td>0.10</td>
<td>0.2</td>
<td>0.4</td>
<td>1500</td>
<td>0.21</td>
<td>0.04</td>
<td>0.02</td>
<td>1.07</td>
</tr>
<tr>
<td>445+00· 487+00</td>
<td>20</td>
<td>-11.0</td>
<td>6.00</td>
<td>17.00</td>
<td>2</td>
<td>0.035</td>
<td>4200</td>
<td>2.2</td>
<td>0.13</td>
<td>0.2</td>
<td>0.4</td>
<td>580</td>
<td>0.35</td>
<td>0.06</td>
<td>0.01</td>
<td>1.09</td>
</tr>
<tr>
<td>487+00· 498+00</td>
<td>20</td>
<td>-11.0</td>
<td>6.03</td>
<td>17.03</td>
<td>2</td>
<td>0.035</td>
<td>1100</td>
<td>1.9</td>
<td>0.11</td>
<td>0.2</td>
<td>0.4</td>
<td>340</td>
<td>0.06</td>
<td>0.01</td>
<td>0.00</td>
<td>1.08</td>
</tr>
</tbody>
</table>

The foregoing analysis permits an early estimate of changes in water surface profile and energy losses which may be used for comparative purposes. Once shoals are selected and prioritized, a complete hydraulic analysis is performed before shoal removal works are initiated.

**Prioritization Step**

Shoals selected by the foregoing process are prioritized based on potential impacts of increased flood risk on the affected watershed. Four parameters were selected to represent the characteristics that an 'expert' water resource manager would use in prioritizing shoals: severity of flooding, potential water resource impacts of shoal removal, local stormwater management capability, and the population of the watershed.

Severity ($P_s$) is a measure of the intensity of land uses in the affected watershed and the susceptibility of those uses to flooding. Resource Impacts ($P_r$) measures the impact of sediment removal, spoil disposal and increased canal conveyance capacity on wellfield recharge, water quality, and natural systems. This parameter allows a project to be credited or penalized for multi-objective benefits or liabilities. Local Stormwater Management ($P_L$) is a measure of a local community’s ability and commitment to provide local flood protection to the affected area. The District manages and maintains the regional water management system and local governments are responsible for ensuring that local water management systems are adequate. This parameter is an indicator of how well the local and regional systems are integrated and how sensitive local
flood protection is to changes in the regional system. Population \((P_p)\) is a measure of the number of people living within the canal service area, whose homes and access to and from home are potentially affected by flooding in the watershed.

Additional parameters may be used, but care must be taken to avoid repeating characteristics already represented by existing parameters. This would implicitly bias the process. Biases are prescribed explicitly by assigning relative weights to the parameters. (This is described in greater detail in the Calibration and Testing section.)

Methods for computing these parameters are provided in the "Canal Conveyance Capacity Worksheets." A sample calculation for C-7 canal is provided in Appendix A. In developing the computation methods, it was important to use readily available information. Since data availability varies widely throughout the District, an attempt was made to use information that experienced, District staff would have or be able to estimate. This approach seeks to avoid spending an inordinate amount of resources gathering detailed information about projects which may not have high priority. In addition, data collection can easily become a bottleneck in this process if the data requirements are too extensive. Where data are not readily available, we rely on experience and judgment of technical experts. Once parameters are computed, they are combined by weighted average to produce a single prioritization factor, \(T_r\).

\[
T_r = \frac{P_s W_s + P_r W_r + P_L W_L + P_p W_p}{W_s + W_r + W_L + W_p}
\]

where \(W_s, W_r, W_L, \) and \(W_p\) are weights for severity, resource impacts, local stormwater management, and population, respectively. \(T_r\) is computed for all watersheds that pass the selection step. A watershed's \(T_r\) value determines its priority relative to other watersheds being evaluated, where a high \(T_r\) value gives a watershed a high priority.

**Calibration and Testing**

If the method is successful, the resulting priorities should agree with choices that are made by an expert water manager. We used a calibration procedure in which a panel of District experts (the Canal Conveyance Capacity Task Force) was required to rank eight watersheds. Values of \(W_s, W_r, W_L\) and \(W_p\) were then selected and adjusted until results of the prioritization process matched the results of the experts' ranking. The selected weights were: \(W_s=6, W_r=1, W_L=1\) and \(W_p=1\). These weights represent the relative importance that
our experts intuitively ascribe to the various parameters. In our case, severity is the most important parameter.

The validity of the method was tested by applying it to three additional watersheds and verifying the consistency of the resulting ranking relative to the previous eight watersheds. Once again, we relied on the panel of experts to verify the results of the method. The authors propose testing this method with additional watersheds before fixing final values for the weights. Once weights are set, they should not be changed, unless a major flaw is uncovered.

Conclusions

A method for selecting and prioritizing shoal removal projects was developed and preliminary testing was conducted. The method provides a systematization of the decision-making process and a simple, direct articulation of the rationale underlying these decisions.

While the method is specifically tailored for shoal removal projects, the parameters and criteria may be adapted to a variety of water resource projects. The method is relatively easy to apply and can be individualized to reflect the values and priorities of an agency and the public it serves. It is intended to use readily available information, engineering judgment and experience.

References

Chow, V. T.  

U.S. Army Corps of Engineers  

U.S. Army Corps of Engineers  

U.S. Army Corps of Engineers  
APPENDIX A

CANAL CONVEYANCE CAPACITY PRIORITIZATION WORKSHEETS*

Canal Name: C-7 Canal
Location: Dade County, Florida
Description: This canal serves a highly developed urban watershed

SUMMARY OF RESULTS:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (2)</th>
<th>Weight (3)</th>
<th>(2) x (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity (Ps)</td>
<td>1.73</td>
<td>6</td>
<td>10.38</td>
</tr>
<tr>
<td>Resource Impacts (Pr)</td>
<td>0.00</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>Local Stormwater Management (PL)</td>
<td>6.00</td>
<td>1</td>
<td>6.00</td>
</tr>
<tr>
<td>Population (Pp)</td>
<td>8.00</td>
<td>1</td>
<td>8.00</td>
</tr>
</tbody>
</table>

TOTAL = 24.38

\[ T_r = \frac{\text{TOTAL}}{9} = 2.71 \]

SEVERITY PARAMETER (Ps)

<table>
<thead>
<tr>
<th>Uses</th>
<th>% area occupied (1)</th>
<th>% use inundated (2)</th>
<th>weights (3)</th>
<th>(1)x(2)x(3) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (Buildings)</td>
<td>61.0</td>
<td>30</td>
<td>0.10</td>
<td>48.80</td>
</tr>
<tr>
<td>Residential (Sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial (Buildings)</td>
<td>7.0</td>
<td>30</td>
<td>0.08</td>
<td>4.48</td>
</tr>
<tr>
<td>Commercial (Sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial (Buildings)</td>
<td>10.5</td>
<td>30</td>
<td>0.06</td>
<td>5.04</td>
</tr>
<tr>
<td>Industrial (Sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Essential Services (Facilities)</td>
<td>8.0</td>
<td>40</td>
<td>0.10</td>
<td>6.40</td>
</tr>
<tr>
<td>Essential Services (Access)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensive Agriculture</td>
<td>1.0</td>
<td>90</td>
<td>0.06</td>
<td>5.40</td>
</tr>
<tr>
<td>Intermediate Agriculture</td>
<td>0.5</td>
<td>90</td>
<td>0.04</td>
<td>1.80</td>
</tr>
<tr>
<td>Non-intensive Agriculture</td>
<td>0.5</td>
<td>90</td>
<td>0.02</td>
<td>0.90</td>
</tr>
<tr>
<td>Recreation/Open Space</td>
<td>6.0</td>
<td>30</td>
<td>0.01</td>
<td>1.80</td>
</tr>
<tr>
<td>Vacant/Undeveloped</td>
<td>5.5</td>
<td>30</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Roads</td>
<td>N/A</td>
<td>35</td>
<td>3.00</td>
<td>105.00</td>
</tr>
</tbody>
</table>

TOTAL = 258.72

\[ T_s = \frac{\text{TOTAL}}{3} = 86.24 \]

Duration: (select one)

<table>
<thead>
<tr>
<th>Duration</th>
<th>&lt; 1 week</th>
<th>&gt; 1 week</th>
<th>&gt; 1 month</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D_s)</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

\[ P_s = 0.02 \times D_s \times T_s = 1.73 \]

* text and numbers in italics represent actual data for the C-7 canal basin
RESOURCE IMPACT PARAMETER (P_r)

<table>
<thead>
<tr>
<th>Resource Impact</th>
<th>This change will make conditions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>How will sediment removal and spoil disposal affect recharge to an aquifer and/or delivery capability to wellfields?</td>
<td>1. better ( + 1) 2. no change (0) 3. worse (-1)</td>
</tr>
<tr>
<td>How will increasing conveyance affect recharge to an aquifer and/or delivery capability to wellfields?</td>
<td>0</td>
</tr>
<tr>
<td>How will sediment removal and spoil disposal affect water quality?</td>
<td>0</td>
</tr>
<tr>
<td>How will increasing conveyance affect water quality?</td>
<td>0</td>
</tr>
<tr>
<td>How will sediment removal and spoil disposal affect natural systems?</td>
<td>0</td>
</tr>
<tr>
<td>How will increasing conveyance affect natural systems?</td>
<td>-1</td>
</tr>
</tbody>
</table>

TOTAL (algebraic sum of 3 columns) = x = -1

For each potential impact place the appropriate score in column (1), (2) or (3). Calculate the total score (x) by adding the scores from all three columns. The parameter value, P_r, is obtained from the following relationships:

(a) If the total score (x) is a positive number and all of the individual scores are positive or zero, then, \( P_r = x + 4 \)
(b) If the total score (x) is a positive number and some of the individual scores are negative, then, \( P_r = x \)
(c) If the total score is a negative number, the parameter value, P_r equals zero.

\[ P_r = 0 \]

LOCAL LEVEL STORMWATER MANAGEMENT (P_L)

This parameter is an indicator of the level of interest and participation in providing local flood protection. Please assign scores ranging from 1-10 to each of the following three categories: (A score of 10 indicates the highest degree of local level stormwater management.) The value (P_L) is obtained by adding the three individual scores and dividing by three.

<table>
<thead>
<tr>
<th>Local Stormwater Management</th>
<th>Score (1 - 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ability of the local stormwater management system, by virtue of its design, operation and maintenance, to deliver stormwater runoff to the regional canal.</td>
<td>2</td>
</tr>
<tr>
<td>The availability of funding for local stormwater management.</td>
<td>8</td>
</tr>
<tr>
<td>Level of current and future stormwater master planning in the area.</td>
<td>8</td>
</tr>
</tbody>
</table>

TOTAL = 18

\[ P_L = \frac{\text{TOTAL}}{3} = \frac{18}{3} = 6 \]

**POPULATION PARAMETER (P_p)**

<table>
<thead>
<tr>
<th>Population</th>
<th>P_p</th>
<th>Population</th>
<th>P_p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 999</td>
<td>1</td>
<td>100,000 - 149,999</td>
<td>6</td>
</tr>
<tr>
<td>1000 - 4999</td>
<td>2</td>
<td>150,000 - 199,999</td>
<td>7</td>
</tr>
<tr>
<td>5000 - 9999</td>
<td>3</td>
<td>200,000 - 249,999</td>
<td>8</td>
</tr>
<tr>
<td>10,000 - 49,999</td>
<td>4</td>
<td>250,000 - 299,999</td>
<td>9</td>
</tr>
<tr>
<td>50,000 - 99,999</td>
<td>5</td>
<td>&gt; 300,000</td>
<td>10</td>
</tr>
</tbody>
</table>

Select the appropriate value of \( P_p \) from the adjacent table.

\[ P_p = 8 \]

* text and numbers in italics represent actual data for the C-7 canal basin
WASHINGTON STATE'S FLOOD CONTROL
ASSISTANCE ACCOUNT PROGRAM

David K. Carlton
KCM, Inc.

Introduction

In the past 20 years, six large storms in the State of Washington have caused widespread flood damages in several river basins. Each of these events caused millions of dollars in damage, with the 1986 and 1990 events being the most significant. Historically the state has assisted local governments in the construction and maintenance of flood control facilities such as levees, dikes, pump stations, and dams. During the 1980s, the state realized that many communities had adopted no plan or process to deal with flooding. All flood-control projects were site-specific and completed on an ad hoc basis. Since 1986, the Washington State Department of Ecology (Ecology) has been providing grant money to municipalities throughout the state to assist them in developing Comprehensive Flood Hazard Management Plans (CFHMP). The development and adoption of these plans by local entities and their approval by Ecology are requirements for approval of new grants to local entities for maintenance or replacement of flood control facilities. The plans must be comprehensive in scope, address both non-structural and structural alternatives, and include the entire 100-year floodplain in the planning area (Ecology, 1991).

These requirements, together with the impacts of several recent major floods in western Washington, have led to a significant change in the way many communities approach floodplain management and flood control. This paper discusses the purpose of the program, the required components of the plan, and findings from KCM’s experience in creating, adopting, and implementing plans in several small communities. The primary focus is on the benefits to the public when communities comprehensively examine their policies and procedures related to floodplain management in the context of physical and fiscal realities. The programs developed under this process are realistic from an economic and public policy aspect; they are designed to fit the physical realities of the communities.

Requirements of a Comprehensive Plan

Ecology has set minimum standards for development of Comprehensive Flood Hazard Management Plans. The standards and procedures were developed to ensure that the final plan meets the local community’s needs, is
environmentally sound, reflects the realities of existing problems and the regulatory climate, and can be implemented. The standards are:

- citizen involvement throughout the planning process,
- interagency coordination,
- establishment of goals and objectives for the plan and the planning process,
- review of all pertinent Federal, State and local regulations,
- research into past studies and projects,
- determination of the need for flood hazard management measures (problem identification),
- identification of management alternatives,
- analysis of alternatives for environmental and fiscal impacts,
- development of recommendations, and
- prioritization of recommended actions.

Citizen Involvement

Because these plans are comprehensive and many competing ideas arise as to how best to deal with flooding, Ecology has mandated that local citizens be involved in the decision-making process. This is accomplished through establishment of a citizens' advisory committee, whose members typically represent property owners, habitat managers, local Indian tribes, politicians, and public works officials. This involvement ensures that community concerns are addressed and allows for better education on flood hazard management for policy makers and citizens. The more diverse the group, the more likely it is that the final plan will represent implementable consensus.

Interagency Coordination

Representatives from regulatory agencies, the U.S. Army Corps of Engineers (Corps) and the U.S. Department of Agriculture's Soil Conservation
Service (SCS) frequently asked to participate in the process to ensure that their concerns and abilities to help implement the alternatives are properly considered.

**Goals and Objectives**

Each plan must target a set of short-term and long-range goals and objectives for management of the floodplain. Common goals are minimizing the expenditure of public funds, preventing the loss of life and property, avoiding new problems, preserving the river’s character, and promoting multiple uses of the floodplain that are compatible with flooding (KCM, 1991). These policies are typically developed by the citizens’ committee and recommended to the local governing body.

**Federal, State, and Local Regulations**

All applicable regulations are summarized in each report. These include such things as the National Flood Insurance Program (NFIP), Corps 404 permits, and applicable state permits. On average, approximately 20 sets of regulations are described. A concise, comprehensive presentation of permit requirements and mitigation required for the protection of fish habitat proves helpful in the decision-making process. Many people are unaware of the myriad of agencies requiring permits for any construction within a floodplain. State and local regulations often rule out options that are common in other parts of the country (e.g., dredging or concrete channels).

**Past Studies and Projects**

The Corps, the U.S. Geological Survey (USGS), and the SCS performed many studies for communities throughout the state. Frequently, their recommendations were not implemented because the projects were unacceptable to the community or funds were unavailable. But these studies typically generated a great deal of hydrologic, hydraulic, and survey data that remain useful. Historical flood data and economic data are also commonly available. Using this information can greatly reduce the cost of developing the CFHMP and it offers consultants preparing the plan some insight into the community’s values.

**Determine the Need for Flood Hazard Management Measures**

Problems attributable to flooding must be identified and their severity determined. Riverine flooding, stormwater management problems, water quality
issues, streambank erosion, mudflows, and alluvial fan flooding must be identified and their severity assessed. This allows determination of whether the community’s flood hazards management program should be changed as well as the selection of a range of alternatives that could solve the problems.

**Identify Management Alternatives**

Generic management alternatives are usually developed for the community’s consideration. Alternatives such as levees, groins, gravel bar scalping, floodproofing, and open space preservation are presented with descriptions of how each is used, the problems they would address, their environmental and fiscal impacts, and the permits that would be required.

**Analyze Alternatives for Acceptability**

From the list of generic alternatives, communities develop and rank a list of acceptable alternatives. They use this list to identify one or more alternatives as potential solutions to the problems previously identified. These alternatives are analyzed in detail to determine their fiscal and environmental impacts, and a solution is recommended by the citizens’ committee.

**Development of Recommendations**

Final recommendations are based on a set of criteria that allows comparison of the alternatives. The following criteria are frequently used to select and prioritize site-specific measures for implementation:

- Does the alternative solve the flooding problem? Only alternatives that resolve the problem are considered.

- Is the alternative a permanent solution? Preference is given to permanent solutions.

- Can the community afford the alternative? Funding limitations are very common.

- What are the environmental benefits or costs of the alternative? Preference is given to alternatives that enhance the natural environment.

- Is the alternative the most cost-effective of the appropriate solutions? Alternatives that resolve the problem at the lowest long-term cost are preferred over more expensive solutions.
Does the alternative allow multiple use? Alternatives that offer multiple use (e.g., parks, trails, habitat, or agricultural use) are preferred over single-purpose features.

The criteria that are developed are used to recommend one or more of the alternatives for implementation.

**Prioritize Recommended Actions**

Each plan must include a set of recommended actions, which usually include modifications to existing ordinances, development of educational programs, floodproofing or relocating structures, structural projects, and other non-structural actions. By consensus of the citizens' committee, each action is prioritized and a schedule is developed for implementation.

In addition to the above standards set by the state, KCM has found it to be essential to identify potential funding sources as part of the planning process. Recently, we have included in the completed plan a chapter on funding options the community can use to implement the plan. Common options include stormwater utilities and Flood Control Zone Districts, which are special local taxing authorities. Identifying sources of funds is becoming more critical as federal funds become harder to obtain. The question of funding often results in communities, realizing that they must fund the implementation of the program, being more accepting of lower levels of protection and non-structural solutions.

**Findings**

In the past four years, KCM has worked to develop comprehensive plans for communities ranging in population from less than 4,000 to over 300,000. All were participants in the NFIP and had approved local ordinances. However, many were not interested in additional regulation of private property or even in the enforcement of NFIP standards. Many preferred to control floods with levees, dams, dredging, or channels to protect existing development on the floodplain and allow continued development.

The development of a CFHMP, however, can be an enlightening process for the people involved. Many develop a better understanding of the severity of flooding problems in their community and the causes of problems (e.g., people building in unsafe locations), as well as a better sense of who might pay for solutions and who would benefit. No longer able to rely on the federal or state government to implement massive structural solutions, communities have become much more aware of the responsibilities of individual property owners. Public officials and local citizens are unwilling to pay large sums of money to protect structures belonging to a small percentage of the populace. They are
willing to implement programs to eliminate drainage problems that occur on a frequent basis, but are not, in general, willing to design for the 100-year event.

Reaching consensus on a plan of action is frequently difficult because of the number of competing interest groups, federal and state agencies, tribes, and private property owners. Frequently, because of this consensus-building process, new and useful interagency agreements and cooperation are developed. Communities become more willing to work with the tribes, habitat managers, and other regulatory agencies to implement the common goals of preservation of the riparian environment and protection of existing communities. The process of developing CFHMP has been a positive and eye-opening experience for the communities KCM has worked with. Many have changed their views of flood hazard management and have developed a more holistic approach to the management of riparian areas.

References

KCM, Inc.

Washington State Department of Ecology
Introduction

Since the 1970s, the Federal Insurance Administration (FIA), the organization within the Federal Emergency Management Agency (FEMA) that administers the National Flood Insurance Program (NFIP), has gained valuable experience through an ongoing program to assess the performance of buildings that have incurred flood damage. After major floods, FIA and the FEMA Regional Offices also periodically conduct field assessments of damaged buildings and provide technical guidance to local governments and the building industry on proper enforcement of NFIP regulations governing substantially damaged buildings.

In the fall of 1992, after the unprecedented wind and flood damages caused by Hurricanes Andrew (Dade County, Florida) and Iniki (Kauai County, Hawaii), FIA greatly expanded the scope of its normal damage assessment and post-disaster activities. This included forming and activating Building Performance Assessment Teams (hereinafter "Assessment Teams") composed of experts in wind and flood-damage-resistant design and construction.

This paper describes the composition, purpose, and role of the Assessment Teams and makes recommendations on their future use in post-disaster settings.

Purpose of Assessment Teams

The purpose of the Assessment Teams was to evaluate the effectiveness of past design and construction practices in Dade and Kauai Counties by surveying both the damage and successful performance of buildings subject to the forces of Hurricanes Andrew and Iniki. The basis for forming the teams and compiling the reports is the assumption that improved performance of buildings in wind and flood hazard areas can be attained when

- Observed failure modes can be mitigated using basic and widely recognized practices and standards for new and repair construction;
- Observed building successes can be used as evidence to reinforce the use of these practices and standards; and
• Federal, state, and county governments and the private sector work in close cooperation to ensure that repair work and new construction practices will mitigate against future hazards while remaining cost-effective and practical.

Organization of Assessment Teams

In organizing the Assessment Teams, which ranged in size from 8 to 12 members, the intention was to blend expertise from various levels of government with that of private engineers and architects knowledgeable about local building codes and practices (Table 1). This approach strives for broad administrative representation, technical diversity, and, importantly, support and input from local government, the body ultimately responsible for changing and enforcing building codes during post-storm reconstruction. Inclusion of representatives from local government in every step of the process—from field evaluation to formulation of recommendations—greatly enhances the likelihood that these recommendations will be politically and technically viable and therefore adopted and implemented.

Table 1. Idealized assessment team representation.

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>Technical Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEMA/FIA</td>
<td>Wind Engineering</td>
</tr>
<tr>
<td>FEMA Regional Office</td>
<td>Flood-Resistant Construction</td>
</tr>
<tr>
<td>State Government</td>
<td>Floodplain Management</td>
</tr>
<tr>
<td>Local Government</td>
<td>Geotechnical</td>
</tr>
<tr>
<td>Private Sector Engineer</td>
<td>Planning</td>
</tr>
<tr>
<td>Private Sector Architect</td>
<td>Local Construction Practice</td>
</tr>
</tbody>
</table>

1 Natural & Technical Hazards Division Staff
2 Also serves on the Interagency Hazard Mitigation Team
3 Staff from Building Department (appointed Representative of Mayor, Town Administrator, etc.)
4 Intimately familiar with either the Building Code in effect or local construction and building permit practices
5 Other specific hazards as applicable (seismic, fire, etc.)
The Assessment Teams also served as a technical resource for the Interagency Hazard Mitigation Team (IHMT). An important benefit of this was the formal incorporation of the Assessment Team report as a technical addendum to the IHMT report. This provided a detailed and technically sound basis for formulation of IHMT recommendations.

For both disasters, two Assessment Team members also served on the IHMT. This helped ensure that efforts of the two groups were coordinated and complementary. Considering the overwhelming magnitude and extent of impacts in both Dade and Kauai counties, assistance of the field-oriented and technically focused Assessment Teams freed the IHMTs to concentrate on the myriad of broader mitigation issues.

Conclusions

Based on experiences gained from the FEMA-sponsored Building Performance Assessment Teams activated after Hurricanes Andrew and Iniki, the following conclusions can be drawn:

- The Assessment Teams can greatly assist in the diagnosis of damages due to design and construction shortcomings, make highly specific and viable recommendations for reducing damages to future construction, and assist in the post-disaster training and education of building officials, builders, design professionals, and homeowners.

- The Assessment Teams provide a highly technical resource, which assists and complements the well-established IHMT process. In turn, this helps unify the efforts of the National Flood Insurance and Disaster Assistance programs in conjunction with the FEMA Regional Offices.

- The Assessment Team process emulates field evaluation activities undertaken by the national model building code groups, state building code associations, and engineering and materials research groups. It therefore provides a logical and effective avenue for coordination and promotion of consistency between FEMA’s programs and programs of these groups.
Recommendation

Based on these conclusions, FIA should formalize the concept and activities of the Assessment Team for responding to major flood events and train additional headquarters and regional staff to serve on these teams.
On November 7, 1977, the Kelly Barnes Lake Dam above Toccoa Falls College failed in the early morning darkness, killing 39 people. As a result, the Georgia Safe Dams Act was passed and became effective July 1, 1978. The Act was somewhat unique in that only existing high-hazard dams (probable loss of life in the event of sudden failure) were regulated and all other existing dams did not have any standards to meet.

It became apparent early on that the existing non-regulated dams would continue to become "category one" (high-hazard) dams as development of floodplains below dams continued. Therefore, the Governor's Task Force on Dam Safety assumed the task of developing a model dam safety ordinance to prevent development in the dambreak flood zone. Gwinnett County's Board of Commissioners agreed to consider the information developed as a supplement to their existing floodplain management ordinance. If this approach were successful, other local governments might follow in their footsteps.

The Safe Dams Program from the Environmental Protection Division of Department of Natural Resources, the State Soil and Water Conservation Commission, and the Soil Conservation Service completed over 50 dambreak routings of category two dams and developed flood inundation maps of the areas below each of them. The dam-break inundation floods were delineated until the flood waves returned to the defined 100-year floodplain. Approximately 1,200 acres were defined as being in the dambreak zone but outside the 100-year floodplain (an average of 24 acres per dam).

Unfortunately, the Gwinnett County Board of Commissioners failed to act on the proposed ordinance and nothing happened for a decade except that more unregulated dams became category one because of continuing downstream development.

In April 1989, a small dam in Cobb County was reclassified category one and the local homeowner's association was upset because of the downstream development that caused the reclassification. The members contacted their local legislator, who introduced an amendment to the Georgia Safe Dams Act impacting development below dams in the winter of 1990. Unfortunately, the Safe Dams Program was not aware of the pending legislation and had no input into its formation. In fact, we discovered the amendment quite by accident. Our office was aware that an exemption for Soil Conservation Service Watershed Dams was passed during the 1990 legislative session. We requested a copy of the signed amendment so that we could incorporate the amendment when the Act was reprinted during summer of 1990. This amendment was anticipated, but there was the other amendment on the reverse side which already has had far-reaching effects.
The surprise amendment required that before a permit for a structure/facility could be issued by a local unit of government which would result in changing the hazard classification of the dam, the local government had to notify the owner of the dam of the pending permit by certified mail. Because of this amendment, the Rules for Dam Safety were rewritten to address these and other needed changes to bring them up to date. It should be noted that the amendments to the Act and Rules do not prevent development below category two dams. The amended rules were adopted in September 1990. At that time, our office began efforts to educate local governments of the amendments to the Act and Rules.

Because of the original dambreak rooting report, Gwinnett County became the first county to inform dam owners about pending development downstream. To date, there have been three dams involved: Kilpatrick Lake Dam, Cardinal Lake Dam, and Norman Lake Dam.

**Kilpatrick Lake Dam**

Under the amended Rules, Gwinnett County was required to provide a dambreak routing of a sudden failure of Kilpatrick Lake Dam that would define the dambreak inundation zone. The developer’s engineer ran the dambreak analysis, the County provided it to our office for review, and we approved the analysis. The developer then chose to site his houses above and outside of the dambreak flood zone.

**Cardinal Lake Dam**

The developer’s engineer provided the dambreak analysis, which was approved. The Cardinal I Homeowner’s Association lobbied Gwinnett County nearly two years to prevent the development in the dambreak zone. They also lobbied their local state representatives. It was resolved in late February when the developer agreed to regrade the lots in question so that the fill pads for the houses were two feet above the dambreak flood elevations and outside the 100-year floodplain.

**Norman Lake Dam**

Our office performed a dambreak analysis of this dam recently to confirm that existing development below the dam was outside of the dambreak flood zone and that the dam was correctly classified. Since then, the area immediately below the dam has been developed. To date, there is no readily apparent solution to resolve this situation. The Lake Norman Homeowner’s Association is lobbying Gwinnett County to prevent houses from being built. The developer
is adamant about developing the property. Gwinnett County has received legal advice from its attorney saying that the building permits should be issued. His reasoning relates to the recent court ruling against South Carolina concerning restrictive zoning on the coastal shoreline. It appears that the development will occur in the dambreak flood zone and the dam will be reclassified and regulated.

Conclusion

As you can see, the Safe Dams Program and the Governor's Task Force on Dam Safety had major input on a model floodplain ordinance for local adoption by Gwinnett County with no success. At the state level, the Safe Dams Program had no input to recent amendments to the Safe Dams Act.

However, the 1990 amendment to the Act and the subsequent amendments to the Rules did have a very positive effect. Now both local governmental units and developers realize that their decisions/actions can have huge impacts on upstream dam owners. Also, dam owners now have an opportunity for input to the decision process. In the past, the owners' first chance for input was when our office notified them that the dam had been reclassified due to downstream development. At that time, the development was a fait accompli as was the reclassification and regulation of the dam.
FLOODPLAIN MANAGEMENT
COMMUNITY NEEDS SURVEY

William H. Lesser
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Bureau of Flood Protection

Introduction

In April 1991, the Department of Conservation and Recreation completed The Floodplain Management Plan for the Commonwealth of Virginia. This comprehensive plan included a full assessment of the status of floodplain management in the commonwealth. Chapter eight concludes the plan with a multi-year strategy for floodplain management. One element of chapter eight specifies the need for a locality needs survey. It states,

A survey will be conducted that will ascertain a flooding history, program needs, the need for flood control projects and their ability to participate as a local sponsor, adequacy of floodplain mapping, training needs, familiarity with flood warning programs, and other information . . . It [the data] will also be used to formulate project requests with appropriate federal agencies, and to assist in delivering appropriate assistance to the locality.

Background of Need

The seriousness and character of flood hazards posed to individual communities varies widely across Virginia. The use of a community needs assessment sent directly to the communities has provided two separate types of information. One is specific data, able to be quantified, such as the number of structures in the floodplain or the amount of flood damage, which to date has been of questionable accuracy. The second is information which may not be as easily quantified yet reflects the sentiments of local officials about local floodplain management. These comments were not easily quantified yet have important bearing upon local floodplain management needs.

Format and Distribution

Care was taken to avoid unclear questions, unexplained acronyms, and insufficient space for the responder to make a comment. Print was large enough to be uncrowded and readable. It was long enough (12 pages) to ask everything wanted. The questionnaire consisted of 96 different questions separated into nine identifiable sections, including
The community needs assessment was mailed to all localities in the commonwealth, whether they were on record as having identified flood hazard areas or not. A total of 294 questionnaires were mailed out. A cover letter directed to the Chief Executive Officer was mailed with the questionnaire. There was discussion about the appropriate addressee. In some cases the chief executive officer is not familiar with activities related to floodplain management. However, considering the questionnaire was meant to reflect broad community concerns it was most appropriate that the CEO be involved with the response.

Return Rate of Questionnaire and Findings

A vast majority of the responses were returned before the deadline noted on the cover letter. Those communities with more than 100 flood insurance policies that did not return their questionnaires were telephoned and reminded, and in most cases cooperated and sent in their questionnaire. In many of these cases they had lost the original survey. Unfortunately, several large coastal cities with a high National Flood Insurance Program (NFIP) policy base did not return questionnaires despite a follow-up phone contact. Several communities commented that there had been an onslaught of questionnaires and they simply did not have the time. An analysis of the return rate for all communities with over 25 policies, of which there are 89, shows that 49 (or 55%) returned their surveys—a reasonably successful rate of return. Tables 1 and 2 reflect the return results, both overall and based upon number of NFIP policies.

The summary tally (available from the author) contains numerical totals for those questions which lend themselves to being quantified. Additionally, the following high points stand out:

- 85% of communities consider the flood hazard potential of their community at least "moderately threatening causing inconveniences for a limited number of personnel," demonstrating that flood hazards rank as being of some importance in the eyes of many Virginia communities;
Table 1. Return results for communities overall.

<table>
<thead>
<tr>
<th>Surveys Mailed</th>
<th>Returned</th>
<th>% Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counties</td>
<td>95</td>
<td>44</td>
</tr>
<tr>
<td>Cities</td>
<td>42</td>
<td>21</td>
</tr>
<tr>
<td>Towns</td>
<td>157</td>
<td>33</td>
</tr>
<tr>
<td>Totals</td>
<td>294</td>
<td>98</td>
</tr>
</tbody>
</table>

Table 2. Return results according to numbers of flood insurance policies in each community.

<table>
<thead>
<tr>
<th>Number of Policies</th>
<th>Number of Communities in State</th>
<th>Returned</th>
<th>% Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 1,000</td>
<td>7</td>
<td>5</td>
<td>71%</td>
</tr>
<tr>
<td>Between 1,000 and 500</td>
<td>5</td>
<td>4</td>
<td>80%</td>
</tr>
<tr>
<td>Between 500 and 100</td>
<td>25</td>
<td>10</td>
<td>40%</td>
</tr>
<tr>
<td>Total Over 100 Pol.</td>
<td>37</td>
<td>19</td>
<td>51%</td>
</tr>
</tbody>
</table>

- localized stormwater and drainage system flooding is very prevalent;
- 21% have had flood damage in areas not mapped as 100-year floodplain on the Flood Insurance Rate Map (FIRM);
- 58 of the 95 communities have publicly owned structures in their floodplains;
- 22 of the 31 communities with flood warning and emergency response plans feel their emergency response plans need improvement;
• 13 of 65 communities indicated they have had structures relocated out of flood hazard areas (far more than previously known);

• 8 of 42 communities feel that their repetitively flooded areas would be suitable for a public park or open space area if a relocation project were undertaken;

• 34 communities have some effort underway to consider flood control structures, 20 of these involving some written documentation supporting the need;

• FEMA floodplain studies continue to be used more so than other studies but others are used, indicating that the floodplain studies programs of other federal agencies continue to play a useful local role;

• watershed development and floodplain development have altered runoff characteristics, making FIRM's no longer accurate in some cases;

• 8 of 79 communities indicated there was a "very strong need" to conduct flood studies in their A zones, and 36 of the 79 indicated a moderate need;

• 51 of 92 that answered the question indicated they had seen a copy of The Floodplain Management Plan for the Commonwealth of Virginia; and

• 82 out of 85 communities would be in favor of a regulation that required realtors to specifically disclose whether or not a property for sale is in a floodplain.

Based on the survey results, the three most important services that could be provided from the state floodplain management program are

• assistance with map review and possible revision opportunities,

• providing comprehensive floodplain management planning assistance, along with assistance with specific mitigation planning projects, i.e., floodproofing and relocation of structures, and

• providing flood loss reduction plans for individual properties.
The following list ranks the topics of highest priority (1) to lowest priority (9) for NFIP workshops.

(1) How to determine base flood elevations in A zones

(2) How the NFIP requirements are addressed in the Virginia Uniform Statewide Building Code

(2) (Tied for second with above) Variances from NFIP requirements: under what conditions and how

(3) How to read a Flood Insurance Rate Map

(4) How to read a Flood Insurance Study

(5) Federal disaster relief after floods: is there any and what are the eligibility requirements?

(6) How to read the Flood Boundary Floodway Map

(7) Using elevation certificates and floodproofing certificates

(8) Floodproofing, retrofitting, mitigation: what, how, where?

(9) "Historic structures" and the NFIP requirements.

Conclusions

This survey provided a wealth of information for a minimal investment of time. This approach is highly recommended.
FLOODED WITH RELIEF: ISSUES OF EFFECTIVE DONATIONS DISTRIBUTION*

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Introduction

Recent large disasters (e.g., Hurricane Hugo, Loma Prieta Earthquake, Hurricane Andrew) have highlighted the problems of donations during disaster. In this paper, I draw upon the concept of "cross training" to highlight donation problems. Researchers have realized that the social impacts of disasters have more similarities than differences (Quarantelli, 1987). Among practitioners, the Federal Emergency Management Agency's (FEMA) "integrated emergency management system" also reflects the central theme of this conference, "cross training." Thus, planners can draw upon lessons learned from other disasters to deal with a multitude of floodplain emergency response issues. Drawing upon my recent work following the Loma Prieta Earthquake and Hurricane Andrew, I briefly discuss problems and potential approaches to the donations process. Thus, I suggest an agenda that would facilitate understanding and improving the donations process.

The Donation Process

A driving force during and following disasters is altruism. Research documents that altruism abounds during and following disaster. Simply stated, people will help people after disaster. Researchers have documented altruism while people are stranded during a blizzard (Fritz et al., 1958; Neal et al., 1988), tornadoes (Zurcher, 1968), and floods (Phillips, 1988). Specifically, research shows that (1) family and friends serve an important first source of aid, (2) ad hoc groups form to help during a disaster, (3) local, regional, and national volunteer groups offer services, and (4) individuals are willing to offer their services. Armed with this knowledge, let's explore how we can clearly define the issue of donations during a disaster.

*I thank the Natural Hazards Research and Applications Information Center/National Science Foundation "Quick Response Program," and the Institute of Emergency Administration and Planning, University of North Texas, for their support of this research. However, the findings and conclusions are strictly those of the author.
The Loma Prieta Case

Donations became a major problem after the Loma Prieta earthquake. I observed 18-wheelers arrive unannounced at the local American Red Cross chapter. The source of the goods usually puzzled both local and national ARC representatives. Thus, in addition to problems of feeding and sheltering, the local chapter had to deal with a warehouse of goods that for the most part they could not use and did not know what to do with initially.

Furthermore, some of the donations included perishable food (bananas, apples) or unneeded items (e.g., mink teddy bears). These inappropriate goods further strained the system. First, the ARC needed to use volunteers to sort these items rather than tend to other tasks. Second, because engineers declared many potential or designated warehouses unusable due to structural damage, these goods used precious storage space.

The Hurricane Andrew Case

The aftermath of the Loma Prieta Earthquake only hinted at the massive donation problems that were to follow Hurricane Andrew. Based upon the Loma Prieta experience, the ARC stressed that they preferred cash donations of material goods. The ARC preferred cash since it could turn money into any resource needed, it could track money more easily than other donated goods, and it needed no major warehouse to store money. The ARC, however, still requested and received some in-kind donations.

The Salvation Army took a different approach. They welcomed any and all contributions. As one high ranking officer told me in Homestead, they preferred having too many items rather than not enough. Thus, the two major volunteer organizations dealing with donations took opposite approaches to the problem.

To further exacerbate the situation, businesses, schools, and individuals from throughout the United States sent various types of goods and items unannounced. Many of them went unused. The massive influx of goods created problems of distribution, spoiling of perishable foodstuffs, and rotting donated clothes lying in mud puddles. Although well intentioned, entertainer Jerry Lewis exacerbated the problem. During his national telethon, he urged people to send food and clothes to South Florida.

Other items became difficult to use. For example, the well intentioned contributed many canned goods for the relief effort. However, opening and preparing foods from small cans wastes time. These small cans need resorted so volunteer cooks can prepared a specific meal (e.g., mixing small cans of green beans, corn, beets, and sauerkraut into one pot is not appetizing). Volunteers lamented that they hoped the "next time," donors would send institution-size canned food loaded on pallets.
These examples only begin to illustrate the massive problems following Hurricane Andrew and the Loma Prieta Earthquake. The examples only begin to hint at not only problems, but potential solutions. Below, I outline a process to better understand the donations process, and make a few modest suggestions.

Research Needs and Policy Development

To respond effectively to the donations problem, we need a systematic, scientific approach to provide an accurate portrayal of the donations process. From these data, we can develop an effective policy at the federal, state, and local levels regarding donations. Below, I discuss some important initial steps.

First, we need to find out who donates. More specifically, we need breakdowns by types of organizations (e.g., corporation, church, other), individuals, or other entities. Furthermore, we need to identify more specific characteristics as social class, sex, ethnicity, age, geographic region, previous disaster victim, and other related factors.

Second, we need to know what is donated. We need to know how much money is donated, what type and the value of in-kind donations, (and whether these donations are requested or not), and the type of "people resources" that become available (and what type of people resources have and have not been requested). We can further our analysis by adding other factors such as the type of disaster or its geographical location.

Third, we should identify the designated recipient of the donated goods. This designation may influence how the donated items are received and stored. Donations may be designated for any victims or a specific type of victims. Donations may go directly to the victims, or may be given to other organizations (e.g., Red Cross, Salvation Army) to distribute. Also, donations may be designated for a specific individual in a specific geographical region.

Efforts of volunteer organizations and federal agencies should be coordinated. As an initial start, a donations policy should be outlined in the Federal Response Plan. This document drives federal disaster response following a catastrophic disaster, but only one short paragraph mentions donations, and the document ignores issues of coordination and distribution.

Second, these organizations must further educate the public about donations. Donors should be urged to give cash. In-kind donations should be arranged in advance with businesses or other organizations. Thus, if an item is needed, the coordinating agency can quickly call upon a donor.

Summary

Recent major disasters have highlighted the problems created by massive donations. These problems include coordination between agencies, not enough
staffing, and different philosophies about obtaining or distributing donations. Thus, we urge emergency managers in high flood hazard regions to take a proactive stance regarding donations. Contact and work with key officials before the flood occurs. Anticipate unwanted donations. Arrange for in-kind donations before the flood. This type of "cross training" will prepare a community for the real event.

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MANAGING GOVERNMENT CONTRACTS: TIPS FOR KEEPING YOUR SANITY

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Introduction

Now that you have finally landed that big government contract, now what? No, don’t panic—organize! It is imperative that immediately upon receipt of a notice to proceed that all team members and subconsultants are notified and an action plan established. Assemble an organizational chart for use as a blueprint for the tasks and more importantly, to serve as a flow chart for communication of information regarding the project throughout its entirety. Also before the project begins, an internal organization and filing system should be established so that all pieces of the job can be readily accessible for review by all team members.

Divide and Conquer

The best approach to both cost effectiveness and time management is to divide the entire project into smaller tasks. This will help you focus and make you organize. It is suggested that the project be divided into approximately 10 basic categories:

(1) project goal(s);
(2) background information;
(3) establish design criteria and priorities;
(4) acquire design specifications and standards, if any;
(5) determine computer requirements;
(6) type and quantity of production drawings, reports, etc.;
(7) results and recommendations;
(8) quality control;
(9) assembly of all final products for the client; and
follow-up with the client regarding performance and overall comments for use in future jobs.

Take the time necessary to establish a project time schedule and to assign each smaller task to an individual team member. Assuming of course, that the original team you put together on the proposal still exists! If not, rearrange your new team "ASAP." The process of delegation will make it necessary to assess the skills and shortcomings of each staff member so that you can effectively delegate the work assignments ahead. Your company structure should have a system that rewards individuals for work on time and within budget as well as penalizes individuals who are not preforming up to par and/or not working as a part of the overall team. As part of the management of the project, both short- and long-term individual and team goals should be developed, written down, and distributed. This will help assess both the status of the job as well as team and member performance.

Delegate

It is necessary at this point to identify one person as the point of contact. This will centralize all communication within the management of the project as well as make the client very happy. The most important decision to be made in this phase of the job is who will be the project leader. This should be one of the most important people in your organization whom you trust and can depend on; however, do not choose a project leader who has all the capabilities but is overwhelmed with many other assignments. The end result will be burnout and frustration, and none of the projects will be completed to anyone's satisfaction.

Another action that can be taken is to assign an assistant project leader. This will insure that the leader will have someone readily accessible for help when many different things are happening in regards to the work effort. This will also allow for continuity on the project should something happen to the original team. This process is doubly important for the upward mobility of your staff. Each and every leader and engineer should be a mentor for someone else in the firm. This will produce a united team as well as build good will and morale among the employees. The arrangement should be friendly, open, and honest, with a focus on teaching others all the pertinent aspects of what it means to be a professional. This will reflect positively on your firm and employees for this as well as future endeavors.
Communication

Without a doubt, communication is the number one ingredient for the successful completion of any project large or small; however, it is especially important on large government contracts because of the amount of work that has to be completed as well as the interconnection between tasks. This concept has more recently been referred to as "partnering." Employees that have both poor and/or lacking communication and people skills will only bring down the efforts of the team in the overall scope of the project. Should difficulties arise and communication break down, it should be the duty of the principal-in-charge to meet with all parties involved to air disagreements and resolve issues that may later threaten the successful completion of the contract. Only if absolutely necessary should the original project leader be removed from the job.

It can not be stressed enough how very important communication is. You will do well to insure that the project leader in charge of the day-to-day activities has excellent communication and negotiation skills, because the scope of project, regardless of size, will change and evolve as time goes on.

Budget

Assign a dollar value to each task along with corresponding "people-hours." Let your staff know exactly how much time and money they have to perform each item. Establish a system to reward your successful personnel. Monitor the progress of the job each month, reconciling the money and time spent with your previous estimate. Adjust the old budget to reflect what is actually happening with the billing. You may need to go to bimonthly review if the project involves a tight time frame, a large staff, and/or numerous billing hours.

Another tip is that, if any changes in the scope of work occur, as they usually do, or disagreements arise between you and the client over project scope, they should be addressed immediately. It should also be determined at that time if the work will require a change in compensation from the original contract.

Paperwork

The most overwhelming thing about any size contract is the amount of paperwork that needs to be completed. Therefore, force yourself to do it first thing in the morning, when you are fresh and most relaxed. As hard as it seems, stay on top of it—this will pay off many times over.

Time should be taken to create some simple forms using a spreadsheet or word processing software to track telephone conversations, change orders,
unanticipated problems, delays, schedules, deadlines, and project milestones. There is also software available specifically designed for project management. No matter which one you choose its procurement is highly recommended.

**Document Everything!**

It is imperative to create a cohesive "paper trail" by keeping copies of all correspondence and documenting telephone conversations as well as all other pertinent data. Follow up verbal communication with a brief letter to the client or at least an internal memo to the project file. The use of a three-ring binder/notebook is an ideal way to organize this data for convenient future reference. In addition, add books as the project grows and keep them all in centrally located place that all staff members can freely access.

**Summary**

The most important steps to the successful management and completion of any large government contract, are

- organization,
- division,
- delegation,
- paperwork documentation, and most importantly,
- communication (partnering).

Take extra time in the beginning to divide and set up the entire project. Before delegating tasks to each individual, remember that companies do not complete projects—*people do!* Keep the lines of communication open at all times and listen to the comments and ideas of your staff. Discuss and resolve any problems as soon as they are realized. Finally, document everything relating to the day-to-day activities of the contract. As a last resort, take a day off and relax so you can Keep Your Sanity!
Part Eight

Project Engineering
PROBABILITY OF A GIVEN DISCHARGE BEING EXCEEDED BETWEEN TWO POINTS ON AN ALLUVIAL FAN

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In areas subject to alluvial fan flooding, the path and flow rate of a particular flood are not completely predictable—even if the flow rate is known at a given point (i.e., the apex). Dawdy (1979) solved the problem of assigning flood frequency to any location on an alluvial fan under the simplest of boundary conditions. Although the boundary conditions specific to any particular site may be much more complex than those discussed by Dawdy, the framework for solving the flood frequency problem is essentially the same. One such set of conditions is the existence of barriers to otherwise unrestricted flowpaths.

Barriers to flowpaths on alluvial fans or similar landforms may be natural, such as rock outcrops, or they may be artificial, such as road or railroad embankments, levees, and training dikes. This paper presents a derivation of the method of determining the flood frequency between two points on an alluvial fan under the simple boundary conditions given by Dawdy. The method can be used to investigate the downslope effects of protecting a subdivision with a levee and channel system or by placing a culvert and training dikes under a railroad embankment. The effect of such structural measures is to increase the flood risk downslope (by increasing the probability that flood paths lead to the outlet of the structure). The method derived in this paper can be used to quantify that increase.

Consider a rectangular channel that has a topwidth, $w$, which is a function of the discharge it conveys: $w = w(q)$. Assuming that the location of the channel is uniformly distributed within a width, $W$, and the probability density function describing the occurrence of a discharge, $Q$, somewhere within that width is $f_q(q)$, the probability that a discharge of $Q$ passes between two points, $a$ and $b$, can be determined as follows.

Because the channel is rectangular, the amount of flow in a section of the channel is roughly proportional to the topwidth of that section. That is, if $q$ is the discharge of the channel shown in Figure 1, then the discharge, $q_r$, in the cross-hatched area is

$$q_r = \frac{w_r q}{w(q)}$$  \hspace{1cm} (1)
Figure 1.

Thus, for a discharge, $q_0$, to pass between points $a$ and $b$, given that the total discharge in the channel is $q$, the right side of the channel must be between the points

$$\frac{q_0 w(q)}{q} \text{ and } W_0 + W(q) - \frac{q_0 w(q)}{q}$$

(2)

where we have taken $a$ to be at the origin and $W_0$ to be the width of the opening $(b-a)$. The probability density function describing the location of the right side of the channel is $1/W$, and, therefore, the probability that the right side of the channel is between the two points given above is

$$\frac{1}{W} \left[ W_0 + W(q) - \frac{2q_0 w(q)}{q} \right]$$

(3)
The probability that a discharge exceeding \( q_0 \) passes between two points that define an opening of width \( W_o \) is

\[
P [Q \text{ through } W_o > q_0] = \frac{1}{W_o} \int_{q_0}^{\infty} \left[ W_o + w(q) - \frac{2q_0 w(q)}{q} \right] f_\theta(q) \, dq
\]

Writing \( P \) as the sum of three integrals yields

\[
P = I_1 + I_2 - I_3
\]

where

\[
I_1 = \frac{W_o}{W_x} \int_{q_0}^{\infty} f_\theta(q) \, dq
\]

\[
I_2 = \frac{1}{W_x} \int_{q_0}^{\infty} w(q) f_\theta(q) \, dq
\]

\[
I_3 = \frac{2}{W_x} \int_{q_0}^{\infty} \frac{q_0 w(q)}{q} f_\theta(q) \, dq
\]

If \( f_\theta(q) \) is log-normal, then

\[
P (Q > q_0) = \frac{1}{\sigma \sqrt{2\pi}} \int_{y_0}^{\infty} e^{-\frac{1}{2} \left( \frac{y - y_0}{\sigma} \right)^2} \, dy
\]
where

\[ y = \log_{10}(q_0) \quad (10) \]

Also, note that for a power function \( q \), say

\[ w(q) = \alpha q^\beta \quad (11) \]

or, equivalently,

\[ w(q) = \alpha e^{\beta y \ln(10)} \quad (12) \]

\[ = \alpha e^{2.3026 \beta y} \quad (13) \]

where \( y = \log_{10}(q) \)

\[
\int_{x_0}^{\infty} w(q) f_q(q) dq = \alpha C(\beta) \frac{1}{\sigma \sqrt{2\pi}} \int_{y_0}^{\infty} e^{-\frac{1}{2} \left( \frac{y - \mu'}{\sigma} \right)^2} dy \quad (14)
\]

where

\[ \mu' = \mu + 2.3026 \beta \sigma^2 \quad (15) \]
\[ C(\beta) = e^{2.3026 \beta u + \frac{1}{2} (2.3026 \beta \sigma)^2} \quad (16) \]

In summary, equation (4) can be solved when \( w(q) \) is defined. For the single channel region

\[ w(q) = 9.408 q^{0.4} \quad (17) \]

and

\[ \frac{w(q)}{q} = 9.408 q^{-0.6} \quad (18) \]

Thus, the integrals in equation (5) are

\[ I_1 = \frac{W_0}{W_f} \frac{1}{\sigma \sqrt{2\pi}} \int_{y_0}^{\infty} e^{-\frac{1}{2} \left( \frac{y-\mu}{\sigma} \right)^2} dy \quad (19) \]

\[ I_2 = \frac{9.408}{W_f \sigma \sqrt{2\pi}} e^{0.42 \mu + 0.42 \sigma^2} \int_{y_0}^{\infty} e^{-\frac{1}{2} \left( \frac{y-\mu - 0.92 \sigma^2}{\sigma} \right)^2} dy \quad (20) \]

\[ I_3 = \frac{18.816 y_0}{W_f \sigma \sqrt{2\pi}} e^{-1.38 \mu + 0.95 \sigma^2} \int_{y_0}^{\infty} e^{-\frac{1}{2} \left( \frac{y-\mu + 1.38 \sigma^2}{\sigma} \right)^2} dy \quad (21) \]
On an alluvial fan, $I_1$ is the probability that $q_0$ is exceeded at the apex times the ratio of the width of the opening to the width of the fan. $I_2$ is the probability that a point on the fan at the elevation where the width of the area subject to flooding is $W_f$ is inundated. $I_3$ is similar to $I_2$. The integrands in both $I_2$ and $I_3$ are the same as that in $I_1$ with a change in the mean, $\mu$, to $\mu + 0.92\sigma^2$ and $\mu - 1.38\sigma^2$, respectively.

Conclusion

This paper has presented a derivation of the probability that the discharge that passes between two points on an alluvial fan exceeds a given value. It has shown that the probability is a function of the distance between two points, the width of the area subject to alluvial fan flooding at the elevation of those points, the width of the flood path, and the flood frequency relationship of the apex of the fan.

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Westwood Creek Dam and Pump Station

Gerald L. Robinson, John J. Wills, and Christopher B. Burke
Christopher B. Burke Engineering, Ltd.

Introduction

The region near the confluence of Westwood Creek in Addison, Illinois, has experienced frequent flood damage due to the backwater created by Salt Creek. The solution proposed to eliminate this flooding is a combination of a dam and a 500 cfs pump station. The impacted region consists of single and multi-family residences and major roadways that overtop during flood events. The proposed dam will prevent Salt Creek flood waters from entering Westwood Creek and the pump station will be used to convey the Westwood Creek floodwater over the dam and into Salt Creek. The purpose of the dam and pump station is not to impound a normal pool, but to only function during a flooding event. The project will provide significant flood damage reduction benefits to the Westwood Creek region and have no adverse impacts on the Salt Creek peak flood stages either upstream or downstream of the proposed project. In order to compensate for the loss of flood storage behind the proposed dam, a 200 acre-foot compensatory storage reservoir is proposed to be constructed on the former 19-acre Louis Restaurant site, also located in Addison at the intersection of Lake Street (U.S. 20) and Villa Avenue, approximately one mile downstream of the dam. The compensatory storage reservoir is referred to as the Lake-Villa Reservoir. The restaurant, which historically flooded, was purchased by the Federal Emergency Management Agency (FEMA) and demolished after the August 1987 flood event, which is the flood of record for Salt Creek. The location of the project components is given in Figure 1.

Watershed Characteristics

The Salt Creek watershed begins in Cook County and enters DuPage County at Devon Avenue. The Westwood Creek drainage area tributary to the proposed dam and pump station is 5.9 square miles and the drainage area of Salt Creek at the proposed dam and pump station is about 85 square miles.

Description of Project Components

Following is a more detailed description of the design concept for the dam, pump station, and compensatory storage reservoir.
Figure 1. Map of the project.
**Dam**

The proposed dam will be constructed across Westwood Creek immediately downstream of a compensatory storage pond that was excavated for the Village of Addison’s North Wastewater Treatment Plant. The dam will be constructed of reinforced concrete and an earth berm and will have three 6’ wide x 8’ high sluice gates where normal flow from Westwood Creek will be passed. During a Salt Creek flood event, the motorized sluice gates will close, preventing the backwater from Salt Creek from entering Westwood Creek. The Westwood Creek flows will then be intercepted by the pump station, which lies immediately to the north of the dam section. The proposed dam and pump station will tie into two existing berms. The southern berm is a portion of an existing berm that was created during the construction of the Village of Addison north wastewater treatment plant. The northern berm is part of the Interstate 290 expressway embankment. Access to the dam and pump station during a flood event will be provided across the top of the proposed structure from Addison Road. The northern berm will be sloped down to existing grade at a gentle slope in order to allow for vehicular access to the trash collection area after a flood event has occurred.

**Pump Station**

The proposed pump station will be located immediately north of the dam section and will have three 75,000 gallon per minute (gpm) pumps with a total rated capacity of 500 cfs. Each pump will be equipped with a 60” diameter flap valve on the discharge side. The pump station will be protected by trash racks located immediately upstream of the wet well section of the pump station.

**Compensatory Storage Reservoir**

The proposed 200 acre-feet compensatory storage (Lake-Villa) reservoir is located approximately 5,000 feet downstream of the proposed dam and pump station. The compensatory storage reservoir requires two inlet structures to be constructed in order to convey water from Salt Creek into the two cells of the excavated reservoir. One inlet structure will convey floodwaters in a culvert under Lake Street into the eastern (lower) reservoir cell. A second weir structure will be located between the eastern and western cells.

The outlet for the proposed compensatory storage reservoir will be a pipe connecting to an existing 84" storm sewer located along the southern boundary of the proposed reservoir. The storm sewer connects to the existing Diversey Avenue pump station. This existing pump station has a total installed capacity of approximately 250 cfs. The compensatory storage reservoir will not be dewatered until Salt Creek water surface elevations have fallen below flood stage.
**Flood Control and Hydraulic Impacts**

In order to determine the low flow gate sizes, pump size, and compensatory storage requirements, a detailed hydrologic and hydraulic analysis was performed. Additionally, this detailed analysis was used to demonstrate that no adverse impacts to downstream and upstream property owners occur from the project. The detailed analysis was also used to evaluate economic benefits derived from the project.

**Hydrologic Study Method**

LANDS is the hydrologic model previously used in unsteady flow models developed in the Chicago region. LANDS, based on the Stanford Model developed in 1954 (Crawford and Linsley, 1966), was first applied in the Chicago region in 1968 by the Northeast Illinois Planning Commission (NIPC) for a flood study on the North Branch of the Chicago River (Hydrocomp, 1969). It has been used to represent the hydrology of virtually every stream in northeastern Illinois as part of the Section 208 water quality studies undertaken by NIPC (1976).

Currently, the microcomputer implementation of LANDS, HSPF (Johansen, 1984) is being used to simulate the hydrology for the USC regulatory study. By using HSPF, the hydraulic database will be more accessible for any future changes in the hydrologic calibration. HSPF is also being supported by the Environmental Protection Agency (EPA), so the model will continue to be revised and updated.

The LANDS database contains the meteorological data for a 40-year period of record (NIPC, 1991). The data utilized by the hydraulic model (FEQ) are the unit runoff values for five different land cover categories: hydraulically connected impervious, flat slope grassland, medium slope grassland, steep slope grassland, and medium slope forested. No routings are performed in the hydrologic model. The watershed was subdivided into individual drainage areas for each hydraulic structure along the stream (i.e., bridges, culverts, detention ponds, etc.). The subdivision allowed for distributing the flow rates by reach length.

**Hydraulic Study Method**

The hydraulic model, Full Equations (FEQ), was originally developed to analyze dam failures and associated flood waves. This model was modified to represent the movement of water through the Chicago Sanitary and Ship Canal as part of the Section 208 water quality studies. Later, FEQ was applied to Winfield Creek in DuPage County (Harza, 1983) and has been used to analyze
the hydraulic behavior of many other streams. As a result of these studies, FEQ has been modified to better represent flow through urban watersheds.

The hydraulic program, FEQ, was used to represent unsteady flow for the proposed project. FEQ was used rather than the traditional steady-state models (i.e., HEC-2, WSP-2, etc.) due to the ease of modeling the complex interaction of the dam, pumps, and compensatory reservoirs. FEQ is based on the numerical solution of two governing equations describing one-dimensional flow in open channels (Hey, Franz, and Trybus, 1983). These governing equations express the principles of the conservation of water volume (continuity equation) and the conservation of water momentum (momentum equation).

The dam and pump station was modeled in FEQ as a two-branch system. The low flow path (dam section) was operable during non-flood conditions. The flood flow path (pump station section) became operable only when the tailwater created by Salt Creek was at flood stage. The compensatory storage reservoir was represented as two level pool reservoirs with independent intake stage-discharge relationships. The reservoir was designed to duplicate the storage provided by the Westwood Creek backwater storage zone (located behind the dam and pump station).

Forty years of historic rainfall/runoff dates were used with FEQ to size the Lake-Villa Reservoir and appurtenances so that there were no upstream or downstream impacts. The results of the model were also used to quantify water surface reductions on Westwood Creek and the corresponding flood control benefits.

Summary

The proposed Westwood Creek dam and pump station will prevent the backwater of Salt Creek from damaging structures along the lower Westwood Creek stream reaches. The unsteady flow model, FEQ, was used to model the complex hydraulic operations of the proposed project. A compensatory storage reservoir will be constructed to mitgate the loss of storage behind the proposed dam and pump station. The project will only be operational during flood events on Salt Creek. No normal pool impoundment will be present.

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Part Nine

Erosion
SOIL BIOENGINEERING SYSTEMS
FOR STORMWATER MANAGEMENT AND EROSION
AND SEDIMENTATION CONTROL

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Soil bioengineering systems for stormwater management, erosion, and sedimentation control utilize a natural vegetative approach dating back to the 1500s in Europe. Soil bioengineering is an applied science that utilizes living woody plant material as the main structural component to naturally restore slopes, wetlands, riparian zones, streams, and rivers. Recognizing land and water as living, dynamic systems, soil bioengineering increases the stability, minimizes erosion and sedimentation, and increases the function and aesthetic values through the use of living plant material. These living systems create a foundation of immediate structural stability that grows stronger with time, unlike most conventional approaches. Additionally, they become the basis for plant succession, which enables habitat enhancement and water quality enhancement.

Stormwater management and subsequent water quality enhancement are best served from a basin-wide unit of management. This requires a comprehensive and multi-objective approach to planning, implementation and management. Soil bioengineering systems are natural and vegetative means to fulfill multi-objectives in all three phases. Incorporating soil bioengineering technology in the planning phase allows for its full utilization and benefit realization in the implementation and management of stormwater management.

Soil bioengineering systems typically offer cost-effective solutions for soil erosion and vegetative restoration when compared to conventional approaches. When soil bioengineering is incorporated early in the planning phase, its cost effectiveness can be increased in both the implementation and management segments of projects. This technology has exhibited both short- and long-term maintenance requirements in both slope and riverine projects. Additionally, the plant material donor sites and the projects serve as future harvesting areas due to their rapid regeneration.

Soil erosion is recognized internationally as a major contributing factor of non-point source pollution in riverine systems. Non-point source pollution increases water turbidity by the addition of sediments. These sediments can trigger chemical changes in a water course due to potential nutrients and chemicals present in the runoff. The additional sediment load may also trigger streambank erosion by increases in suspended sediments and bed load. Aquatic and terrestrial habitat may be adversely altered or degraded by the increased erosion. Potable water supplies may require additional costly treatment prior to use. Ultimately the riverine environment and human quality of life may be degraded by the continued increase in non-point source pollution.
Implementation of soil bioengineering for stormwater management and erosion and sedimentation control requires assessment of the contributing soil and geologic conditions, hydrologic and hydraulic factors, climate, vegetation, and future plans. This assessment forms the basis for the design work and subsequent construction process. Proper construction methods are critical for long-term stability and growth, project success, and ultimately, water quality enhancement. Monitoring and evaluation of the installed projects become the basis for future management/maintenance needs if required.

Changes in land use, land management practices, increased population density, and vegetation removal all tend to affect stormwater runoff. These effects on the riverine environment increase the need for stormwater management and watershed enhancement. Soil bioengineering systems serve to mitigate damage and erosion associated with increased runoff. These systems serve to stabilize the upland slopes thereby reducing soil displacement and sediment transport, increasing rainfall interceptor and infiltration of surface runoff into the soil. Wetlands and riparian zones are protected, enhanced, and restored by utilization of soil bioengineering technology, which increases the runoff filtering capabilities of these critical ecosystems. Additionally, aquatic and terrestrial habitat and aesthetic values are increased by providing natural enhancement measures conducive to species and habitat diversity.

Land use and land management changes typically have adverse effects on riverine hydrology and hydraulics. The associated removal of vegetation, change in natural drainage patterns, and potential increase in soil erosion compound the changes in the hydrology and hydraulics of streams and rivers. Generally, overland flow times are decreased, velocity is increased, runoff coefficients are increased, peak discharges are increased, and water quality is decreased by increased stormwater runoff and increased soil erosion.

Soil bioengineering systems mechanically reduce soil erosion and shallow mass wasting by the development of soil reinforcing root matrices within the soil mantle. The development of roots or fibrous inclusions adds significant resistance to sliding or shear displacement. In upland slope projects, soil bioengineering systems are designed to stabilize eroding slopes and restore vegetation, thereby reducing sediment transport via surface drainage. As the systems develop top growth, they intercept rainfall and increase percolation of runoff into the soil, which aids in decreasing soil erosion and surface drainage volume. The velocity of overland flow is decreased by the increased resistance created by the revegetated slopes. These systems are also able to modify shallow subsurface drainage which may have adverse effects on slope or streambank stability.

Vegetated buffers of soil bioengineering systems for wetland enhancement and creation provide a protective zone of vegetation. These buffers function to filter sediment from surface drainage, thereby protecting and enhancing the
habitat diversity and functions of the wetland ecosystems. This protective aspect of soil bioengineering buffers ultimately enhances the water purification and detention aspects of wetlands. Aquatic and terrestrial habitat values are generally enhanced as well.

Restoration of riparian corridors with soil bioengineering systems serves to trap sediment and filter surface drainage, stabilize eroding bank conditions, enhance existing riparian buffers, create new riparian buffers, link disconnected habitat areas, and increase the aesthetics of the riverine environment. These multi-objective benefits of soil bioengineering systems fulfill many goals of stormwater management and create additional benefits that may not be realized with conventional engineering approaches.

Experience and various studies show the benefits of healthy riparian zones as manifested in streambank stability, habitat values, and water quality enhancement. A vigorous riparian corridor stabilizes streambanks by reinforcing the soil mantle with the fibrous inclusion of roots. The vegetation also provides evapotranspiration of soil moisture, which may be a factor in bank instability. The top growth provides shade for water temperature modification, fish cover, and terrestrial and macroinvertebrate habitat. Additionally, the vegetation reduces water velocity during high flows, even along the banks and floodplains.

Riparian zones provide nutrient cleansing of stormwater runoff as well. Soil ameliorants from agricultural through urban land uses may be trapped and in the buffer. These nutrients are at times taken in through the vegetation. A high percentage of the nutrients are prevented from entering the watercourse. This helps prevent a change in chemical makeup of the system which may adversely change aquatic vegetation, affect species, and require additional treatment for use as potable water.

Soil bioengineering systems for stormwater management, erosion, and sedimentation control provide natural and self-sustaining methods to mitigate damages created by increased stormwater and non-point source pollution. When properly planned, implemented, and managed, these systems provide a cost-effective, multi-objective tool for stormwater management. The direct and indirect benefits of soil bioengineering technology are great when compared to most conventional hard solutions to stormwater management and erosion control. The entire watershed—uplands, wetlands, riparian zones, and watercourses themselves—are stabilized and left with a foundation for future health and development. When provided with the right opportunities and tools, the watershed will repair and become self-sustaining over time. Soil bioengineering systems provide the tools and aid the opportunities for this recovery. This technology can solve the problems in a manner that is environmentally and technically sound, and that realizes additional benefits for all.
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State of North Carolina
A DISCUSSION OF SAND TRANSFER ACTIVITIES ON NEW JERSEY BEACHES

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Introduction

New Jersey has approximately 125 miles of oceanfront beaches which are classified as barrier islands, barrier spits, and headlands/coastal bluffs. These beaches are subject to erosion from extratropical storms ("northeasters") which occur with relative frequency during the fall and winter months. These northeast storms are capable of removing large volumes of sand from the beach profile because they typically last for several days and several consecutive high tides. In an effort to mitigate the hazards associated with this chronic erosion, several oceanfront municipalities have obtained New Jersey Bureau of Coastal Regulation (BCR) approval of beach management plans that include sand transfers as a central component.

The three municipalities whose beach management plans are the subject of this paper include the Boroughs of Avalon, Mantoloking, and Manasquan. These municipalities have developed their respective beach management plans based on different concerns and objectives, which will be detailed herein.

Case Studies

Borough of Avalon, Cape May County

The Borough of Avalon is located at the northern end of Seven Mile Beach, a barrier island along the southern New Jersey oceanfront. The critical erosion zone in Avalon is the northern oceanfront, which generally corresponds to the nodal zone where the dominant southerly sediment transport direction diverges from south to north. This condition is primarily controlled by the tidal inlet processes associated with Townsends Inlet, approximately 1,500 feet away. Based on a review of historical shoreline maps and beach profile data, it is apparent that the eroded material is being deposited along the southern (downdrift) beaches in the Borough.

In an effort to address this chronic problem, and to minimize the potential for accelerated erosion and increased storm damages, the borough developed a plan to selectively transport sand from the southern beaches to the critical erosion zone, through the use of a pan scraper. The pan scraper collects unconsolidated material from the borrow zone into its body and spreads it onto the receiving beach in a layer of sand several inches thick by 10 feet wide, until the desired volume of sand has been transferred.
To control the amount of sand transferred, the BCR approval includes specific permit conditions which are designed to minimize potential adverse impacts to the beach/dune system. The first condition requires that the borrow and fill areas be surveyed before and after each transfer operation. These surveys allow the contractor to certify the limits of the borrow/fill areas, the volumes of sand transferred, and the dates of transfer. In addition, the borrow zone is confined to the high tide beach between the berm crest and the seaward dune toe, the depth of scraping is limited to a maximum of one foot per operation, and the sand transfer operation cannot be repeated until the profile data show complete volume recovery on the borrow area beach.

This sand transfer project was designed to replace eroded sand from the high tide berm quickly enough to prevent subsequent smaller storms from directly attacking the dune, which would result in scarping and accelerated dune erosion. In addition, this project seems to have extended the life of a recent beach nourishment by recycling sand from the downdrift, surplus beaches to the eroded, updrift beaches.

**Borough of Mantoloking, Ocean County**

The Borough of Mantoloking is located at the northern end of the Squan Beach barrier spit, in northern Ocean County. The borough oceanfront is developed with older homes, adjacent to well-developed and maintained dunes, and a relatively narrow (<75 feet wide) high tide beach.

The most persistent problem in terms of beach maintenance relates to the repair of dune scarps, which are caused by storm waves. Due to the narrow beach width in this area, even minor storms cause significant scarping of the primary dunes, which weakens the dune system and creates the potential for accelerated dune erosion from subsequent storm events. The natural recovery and repair of these dune scarps can take quite a long time, since narrow beaches do not supply sand to the foredune ridge at a rate sufficient to effect restoration of storm-cut scarps. This, in turn, results in increased vulnerability of the eroded dunes and adjacent development.

In an effort to protect and maintain the oceanfront dunes, and to quickly repair dune scarps, the BCR authorized a sand transfer project which involves the transfer of sand from the berm crest to the eroded dune scarp, through the use of a bulldozer. The permit specifications call for the contractor to begin a one-foot-thick cut of sand approximately 20 feet landward of the berm crest, and push it to the existing dune scarp. This activity can be repeated when the borrow area is naturally restored to the pre-cut elevation. Once the borrow area has been restored, the scraping activity may be repeated until the optimum volume of sand has been transferred to the dune scarp. Upon completion of the scraping activities, all newly placed sand must be planted with beachgrass and fenced off, in order to stabilize the repaired dune.
Borough of Manasquan, Monmouth County

The Borough of Manasquan is located along a coastal headlands area in Monmouth County, adjacent to and downdrift of Manasquan Inlet. The borough oceanfront is developed with a closely spaced row of homes and an asphalt walkway located between the homes and a narrow dune line.

Because of Manasquan's location immediately downdrift of a stabilized tidal inlet, the borough's beaches are sand starved, as the northerly sand transport is interrupted by a large stone jetty on the updrift side of the inlet. As a result, the beach width is narrow, and the berm is susceptible to erosion from even moderate storm events, particularly during the winter months. The beach erosion caused by northeast storms creates a persistent threat to the walkway and the adjacent oceanfront homes.

In response to this condition, the BCR authorized a sand transfer project which involves the movement of sand from the lower beach face up onto the berm. This project is similar to other projects which were implemented and studied in Maryland (Kerhin and Halka, 1981) and, more recently, in North Carolina (McNinch and Wells, 1992). The bulldozing of sand from the lower beach face to the berm serves to increase the elevation of the winter berm and to act as a sand storage buffer to better protect the dunes, the walkway, and the oceanfront homes. The permit specifications for this project require that the borrow zone be limited to the intertidal beachface, where sand is transferred landward onto the berm. The design placement results in a ridge of sand approximately 20 feet wide and four feet high, and similarly to other sand transfer projects, the bulldozing cannot be repeated until the required beach profile data indicate a full volume recovery in the borrow zone.

Conclusion

Based on the preliminary results of these projects, including a review of the pre- and post-transfer monitoring data required as a condition of the permit, it appears that mechanical transfer of sand onshore and alongshore is efficient and can be accomplished without adversely affecting the beach/dune system. The projects have been shown to accelerate the natural recovery of eroded beaches and dunes, without negatively impacting the equilibrium beach profile. As is the case with all sand transfer projects, the critical component is control over the amount of sand transferred (one foot vertical per operation) and the frequency of the transfers (transfer operation cannot be repeated until monitoring data shows complete volume recovery in the borrow area).

It must be emphasized that none of the projects described above have been designed to respond to severe storm events which erode large volumes of sand from the beaches and dunes. Because these projects do not add sediment into the beach system, they are only effective in redistributing sand on the beach
profile in order to maintain short-term protection in the form of a wider dune and a higher, wider berm. In many cases, this added protection can buy enough time to prevent breaching and overwash of the dunes during smaller, more frequent storms. During larger events, such as the December 11, 1992 northeaster which resulted in a Presidential disaster declaration (FEMA 973-DR-NJ), all bets are off!

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GUIDELINES FOR BANK STABILIZATION PROJECTS IN THE RIVERINE ENVIRONMENTS OF KING COUNTY

Jeanne M. Stypula
King County Surface Water Management Division

Introduction

The Surface Water Management (SWM) Division of King County, Washington, has developed guidelines for bank stabilization projects on large streams and rivers. These guidelines will be used by county engineers and scientists for the design and construction of new erosion protection and flood control projects, for the repair and retrofit of existing facilities, and for maintenance activities on levees and revetments. The techniques presented in the document include vegetative systems such as live cuttings and rooted plant stock, rock methods such as riprap, and integrated plant-soil systems such as a vegetated geogrid. Various types of aquatic habitat components for these techniques are also presented.

The guidelines describe project selection, design, and construction and also discuss maintenance and monitoring requirements. Information on the specific characteristics of the region including fluvial processes, fisheries resources, and botanical species are provided along with problem analysis, project design, and construction techniques. Regulatory requirements, permits, and the policy concerns of agencies having jurisdiction in the riparian and aquatic areas are also discussed. Although this document was developed for the physical and biological characteristics of the western Washington region, it may serve as a valuable prototype for other entities that are considering bank stabilization techniques for their specific geographic area.

Floodplain management strategies, including the protection of natural resources in floodplain areas, have become more comprehensive and environmentally sensitive. The guidelines have been produced as one part of the implementation of recommendations of the 1993 King County Flood Hazard Reduction Plan (FHRP). The FHRP emphasizes the need for environmentally sensitive methods when constructing and maintaining flood protection facilities.

For the King County region, the importance of the aquatic and riparian habitat is evident by the variety of anadromous and resident species of salmonids and the numerous terrestrial species. Information on flora, fauna, and the fluvial processes of the area are included in the document to provide the framework for developing bank stabilization projects that will correspond with the region's natural biological and physical processes. Over time these projects will become self-maintaining, providing an additional benefit of reducing long-term maintenance costs. With limited public resources available to maintain
river facilities, there is a need for new cost effective methods in both the design of new projects and the operation and maintenance of existing facilities.

The methods presented in the guidelines require a comprehensive background in river mechanics. The guidelines are intended to be used in conjunction with other published literature, with problem identification and solution analyses conducted by an interdisciplinary design team. The team should consist of an engineer with experience in river systems, an ecologist and botanist knowledgeable in the local habitat and vegetation, and an earth scientist familiar with fluvial processes. Additional expertise may be offered by a landscape architect.

Background

Six major rivers and a large network of tributary streams flow through King County. Most of these drainages originate in the upper elevations or foothills of the Cascade Mountains in the eastern part of the county and flow westward to Lake Washington, Lake Sammamish, and Puget Sound. These rivers and streams are a highly valued natural resource in the county, providing important ecological, economic, recreational, and aesthetic benefits to its residents. As the county’s population has grown, an ever-increasing number of residents have chosen to live, farm, or do business along its rivers and streams. Because rivers and streams are dynamic systems, moving horizontally and vertically over time, many developments along these waterways are continually threatened by erosion.

Erosion of stream and riverbanks is one of two major problems associated with living near these waterways—the other is flooding. Both these problems cause serious property damage in King County every year and tend to occur coincidentally. High flows that cause flooding also tend to cause episodes of accelerated bank erosion. In 1990 alone, well over $15 million in public and private property damage was caused by flooding and bank erosion along King County’s rivers and streams. The cost of repairing damages to County-maintained revetments after the 1990 floods was estimated to exceed $4.5 million.

The Need for a New Approach

In the past, the solution chosen to protect public and private properties from serious bank erosion typically was to cover the eroding bank with a blanket of riprap—large, broken rock—creating a revetment. In recent years, numerous river scientists and public works experts have questioned the traditional view of how bank stabilization projects should be built and maintained. As a result of their efforts, new approaches are emerging.
One of these approaches, a vegetated geogrid, combines soil and plant materials to create a complex grid, or matrix, of these materials in the bank above the ordinary high water mark. A rock toe is usually placed below the ordinary high water mark to provide structural support and to prevent the river from undercutting the repair (Figure 1). As the vegetation in the project site becomes established, the bank becomes stronger. At the same time, the vegetation improves fish and wildlife habitat and reduces local stream velocities. These projects thus provide an environmentally sensitive, low-maintenance solution, and lower long-term costs.

Figure 1. Section view of a vegetated geogrid installation with rock toe key.

Biotechnical bank stabilization techniques, which use soil, vegetation, and rock, have been successful in various places across the United States and Europe. Most significant, however, is that a number of recent projects have proven these methods to be a highly effective approach to erosion control along major rivers and streams in King County. Two of these projects were completed only shortly before the record-setting November 1990 flows, leaving no time for vegetation to become established, but both projects survived remarkably well. Although minor problems were evident, these projects prevented further erosion of the immediate area during unprecedented flooding.
Following the 1990 floods, another biostabilization project was constructed by the SWM Division to repair an existing levee damaged by flood waters. Rather than simply replacing riprap lost in the floods, staff from the SWM Division and U.S. Army Corps of Engineers designed and installed a biotechnical solution. Today, that project, along with the earlier constructed projects, is providing both effective erosion control and environmental enhancement.

In recognition of the success of these new approaches to bank stabilization, the 1993 FHRP recommends these techniques for numerous bank stabilization projects throughout the county. To fulfill this recommendation and satisfy an increasing demand for information about these types of methods, King County has prepared bank stabilization guidelines.

Overview of the Guidelines

The document provides information for designing, building, monitoring, and maintaining bank stabilization projects along major rivers and streams in King County. These guidelines are intended both for newly proposed bank stabilization projects along rivers and streams and for the repair of existing levees and revetments. The focus is on medium to large stream and river systems having mean annual flows of 20 cubic feet per second or more. Fish habitat considerations are integral in bank stabilization projects and are discussed in that context within the document.

The guidelines are not intended as a "design manual" prescribing precise standards and formulas for bank stabilization projects. Rather, they are intended to present ideas and parameters while leaving a fair amount of discretion to the technical experts developing the project. The reasons for this are twofold: first, the science of biotechnical bank stabilization is evolving, and the body of empirical data too limited, to provide the kind of precision found in traditional design manuals; and second, there is as much intuition as practical science in the application of these techniques. Professional and field experience with problem-solving along rivers and streams, and a thorough understanding of the river system in question are all essential in the development of bank stabilization solutions, yet none can be provided by any set of written guidelines.

For that reason, these guidelines are intended for a very specific and well-qualified audience. Users of this document should have a comprehensive background in river systems and specific training in one or more of the following: open channel hydraulics, sediment transport, geomorphology, riparian ecology, or aquatic and terrestrial habitats. Because these guidelines rely heavily on the designer's ability to integrate engineering expertise with the soil, plant, and biological sciences, it is strongly recommended that a team approach be used when developing or reviewing possible bank stabilization projects. At a minimum, the team should consist of an engineer with experience
in fluvial systems, an ecologist knowledgeable in fisheries and riparian biology, and a geomorphologist familiar with fluvial processes. In addition, some projects may require the special skills of a soil scientist, plant specialist, or landscape architect.

The following summarizes the major elements of the document. The Riverine Environment is a description of the geology and ecology of rivers and streams in western Washington, specifically King County. Modes and Causes of Bank Failures illustrates the different erosion mechanisms and characterizes streambank and riprap failures. Project Planning is an overview of what questions to ask, and what data to gather, when conducting preliminary site investigations. Permits and Policies includes a discussion of government regulations, permit requirements, and policy issues that project designers need to understand. The Role and Use of Vegetation emphasizes the use of native plant species, provides descriptions of how vegetation can be used in bank stabilization, and demonstrates the benefits vegetation can provide. Design Guidelines presents various design options for different circumstances, leading to the selection of the best alternative. Construction Procedures illustrates the installation of the design options and provides guidance in construction planning. Monitoring and Maintenance includes post-construction considerations for the repair and maintenance of projects to ensure long-term effectiveness. These topics are followed by a glossary of important terms and a list of references for those seeking additional information. Four appendices provide detailed information on fish species, agency and tribal contacts, riprap design methods, and an example of contract specifications for a biostabilization project.

**Conclusion**

Far from being the final word on bank stabilization techniques, the guidelines are envisioned as a comprehensive, first step in a long-term effort to study, improve, and promote biotechnical bank stabilization in King County and western Washington. Documentation of project successes and failures is essential for directing future designs toward successful results. Readers are encouraged to share their experiences with other practitioners. Refinement of the procedures in this document is expected and encouraged so that others may learn from the creativity of innovative designers.

After thoroughly reading the document, the reader should have a basic understanding of the complexity and utility of the numerous bank stabilization techniques. Throughout the guidelines, additional reading sources have been referenced that should be utilized for design criteria. Because integrated soil-plant-rock systems encompass many scientific areas, no single design reference will cover all aspects of the project elements in detail. The reader will realize success in these projects by beginning with a genuine understanding of the
physical and biological processes of riverine environments and applying of the techniques creatively.

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Part Ten

Nonstructural-Structural Interface
Introduction

A significant finding of the U.S. Army Corps of Engineers (USACE) in the Regional Environmental Impact Statement for the Trinity River and Tributaries (REIS) was the determination that different local policies for floodplain reclamation can alter flooding risks, or increase the potential for water quality and environmental degradation. Cities involved in the North Central Texas Council of Government's (NCTCOG) COMMON VISION program, an ongoing effort to address the challenges and opportunities of the Trinity River in the Dallas/Fort Worth Metroplex, responded to these findings by drafting a Statement of Principles for Common Permit Criteria. The cities expressed their support for a cooperative management program whereby each city retains development permit authority within its jurisdiction, but bases its permit decision on a set of commonly accepted permit criteria. These cooperative efforts have developed to include not only a basic level of common permit criteria, but joint review of permit applications as well. The main product resulting from these efforts is the Corridor Development Certificate (CDC) process. This paper will briefly detail the background of the CDC concept and describe the process itself.

Background

The REIS was initiated in the mid-1980s, as the USACE Fort Worth District became aware of numerous unrelated development projects being proposed along the Trinity River and its tributaries in Dallas, Denton, and Tarrant counties, Texas. Because the projects were felt to have, whether individually or cumulatively, the potential to compromise the existing protection afforded to floodplain residents, as well as impacting on wetlands and other natural resources, the USACE District Engineer determined that was necessary to develop a regional perspective to properly evaluate the impacts of individual permit decisions in accordance with the spirit and intent of the National Environmental Policy Act and other applicable laws.

The final REIS considered several different floodplain condition scenarios, indicating that there were potentially significant cumulative impacts associated
with inconsistent permitting strategies throughout the corridor. Three central issues arising from these findings were the level of flood protection appropriate to respond to 100-year or Standard Project Flood (SPF) conditions, the relative accuracy of the REIS hydraulic and hydrologic analyses, and the equity of local implementation of floodplain management regulations.

In response to these findings and the potential for much stricter USACE floodplain criteria in the region, policy positions were developed through NCTCOG calling for a cooperative management program using common permit criteria which are derived from criteria now being applied by the USACE permitting process. They also called for expanded technical assistance by the USACE and a regional review and comment process by other local governments for major actions within the corridor. One of the most important products of this response is the CDC manual and process.

What is the CDC Process?

When the local governments, acting through NCTCOG, began discussions to create a common permitting process, one of the first realizations was that there was indeed an inconsistent approach to floodplain regulation throughout the corridor. With the specter of extremely strict USACE criteria being put into place, the local government elected and staff representatives realized that the existing factors determining floodplain management decisions for each community had to be reevaluated. The CDC process is simply the manner in which the participating local governments agreed to approach floodplain permitting decisions. The cities have agreed to use commonly accepted criteria and a common permitting process to ensure the availability of a more consistent level of information to make permitting decisions. In addition, an added corridor-wide "review and comment" of all CDC applications has been woven into the process. NCTCOG will serve as the information clearinghouse for application and permit information.

This cooperative process has been designed to satisfy the requirements of the Federal Emergency Management Agency (FEMA) and the Texas Water Commission (TWC) regarding city floodplain permit actions within the Trinity River Corridor and to effect close coordination with the USACE and other state or federal agencies that have their own permit processes. The CDC process has been designed to not conflict with other state and federal programs in place that regulate floodplain development.

Geographic Area of Regulation

The participants have defined the Trinity River Corridor as the river segments from the dams of the major USACE and water supply reservoirs in the
Dallas/Fort Worth Metroplex. Through a long period of negotiations between the local communities and USACE, the corridor has been delineated into two zones: the regulatory and review zones (Figure 1). The regulatory zone approximates the area within the 100-year floodplain, and the review zone represents the remaining area between the regulatory zone and the designated SPF boundaries of the river corridor. The regulatory zone is the area in which any and all development activities will require a CDC permit to occur. The review zone is the area in which development activities will require review of Part I of the CDC application by the appropriate local government. Although no permit is automatically required, the purpose of this zone will be to maintain data on activities occurring in this portion of the watershed. In addition, the cities participating in this program may require regulatory zone requirements for areas in the review zone within the municipality's jurisdiction.

Any public or private development within the regulatory zone of the Trinity River Corridor must obtain a CDC prior to start of any development activity. A development activity by a city within the Trinity River Corridor will be treated like any other application for a CDC and will undergo the USACE permit process, and if applicable, the regional review and comment process discussed later. To avoid conflicts between adopted policy and city ordinances, the municipal application will then be considered and acted upon by that jurisdiction's policy-making body, e.g., City Council.

**CDC—Common Permit Criteria**

In order to ensure that a consistent design level of protection is provided in each CDC application, a set of permit criteria has been developed and a CDC manual published and released. The applicants for a CDC would be required to provide sufficient detailed information to document compliance. The criteria includes the following.

**Hydraulic Impacts—Projects within the Regulatory Zone**

1. Water surface elevations. No rise in the 100-year flood or significant rise in the SPF water surface elevations for the proposed condition will be allowed.

2. Storage capacity. The maximum allowable loss in storage capacity for 100-year flood and SPF discharges will be 0% and 5%, respectively.

3. Velocities. Alterations of the floodplain may not create or increase an erosive water velocity on-site or off-site.
(4) Conveyance. The floodplain may be altered only to the extent permitted by equal conveyance reduction on both sides of the channel.

Hydraulic Impacts—Tributary Projects

For portions of tributary projects that are within the regulatory zone of the Trinity River, the maximum hydraulic impacts are the same as those for mainstem Trinity River regulatory zone projects.

Cumulative Impacts

The upstream, adjacent, and downstream effects of the applicant’s proposal will be considered. The proposal will be reviewed on the assumption that adjacent projects will be allowed to have an equitable chance to be built, such that the cumulative impacts of both will not exceed the common criteria. Hydraulic data should be supplied to show the impacts of adjacent developments (e.g., HEC-2 modeling with blocked off conveyance).

Design Level of Flood Protection

The engineering analysis will include the effects of the applicant’s proposal on the 100-year flood and SPF and should demonstrate meeting USACE, Federal Emergency Management Agency (FEMA), TWC, and local criteria for both flood events.

(1) For levees protecting urban development, the minimum design criterion for the top of levee is the SPF plus four feet, unless a relief system can be designed that will prevent catastrophic failure of the levee system.

(2) For fills, the minimum design criterion is the 100-year flood elevation plus one foot, unless a relief system can be designed that will prevent catastrophic failure.

Borrow Areas

The excavation of borrow areas to elevations lower than the bottom elevation of the stream is generally hydrologically undesirable. The volume of such excavations, above the elevation to which the area can be kept drained, may be considered in hydrologic storage computations.
**Preservation of Adjacent Project Storage**

The applicant will be required to respect the valley storage provided by adjacent projects by ensuring that their hydraulic connection to the river is maintained. If the project blocks the hydraulic connection of the adjacent project, then the applicant will be required to provide additional valley storage to offset the loss caused by the blockage of the hydraulic connection.

**CDC—Consistent Analysis**

To insure that all proposed developments are afforded a complete and consistent level of analysis, all applications will include the following components at a minimum.

**Project Plans**

Project plans will be submitted as part of the CDC application. The plan should show the location of the FEMA regulatory floodway and the layout of cross-sections used in the hydraulic model. Proposed changes to the floodway will also be shown.

**Hydrologic Data**

Design discharges for the 100-year and SPF storm events shall be based on urbanization consistent with CDC future scenario(s) model provided by the USACE.

**Hydraulic Data**

Water surface elevations at the upstream, middle, and downstream ends of the project (for pre-project and with-project conditions) for 100-year flood and SPF discharges consistent with the appropriate USACE CDC future scenario(s) model should be provided with the CDC application. Hydraulic calculations should be continued for a distance great enough upstream and downstream of project to verify water surface elevations are not raised by the proposed hydraulic modifications. In all cases, the best available data on water surface elevations will be utilized. Printouts and plots from an approved hydraulic model (HEC-2) of cross-sections for pre-project and with-project conditions should be part of the CDC application. Water surface profiles for 100-year flood and SPF for pre-project and with-project conditions should also be included.
Elevation, Storage, and Discharge Data

Elevation, storage, and discharge data for pre-project and with-project conditions will be required.

USACE Jurisdictional Review

Applicants should provide written correspondence from the USACE indicating whether the Corps jurisdiction applies to the project area.

Resource Data

Applications will provide information on environmental/cultural resources, including:

1. Engineering and environmental resource data which tabulates the impact on land cover types and habitat units; and

2. Any plans for erosion control, general landscaping, or other practices to minimize potential water quality and other environmental impacts. Projects areas which are within USACE jurisdiction are also required to provide identification of mitigation required for loss and/or alteration of high value habitats. Developments which propose to relocate or alter a natural channel will also submit more detailed environmental data and a stream rehabilitation program.

Maintenance and Operation Data

An estimate of annual maintenance and operation costs for the hydrologic and hydraulic aspects of the project will be required. Parties responsible for costs associated with maintenance and operation in perpetuity for the "as designed" condition will be identified. If maintenance is to be accomplished by an agent other than the community, a legal provision for community monitoring and backup maintenance is required.

Erosion Control Plan

The applicant is required to contact the appropriate regulating jurisdiction to obtain specific local erosion control requirements and plan submittals.

The CDC Process

The CDC process does not add any new hurdles for the development community. Instead, it provides a clear order to the development procedures
already in place. The new features the process adds include the opportunity for regional review and the emphasis of consistency throughout the permit process. The following flow chart (Figure 2) details the process. In a more simple terms, the CDC application review process can be broken down into five basic steps.

**Step 1. Determination of Applicability by City**

Does the city have jurisdiction regarding this application? Is it within the Trinity River Corridor? Is it within the regulatory or review zone? Is it exempted from the process? If the city has jurisdiction for the project, the review process proceeds. If not, the city informs the applicant in writing.

**Step 2. Jurisdictional Review by USACE**

The Fort Worth District staff of the USACE will perform the jurisdictional review and provide preliminary hydraulic/hydrologic technical data required by the common permit criteria in coordination with the city and the applicant. This review will occur within 30 days of submittal to USACE, provided all required data has been received.

**Step 3. Notice of Intent to Process by City**

The city will review the application materials and USACE findings within its own time frame. If the city decides to deny the application at this point, the process ends. NCTCOG will be provided a copy of this action. If the city decides to continue the process, then it will assure that the application is complete, assign a CDC identification number, and provide the full application to the USACE for a permit determination, to FEMA if a conditional map revision is required, to the TWC if their jurisdiction applies, and to NCTCOG for incorporation into the Trinity River Information Network (TRIN) tracking system.

**Step 4. Parallel USACE, FEMA, TWC, and Regional Review**

If the application is subject to a USACE individual permit, then the public notice and review/comment process will be initiated by USACE (including the other affected local governments). If the application is not subject to a USACE individual permit, then the city will distribute a notice and materials directly to the other participating local governments. The FEMA and TWC review processes will occur simultaneously. If under USACE jurisdiction, USACE will decide whether to issue its permit and so notify the city and applicant. Likewise, FEMA will notify the city regarding any requested conditional map
Figure 2. The corridor development certificate process.
revision and the TWC for any plan of reclamation. The other participating local governments will have 30 days from receipt of the Notice of Intent to Process to provide the city with written comments. Time extensions for the written comments may be granted by the city. If no response is received from a participating entity during the comment period, it is assumed that a "no response" implies no comment for documentation purposes. Applicant appeals from the permit decision may be sought from the individual jurisdiction.

Step 5. Formal City Action

The final step in the application review process is formal approval, approval with conditions, or disapproval by the city within the CDC area. If a USACE permit, a FEMA conditional map revision or a TWC plan of reclamation is denied the applicant, the city will not issue a CDC. If approved by the city over the expressed unfavorable opinions of other participating local governments, a written summary of the justifications for the city's action will be attached to the approval action. A copy of the final disposition of each CDC application will be provided to NCTCOG for the permanent corridor records. The CDC permit process will be subject to the participating jurisdiction's appeals process.

If no development activities occur by the end of five years from the date of issuance of the CDC permit, the applicant will have an opportunity to apply for a three-year extension or the CDC permit shall cease to be valid. Summary project status reports are required to be submitted to the permitting local government annually. Any significant changes to the project by the applicant or the city requires the re-evaluation of the permit and may result in a reapplication.

Conclusion

This paper has documented in brief terms an innovative permitting strategy to impact development patterns on a regional basis. The cumulative impacts of development activity on the hydrologic and hydraulic character of the Trinity River Corridor are being acknowledged and planned for. The initial success of the development of the CDC process and its early implementation is due in large part by the responsible leadership of the local governments involved. It is the hope of NCTCOG that as the permitting strategy is fully implemented it will become a model for other areas of the country facing the same complex floodplain management issues.
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Background

Attitudes toward floodplain management have changed significantly in the past few years in Sacramento County, and the policies regarding development in floodplains have likewise changed. To reflect the changes, the Public Works Department prepared a document outlining the overall floodplain management program for the County and stating specific policies regarding development in a floodplain. The purpose of the document is to present the overall floodplain management program, provide specific development policies, and the rationale and intent behind the policies. The document is scheduled to be adopted by the County Board of Supervisors in March 1993.

The backbone of the floodplain management program is preparation of master drainage plans. Master drainage plans are being prepared that will provide plans for floodplain development in each watershed. The master plans will incorporate a variety of flood control, environmental, and recreation objectives. The premise is to get ahead of development and allow the master plans to determine how a floodplain is managed rather than letting development dictate, as has occurred in the past.

Preparing master plans for each stream will take several years; meanwhile, development pressure continues. Policies have therefore been proposed to guide development near floodplains in the interim. The interim policies are intended to keep development out of floodplain corridors in undeveloped areas until the master plans can be prepared. In developed areas, the policies allow for development along the floodplain consistent with the specific flooding characteristics of a stream.

The policies are important to the local development community and County staff for several reasons. This is the first time floodplain development policies have been written for the County, and these are new policies that represent a change in direction from past practices. The document also explains the rationale and intent of each policy, which helps the layperson better understand them. Knowing the intent of policies also allows flexibility in their implementation. Since many of the policies are tailored to individual stream groups, the discussion of rationale increases understanding of the differences in stream policies.

The policies have resulted in many benefits to developers and County staff. While developers oppose individual policies, the ground rules are set and they can factor these policies into their land acquisition decisions. Decision makers have been given insight into the technical issues behind engineering
recommendations, which is very important. In the past, the board was somewhat leery of some Public Works recommendations because they did not really understand the reasoning behind them, and they certainly did not understand why two similar projects on the same stream were treated differently. Explaining the differences and the reasoning behind proposed policies in written form allowed the Board to better understand the problems and lessened the mistrust of our recommendations.

The interim policies have been divided into two categories: countywide, and watershed-specific. Countywide policies include those of general applicability. Watershed-specific policies are supplementary to the countywide policies and are based on specific characteristics of individual stream groups. The policies govern development of individual sites only. Policies that are implemented on a regional basis are not explicitly included. For example, detention is not required of individual projects since we prefer to construct regional detention facilities.

An important concept included in our policies discussion is the allowance for engineering judgement in the implementation of the policies. The policies as written are intended to apply to 98% of development, but could not possibly encompass all situations. Staff will recommend exceptions to the policies for projects where circumstances warrant them, provided they meet with the intent of the policies as outlined in the document. The document itself should provide some relief from "mindless bureaucrats" blindly implementing policy as though it were etched in stone.

Countywide Policies

Buildable Areas

This policy requires specific buildable areas above the 100-year floodplain for all newly created lots. The minimum buildable area is based on the zoning and lot size. For example, nearly all of a residential lot must be above the base flood elevation. This denies creation of trouble parcels where residents have a stream through their property, and where it is likely that landscaping, fencing, etc., will be constructed that will impact stream flow.

Fill in the Floodplain

With certain exceptions, fill shall not be allowed where the depth of the 100-year flood is greater than two feet. Also, there will be no net loss of storage in the 100-year floodplain, with in-kind replacement (hydraulically equivalent) of lost floodplain storage. This policy limits the loss of floodplain storage, maintains a minimum flood corridor width, and keeps development out of most of the conveyance area of a stream.
Access

Vehicular access to newly created parcels shall be above the 10-year flood elevation. Creation of parcels that require or encourage stream crossings for single lots will not be allowed. This ensures that all parcels have reasonable access and discourages parcels that are likely to have private stream crossings, imported fill, landscaping, fencing, etc., within the floodplain, which often increases flooding to neighboring parcels.

Pier Foundations

Pier foundations for structures are only acceptable when they are outside the conveyance area of a stream, with exceptions for existing parcels that are entirely in a floodplain. The intent is to keep buildings from being built too close to streams.

Fences

Fencing is prohibited in the floodway of streams. Open fencing is required within all floodplains. Some exceptions are made for agricultural parcels. This policy recognizes the need to protect property while minimizing flow restrictions.

Easements

Dedication of floodplain easement will be required over the entire 100-year floodplain upon development of a site. When a site is not fully developed, some of the easement may be returned to the property owner if developed consistent with an adopted master plan. This policy describes easement requirements upon development of a site.

Fair Share Contribution

All development must make a fair share contribution toward the cost of environmental mitigation, water quality and flood control detention, and master plan studies, above and beyond the existing drainage fee. The current drainage fee is a developer fee that provides only for construction of pipe and open channel facilities. The items described above are new requirements and are attributable to all development within a watershed. Therefore, all development should contribute to these costs.

Levees

Levee construction is not allowed to reclaim floodplain land for new development. However, if levees are approved, a minimum 200-year protection
is required. By adopting this policy, the County has recognized that constructing levees to reclaim floodplain for new development should be avoided if at all possible. However, at the same time it is recognized that if it is politically necessary to allow levees, a higher than normal level of protection is required.

**Miscellaneous**

Concrete lining will be discouraged except in infill areas where consistent with existing adjacent reaches of a stream. Naturally appearing channels will be encouraged in currently undeveloped areas. Stream improvements will be designed for low maintenance, reflecting future vegetative growth. Development adjacent to floodplains shall provide a public street paralleling at least one side of the floodplain. These policies reflect the concept of providing floodplain corridors that are amenities to the community.

**Watershed-Specific Policies**

**Natural Streams**

These streams have been identified by the County as aesthetically important to the community and may not be significantly altered or improved for flood control purposes. Development is not allowed in the 100-year floodplain of these streams. Unfortunately, development was allowed to occur very close to the stream banks before adoption of the ordinance protecting the streams. This development was based on plans to deepen the existing creeks and line them with concrete. The result is that some structures are at risk of flooding under the existing condition, and additional development in the floodplain will only aggravate flooding problems. Therefore, development may not cause any offsite increase in the base flood elevation unless easement is provided over the impacted areas.

**In-fill Areas**

These include areas already developed where channel improvements have previously been made, and where future improvements are not prohibited. Floodplain encroachment will be allowed outside of floodways where the depth of the 100-year flood is less than two feet, provided there is no impact to adjacent structures. Loss of floodplain storage is acceptable in these areas; however, regional detention will be provided elsewhere in the same watersheds to make up for the impact of this lost storage. The intent for these areas is to allow them to develop consistent with adjacent development.
Undeveloped Areas

Undeveloped areas provide an opportunity to plan floodplain corridors prior to development. Therefore, development will be restricted from occurring in these floodplains until such time as master drainage plans are established. Minimum setbacks from streams are set based on the size of watersheds, and allowances are made for some development along the edges of floodplains. Development outside floodplains is allowed.
DAM FAILURES AND THEIR EFFECTS ON THE FLOODPLAIN

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Introduction

Humans always have and always will depend on water to survive. As human needs for water increase, the supply management needs to increase as well. Dam construction is one way to meet water supply needs. Dams provide flood control as well as water for drinking, recreation, irrigation, fire protection, and many other uses. Dams are a vital part of a growing society, yet they involve risks that few people think about. There always exists the potential that a dam could fail.

When most of us hear the word dam, we think of large concrete structures such as Hoover Dam. These dams, while well known, make up only a few of the dams in the United States. A standard definition of a dam is "a water retaining structure that is either 25 feet tall or can store at least 50 acre-feet (one acre, one foot deep) of water." There are at least 100,000 structures in the United States that meet the definition of a dam (Iarossi, 1992). Most of these dams are smaller privately owned structures. Consequently, these dams do not receive as much attention as does a Bureau of Reclamation (BOR) or a Tennessee Valley Authority (TVA) dam. The number of dams in a state varies. Georgia has over 4,000 dams within its boundaries. Organizations such as BOR and the TVA have specialized departments for inspection of their dams to insure they are operating safely. It is the smaller, privately owned dams and their breach zones that need regulating to ensure the safety of people living downstream.

Some Major Failures

Several major dams failed in the 1960s and 1970s, bringing the issue of dam safety to the forefront. The following is a brief discussion of three dam failures: Sheep Creek Dam, Teton Dam, and Kelly Barnes Dam.

Sheep Creek Dam in North Dakota was a 60 foot high earthfill embankment with a crest length of 1,100 feet. In May 1970, six inches of rain fell within the drainage basin, filling the reservoir for the first time and placing the service spillway into operation. Before long, flows were observed outside of the pipe at the spillway basin. The reservoir level rose to approximately 5½ feet above the top of the spillway inlet. The dam breached a few hours after the spillway went into operation. The time required for complete failure was less than five hours (U.S. Department of the Interior, 1991).
Probably the most notable dam failure was the Teton Dam. Teton Dam was a zoned earthfill dam with a low-permeability central core. It rose 305 feet above the riverbed, was about 3,000 feet long, and would have formed a 288,250 acre-foot reservoir. The spillway was a gated chute structure on the right abutment. Low-level reservoir releases were to be controlled by a river outlet works in the left abutment and by an auxiliary outlet works in the right abutment. During the initial filling of the reservoir trouble developed. On June 5, 1976 a large leak near the right abutment in the dam—about 130 feet below the crest—washed away the embankment and caused the dam to breach. Eleven people died and $400 million in property damage occurred (Jansen, 1988).

On November 7, 1977, the Kelly Barnes Dam in Georgia failed. It was an earth and rockfill structure originally built in 1899 as a rock crib dam. During the 1930s and 1940s there were modifications made to the dam. After the modifications, the dam was 40 feet high, 400 feet long, and contained a 40-acre lake. After a period of heavy rains, the dam failed. The flood wave from the dam’s failure flowed through the mountains and over a series of falls, eventually flooding Toccoa Falls College. A trailer village for married students, a dormitory, and some college buildings were in the floodplain below the dam. The flood destroyed this area, killing 39 people and causing nearly $2.5 million damage (Georgia Department of Natural Resources, n.d.).

While this dam was relatively small, the impact of its failure was large. It was the culmination of two decades of dam failures, bringing the issue of dam safety into the public light. Over the next two years, President Carter issued executive orders that would lead to the development of the Federal Guidelines for Dam Safety and creating the Federal Emergency Management Agency (FEMA). FEMA has responsibility for promoting dam safety and coordinating national dam safety activities. In 1980, officials created the Interagency Committee on Dam Safety (ICODS) to encourage the establishment and maintenance of effective federal and state dam safety programs for protecting human life and property (Iarossi, 1992). In 1984, state dam safety officials formed the Association of State Dam Safety Officials (ASDSO). To date, 48 states are members.

Recommendations

While dam safety has come a long way in recent years, there is still room for improvement. Every effort possible must be made to reduce the potential for failure of high hazard dams. What can be done to improve the situation?

The first item is relatively easy. ASDSO, in conjunction with FEMA, already provides public awareness workshops, pamphlets, and other educational material. This effort needs to be expanded. There also needs to be greater incentives for state dam safety regulators to develop their programs along the
ASDSO model dam safety guidelines. Additionally, FEMA should encourage states that do not have a dam safety program to establish such a program, and should try to stop attempts to eliminate existing dam safety programs, such as New York's current effort.

One of the biggest problems with dams is simply locating and categorizing them. Attempts are still being made to locate dams that are unknown to state dam safety programs. One step helping Georgia stay informed about new dam construction is an arrangement with the U.S. Army Corps of Engineers (Corps). Apparently, many people were informing the Corps about their intentions to build dams, but this information was not being passed along to the state dam safety program. This allowed dams to be built and sometimes go several years before addition to the state inventory. The Corps' large fines and emphasis on 404 permits create a greater incentive to notify the Corps of any intentions to build. A policy has been established where the Corps and Georgia's Safe Dams Program exchange information concerning the construction of any dams in Georgia.

Another idea is for each state to adopt an amendment similar to the one incorporated into Georgia's Safe Dams Act. This amendment requires the local governing authority to notify the state of any proposed development downstream of a low hazard dam. The amendment also requires that a dam breach analysis showing flood velocities and elevations be provided. This gives the local government the opportunity to restrict development within the dam breach zone. It also guarantees that dam owners be notified in advance if their dams are about to be changed to high hazard (regulated) dams. Previously, the owners were not notified of the change until the dam had been reclassified and they faced a large bill to upgrade the dam.

Another approach that needs to be considered is to require all dams be designed by a qualified registered engineer experienced in dam construction and monitored during construction. This may cost the prospective dam owner more initially, but it should reduce operational costs and potential failures. For this to be truly effective, each state must have sufficient staff to oversee this process. The current downstream hazards should not be a consideration in determining whether a dam must be designed by an engineer. They all have the potential to become a high hazard sometime. One cannot expect all construction in the breach zone of a dam to be halted, especially given the shortage of real estate in some metropolitan areas. It is best to build the dam properly instead of retrofitting it. Proper maintenance is necessary to ensure continuing structural integrity.

It is impractical to expect states to provide continuous monitoring of every dam within their boundaries to ensure proper maintenance. Organizations such as FEMA, ASDSO, and the states must work to educate the owners on the importance of proper maintenance. Additionally, there are case histories
available to impress upon the owner the potential liability and the need for a routine maintenance program.

**Dams and the Floodplain**

The presence of dams must be considered when developing floodplain management plans. The dam breach zone must be considered when proposed development permits are being reviewed. It is not correct to assume that the 100-year floodplain and the breach zone are the same. The breach zone can cover a larger area. Therefore, local governments should use the 100-year floodplain and the breach zone when reviewing zoning and development. It is not practical to eliminate totally developments within the dam breach zone. Consideration must be given to the type and density of development in the breach zone, as well as the possibility of dam reclassification.

**Conclusions**

Finally, it must be pointed out that dam failures, like fires, cannot be totally eliminated. Still, additional public education, better coordination between the state, local, and federal governments, and improved dam construction can minimize the number of failures of high hazard dams. By careful regulation and interagency coordination, dam failures and their impact on flood plain management can be greatly reduced.

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Part Eleven

Summary
CONFERENCE 1993 SUMMARY

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Federal Emergency Management Agency Region X

First, I would like to give you my interpretation of a wrap-up speaker’s assignment. The final speaker is supposed to somehow summarize the conference within a context of how the various speakers contributed to its theme. At the same time, he or she makes everyone feel great about the accomplishments of the last several days and demonstrates the worth of the conference material. Finally, wrap-up speakers are supposed to impart a warm, shining glow to each participant so that they feel inspired to take the material from the conference and charge back to their jobs and Do Great Things to Advance Floodplain Management. I’m going to try to accomplish all three of these goals, so I hope you will bear with me.

You know, at past conferences we have had some pretty good wrap-up speakers and they have been of several different types. Some have been the "heavies" of program areas, like Federal Insurance Administrators, who have talked about new federal policies, major new insurance initiatives, or pending legislation. The messages have been good ones: I am certainly glad that the National Flood Insurance Program is self supporting, for example. I know now what pays for my beer, my pretzels, and my racing canoes—it’s flood insurance premiums! So messages like that are always good and welcome.

Then we have had some pretty inspirational speakers like General Hatch from the Corps of Engineers. Those of you who have heard the General speak know that not only is he an inspirational speaker, but that he also has a very global perspective.

We have heard on a number of occasions from Jim Rose of the Federal Insurance Administration, who has an almost clerical quality to his parting words. He is always welcome as a wrap-up speaker.

And then we have had folks like Chris Brown, formerly of American Rivers and now of the National Park Service, whose slide presentations about the water-related environments that we all work in have been inspirational and have demonstrated the myriad of benefits available from cooperative river corridor projects that involve multiple stakeholders.

As you can see, I am following a list of accomplished, qualified, and inspirational speakers of the past. Therefore, although my assignment is a daunting one, I hope that I can provide you with the same kind of summary and philosophical energy today.

Therefore, let me tell you what my own mission statement is. I sincerely believe that if the Association of State Floodplain Managers is going to maintain its leadership role in flood hazard management in the United States, it will not be simply through new legislative initiatives, the instigation of various tweaks
and twists to the National Flood Insurance Program, or by our returning home to the various jobs from which we all came and continuing with our day-to-day work.

The point of this conference was to show you what was going on outside your normal circle of contacts in the hope that you would make the linkages between what they do and what you do; to show you that their knowledge and methods could be applied or modified to fit your needs; and to encourage you to then go back to your jobs and start to see that holistic floodplain management is more than just what you do in your own specialty. If I can leave you with the importance of this point and leave you inspired to charge home and continue using this philosophy for learning and finding new ways to do things, then my mission will have been accomplished.

Those of you who know me have already guessed that I would relate "cross training," the first half of the theme of this conference, to athletic activities. But to me, cross training is what you do when you cannot do your regular workout or your normal activity. "Training" means to me a repetition of something you already know. As a runner and canoe racer, I use cross-training as a way to maintain conditioning when I’m injured, or when I’m overtrained in one of those events, or when I don’t have access to the equipment I need. That’s why I see some other terms that help me better define this concept and I offer those to you—not in contradiction of previous definitions—but in the hope that it may help you, too, to solidify your own concept of "cross training."

"Cross learning" is a term I can better identify with. Actually, I think I see the crossing-over theme as including cross learning, cross searching, and cross finding. For me, it is more a matter of seeking out information that I don’t already have.

Now let’s look at "light the torch," the second facet of the conference theme. I know that lighting the torch got its start because the next summer Olympic Games will be held here in Atlanta. But aside from that, why not "light the fire?". Maybe that reflects a vision of Dan Cotter and Cynthia Pollnow burning all the paper flood maps in their quest for the dominance of GIS format for all flood hazard maps.

Or "light the lantern." Maybe that’s Bob Freitag and the rest of the disaster mitigation people searching long and hard into the post-disaster night for some response/recovery honcho who will listen to the mitigation message. We all know that he’s been searching for a friendly ear in the recovery community for over a decade now!

Or maybe it should be "light the stove." That could be the states trying to heat up the engineering issues that they sometimes bring to FEMA for resolution, sometimes getting a less-than-desired response in either timeliness or in substance. Like last night when John Matticks, the boss of the Office of Risk
Assessment, bared his breast to the shots of all comers when he hosted an open forum on engineering and mapping issues.

I think that the most appropriate pyrotechnical term might be to "light the afterburners." Because that is what I picture we all need to do when we venture into the cross learning arena. Cross learning is what we must do, and with a fired-up spirit is the way we should do it.

Let me show you how some of our presentations have really fit that theme. First, we had Jerry Louthain who challenged each one of us to go out and meet a new fellow conferee. His point was to have us meet someone new and to see what they could offer us and then to offer what we had to them. Then Jay Northrup gave us his now-famous analogy of the pirouetting football player to get us started right.

Later, Doug Plasencia related cross training to the multi-objective management concept. Then came R. D. Ross, who's a great speaker in any forum. He talked of the crossover of the National Flood Insurance Program style of insurance to multi-hazard insurance.

Next, it was Gary Wamsley, the project manager of the National Academy of Public Administration's study of the Federal Emergency Management Agency. He hit us with his bombshell talk and revealed an environment that may change our world radically and require that we learn new skills and perceptions just to keep our jobs.

Chris Brown of the National Park Service, speaking in a breakout session, demonstrated that the multi-objective management philosophy that his River and Trails Assistance Program lives by is a ready-made opportunity for floodplain managers to work with and observe professionals in other areas such as wetlands, recreation, volunteerism, and civic groups. Frankly, I see this as one of the easiest ways for a floodplain manager to get his or her feet wet in the cross learning game. If you are hesitant at all about initiating contact with those related professions, becoming a player in one of the Park Service's efforts lets you start by becoming a part of someone else's project instead of driving one yourself.

We got a chance to hear from Chris' successor, Kevin Coyle, the present Director of American Rivers. Whereas his organization used to define themselves primarily as dam busters, now they are focussing on the entire watershed area including the headwaters, the maintenance of flow, and the near-stream or riparian zone.

And just a few moments ago, Frank Thomas told us about late-breaking news that we hope will bode well for the advancement of an institutionalized multi-objective view of flood hazard management.

From this, I hope you can see why cross learning is relevant to us now. Our changing environment demands it. The new legislation that Frank talked about may mandate that we learn new skills and learn to operate with new laws.
The location of the NFIP may be changing and we may have to operate in a different government format. It might be better or it might be worse. The whole role of FEMA may be changing. We have taken lots of hits lately for our support of civil defense. Maybe with the reduced role of civil defense, we could look forward to refocussing those resources on natural hazards. That is what those of us in natural hazards have talked about for a long time.

Finally, the last part of my mission is to leave you inspired. Each one of us holds the keys to the successful generation of cooperative flood hazard solutions. Those keys are perseverance and perspiration. I think those are the operative characteristics of successful missions and projects. When I look around and see who our heroes are, I don't see many moderates. I see zealots, missionaries, visionaries, and hard chargers. To these heroes, moderation and complacency are for wimps!

I see Gilbert White who devoted a lifetime to the idea of floodplain management . . . and Jim Goddard who has done the same. . . I see Frank Thomas and Larry Larson who are following suit. . . And then, I see the new kids like French Wetmore, Bob Freitag, and Tim D'Acci who look like they are headed in the same direction. These people all share a common characteristic: they are not moderates in their professions.

So, we should start to follow their example. Start doing more than just what your official job description says to do. Look outside your present circle of contacts. Look in new and nontraditional places for new answers and new twists. Look real hard.

My mother used to tell me and my three brothers that it was much better to aim for the moon and hit the fence post, than it was to aim for the fence post and hit the ground. So aim real high.

There you have it. . . Make the most of the knowledge you have gained here at this conference. Look into other disciplines for help and ideas. And then light your afterburners and aim high.