From the Mountains to the Sea—
Developing Local Capabilities

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

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Portland, Maine
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The Association of State Floodplain Managers, Inc.
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"From the Mountains to the Sea—Developing Local Capabilities" was the focus of the 19th annual conference of the Association of State Floodplain Managers, held in Portland Maine. This marked a return to Portland for the Association, as the annual conference was held there in 1984 as well. The ensuing 11 years have seen considerable change in floodplain management as well as in the Association itself.

The theme for the 19th annual conference was particularly fitting in light of the current national effort to elevate and promote mitigation in our efforts to reduce flood losses. There is a catch phrase being used in connection with the promotion and that is "all mitigation is local." The Maine Department of Economic and Community Development as well as the New England Floodplain and Stormwater Managers Association, are to be commended for the extraordinary effort put forth and the excellent conference agenda provided. The need for local leadership in floodplain management as well as educational efforts at the local level was stressed.

Pre-and post-conference classes involving basic floodplain management, map revisions, and mitigation planning were absolutely full, attesting to the demand for floodplain management training at the local level.

The conference was carried out in the format of a New England town meeting, which provided not only an entertaining approach but also a constant reminder of the importance of local decisionmaking. The agenda allowed participants the opportunity to learn of mitigation activities employed by localities in the aftermath of the 1993 Midwest floods, and hear of program and policy changes at the federal level that will encourage better flood loss reduction decisions at the community level.

As you review these proceedings, keep in mind that building local capability is a continuing educational process. New ideas, new policies and programs, and new people are added to the mix daily. The development decisions made by local officials that do not correctly account for the threat of flood damage will ultimately be revisited on the community. The cost of poor decisionmaking at the local level is often levied against all citizens.

George Hosek
Chair
Association of State Floodplain Managers
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Many unnamed people assisted in some way through their support and encouragement. We thank you all!

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Section 1

Case Studies of Local and Regional Recovery, Comprehensive Management, Multi-purpose Projects, and Mitigation Planning
THE OCTOBER 1994 FLOOD OF HARRIS COUNTY, TEXAS

Andrew C. Yung
Harris County Flood Control District

Alfred J. Garcia
Harris County Flood Control District

Introduction

Between October 15 and October 18, 1994, meteorological conditions combined to set up one of the most extreme and intense storm systems in recent history over southeast Texas. Rainfall amounts generally ranged from eight inches to 30 inches during the four-day period over a 38-county area. According to the Houston Chronicle, 22 flood-related deaths were reported and 15,775 homes were damaged from severe flooding of the rain-swollen bayous and creeks of southeast Texas (USGS, 1995). Thirty-five counties were declared disaster areas by the federal government (NWS, 1995). As of April 26, 1995, $32 million in federal disaster assistance had been provided to the communities of southeast Texas (Houston Chronicle, 1995).

During the four days, between 10 and 30 inches of rain fell across the 4,000 square mile San Jacinto River watershed (Fitzgerald, 1994). The West Fork San Jacinto River enters northeast Harris County, Texas, near U.S. 59 just upstream of Lake Houston where it converges with the East Fork San Jacinto River. From Lake Houston, the San Jacinto River drains directly through east Harris County, Texas. This was the site of one of the largest direct measurements of stream flow ever obtained in Texas. A measured 356,000 cubic feet per second was made on the San Jacinto River near Sheldon, approximately 12 miles northeast of Houston’s central business district (USGS, 1995).

A Local Perspective

The following account of the October 1994 event is from the perspective of the Harris County Flood Control District (HCFCD). HCFCD is responsible for planning and constructing flood control projects and maintaining 3,000 miles of flood control projects, bayous, creeks, and ditches in Harris County, and the City of Houston.
The HCFCD observed rainfall beginning on Saturday morning, October 15th, at about 6:00 am, which continued until around midnight on the evening of Tuesday, October 18th. "According to one meteorologist, the rain was a result of tropical moisture from a remnant of the Pacific Hurricane Rosa, combined with other meteorological phenomena" (Fitzgerald, 1994).

Description of Flooded Reaches

The runoff produced by this event resulted in flooding along several major tributaries to the San Jacinto River and the river itself within Harris County. These tributaries included Spring Creek, Cypress Creek (including Little Cypress Creek), Willow Creek, Sims Bayou, Brays Bayou, and Greens Bayou. In addition, Cedar Bayou and Clear Creek (both of which drain directly to Galveston Bay near the mouth of the San Jacinto River) also experienced significant flooding (Fitzgerald, 1994).

In Harris County alone, some 3400 houses and business in 90 subdivisions were impacted by high water. The hardest hit areas were the low-lying areas adjacent to the San Jacinto River in which more than 1300 homes/businesses were flooded, and in the Sims Bayou watershed where approximately 750 structures were affected. Cypress Creek flooding resulted in damage to about 400 structures. The remaining tributaries had minor flood damages by comparison (Fitzgerald, 1994).

The Flood

**Monday, October 17th**

By Monday morning at 6:30am, it was already apparent that flooding would occur in Harris County. Local radio news broadcasts were reporting that U.S. 290, a major thoroughfare linking Austin and Houston, in the northwest quadrant of the county was under water in two places, effectively cutting off the town of Waller on both sides. They further reported that residents in the town of Hockley (just east of Waller) had stated that 10 inches of rain had fallen during the night.

HCFCD decided to begin staffing its ALERT center around the clock. From there, flooding events can be electronically monitored through an automated flood warning system. Phone banks were set up to respond to calls from various interested parties (individual homeowners, the media, and government officials). News media from local television stations sent feedback to their parent stations nearly continuously. Various HCFCD staff were dispatched to the field to view the flooding first-hand, while other staff monitored the precipitation and river stages from the ALERT (Automated Local Evaluation in Real Time) system.

From the field, it was observed that much of the upper end of the Cypress Creek watershed was under water. Near Hockley, most of the roads north and south of U.S. 290 were impassable. At the Cypress-Rose Hill bridge over Little Cypress Creek, the water was rushing over the road approximately two feet deep.
In the upper reaches of Spring Creek, the northern boundary between Harris and Montgomery counties, the scene looked similar to that of Cypress Creek near Hockley. At State Highway 249, a major thoroughfare across Spring Creek, the flow in the north overbank had completely submerged the roadway. State troopers had reported that a car had washed off of the road. The rain continued to fall throughout the day and on into the night. It was evident that the one gage from which HCFCD was receiving information on Spring Creek was malfunctioning. The ALERT system had suggested that Spring Creek had peaked at about 1:00 pm on the afternoon of October 17, when in fact, according to a resident who called the ALERT center, the creek was into his yard and still rising at 11:00 pm. HCFCD staff switched to a mode of getting information out of the resident who had called to obtain as much data as possible about current conditions.

**Tuesday, October 18th**

Harris County was greeted the next morning by more rain which had poured down nearly continuously since Saturday morning. Reports were coming in from HCFCD personnel that Little Cypress Creek was diverting flow down Telge Road, effectively short-cutting its natural course to Cypress Creek. In the ALERT center, where staff had been monitoring stream stages throughout the night, televisions were tuned in to the morning news programs to catch the latest glimpses of area flooding. Sims Bayou was out of its banks and flooding many areas. In the South Acres subdivision, some 400 homes were inundated. Pictures were broadcast of people in vehicles being rescued by local area firemen in airboats, people in the water pulling rafts stacked with their belongings, and water everywhere.

The City of Pearland, along the Harris/Brazoria county line, which had received 20 to 25 inches of rain during the four days, was "sending a near record flood wave down Clear Creek during the late morning hours of Tuesday October 18. Record flooding occurred on Cedar Bayou along the Harris/Chambers county line when over 20 inches of rain fell over the headwaters in the early morning hours of Tuesday October 18. This produced severe flooding in the watershed particularly the communities of Crosby and Baytown" (NWS, 1994).

Sometime that afternoon, Spring Creek crested at Spring, Texas, at a record discharge of 78,800 cfs and a stage exceeded the previous flood of record set in November 1940 by 10.5 feet. According to the U.S. Geological Survey, this peak was estimated at 1.7 times greater than the 100-year flood (USGS, 1995).

Both Interstate 45 (in Montgomery County) and U.S. 59 (in Harris County) along the San Jacinto River were closed due to roadway overtopping. The Inverness Forest Levee along Cypress Creek (constructed following the floods of May and June of 1989) functioned very effectively, protecting the Inverness Forest Subdivision. This subdivision had a history of flooding during high frequency flood events. During the May 1989 flood, 136 homes
were inundated in the subdivision. During this event, however, no damage was reported.

Many of the other bayous in the greater Houston area, though not causing flooding, were at bank full throughout much of the day.

**Wednesday, October 19th**

The sun came out. An aerial survey of the damaged areas was organized. It was determined that Sims Bayou, the San Jacinto River, Cypress Creek, and part of Spring Creek would be flown to inspect areas of high damage within the county. By the time the helicopter was airborne, Sims Bayou was back within banks. However, the San Jacinto River was still on the rise. As the survey team flew over Lake Houston Dam, the peak was occurring. It is estimated by the National Weather Service that the 3000-foot spillway at the dam (crest at elevation 44.5) was discharging 356,000 cfs and crested at an elevation of 52.8. The previous record was set in May of 1989 at an elevation of 49.6 (NWS, 1994). The view from the sky showed high tailwater conditions. There was apparently only a few feet of head difference between the headwater and tailwater on the weir. Travelling upstream from the dam, it was obvious that many of the lakeside communities were being affected by the impounded water behind the dam.

At U.S. 59, there was another amazing sight. Two days earlier, the West Fork San Jacinto River was merely at bank full stage, close to overtopping the service road which passed underneath the highway bridges. Now, the river was several miles wide, inundating all lanes of U.S. 59 impacting traffic in both directions, and cresting 12.8 feet above the previous record stage set in May 1989 (Fitzgerald, 1994).

The survey team continued upstream to the mouth of Spring Creek and then up Spring Creek to the mouth of Cypress Creek. Just upstream of that point, along Cypress Creek, a long narrow strip was seen in the water. It was a two-story house, but only about six inches to one foot of the roofline was visible. The backwater effects from Spring Creek were having a tremendous impact on Cypress Creek.

Cypress Creek was just peaking near Interstate 45 as the helicopter flew the lower reaches of the stream. It was noted that the Inverness Forest Levee was still functioning flawlessly. Significant flooding could be seen from the air in all of the major problem areas along Cypress Creek between the mouth and U.S. 290.

As the survey continued west to the area which had 19 to 20 inches of rain over the past four days, a large area of overflow from Cypress Creek to Addicks Reservoir in western Harris County was observed. This overflow zone occurred because the drainage divide between the two watersheds is only four to six feet above the channel bank of Cypress Creek. This was the first observance of the overflow since the flood of 1979 along Cypress Creek. Katy-Hockley Road (a north-south thoroughfare through this zone) became a canal and the rice fields of western Harris County were all under a tremendous amount of water.
The survey team then headed northeast toward Spring Creek and Interstate 45. At that location, the water had subsided enough to observe that the Northgate Crossing Levee had breached. Fortunately, the subdivision behind the levee had never been built. The cause of this failure was probably overtopping due to the excessively high water along Spring Creek. The levee had been designed for 100-year protection with three feet of additional freeboard per Federal Emergency Management Agency/National Flood Insurance Program criteria. It was noted that the breach occurred on the downstream side of the Interstate 45 bridge where the channel makes a tight bend and the slope is protected by concrete paving. The high velocities produced in that bend may have aggravated the situation.

Along the lower San Jacinto River below Lake Houston Dam, in the Rio Villa and Banana Bend areas, houses elevated 16 feet above normal river levels were inundated.

**Thursday, October 20th**

By midnight, all stream hydrographs were receding. The ALERT center was staffed by two HCFCD personnel to monitor the situation and answer any remaining phone calls from concerned homeowners and the media. One crew remained in the field to relay field conditions back to the ALERT center. At about 4:00 am, the field crew was sent to Interstate 10 and the San Jacinto River to see if the bridges were passable. At about 5:00 am, a local radio station called to see if Interstate 10 was open. It was confirmed that the field crew was able to get across but that did not necessarily mean that the roadway was open to traffic.

Shortly after 10:00 am, four oil pipelines ruptured and ignited. According to one local television newscast, the pipelines spread a slick about "six or seven miles long" (according to one television newscast) along the San Jacinto River, which subsequently caught fire. Several barges and a railroad bridge were set ablaze. The travelling conflagration headed for the Rio Villa and Banana Bend subdivisions just upstream of Interstate 10. The Interstate was closed again. The fire eventually burned itself out but not before igniting several structures along the river which were still inundated by flood waters. Other than the closings, Interstate 10 was largely unaffected. After the fire extinguished itself, the process of clean-up and analysis of this most recent event began.

**Conclusion**

Approximately 3400 structures in Harris County were inundated along the San Jacinto River and its tributaries. Record flooding was experienced on the San Jacinto River, Spring Creek, Upper Cypress Creek, and Cedar Bayou (Fitzgerald, 1994). Along the San Jacinto River, in the Banana Bend and Rio Villa areas, the river cut a new path, bypassing the old meanders along which those two subdivisions were built.
A number of lessons were learned from this event. First, there exists a need to turn phone calls from residents into information resources to rely upon for good field data. Second, the many high water marks taken after the flood gave excellent information to pinpoint anomalies in hydraulic characteristics that will in turn help engineers develop better analytical models for design and better understanding of real storm events. And last, though certainly not least, it was realized that although proper flood control planning and floodplain management may not have solved all of the problems experienced during this flood, they will definitely aid in reducing the damage caused by more frequent events in the future.

References

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Houston Chronicle

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National Weather Service

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CUSTOMIZING FLOODPLAIN MANAGEMENT TO ACTUAL SITE CONDITIONS

Sidney W. Smith  
David E. Adamson  
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Introduction

Rivers and streams and their accompanying floodplains are individually unique and, therefore, the solutions to flood mitigation along those rivers and streams should be tailored to meet their many intrinsic conflicting requirements. From the steep rugged streams of the Rocky Mountains to the large lumbering rivers of the Mississippi River basin, floodplain conditions vary widely. Thus, floodplain management solutions should be site specific. General solutions that sound noble and appear good on paper sometimes lose appeal when adapted to specific situations. It is our intent to explain the many flooding problems encountered in Davis County and to explain how we solve those problems by customizing the management to the unique problems.

Davis County Flood Mitigation

The typical Davis County stream is anything but typical. The topography varies widely, even between adjacent streams in the same mountain range. These terrain types consists of steep, narrow mountain canyons, alluvial fans, valleys, ravines, irrigation channels and structures, and deltas, as the channel travels from the top of the mountain to the Great Salt Lake. The slope of the drainage channel varies from more than 15% in the mountain drainage basin to 10% at the canyon mouth to less than 0.2% as the stream nears the lake. The average drop of the streams from the top of drainage to the lake is about 5000 feet. This drop is accomplished in less than 10 stream channel miles.

Mountain Drainage Basins

The mountain drainage basins are relatively small (from two to ten square miles). The canyon walls are very steep, rocky, and rugged. The vegetation varies greatly—from sagebrush and scrub oak to aspen and pine forests. The canyon stream channels are generally steep, narrow, and rough. Some stream channels are well vegetated and overgrown with brush, and others are nearly barren of large vegetation. The reason for the contrast of channel vegetation
CUSTOMIZING FLOODPLAIN MANAGEMENT TO SITE CONDITIONS

will be discussed later. The elevation at the top of drainage basin is greater than 9000 feet MSL and is approximately 5000 feet MSL as the stream channel exits the mountain drainage basin.

Debris Flows

These steep, narrow canyons can create high energy flash floods. A major debris flow occurrence depends on three things; debris and sediment in the channel bottom, abundant water to mobilize the sediment, and a triggering event (landslide, overgrazing, fires) to initiate the debris flow. Sufficient water and a triggering event could be present at any time. However, the size of the debris flow is dependent upon the amount of sediment and debris that has accumulated in the channel. The amount of debris and sediment in the canyon channel is a factor of time. The time required for a large amounts of sediment and debris to build up is estimated to be in the range of centuries for Wasatch Front mountain drainages. If a canyon has had a large debris flow within recent recorded history, it is highly unlikely that another could be generated at present. A smaller flow could occur, but with less damage.

An inspection of canyon channels that produced large debris flows in 1923 and 1930 shows very little redeposition of debris and sediment in the canyon channel. A comparison between early 20th century debris flow channels to a channel that had a major debris flow in 1983 (Rudd Creek) reveals very little difference between the cross sections and overall appearance. Channels that have not had a recent debris flow are generally referred to as pristine. The channel bottom is much different from those channels that have had a recent flow. The pristine channel profile is more rounded and U-shaped, with abundant vegetation and growth. A post-debris flow channel is angular and V-shaped, with limited foliage and no large vegetation. The channel cross sections shown in Figure 1 were taken in Parrish canyon (1930 event), Rudd Canyon (1983 event), and Centerville (Deuel, pristine—no event) illustrate the relative potential for mudflow generation. Both Parrish and Rudd Canyons exhibit high erosional scars, considerable bedrock control, and almost identical shapes even though their events were over 50 years apart. Centerville canyon (Deuel Creek) however, has no erosional scars, little bedrock, and a much flatter profile due to accumulated debris in the channel bottom (Williams and Smith, 1990).

The debris flows are contained within the mountain channel and cause very little property damage until they exit the canyon. This is because there are very few buildings or homes in the mountain canyons. However, the debris flows do create scouring and extensive damage to the mountain channel itself. This damage is unavoidable but it is acceptable. It is a natural process that occurs periodically.

Alluvial Fans

Most streams in Davis County flow over alluvial fans as they exit the mountain canyon drainages. In many cases, the stream flows down the ridge
or high point of the alluvial fan. If debris blocks the channel or flood flows exceed the channel capacity, the excess flow leaves the channel and travels away from the stream channel. Therefore, the alluvial fan floodplain is not well defined and difficult to predict. It often encompasses the entire alluvial fan, but the entire fan does not legally qualify as a floodplain. If flood waters leave the stream channel they cause flooding not only on an unpredictable portion of the alluvial fan, but also beyond or downstream of the fan. Most of these fans are totally developed with homes. Wholesale reclamation of the floodplain is not feasible. Generally, when water leaves an alluvial fan stream channel, it flows out of channel for a great distance before it returns (if at all) to the channel. The water usually continues to flow west through depressions and gullies destroying property and homes. The unpredictable nature of alluvial fans would require the displacement of a disproportionate number of homes to the size of the legally justifiable floodplain area for a reclamation plan. We also create a major social problem for families by removing them from their homes so that they may not ever be impacted if we have a flood. Since a major portion of Davis County is built on alluvial fans, a large metropolitan area would be destroyed to protect it from flooding.

There is a better way. The first step is protection from debris flows. The incidence of debris flows has been reduced with vegetation management, including prevention and control of wild fires.

Figure 1. Canyon cross sections.
Debris basins work very well on most of our streams and solve a multitude of problems. They are very affordable in comparison with the alternatives. Cleaning the debris basins is not a problem since the debris is usually a useable gravel product. With the debris removed at the debris basin, it is then very feasible to improve the channel downstream to a stable condition and large enough to carry the 100-year flow. The channel at the lower reaches of the fan often drops into a deep ravine and can be managed by normal floodplain management methods of preservation. As the channel reaches the valley floor we often have delta conditions that are also difficult to manage. In some cases, acquiring the area as a wetlands reserve is feasible. In others cases, channelization with regular maintenance is the answer. Wildlife habitat and open space can be incorporated in the enlarged channels to solve the problems in some areas but each case requires a unique solution. Some stream channels are undersized with large, unmanageable floodplains. In many cases, this condition was caused by the diversion of the stream channel into irrigation ditches. The original stream channel has since been filled in and lost. These channels often have to be recreated.

Debris basins and improved channels allow maximum protection with minimum impact on the developed fans. Floodplain preservation works well for the ravines. Flat lands and deltas require a variety of floodplain management methods.

By customizing the solutions to the actual conditions, critical areas are preserved for existing and future development. Wildlife habitat is protected in many areas and the residents and property owners are also protected. Thus many objectives are met at reasonable costs.

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THE IMPLEMENTATION OF A HAZARD MITIGATION PILOT PROJECT: COMMUNITY ASSISTANCE FOR RAPID IDENTIFICATION OF SUBSTANTIALLY DAMAGED STRUCTURES AND DEVELOPMENT OF A HAZARD MITIGATION RECOVERY PLAN

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Background

When floods hit 38 southeast Texas counties in October 1994, damage was extensive. Over 13,000 residences were damaged. Many of these were substantially damaged. The situation with regard to each damaged structure had to be quickly assessed. At the same time the property acquisition frenzy was occurring. Time was of the essence.

The Federal Coordinating Officer (FCO), Deputy FCO for Mitigation, and the Federal Emergency Management Agency (FEMA) Region VI Mitigation Team for this flood decided it was time to take drastic measures and develop an integrated hazard mitigation strategy to be implemented. Something out of the ordinary had to be done or local governments soon would be overwhelmed. National Flood Insurance Program (NFIP) standards would not be adhered to and affected local jurisdictions would be considered non-compliant.

Through the involvement of many dedicated and concerned people, an innovative approach to the problem was developed. The "Hazard Mitigation Pilot Project" enabled field testing of a worksheet that helped inspectors quickly determine damage cost estimates to flood-damaged structures. As a result, a damage cost estimate process was developed that enabled rapid identification of potentially substantially damaged structures. This paper focuses on the methodology developed to assist the State of Texas to support
HAZARD MITIGATION PILOT PROJECT

local governments in the rapid identification of potential substantially damaged structures.

Innovative Partnerships

The October 1994 flood in Houston, Texas, was an extreme four-day event that produced record flood levels exceeding the 100-year base flood elevations and approximating the 500-year flood level just north of Houston. As the nation's fourth largest city, major land development had occurred in every county of Houston/Harris County Metroplex and entire subdivisions were built in areas now designated as floodway.

FEMA initiated a Pilot Hazard Mitigation Project where volunteer response personnel and professional organizations worked with federal, state, and local government officials in response to the flooding. The Texas Volunteer Building Official Response Team and Texas Floodplain Management Association (TFMA) assisted FEMA's disaster response team with the pilot project. The Building Officials Association of Texas (BOAT); TFMA; Greenhorn & O'Mara, FEMA's Technical Assistance Consultant; and FEMA Region VI staff working together created inspection procedures, inspection forms, and Notice of Inspection Certificates to be posted on inspected structures.

A crucial task was to establish a simplified manner to determine the estimated extent of damage. The methodology had to be simple, quick, and accurate and a standard worksheet developed and tested. The next step was to determine cost guidelines. Suggested cost guidelines for the restoration of flood-damaged structures were developed specific to the disaster and which can be modified for each geographical area.

A generic model was needed to refine costs associated with restoration of a typical flood-damaged residential structure. A 2,400-square-foot residence constructed on a concrete slab with a brick veneer finish and composition roof was used. Costs required to clean, replace and/or repair interior and exterior finishes and mechanical/electrical systems were developed. Allowances were included to account for unusual materials or upgrades and complete demolition of the residence, if necessary. Using this model, the cost assumptions identified were based on major categories of residential construction (cost approach).

To estimate the percentage of damage, there had to be a level of inundation which made a vast difference in the extent of damage and translated into a dollar figure. Almost any amount of flooding would damage floors and floor coverings and any significant amounts of flooding would damage lower cabinets and built-ins. Criteria for potential "substantial damage" structures included the structure's location was in a floodplain and had a reported minimum of four or more feet of water inside. Using the cost guidelines, assumptions and prevailing labor and material costs, a guide to "cost analysis" was developed, resulting in a "dollar per square foot" estimated cost. Then a draft "damage cost estimate" worksheet and accompanying instructions were developed (Figure 1 and Figure 2).
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INSTRUCTIONS FOR COMPLETING DAMAGE COST ESTIMATE FOR FLOOD DAMAGED STRUCTURES

Purpose of Form
To provide a quick and accurate method to estimate the amount of flood damage based on an inspection of damaged residential structures. Structures to be inspected have been selected because they have suffered damage that may equal or exceed 50% of the pre-flood market value. Structures the sustained this level of damage are required to comply with certain floodplain management standards and may be eligible for acquisition programs.

Step 1:
Write your name(s) and date of the inspection in the upper left corner.

Step 2:
Photograph the front of the house and place it in the folder (it can be attached later). This is to document the inspection, not to visually record the flood damage.

Step 3:
Inspect the exterior and interior of the structure and make the following notations on the form:
- a. Indicate type of garage.
- b. Indicate whether or not there was structural damage, such as collapsed or damaged interior supporting walls, exterior walls, roof. If yes, describe damage in comments section.
- c. Measure the high water mark above the slab or foundation sill and indicate on the form.
- d. Draw a circle around the appropriate dollar amount for each category of damage (refer to the attached sheet for a description of average and adjusted amounts). Write in and circle extra adjustments that are appropriate in special cases. Describe them in the space provided.
- e. Write in the dollar amount of any "On Site Adjustment". These are adjustments that are not included in the categories listed on the form. Describe any such adjustments on the space provided.
- f. Calculate the total cost per sq. ft. times the number of sq. ft. for the first floor to obtain the total damage amount and indicate on the form. Note: If part of the second floor is damaged, indicate the amount per sq. ft. for the appropriate category in the "extra Adj" column. For example, if the second floor received one foot of water, write in and circle the adjusted value for floor coverings and sheet rock, etc.

Figure 2. Instruction sheet.
A strategy meeting was conducted with county engineers office personnel and participants representing FEMA, BOAT, International Congress of Building Officials (ICBO), Southern Building Code Congress International (SBCCI), Texas Department of Public Safety Division of Emergency Management, TFMA, and Haag and Associates. The draft "damage cost estimate" worksheet was presented to and the proposed inspection process discussed with meeting participants. It was agreed that the Hazard Mitigation Pilot Project should be implemented and a plan was developed to inspect substantially damaged structures. Inspection criteria were developed, teams identified, and the worksheets field tested. The worksheets and the cost guidelines were adjusted accordingly.

The pre-flood fair market value of each structure had to be determined and a single source would be used to develop accurate valuation. Tax assessment records were used from a central appraisal district to establish pre-disaster fair market value. Appraisal values were then compared to market data and the cost approach. The appraisal cycle was current and the ratio between the assessor’s estimate of value and the true fair market value was deemed acceptable and no adjustments were necessary.

**Permit Application Management System**

At the state’s request, FEMA provided supplemental staff to interview applicants, assist county officials, and process the hundreds of permit requests being received each day. A screening process was established to separate potential substantially damaged structures from those structures that sustained minimal damage (inundation less than four feet). An organized filing system for flood-related permit applications was developed. Files were labeled with the address of each property as indicated on the permit application. Each file contained as a minimum the permit application, completed elevation certificate, and appraisal reports for each address. Supplemental information necessary included maps of subdivisions developed through geographic information system (GIS) and Flood Insurance Rate Maps; alphabetized repetitive loss structures report provided by the Federal Insurance Administration; and copies of applicant interviews which recorded reported levels of inundation and included a copy of any contractor repair estimates and insurance adjuster worksheets.

Once the files were completed, county engineers either denied a building permit if the data indicated a potential for substantial damage or granted a building permit. Those applications denied a permit were set aside for further county/state considerations.

The county reviewed each of the files denied a building permit to identify candidates for a possible hazard mitigation grant or to recommend either removal of flooded structures from the floodway, elevation of flooded structures in the floodplain, or possible acquisition of flooded structures meeting pre-determined criteria. Public meetings then were conducted to explain options available to each of the flooded communities.
Conclusions and Recommendations

The damage cost estimate worksheet and inspection procedures developed enabled county, state and FEMA officials to effectively evaluate the extent of damage. We recommend that local or county governments develop a post-disaster rapid permit application processing system.

References

Federal Emergency Management Agency
National Flood Insurance Program, Community Assistance Series

Montgomery Central Appraisal District
WATERSHED FIRES—
The Making of Mutant Floods

A. Jean Brown
Former California State Floodplain Management Coordinator

Christopher D. Adams
California Office of Emergency Services

Introduction
When watersheds experience a severe fire, it often results in flooding conditions later because the runoff is debris-laden where otherwise flooding would not occur under clearwater runoff conditions. Thus, a burned-over watershed becomes altered or changed, and the process of rainfall and resulting runoff undergoes a mutation, creating an unexpected flood. A typical example of this process is demonstrated within the Pasadena Glen stream and watershed, in the mountain area of East Pasadena, Los Angeles County, California. Before an October, 1993 fire, runoff from even moderately heavy rainfall on the 600-acre watershed could be safely passed through the community of Pasadena Glen Villa. After the fire, though, runoff from even moderately light rainfall that was laden with heavy debris created serious flooding throughout Pasadena Glen Villa.

Under the Robert T. Stafford Act, public assistance (infrastructure), including mitigation by the California Office of Emergency Service and the Federal Emergency Management Agency (FEMA), in combination with the Natural Resources Conservation Service (NRCS) have in the meantime completed emergency protective measures which eliminated small culvert "bottlenecks," to facilitate the passage of storm runoff through the narrow canyon. Runoff from storms in 1995, although heavy at times, was passed through Pasadena Glen without incident due to new box culvert structures and new trash racks installed in 1994.

Setting the Stage
Pasadena Glen Villa is a small community in the foothills above East Pasadena in Southern California’s Los Angeles basin. Pasadena Glen Creek runs through the center of the canyon and 64 residents have built their homes on either side of the creek. Vehicle access is via a narrow two-lane road.
WATERSHED FIRES

crossing the creek at three places (Figure 1). Original construction at the stream crossings was a corrugated metal culvert covered by earth and asphalt. Drainage into Pasadena Glen Creek comes from a 600-acre watershed that rises above the creek elevation of about 1200 feet to about 3700 feet in the watershed. The 50-year mean rainfall in the valley at Pasadena is a little over 22 inches, and the mean in the mountain area is about 30 inches. Precipitation in the 1992-93 season for the Pasadena Glen area was nearly 44 inches in the valley and about 56 inches in the mountain, almost 200% of mean. Several heavy rainstorms occurred that season, yet the Villa avoided any damaging flooding because the flows were relatively clear and the culverts allowed the flow to pass. Then on October 27, 1993, the watershed above Pasadena Glen was ravaged by a fire that swept through the upland and was carried by winds down the canyon, destroying 23 homes in the Villa. Seasonal rainfall for 1993-94 was almost 13 inches in the valley and just over 16 inches in the mountain, about 50% of the mean. Three storms during the 1993-94 rainy season carried major debris from the burned-out watershed into Pasadena Glen Creek. Debris included tree trunks up to 3 inches in diameter,

Figure 1. Lower crossing of the Pasadena Glen Creek.
and rocks as big as 5 feet in diameter. I-beams in the trash rack at the base of the watershed and at the upper end of the Villa were snapped off by large boulders carried out of the watershed. A large boulder whose circumference nearly matched that of one of the culverts blocked the flow and caused the waters to "jump" the crossing and send debris-laden flows spreading down the Villa's only street, where the flow threatened the homes that had survived the fire. Residents quickly reacted by erecting flood protection measures using sandbagging and wooden barriers.

What happened afterward for awhile became a local residents' "nightmare" as they learned to cope with the myriad of federal and state programs that may or may not be available to provide disaster assistance. These programs often take time to come to an acceptable solution. But eventually relief did come, as state and federal agencies "kicked in" their programs. The affected residents formed the Pasadena Glen Villa Assessment District. They have made the commitment to provide for the long-term maintenance of the Pasadena-Glen channels. Although many homeowners' associations' by-laws tend to be exclusionary or self serving, because this homeowners' association was formed after the fire, these by-laws were written specifically to accommodate the requirement to provide an "essential governmental service." The association's commitment to perform long-term multi-hazard abatement provides its not-for-profit eligibility for available FEMA disaster assistance under the Public Assistance Program and for the NRCS Emergency Watershed Protection Program.

Agency Response

Natural Resources Conservation Service

The NRCS's Emergency Watershed Protection Program is used for watershed rehabilitation for protection of life and property due to a natural disaster. After the October fire, the NRCS studied the watershed and networked extensively with public and private sectors to provide residents with site-specific solutions for their respective neighborhoods threatened by inadequate storm drains or minor runoff. In those cases, the Los Angeles County fire department and public works provided the sand and sandbags, and the residents provided the labor. The Kinneloa Irrigation District was the initial eligible applicant, relative to damaged water system infrastructure along with serious threats to private homes as well. The NRCS signed the Project agreement on January 7, 1994. These projects included cleaning out debris from the stream, funding debris barriers to direct flows back into the main channel, erecting a new trash rack at the head of the main channel, and lining the Winifred Canyon Channel with concrete from the canyon crib dam to Pasadena Glen Road. The NRCS also reviewed and recommended that the community follow through with application to FEMA for the large scale repair or replacement flood prevention projects that were outside the purview of the NRCS.
California Governor's Office of Emergency Services

This office operates within all phases of emergency management for each state or federally declared disaster. In this case, a variety of flood protective devices were installed largely on private land to protect lives and property after the October 1993 firestorms in southern California (FEMA-1005-DR-CA). Emergency resources from federal, state, and local levels of government were deployed in response to the fires, but from the onset most agencies were already looking ahead to the potential flooding from winter storms. How these emergency actions to repair or reconstruct damaged facilities are funded under the FEMA infrastructure (Public Assistance) program, and the clarification of what constitutes "emergency work" is often critical to how and/or when an eligible applicant receives state or federal assistance for the proposed fix.

In this case, early efforts to identify a sponsor who would qualify for FEMA assistance and was willing to take on the long-term responsibility were challenging. The Kinneloa Water District was the initial applicant, and the Disaster Survey Report (DSR) was written as a Category B, "Emergency Protective Measure." This DSR was written on March 18, 1994. The reason it took so long (six months) was that the project was initially referred to our office for HMGP consideration. Mitigation staff (state and federal) joined together to convince Public Assistance (state and federal) that they could benefit from our help in "identifying the mitigation opportunity." This is consistent with §206.402 under Subpart M, Hazard Mitigation Planning. But first, we had to convince Public Assistance that they must comply with requirements under Subpart M. Fortunately that is covered in Subpart H, §206.220.

Among other hurdles, we had to shift the immediate focus from fire to flood, and the Public Assistance team had to be convinced that the "watershed" was the "damaged facility." Fortunately, the decision to write the DSR was greatly aided by two storms, February 8, 1994, and March 6, 1994, during which one-half inch of rain caused a serious threat to lives and property in the canyon. These storms re-triggered the "immediate threat" definition, and reinvigorated the "emergency work" requirements provided under §206.225 (a) and (c).

However, because this emergency work went beyond current codes and standards, we followed the direction provided by §206.407 under Subpart M, which establishes the "minimum standards for any repair or reconstruction" and details who may establish "standards for hazard mitigation." Then we had to survive the issue of whether or not you can "mitigate" a Category "B" DSR. Finally, we had to demonstrate the cost effectiveness of the proposed "mitigation" components, which were identified as "required mitigation" (as defined by §206.226) to accommodate the expected increased runoff and mudflows from the watershed's burned areas. We used the COSBEN33 model, and included reasonable societal benefits and secondary costs. All of these decisions are consistent with guidance provided for under OMB.

DSR #206722 was written to "Construct approximately 320 lineal feet of concrete box culverts in designated places along Pasadena Glen Road to reduce (risk from) hazardous mud and debris flows to homes in the area" (Figure 2). Four culverts were installed for approximately $1 million. With the new projects in place, runoff from heavy rains during this 1994-95
season, which so far has averaged almost 170% of the mean, have been carried down Pasadena Glen Creek without any incident. The flows are still muddy and are carrying sediment, but there is no longer the large debris experienced the year before.

**Summary**

While the Stafford Act clearly "encourages hazard mitigation," as noted above, there are many impediments in the process that in fact discourage mitigation. As we find ourselves arguing about eligibility, it is really the level of assistance that is being debated. How much is enough, and who should pay for it? We are thus joined with the debate of "cost containment" versus "cost benefit," and what the federal role should be.
KOYUKUK RIVER FLOOD RECOVERY AND MITIGATION: RELOCATION AND FLOODPROOFING ACHIEVED BY FLOOD DEPTH ANALYSIS, EROSION ANALYSIS, AND SITE SUITABILITY ANALYSIS

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Introduction

Two vigorous weather systems during the second half of August 1994 brought in deep levels of moisture out of the Bering Sea to northwest Alaska. With each system, strong northwesterly flow caused heavy precipitation, first as the warm moist air was brought in over the existing cold air, and again in advance of the passage of the cold front. Rain was heaviest on west- and southwest-facing slopes, enhanced by the terrain upslope. Due to the southwest-northeast orientation of the Koyukuk River basin, it was hit especially hard by these rains.

The area impacted includes approximately 100,000 square miles along two major river systems—Koyukuk and Kobuk. Fourteen communities were affected by the floods. The three villages of Allakaket, Alatna, and Hughes were severely impacted. On August 26, 1994, Governor Hickel declared a state disaster in response to ongoing and predicted floods. Allakaket and Alatna were evacuated by Army National Guard helicopters on August 28, and Hughes was evacuated three days later. President Clinton declared a national disaster on September 13, mobilizing the Federal Emergency Management Agency (FEMA).

Flood water destroyed roads and bridges, schools, clinics, community fuel tank farms, power facilities, public water and sewer facilities, and other public property. Hundreds of area residents lost homes, personal property, and subsistence food and fuel items.

Almost 100 homes received damage from the floods in the villages and 38 were completely destroyed (Alaska Department of Emergency Services, 1994). Many homes floated off their foundations in Allakaket and Alatna; some homes survived the relocation intact, and have since been releveled and reoccupied. But most were destroyed. More than 300 people were displaced from their homes by the flooding. Most of these residents were temporarily...
relocated to Fairbanks, which is very difficult for their cultural needs. Thus, getting the residents back to their villages was very timely.

The Koyukuk River floods challenged a broad scope of my planning skills. The flood site is a unique remote environment of cultural sensitivity. Two distinct native groups inhabit the area (Athabascan Indians and Inupiat Eskimos). Previous mapping of the area is vague. In addition, the land status in rural Alaska is unsettled. Public and private facilities have been constructed on land where ownership interests were not defined. Many communities do not have land available for community expansion. Native corporation land title is clouded until restrictions are satisfied. Unresolved land title issues hinder economic and community development in both the public and private sectors.

Despite all the above-mentioned difficulties, we aggressively set out to map the areas along Allakaket, Alatna, and Hughes. Our objective was to compare and analyze the historical map and aerial photographic data on river channel changes, and to apply geologic interpretation of geomorphic river processes to predict areas of erosion of the Koyukuk River near Allakaket, Alatna, and Hughes within the near future up to 100 years.

The U.S. Geological Survey used standard LP 111 hydrologic analysis of the gaging station data, using the 1994 flood as the historic peak. The 1994 peak was the highest in the past 20 years. For all practical purposes, the 1994 flood was recorded as a 100-year event.

We also hired a riverine geologist to study the effects of erosion. In this investigation, map and aerial photo data were collected and analyzed for sequential change and geomorphic river channel processes. Channel erosion and deposition were determined by bank erosion rate measurements using a Bausch and Lomb Zoom Transfer Scope. Channel changes were plotted for the Allakaket and Alatna area at the Koyukuk-Alatna River junction, and for the larger area extending approximately five miles up and downstream. The measured rate of change was extrapolated to predict the probable area of 100-year erosion. Special circumstances such as meander cutoff and valley wall influences were evaluated. This data shows river channel migration rates on the Koyukuk River, Alaska, to be from one to seven feet per year, predominantly on the outside of meander belts.

Allakaket

Virtually all of Allakaket was flooded. Only a few houses built on piles and one house south of town built on a gravel pad were not damaged by inundation of at least the subfloor. Flood depths in the northern, older section of town along the river bank ranged from 6 to more than 10 feet. Log buildings in this area that were not anchored to their foundations commonly floated away for distances from a few feet to several miles. One structure was found intact more than 36 miles downstream from Allakaket. The airstrip on the west side of town and most of the sloughs and abandoned channels in the area were flooded to depths of 10 feet and more. An area of higher ground lies south of the older part of town, about 2,000 feet south of the
river. Newer houses there, referred to locally as "HUD houses," are built on piles, about 5 feet above gravel pads, which are 1 to 2 feet above the floodplain. Where the houses were built on highest ground, they were undamaged; where they were built on lower ground, their subfloors and interiors were flooded.

Alatna

All of Alatna was flooded to depths greater than 8 feet except one house, built on the valley wall at the north edge of town. Many log structures floated off their foundations. And even two newer "HUD houses," built on piles about 8 feet above the floodplain, were flooded above the floor. Riverbank erosion is an annual process at Alatna. Some riverbank erosion occurred during the flood, but not significantly more than usual.

Hughes

Most of the center and northern part of Hughes was inundated by 4 to 6 feet of water. Flood-related damage there was mostly caused by inundation. Few structures were removed from their foundations. Hughes is located downstream from a bedrock point on the east bank of the Koyukuk River that constricts the floodplain. This point protected much of the village from high water velocities experienced at Allakaket and Alatna.

Conclusion

Extensive areas in Allakaket were flooded to depths of less than 6 feet. So, engineered foundations can reasonably elevate structures above the 100-year flood. In Alatna, however, most of the village would be flooded to depths of 10 feet or more by such a flood. Engineering foundations to elevate structures above that level in Alatna is more difficult and expensive. As of January 1995, residents of Alatna have decided to completely relocate their village out of the floodplain. At Hughes, either option is reasonable.

The recommended setback for these villages is a distance equal to, or greater than, the highest rate of erosion on the adjacent river bank multiplied by the number of years the structure is expected to last. (For example, at Allakaket, where past erosion has been seven feet per year, a shed expected to last 30 years would be set back 30 times 7 or 280 feet.)

We understand the need to clearly communicate the details of the results of the USGS's and the riverine geologist's study. The clarity of communication is paramount because 1) the current players may not be active players when the final funding decisions are made, 2) the level of understanding at the local level may be low, 3) a first impression of the results of the studies (as you would get when you first see a map) may be the critical factor in determining whether FEMA-supported projects are ultimately funded, and 4) technical analysis must be able to be shown graphically.

With this in mind we have decided on a mapping format that will accomplish our goals. To put all information on one map, we colored the
depths of flooding contour zones (e.g., 0 to 2-foot flood depths are yellow) in colors ranging from yellow to dark red or blue. In essence, dark colors show high risk and deep water while light colors represent low risk and shallow water. On top of the color contour map, we would place erosion zones with a cross-hatched designation. We felt that producing a map like this most effectively communicates flood depths and erosion hazards, without losing any of the detail of flood and erosion studies.

Options to better prepare villages for probable future floods include a review of available flood information to assess its applicability for estimating a 100-year flood, reconnaissance flood-risk analysis, and detailed flood-hazard information reports or Flood Insurance Studies. In many cases, a more thorough analysis of data available from all local and governmental sources would improve flood readiness.

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MULTI-OBJECTIVE MANAGEMENT IN THE VILLAGE OF WOODRIDGE, DUPAGE COUNTY, ILLINOIS, FOR THE SEVEN BRIDGES MULTI-USE DEVELOPMENT

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Introduction

The Seven Bridges multi-use development is located in the Village of Woodridge, DuPage County, Illinois. The site is bounded by the relocated Prentiss Creek on the north, Illinois Route 53 on the east, Hobson Road on the south, and existing single-family residences on the west. Development of the site began in 1989 and upon completion in 1998, the site will contain recreational development including a renowned 18-hole championship golf course (and former home of the Michael Jordan Charity Golf Tournament), and commercial and single- and multi-family residential development. The permitting of the project involved a total of seven agencies including federal, state, county, and village authorities and took 17 months. There are three regulated waterways on the site which involve identified floodplains, floodways, and wetlands.

The multi-objective management goals prior to site development included:

- Floodplain recapture of developable land
- Floodplain compensatory storage
- Site development in a coherent fashion
- Wetlands mitigation
- No environmental impacts off-site

Background

The site of the Seven Bridges development was a family farm until the 1920s, when a portion of the site was converted to the Woodridge Golf Club with its two 18-hole public golf courses. In the 1940s, the land was purchased by
Elmhurst Chicago Stone and set aside to be mined as a quarry. However, the golf courses remained in use up through 1986 when the land was purchased by the present developer, the Forest City–Harris Group of Cleveland and Chicago. The golf courses were kept open until ground for the Seven Bridges project was broken in the summer of 1989.

The area encompassed approximately 395 acres and included three regulated waterways—East Branch DuPage River, Tributary No. 6 to the East Branch DuPage River, and Prentiss Creek. Together, the three waterways involved approximately 155 acres of 100-year floodplain as delineated on the effective Flood Insurance Rate Map for unincorporated DuPage County, Panel 0055B, dated April 15, 1982. Therefore, almost 40% of the site involved identified floodplain.

The previous golf courses received periodic flooding, which made several holes unplayable and scarred the grass on the tees, fairways, and greens. This interrupted use of the course and led to economic damages resulting from unavailability of the courses and restoration of damaged vegetation. The east and west sides of the river received infrequent, shallow flooding, which created concerns for adjacent communities and property owners regarding potential off-site impacts from development of the site. Additionally, there were approximately 22 acres of regulatory wetlands on the site that would require qualification and delineation, alternative site analysis, and a mitigation plan prior to the finalization of site plans and the start of earthwork.

**Project Goals**

The Forest City–Harris Group’s goals for development of the site included:

- Economically feasible recapture of floodplain land for multi-use development purposes.
- Construction of a championship-caliber, 18-hole golf course as the focal point of the proposed residential, commercial, and recreational development. The course would need to be relatively immune from 100-year flood damage.
- Environmental soundness—no adverse impacts to existing or mitigated wetlands, and no increase in floodplain damage off-site due to site development.
- Permittable under the various and sometimes conflicting federal, state, county, and local agency requirements for wetlands and floodplain development.

**Seven Bridges Project**

The project involves the following development types:

- 304 single-family and 298 multi-family residences
- Commercial/business use
Recreational use—golf course, ice arena, and network of nature trails

Combined stormwater management system and wetlands mitigation.

Overall, between the golf course, forest preserve, nature trails, and mitigation areas, almost 48% (or 190 acres) of the site remains as open space. Over 100 mature hickory, maple, and oak trees were preserved or moved within the site. Another 2,700 were tagged for preservation and an additional 1,000 were planted on the site. As of spring 1995, the recreational and single-family residential developments are complete, the multi-family development is about 20% complete, and the commercial development is just beginning.

Stormwater Management System

The key to meeting the project goals was the site stormwater management system designed and permitted by Christopher B. Burke Engineering, Ltd. This involves:

- Relocation and lengthening of Prentiss Creek
- Construction of 4 dams/control structures, 12 bridges, 5 culvert crossings
- 434 acre-feet of compensatory floodplain storage in a series of interconnected lakes and ponds
- Wetlands mitigation area.

The reach of the East Branch DuPage River, which flows from north to south and nearly bisects the site, was straightened many years ago for flood control purposes. With the exception of the dam at the mouth of Prentiss Creek, there were no additional modifications to the East Branch DuPage River.

Relocation of Prentiss Creek

Prior to the Seven Bridges project, the mouth of Prentiss Creek was 2,100 feet downstream (west and southwest) of Illinois Route 53 and its confluence was at mile 37.2 of the East Branch DuPage River. As part of the site stormwater management system and wetlands mitigation project, the reach of Prentiss Creek immediately downstream of Route 53 was relocated north of the previous location. The relocated creek was directed west, then south and parallel to the existing, unmodified East Branch DuPage River. After passing through 150 feet of a triple barrel, 106" x 68" elliptical RCP culverts, Prentiss Creek was lengthened by approximately 1,850 feet. The mouth of Prentiss Creek is now located at East Branch DuPage River, mile 36.6. The lengthening of Prentiss Creek allowed the integration of floodplain compensatory storage into the relocated channel.
**Bridges**

All road, golf cart, or pedestrian bridges on the Seven Bridges site have the low chord above the 100-year or base flood elevation (BFE).

**Fill Placement in Regulatory Floodplain**

The residential construction involved areas either naturally above the BFE or elevated by placement of fill. The residential, commercial, and business areas have already been removed from the floodplain through Federal Emergency Management Agency (FEMA) Letters of Map Revision (LOMRs). Overall, approximately 75 acres were removed from the floodplain. This represents almost 48% of the total pre-project floodplain area.

The tees, greens, and fairways of the golf course were constructed to also be outside the floodplain in order to avoid the past mistakes of other golf courses in the area where stormwater management systems used the fairways for floodplain storage. In fact, the stormwater management system for Seven Bridges has been integrated into the course layout by providing water hazards for 14 of the 18 holes on the course.

**Compensatory Floodplain Storage**

The compensatory floodplain storage is at a ratio of 1.5 to 1.0 for pre-project floodplain storage volume lost. This was the first project of this size in DuPage County that provided this ratio. The compensatory floodplain storage is contained within two features of the site stormwater management system. One involves the 25 acres of interconnected lakes of the relocated Prentiss Creek. The other utilizes the on-site increases in East Branch DuPage River profiles resulting from the dam at the downstream end of the site, coincident with the revised location of the mouth of Prentiss Creek. This structure is located just upstream (north) of Hobson Road.

**Dams**

The four dams consist of stacked gabions with a poured in-place concrete top pad for the abutments and the sides and bottom of the rectangular discharge weir contained on each structure. The dams are low-maintenance and self-operating without any mechanical or electrical features. The weirs are used to regulate the structure discharge for all frequencies up to the 100-year event, in accordance with FEMA, state, and county approved discharge rates.

**Culvert Crossings**

The culvert crossings can pass the 100-year flood without overtopping and consist of a triple barrel, 106" x 86" elliptical RCP culvert, a 150-foot-long set of culverts along Prentiss Creek, and four crossings along Tributary 6.
Wetlands Mitigation

As stated previously, 22 acres of wetlands were filled and mitigated through an individual permit issued through the Chicago District of the U.S. Army Corps of Engineers. The mitigation project was integrated into the stormwater management system along the relocated Prentiss Creek.

Project Permitting

The following agencies were involved in the overall permitting of the project:

- U.S. Army Corps of Engineers—wetlands
- Illinois Environmental Protection Agency—wetlands
- Federal Emergency Management Agency—floodplain recapture integrated with the site stormwater management system
- Illinois Department of Transportation, Division of Water Resources—floodway construction
- Illinois Department of Transportation, Dam Safety—dam permitting
- DuPage County Department of Environmental Concerns—floodplain recapture, stormwater management system, wetlands mitigation projects
- Village of Woodridge—all aspects of site development except wetlands

The permitting required six steady-state computer models plus a dam break model to analyze the downstream impacts of potential failure of the Hobson Road dam. The six hydrologic and hydraulic models involved existing and proposed conditions for each of the three waterways and were required to demonstrate that velocity, conveyance, and floodplain storage were not diminished.

Summary

By removing an additional 75 acres of the site from the pre-project 100-year floodplain, the Seven Bridges site in Woodridge, Illinois has shown that multiple objectives can be integrated into the site design of large-scale development projects. The project has accomplished this by turning complex water resources constraints into an asset.

The former floodplain land has been reconfigured in an environmentally sensitive way to control water through avoidance of off-site impacts, provide developable land, and establish renowned recreational areas. This award-winning project clearly demonstrates that when properly engineered, a stormwater management system can be designed to meet all the permit requirements, protect key site development from flood damage, be aesthetically pleasing and remain economically feasible.
FLOODPLAIN MANAGEMENT IN THE LAS VEGAS VALLEY

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Introduction

The Las Vegas valley and Clark County have a long history of flooding and flood damage. The Las Vegas valley is unique in that it is surrounded by mountain ranges with steep slopes that empty onto alluvial surfaces. Ultimately stormwater runoff has to pass through areas that are being rapidly urbanized. The steep slopes and unpredictable flow paths on the alluvial fan surfaces compound the flooding and engineering problems facing developers and the Clark County Regional Flood Control District. The problems also include the possibility of flood waters transporting tremendous amounts of debris and sediment. In the urbanized areas of the Las Vegas valley, development and pavement of the desert increases direct runoff and speeds its flow. It is difficult to convince newcomers that the threat of severe flooding exists in a desert region that receives only 4 inches of rain annually. More recently, since the 1960s, the Las Vegas valley has experienced unprecedented, rapid growth.

In response to severe floods and the ever-present threat of future flooding, the Clark County Regional Flood Control District was formed by the Nevada legislature in 1985 to develop a coordinated and comprehensive flood control master plan to solve flooding problems, to regulate land use in special flood hazard areas, to fund and coordinate the construction of flood control facilities, and to develop and fund a maintenance program for flood control facilities. The Flood Control District administers programs including Master Planning, Capital Improvement Programming, Corps of Engineers cooperation, Regulatory Programs, Flood Warning, Environmental Mitigation, Public Education, and Operation and Maintenance. Funding for the District’s programs is derived from the 1/4 of one percent sales tax which was approved by the voters in 1986 and first collected in March 1987, just seven years ago.
District Programs

Master Planning

The District was the first to develop a comprehensive master plan that not only takes into account existing development, but also addresses the probable effects of future development. The master plan for the Las Vegas valley includes $900 million worth of the various forms of flood control facilities. The District covers all of Clark County, with a majority of District projects located in the Las Vegas valley. Individual master plans are developed for each of Clark County’s outlying areas as well. By statute, the master plans must be updated every five years to consider the progress of the capital improvement program and private development.

Capital Improvement Program

We receive approximately $30 million per year from the sales tax revenues and we are proud to say that less than 10% of that goes to our operating budget. The remainder is dedicated primarily to the capital improvement program for the construction and maintenance of flood control facilities and other District programs. In 1990, we issued $80 million in bonds so that we could accelerate construction of several needed facilities. We have nearly completed all of the projects on our bond list and are now receiving some major flood protection benefits that did not exist just three short years ago. To date, we have spent nearly $220 million on the projects in our master plan. The capital improvement program has been developed and is reviewed annually. The District adopts a 10-year construction program for the needed facilities. These improvements include detention basins, channels, storm drains, and bridges.

There are six governmental entities within Clark County that use District funds to implement the master plan—Clark County and the cities of Las Vegas, North Las Vegas, Henderson, Boulder City, and Mesquite. Each of the entities within Clark County take the lead with respect to each hydrographic basin. According to our policies, each entity must consider 10 rating factors in assigning construction priorities when developing the 10-year construction program. The factors include population affected, assessed value of the land impacted, public perception of need, emergency access and public inconvenience, cost avoidance, availability of other funding sources, relationship to other projects, timing and implementation, environmental enhancement, and annual maintenance cost.

Corps of Engineers Cooperation

We are always looking for ways to stretch our dollars. We have been successfully involved in jointly funded projects with the Nevada Department of Transportation (NDOT), the Regional Transportation Commission of Clark County, special improvement districts, private developers, and we hope to succeed in participation with the U.S. Army Corps of Engineers. The District
is working with the Corps in an effort to secure federal funding to advance the implementation of the master plan. We work most closely with the Los Angeles District, which covers southern Nevada.

These studies began in 1984 with the reconnaissance phase, which is funded 100% by the federal government. The result of the reconnaissance study was that, based on federal benefit/cost analysis, the Tropicana/Flamingo washes appeared to be the best candidate. The feasibility phase was completed in 1991 and the project was authorized by Congress in 1992. The project is currently in preconstruction engineering and design. Its purpose is to provide 100-year flood protection to a large area that not only includes the alluvial fans west, but also the area east including the commerce and tourism district along the Las Vegas strip. The project includes 28 miles of primary channels, upsizing two existing detention basins (Red Rock and Upper Flamingo), building two new detention basins (Tropicana and Blue Diamond), and four debris basins.

The estimated cost of the project is $217 million with the District's share being 25% or $54 million. Of the $54 million, the District is receiving credit for about $10 million for previous work on the system, therefore our cash required is estimated at $44 million. The federal government’s share is $163 million. Without federal dollars, the District in the next 10 years would fund approximately $160 million in facilities countywide. With federal dollars, the area will see $340 million in facilities. The Corps project is estimated to take eight years to build. Construction will begin this summer on the first feature of the project, expansion of the Red Rock Detention Basin.

**Regulatory Programs**

Our regulatory programs include the development and publishing of drainage design standards, uniform regulations, land development review, and floodplain mapping. The District is involved with land development drainage design reviews when the property is affected by a federal Special Flood Hazard Area or is adjacent to a master planned facility. Upon approval of a development drainage design report by the local entity, the District reviews the study from a regional and National Flood Insurance Program compliance standpoint and offers a concurrence with the entities’ approval.

The District has also become a partner with the Federal Emergency Management Agency (FEMA) in restudying and updating the flood insurance rate maps. FEMA has and will continue to fund restudies. Likewise the District is funding and managing restudies. The restudies are being phased in over time as major flood control features that have a positive impact on existing flood zones are constructed and come on-line.

**Flood Warning**

Our flood warning system includes over 87 remote gages that detect and transmit radio information on precipitation, wind speed, wind direction, humidity, temperature, or depth of flood water throughout the county. We
can also monitor weather satellite and radar information through on-line computer link services. This allows for real-time flood warning messages to get out to the emergency response crews and the public.

**Environmental Programs**

Our environmental programs include the development of an Environmental Impact Statement and Biological Opinion, which addresses the impact of implementation of our master plan projects on the environment and the endangered desert tortoise. We also administer our National Pollution Discharge Elimination System permit (NPDES), which serves to monitor stormwater quality in the valley. We are entering the last year of a five-year permit. The permit authorizes discharge from six stormwater outfalls to the Las Vegas Wash. All of the entities in the Las Vegas valley and NDOT are named as co-permittees, with the District named as the lead agency. The District funds 80% of consultant services for compliance activities and NDOT funds the remaining 20%. Consultant services cost approximately $200,000 per year. Each of the entities is responsible for the cost and staffing for the implementation of other best management practices.

**Maintenance**

The District funds operation and maintenance at approximately $2 million annually to maintain the new and existing regional flood control facilities. We have developed an operations and maintenance manual for use by the participating entities who must develop annual work plans to support their requests for operations and maintenance funds. We expect that our revenues will shift gradually toward funding operations and maintenance and away from capital improvement as we near completion of the master plan.

**Public Information**

Through our public information program we continue to educate the new residents and tourists as well as the long-time residents to the dangers of flash flooding in the desert. As part of the program we also outline what the District has done in the past and what will be done in the future to reduce the threat of flooding.
INNOVATIVE ICE JAM FLOOD MITIGATION: HARDWICK, VERMONT, CASE STUDY

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Introduction

Many small communities across the northern United States are located on small, unregulated rivers that generate impressive breakup ice jams. These rivers generally grow thick ice covers throughout winter. In early spring, rapid increase in discharge from snowmelt and rainfall can suddenly break up the ice cover and move it quickly downstream. This ice run may stop abruptly against obstructions such as sharp river bends or solid ice sheets on flatter reaches. The resulting ice jams can block flow so thoroughly that serious flooding may result within an hour of their formation.

Flood damage from breakup jams can amount to hundreds of thousands of dollars in towns consisting of a few thousand residents. Furthermore, the jam’s sudden appearance and its uncertain consequences can severely strain local flood-fighting resources. Commonly, however, losses are insufficient to justify conventional flood-control structures such as dams and levees. Environmental and recreational concerns also tend to render conventional structures unattractive.

Recognizing these problems, the Cold Regions Research and Engineering Laboratory (CRREL) (part of the U.S. Army Corps of Engineers) is

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developing low-cost technology to control breakup ice jams in small rivers. The primary goal is safe, reliable ice control at a construction cost of about $1,000 per foot of river width. In addition, the structure must have low environmental and recreational impacts, and should be robust and easy to maintain.

The Federal Emergency Management Agency's (FEMA's) Hazard Mitigation Grant Program (HMGP) offers a way for small communities to access ice-control technology, provided it is cost-effective. Created by the Robert T. Stafford Act in 1988, the HMGP provides matching funds for hazard mitigation projects such as acquisition of flood-damaged property, stormwater management improvements, and flood protection measures. Communities in disaster-declared counties can apply for HMGP funds. As modified in 1993, the HMGP receives funding equal to 15% of the cost of FEMA disaster recovery programs and can provide 75% of the total mitigation project cost. Local share can include donations and support-in-kind. The HMGP is jointly administered by FEMA and the state agency designated by the governor.

Concept Development

CRREL possesses the world's largest refrigerated hydraulic laboratory and built in it a large-scale (1:10) model of a river reach to investigate the dynamic ice-structure interaction process in detail. Model features included a movable bed to examine scour effects, scaled ice properties (thickness, strength, and piece size) and continuous measurement of flow rates and water levels.

Preliminary tests revealed that structures spanning the river (e.g., wire mesh) and discrete structures (e.g., boulders) both could work. They must be rugged enough to arrest initial ice movement. Once arrested, however, the ice quickly forms a thick, grounded ice jam at the structure that transmits most of the load to the riverbed; this jam then propagates upstream. Locating the structure adjacent to a natural floodplain limits the resulting stage rise by providing a flow bypass channel. Discussions with state and federal permitting agencies indicated that boulders separated by wide gaps for canoe passage would likely meet environmental and recreational concerns. Detailed testing focused on this concept.

After extensive testing at CRREL, the refined concept consists of a few massive, sloped blocks placed across the river adjacent to a treed floodplain (Figure 1). The blocks are partially buried in a riprap blanket to prevent bed scour and block sliding. Ice ride-up during jam initiation provides a download on the sloped blocks to help hold them in place. The sloped faces also act as relief valves for extreme events: the jam can release over the blocks without causing structural failure. The blocks are simple to make of quarried stone or formed concrete, and the wide spaces between them allow easy fish and canoe passage.
Figure 1. Overall layout of ice control concept. Sloped blocks arrest ice run and form a grounded ice jam, flow bypasses jam through floodplain.
Implementation

Good model performance encouraged CRREL to seek a field site to validate this new structure. Severe ice jam conditions occur in the Town of Hardwick (population 3,000) on the Lamoille River in north-central Vermont. During the past 30 years, Hardwick has experienced 10 ice jam floods and 20 additional jams that caused concern but no flooding. The worst three ice jam floods each caused damage over $100,000, yet studies during this period showed that conventional ice-control structures do not achieve favorable benefit/cost ratios.

The performance potential and low cost of the new structure convinced the Hardwick Select Board to participate in its full-scale validation. CRREL selected a good site 0.8 miles upstream of the natural ice jam location in Hardwick Village. Earlier disaster declarations allowed Hardwick to qualify for HMGP funds. FEMA offered preliminary approval of 50% matching funds pending the town’s securing the requisite permits for construction.

The Corps must issue a permit authorizing construction in most rivers or navigable waterways. FEMA must also assess the impact of any structure on adjoining floodplains and the floodway to ensure that it will not increase flood levels within the community. Furthermore, the Vermont Agency of Natural Resources must issue a permit for construction in a river covering water quality and recreational issues. These agencies in turn seek input from other groups with environmental, recreational, or regulatory interest in the project. CRREL prepared hydraulic analyses and other technical input to these permit applications, and demonstrated the model structure’s performance to federal and state representatives. Hardwick secured all permits by early August 1994.

Construction took place during September 1994. The structure consists of four quarried granite blocks, each measuring about 10 ft long x 8 ft high x 5 ft wide and bolted below grade to two anchor blocks for a total weight of 42 tons. The river channel is about 90 ft wide, allowing 14-ft gaps between the blocks. The adjoining treed floodplain has a usable width of about 150 ft. The blocks were buried 3 ft deep in a heavy riprap blanket; they protrude about 1 ft above the top of the bank. Riprap also protects the banks from scour where floodplain flow returns to the channel.

A local quarry donated the shaped granite blocks and waste granite for riprap. FEMA matched the local share, which also included land purchased for the project site. Because the structure has nationwide applicability, CRREL provided engineering services for this demonstration project. Total construction cost, including the value of the donated granite but not the value of engineering services, was about $100,000 or $1,100/ft of river width; land acquisition was an additional $8,000. Following construction, CRREL installed water-level transducers, a data logger, a video camera, and flood lights to monitor the structure’s performance.
Field Performance

Hardwick's 1994-95 winter saw above-average temperatures and two ice breakups: January 15 and March 16. CRREL's instruments recorded both.

The ice cover upstream of the new structure had grown to nearly one foot thick by early January. Suddenly, two days of 50-60°F temperatures and light drizzle initiated breakup on the Lamoille River. Early on January 15, the structure arrested an ice run and formed an ice jam, which it then held for seven hours. A separate, natural ice jam formed several miles upstream and threatened minor flooding of a home and a state road. However, no jam formed below the structure in Hardwick Village. Water levels upstream of the structure rose to bank-full, but the small ice volume and rapid melt rates permitted all flow to pass through the jam rather than over the floodplain. This flow helped to deteriorate the ice cover in Hardwick Village. When ice finally did release at the structure, it washed completely through the village without jamming and caused only minor (2-3 ft) water-level rise.

Seasonably low temperatures returned in February, and by early March the river had again generated a 1-ft-thick ice cover. However, mild conditions without much rainfall or snowmelt significantly deteriorated the ice before a

Figure 2. Ice shoved 5-6 ft above blocks during mild breakup on March 16, 1995. Thicker, stronger pieces typical of severe breakups clog gaps better and form thicker grounded jams.
gradual breakup on March 16. Ice shoved several feet above the blocks at the structure (see Figure 2), yet the thin, weak ice pieces slowly passed through one gap without forming a stable jam. A small, natural jam again formed several miles upstream, but it threatened no flooding. No ice jam formed in Hardwick Village, and ice moving through the structure passed harmlessly through town with only minor water-level rise. This result was similar to model tests conducted with thin, weak ice. Essentially the structure will not form an ice jam under conditions too mild to pose a natural ice jam threat.

Although both breakup events were unlikely to threaten serious flooding in Hardwick, the January event offered a good first test. The structure arrested an ice run, formed an ice jam, and held it for several hours. This ice was unavailable for jamming in Hardwick Village, and its subsequent release was completely uneventful. CRREL is analyzing data from both events for comparison with model results.

General Applicability

This innovative, sloped-block ice-control structure performed well during its first field season. For small rivers with suitable sites, it holds great promise to control breakup ice jams at low cost. Nevertheless, much work remains. Over the next few years, CRREL will assess the structure's performance and its environmental and recreational impacts, determine its range of applicability in terms of river hydraulics and ice conditions, and formulate design guidance for Corps districts to disseminate the technology to interested state and local officials.

Commitment and cooperation at the local, state and federal levels during the three years from conceptual tests to construction made this demonstration project possible. Similar collaboration will be needed to apply low-cost ice-control technology in general. Corps districts will offer design guidance for new technology as CRREL develops and validates it. Communities with ice jam problems can access this technology through their state floodplain managers and FEMA's HMGP. The Corps and FEMA will ensure proper implementation using their standard regulatory reviews. This approach potentially offers small communities a cost-effective way to reduce ice jam flood damage, the ultimate goal of this effort.
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Section 2

Building Local Capability
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Introduction

In March 1994, the Commonwealth of Massachusetts State Hazard Mitigation Officer, Richard Thibedeau, drew up a proposal to develop a hazard mitigation workbook for use by local government and/or citizen groups to prepare a streamlined, cost-efficient hazard mitigation plan. Massachusetts' home-rule form of government means that municipalities have the prime responsibility for implementing such hazard mitigation activities as regulation of land use, retrofitting, and stormwater management. Enabling communities to develop mitigation plans with a step-by-step guide was seen as a practical way to expand local capability to deal with hazard events. In June 1994, the Commonwealth of Massachusetts State Hazard Mitigation Officer applied for a Hazard Mitigation Assistance (HMA) grant through FEMA Region I. The news in October 1994 that the HMA grant had been eliminated nationwide did not deter the state's efforts to pursue this proposal.

Massachusetts has had a State Hazard Mitigation Plan in place since 1986, with updates following disaster events in 1987, 1991, and 1992. Federal guidance in recent years has emphasized that states should ensure appropriate local participation in the development and implementation of hazard mitigation planning. With 351 municipalities in Massachusetts with strong traditions of home rule, as well as varying vulnerability to natural hazards, it has been challenging to find a way to incorporate local participation in the planning process. The expectation that new flood insurance reform legislation that includes mitigation funding will place emphasis on communities that have developed local mitigation plans has motivated the state to find a way to assist communities with local plans. A requirement or mandate for communities to prepare such plans, under Massachusetts state law, would mean that the state would have to establish funding to assist each community. It would also require an additional layer of regulation for overburdened local governments. A workbook developed to guide interested communities through the hazard mitigation planning process,
however, can fulfill the need for local planning, improve local capabilities at managing flood and other hazards, and enrich the knowledge base for state mitigation planning. Developing such a workbook would enable the State Hazard Mitigation Officer (SHMO) to respond to requests from communities that want to prepare a local hazard mitigation plan, and will encourage municipalities to think through hazard mitigation needs and opportunities, allowing them to implement mitigation activities in a pre-disaster atmosphere. The workbook could be adapted for other areas of the United States.

Process, Problems, Solutions

As noted, the state was unable to use a HMA grant to develop this proposal. FEMA Region I staff were enthusiastic about the proposal, however, and over the fall and winter of 1994, helped the SHMO explore additional sources of funding and assistance. Due to time limits on some sources and specific roles and scope limitations of others, the use of such resources as the earthquake and hurricane funds, the Wind and Water Technical Assistance Contract, and state capital funds were ruled out. In February 1995, Flood Hazard Management Program staff re-examined task descriptions under the NFIP Community Assistance Program (CAP-SSSE), and amended their statement of work to allow program staff to begin developing the workbook under Task HQ110, "Develop an Implementation Plan for a Specific Hazard Reduction Measure." This task allows program staff to develop a publication that will provide information on hazard-specific measures to reduce damage. Within the required scope limitations, program staff can develop guidance on only flood mitigation measures, but look forward to garnering assistance in the future to include multiple hazards, such as wind and earthquake.

At the same time as the statement of work was being amended, the state’s Department of Environmental Management was able to allocate funds to hire a contractor to assist program staff in developing the workbook. A selection process secured the services of Clancy Philipsborn, president of The Mitigation Assistance Corporation of Boulder, Colorado, to provide research and technical assistance in developing this document.

Local Participation

In the original workbook proposal, the SHMO recommended that the workbook be field-tested using a pilot community. During the search for ways to make the workbook happen, Flood Hazard Management Program staff became aware that the town of Marshfield was beginning to develop its own local hazard mitigation plan. Rather than work in isolation on a guide to local planning, and then get feedback from a municipality, staff and the SHMO then proposed to work alongside the town of Marshfield to develop the workbook.

The town of Marshfield is a coastal community in Plymouth County, on the south shore of Massachusetts Bay. The town’s 1990 population was 21,531; the 1990 census lists a total of 8,877 housing units in Marshfield.
Much of the town’s floodplain is densely developed, primarily with single-family dwellings. Approximately 90% of the structures in the floodplain predate the town’s entry into the National Flood Insurance Program on October 14, 1977. The town was an attractive resort area from the turn of the century through the 1930s; after the Great Depression and World War II, development followed a pattern typical to that of other Massachusetts coastal communities, with summer cottages being converted to year-round residences. It could now best be described as a small, middle-class "bedroom community" whose residents commute to Boston and its environs to work. The town has a long history of flood problems, with significant property damage occurring in the 1978 blizzard, the October 1991 northeaster, and the December 1992 northeaster. After 1991 storm, community residents activated a Coastal Advisory Committee that worked with town officials to help manage post-storm rebuilding and streamline permitting procedures.

The town had been participating in the Community Rating System (CRS) since 1990. In 1992, the town Board of Selectmen appointed the 13-member Coastal Advisory Committee to manage the CRS program and other related floodplain management needs. The committee was able to file a modification for a Class 7 rating by the end of 1992, garnering a 15% discount on residents’ flood insurance policies that took effect in October 1994.

The committee has conducted several successful outreach projects and has convinced town officials to allocate funds to maintain flood control structures in the town. They provide a unique example of how local residents can effect change and implement hazard mitigation measures. Establishment of the Coastal Advisory Committee allowed residents with expertise in the real estate and construction fields as well as a wealth of local knowledge to have input into town-level decision making. This process also helped the town achieve goals that would have been unreachable given limited town funds.

The town’s Floodplain Management Plan and Repetitive Loss Plan were developed to identify flood mitigation goals for the town. These goals include items creditable under CRS, such as conducting a certain number of outreach projects per year, and further protecting special hazard areas such as sand dunes. Items they identify that may not gain credit under CRS, but that were viewed as vital in minimizing future flood damage, include preserving the town’s significant wetlands and sensitive habitats, maintaining the existing seawalls in front of homes, maintaining a tidal floodgate, and ensuring adequate staffing levels of emergency response personnel. The town’s primary future goal identified in the Floodplain Management Plan was development of a Hazard Mitigation Plan. This would allow for hazard assessment and identification of mitigation opportunities and funding sources in a non-emergency situation.

Immediate Goals

Having secured the commitment of the town and The Mitigation Assistance Corporation to begin the process of developing the workbook, the following tasks will be completed within two months. First, the consultant will research
and acquire an inventory of the latest hazard mitigation practices and programs in the United States, including local plans that may have been developed, or state plans that include directives for local planning. The consultant will review the current Massachusetts State Hazard Mitigation Plan, and Marshfield’s Floodplain Management and Repetitive Loss plans to identify compatible mitigation priorities, applicable environmental regulations affecting implementation of mitigation actions, and how to integrate CRS goals into the planning process. The contractor will then identify the steps necessary to enable a local government and/or citizens’ committee to proceed through a planning process that will result in a formally adopted hazard mitigation plan that identifies sources of funding and technical assistance.

Working with state hazard mitigation personnel and Marshfield committee members and town officials, the consultant will develop a framework for the workbook and enumerate all items that should be contained. At the end of June, a working session with the town committee, town officials, and active residents will be conducted, resulting in a "how-to" report for identifying local hazard mitigation problems, solutions, and resources. The physical document will be created by Flood Hazard Management Program staff. It will result, by September, in a preliminary version of the workbook, in a loose-leaf binder format. This draft document will be distributed to the 78 Massachusetts coastal communities for review and input. The preliminary nature of the product is scheduled to allow communities and states to assess the impacts of the NFIP Reform Act and new mitigation funding requirements on how they can develop plans to meet those requirements. The document will include a "Who's Who" for regulatory authorities; a list of agencies and organizations providing technical assistance and/or funding; a definition of hazard mitigation and an outline of FEMA/FHA’s goals of reducing flood losses nationwide; and worksheets that provide a step-by-step format for communities to assess their hazard vulnerability, identify important issues, and come to a consensus on solutions and mitigation goals.

**Long-Term Goals**

Long-range goals for development of the workbook include strengthening hazard mitigation programs statewide by furthering hazard mitigation knowledge, expertise, and capability at the local level; pre-identifying mitigation opportunities to expedite the 404 Hazard Mitigation Grant Program following future disasters; and developing a working partnership among federal, state, and local agencies to address and implement hazard mitigation programs in Massachusetts. The need for local hazard mitigation planning has become apparent through the state’s implementation of the Hazard Mitigation Grant Program. When grants were announced following the 1991 and 1992 disasters, many communities were unable to assemble the staff and resources to make an application during the immediate post-disaster phase. In some communities that were successful in obtaining grants, one town department had applied for a specific project, but other town officials were unaware of
the availability of the grant, again due to the hectic atmosphere of the post-disaster scenario. Many communities applied for grants for projects that were deemed an excellent use of funds, but then encountered difficulties and delays because of staff shortages and other limitations in implementing the grant proposal.

Providing a format for communities to plan for hazard events is important in expediting the recovery process and making mitigation happen. In Massachusetts' coastal communities, where so many of the structures in the floodplain are pre-FIRM, identifying opportunities to mitigate damage to existing structures is vital. The creation of a local hazard mitigation planning workbook will help firmly establish local concerns in future state hazard mitigation plans, as well as give municipalities the capability to meet their diverse hazard mitigation needs.
COMPLIANCE AS A MITIGATION TOOL IN ILLINOIS FOR THE GREAT MIDWEST FLOOD OF 1993

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Shortly after flooding began in the upper Mississippi basin in 1993, it became readily apparent that flooding in Illinois would reach catastrophic proportions. In response to this threat the Federal Emergency Management Agency (FEMA) and Illinois Department of Transportation, Division of Water Resources (DWR) began to formulate a strategy to deal with the damage sure to occur from this event. The strategy had to deal with all different types of communities: sophisticated and unsophisticated, urban and rural, developing and stagnant. The strategy decided upon was called "Compliance as a Mitigation Tool," and is somewhat similar to the strategy known as "Tough Love," used to deal with troubled teenagers. That is, local officials would be given as much help as possible in responding to the aftermath of the flood and in enforcing their community regulations. However, pressure would be kept on the communities to enforce their floodplain management requirements.

The 1993 flood was truly of catastrophic proportions. In the three affected states served by FEMA Region V (Minnesota, Wisconsin, and Illinois) 134 counties received a Presidential Disaster Declaration. As of September 1993, 27,762 applications for disaster assistance had been received in the three states.

The hardest state hit in terms of damage was Illinois. Over 6,000 houses were damaged; over 16,000 people were displaced from their homes; and 10,000 jobs were lost. Thirty-nine counties received a Presidential declarations; 18 communities were severely flooded; 873,000 acres of farmland were flooded (about 3% of the state’s planted acreage); there was $425 million in damage to crops and unplanted land and $110 million in damage to buildings and farm equipment; nine highway bridges on the Mississippi River and two on the Illinois River were closed; and 140 miles of highways were closed.

In all, the federal/state compliance team worked with 63 communities in Illinois. The large number of communities forced us to look at several different factors in planning our strategy. Possibly the most important factor was how to determine which communities to visit. After much discussion, it
was determined that structural damage would be the deciding factor. A number of communities were placed on the list based on staff observations during the flood. In addition, we were able to access information included in individual assistance (IA) applications. Using the IA application data, we added any community to the list which had three or more structures with three or more feet of flooding over the first floor. We then looked at a number of other factors. Only three of the communities that would be visited were new to the National Flood Insurance Program (NFIP). Forty-four of the communities that would be visited had been in the regular phase of the NFIP for more than eight years. Twenty-four had received a community assistance visit (CAV) since 1990. Out of the 19 counties that would be visited, only two outside of the Chicago metropolitan area had increased in population between 1980 and 1990 according to the U.S. Census Bureau. Thirty-three of the declared counties would be considered rural and six considered urban. Forty-four of the communities "CAVed" were cities or villages. Only 16 of the communities visited had adopted either the BOCA or UBC Building Codes. Only half of the communities in Illinois are zoned, and although the number for incorporated communities is higher, it is not 100%.

The strategy decided on included a combination of workshops, one-on-one meetings, use of Geographic Information Systems/Global Positioning technology (GIS/GP), CAVs, and the use of several innovative funding techniques. All these were mixed with a fair amount of evolving procedures. During August and September 1993, eight workshops for flood-damaged communities were held along the Mississippi River. Topics covered at the workshops included floodplain regulations; determining substantial damage; flood hazard mitigation strategies; retrofitting, elevating, and floodproofing; removal of frequently flooded structures; funding for mitigation; flood insurance; and floodplain mapping. We should note that we had nearly 100% participation from invited communities.

The workshops were followed by one-on-one meetings with communities to reinforce topics covered at the workshops. The meetings were conducted by Natural Hazards Program Specialists from Regions III, V, X and FEMA Headquarters along with DWR staff. All communities were provided with a list of Region V phone numbers and contacts to turn to for assistance. In addition, communities were advised to contact the Public Assistance Program to request funds for hiring technical experts.

For the first time in a disaster, GIS/GP technology was used to provide maps showing the location of potential substantial damage sites. Data sheets were also prepared using digital pictures and information such as addresses, a location map, damage information, and type of construction. The maps and data sheets were then provided to the communities to assist them in determining the location of substantially damaged structures. Later, determination information was requested from communities using the information included on the data sheets. One unexpected side effect of this projects was realized when a local official was heard to say "We've got to be careful with these determinations, because FEMA's eye-in-the-sky is watching us."
Finally, 64 communities were CAVed in 1994 by the federal/state compliance team. Depending when the last CAV occurred, either the entire community or just the flood damaged areas were toured. Problems found in the communities were generally divided into three categories: complete failure of enforcement of the community's ordinance, desire to enforce the ordinance but lack of skills, and desire and skills to enforce the ordinance dulled by political pressure to ignore the requirements. Technical assistance was provided to those communities who lacked the skills to enforce the ordinances and pressure was turned up on the remaining communities to encourage compliance.

The major tool used to encourage communities in Illinois to enforce their ordinance was the withholding of Section 404 funds and other forms of federal and state assistance. It has been standard procedure in the region to explain to communities that they had to be fully compliant to be eligible for financial assistance. The decision was made to withhold funds if non-compliance was verified, the communities were notified that they were non-compliant, and they failed to mitigate the non-compliance. All communities were CAVed to determine eligibility. In addition, if we became aware of subsequent non-compliant actions we contacted the communities via certified letter. In either case, the communities were given a deadline to bring the non-compliant structures into compliance. If they failed to meet the deadline, then a letter was sent to the State Coordinating Officer to recommend that funds be withheld. In addition to Hazard Mitigation Grant funds, the state decided to withhold Community Development Block Grant funds. Later volunteer agencies also decided to withhold funds. At the beginning, funds were withheld from seven communities, but the figure has gone up and down since then. Currently four communities are on the list. We have found that this has been a very effective tool, not only for the affected communities but also for the others. As word got around that we meant business, it was apparent that other communities were increasing their vigilance.

Prior to withholding any funds, Congressional staffs were briefed regarding our actions. They were fully supportive of the entire effort. We are currently undertaking three additional actions to encourage compliance and mitigation. We are working with communities to prepare mitigation plans. Included in the planning effort is a section on upgrading the communities' compliance efforts. We are also in the process of contacting those communities in which offers were made to buy out flood-damaged structures but the offers were rejected. The communities are being asked to provide the substantial damage determinations for each rejection, so that we may determine whether the structures need to be elevated. Finally, we are beginning to conduct what we are calling close-out CAVs. We are visiting those communities where, based on earlier visits, there appears to be a high risk of non-compliant reconstruction. After conducting the field tours, we will then decide whether a meeting is necessary, or whether a letter will be sent congratulating the community on its diligence.
What have we learned from this process?

- Local officials need better training, regardless of community size or sophistication. Training should be aimed at all local officials and should be backed up with newsletters.

- There is a need for better codes. The lack of good local codes slowed down the recovery process.

- More concise guidance is needed. Guidance that tries to address all variables and is not state-specific is a hindrance.

- After a disaster, federal and state coordination needs to take place on almost a daily basis.

- The most important lesson learned is that compliance is a mitigation tool. A community responds to compliance by mitigating.

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DISSEMINATION OF FLOODPLAIN MANAGEMENT STANDARDS AND PROCEDURES TO LOCAL OFFICIALS

Daniel W. Soule
Maine Code Enforcement Officer Training and Certification

Maine’s Code Enforcement Officer Training and Certification Program has certified 418 individuals and counts 346 Maine communities compliant with the State of Maine Code Enforcement Officer Certification Law, which was enacted in 1988. The program has had a profound impact on local code enforcement efforts in the state.

In order to really understand this accomplishment and the impact upon floodplain management and other code enforcement, one must first understand the historical setting of code enforcement in the State of Maine. Maine is a very large and diverse state. Diversity describes its physical characteristics, its weather, its institutions, and its people. Maine has over 3,478 miles of coastline, 5,780 lakes and ponds including 40-mile-long, 74,890-acre Moosehead Lake, 5,100 rivers, and 2,772 square miles of floodplains. There are urban pockets, but most of the state is rural. The principal governmental entity is the town. Those towns and town governments are as diverse as the other elements of the state. There is a very strong tradition of local autonomy. Many of Maine’s towns were functioning as seats of local government 100 years before there was a federal government. Code enforcement in Maine has developed from many different and diverse foundations. Since the turn of the century, fire codes have been a part of the picture. There have been health and safety laws in place for decades. Since 1954, state law has required municipalities of 2000 population to have a local building inspector. Since the 1960s the state has enacted environmental protection and developmental control laws, air and water quality standards, natural resource protection, etc., all administered and enforced by the State Department of Environmental Protection (DEP).

Over the past three decades, as the state enacted and developed more and more comprehensive regulations, the local governmental unit remained strongly individual and independent. In 1971 Maine passed a progressive and unique law, the Mandatory Municipal Shoreland Zoning Act. All coastal shoreland, wetlands, great ponds (10 acres or more), rivers, and most streams were to have protected areas within 250 feet of these natural
resources. These resources were to be identified, categorized, and zoned for protection and/or appropriate development. As was the nature of political reality, this shoreland zoning was to be a local ordinance with a local code enforcement officer to enforce the standards. During the 1970s, the state also saw many communities participating in the National Flood Insurance Program (NFIP). By 1974–1975 most Maine communities with floodplain areas had enrolled in the NFIP. Ten years ago one might say the state had a number of appropriate codes and standards enacted by the state, administered by the state with a supporting level of local enforcement with appropriate laws and ordinances. Then came a series of coastal storms and a couple of spring ice jams in northern rivers. The destruction that followed in the wake of these disasters, coupled with the boom development in the southern part of the state in the 1980s, pointed out that effective code enforcement was not what it could be.

In 1988 the legislature enacted a growth management law. This law recognized a need for more coordination between state and local efforts. It took a more aggressive approach to land use planning and regulation. A small part of that act created the Code Enforcement Training and Certification Program, recognizing that any planning and implementation of subsequent ordinances requires trained competent enforcement officers.

The Code Enforcement Program is mandated to improve enforcement of land use laws and regulations at the local level. It does this by providing quality training of a basic and advanced nature for code enforcement officers to make them more knowledgeable about federal, state and local code enforcement; establish better communication and coordination between municipalities and state agencies; keep them current with legal, procedural, and technical data in the areas of their job responsibilities. The Office of Community Development is primarily a technical assistance agency for the municipalities and their employees involved in land use regulation and code enforcement activities.

The law, Title 30-A M.R.S.A. § 4451, requires that beginning January 1, 1993, municipalities hire, for purposes of codes enforcement only, individuals who have been certified by the Office of Community Development, with the exception that new employees are given 12 months to achieve the required certification. The law defines code enforcement officer as any individual at the local level who enforces laws, codes, standards, and ordinances in the areas of shoreland zoning, subsurface waste water disposal, internal plumbing, building standards, and land use regulation including floodplain management. It requires certification only in areas of actual job responsibility; requires examinations to document competency for certification; and requires continuing education for recertification.

The Code Enforcement Officer Training and Certification Program was not eagerly accepted at first. Those communities with established programs wished to be left alone as did those with little or no local code enforcement. The diversity of code enforcement throughout the state was like other elements of the Maine character—extreme. It contributed both strengths and weakness in the development of effective enforcement at the local level.
There was no such thing as "a code enforcement officer in Maine;" there was "that code enforcement officer in that town and that code enforcement officer in the next town." There was no consensus as to what a code enforcement officer was or what the job responsibility was. On the other hand, when the local administration had been given good information and signed on to the importance of the regulations, the local administration and enforcement became more effective because it had local authority.

Five years later, although there is still a great difference from town to town, a better picture is now emerging as to what a municipal code enforcement officer is and what the position is all about. Diversity is still the rule. However, the program has given to the code enforcement community a unity of technical data, procedures, and purpose that did not really exist on the state scene previously.

There are two basic parts to this program: training and certification. The program provides training of both a basic and advanced level, in topics of interest and need for the code enforcement community. Since we began training in 1991, we have developed and delivered 13 different basic training workshops and three advanced training workshops. They include Legal Issues for Code Enforcement Officers, Inspection of Subsurface Waste Water Disposal Systems, Basic Floodplain Management, Wetland Identification and Delineation, Shoreland Zoning, Introduction to Building Standards, and Issues in Floodplain Management, to name a few. New topics continue to be developed. With five different and diverse areas of job responsibility to cover there are a great many topics that must be presented if we are to meet our mandate to present both basic and advanced training for all our clients. This presents a huge logistical challenge. We develop and deliver this training around the state. Our workshops are presented in a number of university and technical college sites on a repeating schedule of 24 months. A manual is developed for each workshop that serves as a text and is also useful as a home study course. In addition, most of our workshops are videotaped to provide self-study material. The two-day workshop, "Substantial Damage/Improvement," for example, was edited and is used in a one-day "talk a tape" training session.

The law requires certification documentation of competency by examination, and further states that an individual need only be certified in the areas of his or her actual job responsibility. The law mandated that the office sort out, by rulemaking, what the actual standards and procedures should be for certification. Because of this element, developing a certification examination that would be reasonably challenging yet fair and meet the directive of the law, became a real problem. The solution was to develop a series of examinations.

To become certified, every applicant must successfully complete at least two different examinations. One examination (called the Part I exam) is required of every candidate for certification. It is based upon a general knowledge of legal issues, basic enforcement techniques, and an overview of code enforcement in Maine. It is knowledge that every code enforcement officer should be familiar with whether the individual is administering the
floodplain ordinance, inspecting shoreland development, or enforcing a building code.

There are also five Part II examinations, each based upon the more specific elements of the areas of code enforcement enumerated in the law: shoreland zoning, building standards, internal plumbing, subsurface waste water disposal, and land use regulations.

Each examination contains two sections. The first section of each is a number of multiple choice and true or false questions taken without benefit of resources. The second section of each examination is a practical exercise. The code enforcement officer is given copies of laws, ordinances, forms, tax maps, Flood Insurance Rate Maps, and zoning maps to help in making a decision and take the appropriate action. Questions concerning floodplain management have been part of our certification examination from the beginning. We now have 318 individuals certified in the area of zoning and land use regulations, which includes floodplain management.

According to the law, recertification is achieved by obtaining continuing education credits within five years. Twelve contact hours in each area of responsibility are required to continue the certification. For purposes of recertification the area of legal issues and enforcement techniques counts as an area of responsibility. There is also an optional certification in Rule 80K, Court Procedures, for actual prosecution of land use regulation violations. To be recertified in all areas would require seven times 12 hours or 84 hours during the five-year certificate period. To be recertified as a town building inspector only would require 12 hours in the area of building standards and 12 hours in legal issues and enforcement.

Floodplain management has been an element of our land use regulation training since the beginning of the program. Since 1991 a workshop titled "Introduction to Floodplain Management" has been a part of the curriculum. It has been delivered twice, each time at five or six sites around the state. Three hundred and forty seven individuals have attended this training. It will be offered in eastern and northern parts of the state before the end of 1995. In addition, "Issues in Floodplain Management" (substantial damage/improvement and FEMA Technical Bulletins) has been offered to code enforcement officers who wish more advanced training.

Both quantitative and qualitative analyses show great strides being made toward more effective code enforcement at the local level in the last five years. The numbers speak for themselves. The results of two different audits, one by the National Oceanic and Atmospheric Administration and one by a University of Maine professor, indicate a greater proficiency in floodplain management, both in standards and process, on the part of code enforcement officers between the period prior to 1990 and the present. Reports from community assistance contacts (CACs) and community assessment visits (CAVs) in the past two years indicate a greater understanding of the regulations. The questions asked by code enforcement officers are of an increasingly technical nature.
Although there is still room for improvement, we believe that the program has been a success. We must constantly remind ourselves of the items that we believe are key to that success.

In the Maine tradition, we develop a quality product. We contracted with recognized experts to help develop training manuals that were easy to read and understand yet contain substantive technical material. Workshop instructors are recognized by the code enforcement community as creditable people and effective presenters. Even when code officers have earned their recertification credits they continue to attend, because they believe it is helpful to them. This tells us that our product is a quality product and is appreciated. We approach the training and certification as technical assistance. In keeping with the spirit of no unfunded mandates to local government, there is no cost for tuition or materials to employees of municipalities. We charge a nominal fee for materials for non-municipal employees. We also listen; we make every effort to work on issues for training that are identified as needs of the code enforcement community. The things that work, we keep and repeat. The things that do not work we revise or throw out. We work with other state agencies—DEP, Fire Marshall’s Office, Division of Health Engineering, and the State Floodplain Management Coordinator—to keep the data and procedures in our training current. We address new issues that are brought to our attention by code officers, municipalities, and other state agencies. We also work closely with the organizations of professional code enforcement officers such as the Maine Building and Inspectors Association to work on their issues and to coordinate work they do in professional training to integrate it into creditable work toward recertification.

When the budget axes began to fall a couple of years ago, not only did the growth of the program become threatened, but there was some question about its continued existence. The Growth Management Program, of which we were originally a part, was eliminated and then partially revised. The code enforcement community that had in the beginning been suspicious of us, came to the support of the program. They testified to the legislature that the program was giving them current and much-needed information and developing a professionalism in code enforcement that had been lacking. I would add that in addition to the quality of the information presented in the training sessions, the certification requirements are perceived to be challenging yet fair, and the whole program is flexible so that it can adapt to the needs of the municipalities in the state. Having achieved quality education and professional upgrading in turn should translate into more effective enforcement of regulations from a local level.
TEACHING FLOOD DISASTER RECOVERY PLANNING: A TEXAS CASE STUDY

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Introduction

In October 1994, as much as 30 inches of rain fell within 30 hours in areas of southeast Texas. Although such dramatic rainfall was limited to a few areas, much of the greater Houston area experienced more than 10 inches of rain in a 24-hour period that resulted in widespread flooding. Eventually, 38 counties were declared federal disaster areas.

Federal and state floodplain management staff were deployed to the disaster area to provide training and technical assistance to local floodplain managers and homeowners, and to assist local officials with damage assessment. As Federal Emergency Management Agency (FEMA) and state floodplain management teams met with local officials and disaster victims, it became evident that no jurisdiction was prepared for the administrative and technical challenges that result from large flood events. Communities that were well prepared to address emergency needs did not know how to begin to administer post-disaster inspection and permit programs and provide flood victims with options for avoiding future damage.

Training Needs

During the weeks after the flood, the floodplain management teams maintained close contact with local officials in the affected communities. Through this contact, the FEMA regional office and the state coordinating office, the Texas Natural Resource Conservation Commission (TNRCC), observed that many community officials were unfamiliar with the National Flood Insurance Program (NFIP) rules on substantial damage and post-disaster permitting. The authors are not aware of any community that implemented a flood recovery plan that identified emergency staff, general mitigation options, specific damage reduction projects, or sources of funding to assist disaster victims.
Although most of the communities in the disaster area had experienced several floods in the past decade, the floodplain management teams were surprised by the communities’ low levels of preparedness. The need for flood disaster recovery planning was obvious; therefore, FEMA Region VI and the TNRCC developed a one-day planning workshop to assist local officials in preparing for floods.

Workshop Summary

The primary goal of the workshop was to prepare communities to recover from a large flood. The workshop was presented to a small audience of floodplain managers, emergency management coordinators, and river authority officials in April 1995. The workshop opened with discussions on planning topics, moved to specific modules on flood disaster recovery, and ended with a post-flood tabletop exercise. Shown below are some of the topics included in the workshop:

- Community preparedness after the southeast Texas flood
- The purpose and need for planning
- Post-disaster permitting challenges
- Addressing unpermitted reconstruction
- Determining and enforcing substantial damage rules
- Mitigation funding sources
- Public information and outreach in disaster situations
- Mitigation options for damaged buildings.

Training Recommendations

The critiques of the workshop were favorable, and recommendations for improvement varied according to participant’s interests. Several participants recommended that we lengthen the section on public information and outreach, while other participants recommended that the workshop omit public information training but include lists of public information resources. The most significant lesson that we learned while conducting the workshop was to focus on the audience’s needs and interests. Before conducting the workshop again, we plan to survey participants and tailor the modules to their specific needs.

The informal approach that we followed during the April workshop worked well with the small audience that attended and allowed for significant participation by each student. With a larger audience, we recommend using a more formal approach with a more product-oriented focus that would allow participants to leave the workshop with a well-developed outline of a flood disaster recovery plan. Regardless of audience size, we strongly encourage workshop designers to prepare exercises and drills thoroughly to ensure that the exercises reinforce the workshop objectives.
Based upon our experiences assisting communities after the southeast Texas flood and preparing a post-flood recovery planning workshop, we offer the following observations:

- Existing training opportunities are severely limited in number and scope.
- Most workshops are geared for new floodplain administrators.
- A great need exists for advanced workshops covering a variety of topics.
- The public and many community officials do not recognize the threat of large floods.

We hope this paper benefits community officials and floodplain management trainers by reporting on a specific workshop and by identifying larger training needs.

Possible Resources for Flood Recovery Workshops

Crayford, Forrest J., Jr.

Emergency Management Institute

Emergency Management Institute

Emergency Management Institute

Lesser, William H.
Owen James A. and Arlen D. Feldman

Owen, James A.
FACTORS PROMOTING COMPREHENSIVE LOCAL GOVERNMENT HAZARDS MANAGEMENT

Jack D. Kartez
University of Southern Maine

Charles E. Faupel
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Since the concept of "comprehensive emergency management" (CEM) was first promoted by the National Governor's Association 15 years ago (Whittaker, 1979), local governments have been criticized for not paying as much attention to pre- and post-disaster mitigation and recovery planning as to preparedness and response. The issue of local roles and capacity has increased steadily since the near-simultaneous impacts of Hurricane Hugo and the Loma Prieta earthquake in 1989, through the Midwest flood of 1993, and the elevated federal interest in serious community-level mitigation. Most information about balanced or "comprehensive" local approaches to hazard management comes from anecdotes about exemplary cases like the successful flood/stormwater program of Tulsa, Oklahoma. The Federal Emergency Management Agency's (FEMA's) Community Rating System (CRS) is a developing tool for comparing the strength of different communities' approaches, but it was not created as a research tool for investigating questions about why some cities have developed more comprehensive efforts than others.

We designed a study of over 300 American cities to survey the extent of current efforts in all four phases of "comprehensive " hazards management (mitigation, preparedness, response, and recovery) as well as in a fifth area of distinctive importance: the task of public hazard education. This National Science Foundation-supported study describes the efforts of a cross-section of cities in areas including city mitigation policies and regulations adopted, response preparedness practices, public education activities carried out, and so on, but it is not a substitute for the CRS in any way. Instead, it is designed to look at process and organization and to investigate the question of what influences or factors are and are not associated with greater comprehensiveness in a city's overall hazard management efforts.

Factors in this study include (1) the influence of prior city experience with disaster impacts, (2) relative resources, (3) leadership support, and
(4) state mandates for hazards mitigation in land use planning, among others. But we also have specifically focused on the role of interaction and cooperation between city land use planning agencies and emergency program managers.

**Role of Local Planning Agencies**

Local planning agencies have a potentially beneficial role to play in mitigation, recovery/reconstruction, and public education because they are responsible for many nonstructural controls and for justifying public investment through growth management programs. Land use planners also have expertise in public involvement processes and maintain contact with many constituencies in their cities. Planning agencies thus represent a significant and perhaps inadequately tapped source of partnership and assistance for local hazard managers who want to promote more comprehensive local government efforts. Such collaboration has arisen in various localities usually as the result of repeated disaster impacts and political windows of opportunity, as in cases like Santa Cruz, California; Nags Head, North Carolina; or Tulsa, Oklahoma. But is collaboration also being pursued in local governments other than the exemplary cases? Does interagency collaboration between planning departments and emergency managers make any difference in the overall hazards management approach of cities?

**Hypotheses about Exchange and Cooperation**

Drawing on past research on both interorganizational cooperation and observed problems in municipal emergency management, we defined interaction between a city's planning and emergency management programs as taking place at several levels, from traditional interdepartmental involvement in disaster preparedness and "coordination," to more ambitious and non-traditional exchanges of actual expertise (in areas such as GIS and hazard analysis) and assistance (such as sharing public involvement constituencies) from planning to emergency managers. The concept of interaction used here thus represents more than superficial coordination and includes collaboration. We subtitled this project "Economies of Expertise" because we hypothesized that having more linkages between local emergency programs and ongoing local land use planning should result in more comprehensive approaches to natural hazards management than occur when these agencies work in isolation.

**Study Design**

Mail-out surveys were sent in 1992 to both the designated emergency program manager and the planning director of each of 375 cities that had responded to a 1987 survey of city emergency planning programs conducted by Kartez and Lindell (1987; Kartez 1988). This city sample frame is unique because it represents one of the few longitudinal studies of local hazards
management. The two separate mail surveys used in 1992 were different for each agency; For example, planning agencies were asked for information on mitigation-supporting land use/environmental policies and regulations, but emergency managers were asked about preparedness and response, and public education. But the two surveys also included identical questions in key areas, including reasons for working with the other agency, city recovery policies (which can appear in completely different plans and rules of the two agencies), the organizational climate for cooperation, and other areas beyond the scope of this summary. Finally, planning agencies were asked about how they interact with and assist emergency managers and why their office devotes effort to hazards management. Response rates to this survey, which requires data from both agencies, were very high at 90% and 88% for planning and emergency management offices, respectively, and over 79% for having both agency’s responses from each city (i.e., about 300 cities).

Results

Space allows only highlights of findings from these survey data. First, the results show that the two agencies’ efforts tend to operate independently of each other in that a strong program in a city’s emergency management office does not necessarily predict a strong land use and growth planning effort for hazard mitigation in that same city’s planning department, and vice versa. A principal components analysis of the data from both surveys on city hazard management activities and accomplishments in nonstructural mitigation-related plans and regulations, preparedness planning, recovery planning, and public education revealed two dimensions (i.e., components). The first describes the extent of emergency manager activities in preparedness planning, public education, and recovery preparation. The second dimension describes the city planning department’s programs and policies relating to hazards mitigation and recovery. Figure 1 shows how cities scored on these two dimensions which, by the nature of principal components analysis, are uncorrelated with each other.

These results mean that many cities (in fact, most) do not have equal efforts among all hazards-related programs. As Figure 1 shows, however, there are cities that score above the average scale values of 0 on both dimensions of effort, but there is no general tendency for high effort by emergency managers and planning departments to be correlated with each other. Particularly surprising was the finding (from further analysis of these data) that across all cities, planners and emergency managers disagree more often than not on what the city’s policies for reconstruction are. There was little interagency agreement regarding whether the city does or does not have policies for expedited post-disaster permitting, damage definitions for allowing repairs, policies for nonconforming uses, land acquisition and historic structure review, and other important physical rebuilding issues.
Figure 1. Component scores for cities' efforts on emergency manager vs. planning department activities.
Planning departments do, however, interact with emergency program offices in a wide variety of both traditional and innovative ways. We investigated the extent of that interaction and whether it is related to the cities that do score high on both dimensions of hazard management effort (see Figure 1). On the traditional "disaster planning and coordination" side of interaction, 44% of planning departments take part in annual emergency exercises and 39% have participated in disaster management training. Almost 50% report participating in a multidepartmental hazards committee and 53% worked on the city's basic disaster plan. Fewer planning departments report non-traditional forms of interaction. The most frequent, reported by 37% of planning departments, is to provide emergency managers with access to GIS resources including equipment, data, or technical assistance. About 23% also report asking the emergency manager to comment on land development permits/policies. But only a few agencies report helping prepare the city vulnerability analysis (14%), working with emergency managers on public education (12%) or keeping emergency managers informed of mitigation-related policies (13%). Only 6% of planning agencies report serving as their city's mitigation coordinator.

Does that cooperation and exchange of expertise make any difference? As described earlier, cities were scored on their current activities in emergency management (response plans, public education, and recovery preparations) and in hazards-related land use planning efforts (mitigation-related land use policies and regulations, and again, recovery preparations). Together those two overall scales (components for emergency management and land use planning departments) describe about 60% of the data on city performance.

Cities that score high on both components can be considered to have more "comprehensive" hazards management efforts. To test the effect of planning agencies' collaboration we included data in our analysis on some rival (alternative) explanations for greater city effort on the two hazards management scales. Those rival explanations included prior disasters at different times, chief administrator support for hazards management, city resources, state mandates for hazards management, and the quality of the emergency program manager's planning and coordination process (Kartez and Lindell, 1987).

Regression analyses that predict city scores on the emergency manager and planning agency scales produced some consistent results. Planning department involvement in traditional coordination with emergency managers on disaster preparedness is not related at all to city performance on mitigation, preparedness, public education, or recovery preparations as measured in this study. However, cities scored higher on both dimensions when planning agencies engaged in non-traditional exchanges of expertise and collaborative aid with emergency managers. Those types of collaboration are related to more "comprehensive" hazard management but are also not present in the great majority of cities. Only one other factor—state mandates for local hazard management—was related to "comprehensiveness."
The quality of the emergency manager's disaster planning and coordination process is positively related to emergency preparedness and public education in these data, but not related to the land planning agencies' hazard management efforts. Another difference is that recent (1987-92) disasters are positively related to emergency manager's programs, but severe disasters before 1987 are strongly related to mitigation policies reported by planning departments, showing how disasters have taken time to work through the system. These results at the very least show potential benefits from more collaboration on hazards from local government planning departments. Data from this study also shows that a major motivation for planners to give attention to natural hazards are state legislative mandates for environmental planning.

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Section 3

Public Involvement and Education
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WINNING FRIENDS

Dottie Nazarenus
City of Fort Collins Stormwater Utility

Introduction

John Arnold, a former City Manager of Fort Collins, Colorado (1977-1984), had a good basic tip when selling a project to the public, whether the project was the implementation of monthly fees for a new stormwater utility, or a necessary capital improvement with negative environmental impacts. He believed that if the right decision was made, the public would eventually give their support, although they may never like it. As the city’s representative/project manager, if you could ask yourself if anyone else in your position would have made the same decision and could answer "yes," then you were on the right track.

This philosophy, combined with some exceptional training by Hans and Annemarie Bleiker through their Citizen Participation/SDIC (Systematic Development of Informed Consent) courses, has been my basic guide. The Bleiker's suggestions are so simple and obvious that you really do wonder why you never thought of them before. Their advice—talk in lay terms, describe your project as though you were sitting in a bar and telling a friend about it. Do not use terminology that the average person does not know. It is not easy to find an everyday word for basin or floodplain or even 36-inch pipe. That last one seems easy, but the average citizen probably needs some enlightenment as to what you are talking about. You need to make an effort to explain your terminology or risk losing your audience quickly.

The Basics

Early in the planning process and well before the first public contact is made, it is essential to ask and answer several basic questions: Is this a serious problem and are we the right agency to address it? Who are the potentially affected interests and how are they affected? If it is serious and we are the right agency, why are we addressing this problem now? Is it in the master plan, on the 5-year project schedule, and something we have been planning to do for some time, or has something else happened to give it a higher priority? Be very clear on both the reason for doing it now and that your agency is the right one to do it. The public generally wants to be reasonable.
They expect us as government agencies to have a definite delineation of responsibilities, to carefully collect information, evaluate data, and take the correct action. They need to see that your approach is consistent and sensible.

Identifying the potentially affected interests is tougher but it is absolutely crucial for success. Brainstorm not only all the interests, but their value systems as carefully as you can. Those who will be hurt by the project will want to be directly involved; most others will not participate in the planning process unless there are tangible and significant issues that they believe they can influence or contribute to. As you probably already know, it is very easy for the public to stop or stall a project and if there are suspicions about your conclusions, they may be inclined to do that. They may reject your decisions even though they originally liked them.

I did that last year while serving on a board for my church. The pastor announced one evening that the organ would be moved from the balcony at the back to the front of the sanctuary. Although I personally prefer seeing (and listening to) the organist and choir at the front, I resented the way the decision had been made. It was my church but I had not been given an opportunity to vote on a change that was about to cause a major impact on the various services. I joined the majority of non-supporters who easily prevailed. Now I am ready to go to bat for the move because I have researched the reasons and am convinced that our services will be improved.

Even though the primary reason to move the organ was for the benefit of the pastor in coordinating the services, the importance of winning support from the members, including the organist and choir, was not originally a consideration. The process should have been to take the time necessary to collect and disseminate as much information as possible from all sources; seek input at a formal, scheduled business meeting; address all concerns; and finally, set the plans in place to move the organ after having achieved systematic development of informed consent.

Another case where the public may begin to rely on other sources is if they perceive that you are not providing all information to them. Exactly how much detail and when to provide it can be a hard call to make. If someone has heard a rumor and asks for information, my advice is to be as up-front and truthful as you can and if they are asking about sensitive information not for public dissemination, tell them that. They do not expect you to reveal the details of such things as contract and land purchase negotiations but they probably do expect you to say that the negotiations are occurring and that at some future date the details will be made public.

Do you expect criticism and confrontations at public meetings? People with hidden agendas? I do, and my expectations are that the larger the group, the more intense and threatened they are by my project. One suggestion to diffuse the difficult objector is to ask for more involvement in the project by them so that they begin to have some ownership and move away from extremist or irresponsible positions. If that does not work and they continue to disrupt meetings, the public will eventually differentiate between legitimate needs and wants and discredit the one who objects to everything. Keep in
mind that although you have looked at all the alternatives, a potentially affected interest may actually have a better idea.

Some Techniques

Fort Collins has had a Stormwater Utility since 1982 and we have tried many things to educate citizens and increase public support. The average monthly fee for a typical single-family residence is $5.59. Approximately 20% of the population are Colorado State University students and another 7.4% are residents on fixed incomes, so one goal is to keep fees low and minimize annual increases. Some things that have worked well for us are described below.

Open Houses

Schedule blocks of time, both night and day, to be available with information on a project so that visitors can review the material and ask questions at their leisure. If the project involves a potential change to their monthly stormwater fees, we have the capability to query the billing system, look at an individual's current fees, and calculate the new fees. Although it takes a lot more time, an open house is much less stressful than a public meeting.

Professional Assistance

Offer technical expertise to public schools for science classes that may be interested in a stormwater quality project. You might build a model or take photographs showing where the high water mark would be for their school in a 100-year storm.

Training Sessions

Provide periodic training sessions for other city personnel, such as those in the utility billing and building inspection offices who are asked questions about stormwater fees. It might also be beneficial to show banks and other mortgage lending institutions how to read floodplain maps. Probably 95% of the calls that we get from loan officers are to verify properties that are not in the floodplain, so it reduces our workload enough to make it worthwhile to occasionally give them floodplain maps and some basic training.

Marketing Techniques

Post large signs at major stormwater capital improvement projects saying something like "Your Stormwater Utility Dollars at Work." Stencil smaller information signs near stormwater facilities that let the public know that everything going into this catch basin or channel or storm sewer will drain directly to the river. We have been doing this for several years and believe that it is helping. One out-of-town visitor who decided to change the oil in his car on a neighborhood street was chased by angry residents who saw him drain the crankcase over a catch basin. Since he had not had time to replace
the plug and add new oil before driving away, the hapless visitor was easily apprehended by the police.

**Better Customer Support**

With today's technology, it is easier to "go the extra mile." When a contractor calls for a fee estimate long before the development plans and drainage report are approved, we fill out a form over the phone with as much detail as he has, calculate a rough fee and fax it to him the same day. He has the ballpark estimate that he needs and we have a record of what was calculated based on precisely what he provided.

Last year, the utility installed "voice mail" and it is great. It is very painless to change the messages, so I take several minutes each morning to put my schedule for the day on the telephone. It gives the caller a good idea of what I have planned, when I am likely to return their call, and whom to contact if they choose not to wait for me. It also has the added benefits of providing your messages to you whenever you want them, such as at night, on the weekend or when you are out of town.

**Conclusion**

It can be discouraging to schedule an open house for 8 to 10 hours and have 20 people out of a neighborhood of 5,000 show up; or to provide that fee estimate quickly and have it be completely wrong because neither you nor the contractor knew about some detail that added twice as much impervious area to the development. But it becomes worth the effort when a project goes well; when City Council is pleased with your operation; and, when someone comes in one day to tell you that you helped a friend of theirs a long time ago and they really appreciated it.
COMMUNITY EDUCATION CONCERNING
FLOODPLAIN MANAGEMENT: A LOCAL SUCCESS
STORY IN BOULDER, COLORADO

Linda MacIntyre
Robert Williams
Public Works Department, City of Boulder, Colorado

Introduction

For all communities involved in floodplain management, educating and informing citizens about the inherent risks associated with living and working in a floodplain is a never-ending task. Striving to develop new ways to communicate and make the message more meaningful is challenging. Some people contend that a flood will not happen in Boulder, Colorado, even though this community has the highest potential for loss of life due to a flash flood in the entire state.

Boulder's History of Floods

Boulder lies at the base of the foothills where there is a high potential for flash floods that allow little time for warning (sometimes as little as 30 minutes). Boulder Creek, the major drainage through the city, has a drainage basin of more than 30 square miles. In addition, 13 tributaries serpentine through the city so that about 15% of Boulder is within a floodplain.

Major floods have been recorded on Boulder Creek as far back as the 1860s and 1870s. But because there were few inhabitants and little development, these floods did not cause much damage. However, the flood of May 31—June 3, 1894, changed that. This flash flood cut the community in half for at least five days, washing out street and railroad bridges as it swept through town. Although no lives were lost, it did wreak havoc for all the citizens and businesses.

In 1910, the city hired Frederick L. Olmstead, Jr., to develop a flood control plan for Boulder Creek. In his report, Olmstead writes “The principal waterway in Boulder is Boulder Creek, and its principal function, from which there is no escaping, is to carry off the storm-water which runs into it from the territory which it drains. If, lulled by the security of a few seasons of small storms, the community permits the channel to be encroached upon, it will inevitably pay the price in destructive floods.” Furthermore, he urged
the city to prevent development from occurring along Boulder Creek by developing a linear park that could be used for recreational activities, such as playgrounds and shaded hiking paths. Unfortunately, Boulder took that report and placed it on the shelf for more than 65 years.

In the decades between 1910 and the 1960, numerous floods occurred within Boulder County, but none as large or devastating as the flood of 1894. In the summer of 1965, a major flood occurred on the South Platte River, through Denver, which finally prompted a regional evaluation and approach to flood control. The Urban Drainage and Flood Control District (UDFCD) for the Denver metropolitan area was created and Boulder was one of several municipalities which became a part of the UDFCD.

In 1969, a 25-year flood occurred on Bear Canyon Creek, a major tributary in the south part of Boulder. This flood helped to center the community's focus on the realities of flash floods, and the Boulder City Council was moved to adopt floodplain regulations and, finally in 1973, create a Storm Water and Flood Management Utility, which could assess and collect monthly user fees.

Floodplain Regulations

The city's floodplain regulations have evolved and changed since 1969 and are now designed to address the separate issues of life safety, floodwater conveyance, property protection, and compliance with the minimum standards established by the Federal Emergency Management Agency (FEMA) for inclusion in the National Flood Insurance Program (NFIP). The city's floodplain regulations are specifically designed to place a major emphasis on life safety by identifying that portion of the floodplain (the high hazard zone) where an unacceptably high safety risk exists for people. Our current floodplain regulations, adopted in 1989, established three flood zones for regulatory purposes: floodplain, conveyance zone, and high hazard zone.

Community Education Effort

In 1994, a pro-active community education program was used to focus the community's attention on floods. The Mississippi River flood of 1993 certainly heightened our awareness of the results of flooding. Even so, there is still a "spirit" in Boulder which will argue that a flood can't happen here. May 31, 1994, was the centennial anniversary of our flood of record on Boulder Creek, and we used that historic event to help focus and develop an education program commemorating that flood while, more importantly, getting across our message about flash floods and emergency management.

Our planning task force began during the summer of 1993 and worked to implement the following community education activities in 1994:

- a video about flood education
- design of a four-part emergency management logo
• design of a traveling exhibit with historical photos from 1894 and flood information
• press briefings, press releases, interviews, and guest editorials
• a mass mailing to property owners in the city's floodplain
• paid advertising and feature stories
• informational signs about flood education along Boulder Creek
• two community flood symposiums
• a brochure for a self-guided walk along the path of the 1894 flood
• a flood education activity at the annual Children's Water Festival
• a flood education booth at the annual Boulder Creek Festival.

The 14-minute educational video, *Flood Watch*, took many months to plan and produce. This thought-provoking video focuses on emergency preparedness: what citizens can do to protect themselves and their families during a flood, and impacts of a flash flood. The video includes excerpts from the FEMA video, *The Awesome Power*, but also is largely specific to the hydrologic conditions in the Boulder valley. The amount of rain that can produce a 100-year flood event, information about warning sirens, and local emergency broadcast stations are included. The video was shown periodically on the city's cable television channel, and during city flood-related training sessions. It was also available for use by local citizen and civic groups.

The working group hired a local artist to develop an emergency management logo. The colorful four-part logo depicts Boulder's four highest natural hazard risks: floods, wildfires, wind, and winter storms. The logo was used to visually link the varied components of the public information campaign. Existing Red Cross brochures on emergency preparedness and flood safety were updated with the new logo, and the city's new 1894 Flood Historic Walk brochure also contained the logo. The logo also appeared in paid newspaper advertisements and the Boulder Creek flood booth banner.

A local environmental design firm, ECOS, worked with city staff to design the traveling flood exhibit. Their eye-catching presentation integrates historical information with modern flood education. Pictures from the Carnegie Branch Library for Local History and excerpts from 1894 newspaper reports help to tell what it was like for those who experienced Boulder's last 100-year flood. The exhibit is large enough to draw attention—it stands approximately seven feet high and is shaped like a "T," with three-foot sides. During the summer of 1994, the exhibit was rotated to locations throughout the community, including the local shopping mall, the YMCA, and city facilities like the municipal building, senior center, and libraries. It was also included in the Boulder Creek Festival flood booth.

The city's annual flood preparedness exercise reenacted the 1894 flood scenario in April 1994. Emergency warning sirens were tested, and the five city buildings in the Boulder Creek floodplain were evacuated during the drill. Coinciding with the drill was the kick-off press briefing about the 100-year anniversary of the 1894 flood. The city's media relations liaison assembled a press kit for local media, gave a presentation on the dangers of flooding, and showed *Flood Watch*. 
In April, the Public Works Department mailed out a letter containing information on the NFIP to all residences and businesses located within the floodplain. The letter notified property owners that their property was subject to potential flooding, that flood insurance was available, and how to obtain it. It also carried a flood safety message.

Two local newspapers printed extensive, in-depth articles about the 1894 flood. The Daily Camera featured a four-page article beginning on the front page. The articles included historical facts and anecdotes about the flood, how it affected Boulder residents in 1894, an examination of the city’s flood warning system, and what type of damage the 1894 flood might do if it happened in 1994. The Boulder Weekly devoted its front page to "Life in the Floodplain," and the stories linked historical information to current floodplain regulations and potential hazards to life and property.

About a dozen educational signs dealing with environmental issues, riparian habitat, and aquatic life have been designed and installed along the Boulder Creek Path. Two that give specific information about floods and flood hazards have been installed adjacent to a capital project area to provide a “mental connection” for the reader and show how the city’s flood control funds are being used to provide a safer community.

In early May, the city sponsored two half-day community symposiums about flooding and flood dangers. The symposiums included the City/County Emergency Manager, and speakers from the University of Colorado Natural Hazards Center, NFIP staff, and several local consultants.

One of the most popular components of the education campaign was a new brochure called the “1894 Flood Historic Walk.” Based on the walks designed by the national group Volksmarche, the brochure identified sites and buildings along the 10-km path that were impacted by the 1894 flood.

Local fifth graders were taught about the powerful force of water during the annual Children’s Water Festival. City staff designed a "wheel of misfortune(?)" booth (a shower set to simulate different rainfall intensities) to demonstrate the force of water and flooding. The booth allowed fifth graders to don rain coats, spin the wheel, and experience the force of the water. This was one of the most popular events at the water festival.

The culmination of the campaign was the Boulder Creek Festival booth. This is a community event which typically draws 115,000 people during the Memorial Day weekend. The city and the Red Cross co-sponsored the booth, which contained the new brochures, the traveling exhibit, a continuous broadcast of Flood Watch, and a Red Cross home emergency kit. A related well-attended demonstration was the Fire Department Dive Team’s "swift water rescue," which emphasized the power of water as a resistance force.

Some new elements will be added to the education campaign in 1995. A newly designed one-third page brochure on flood safety tips was included in April 1995 utility bills for residents and commercial property owners. The May 1995 utility bills will contain a follow-up message about flood dangers. Also, Boulder’s neighborhood liaison will talk about flood safety and emergency preparedness at neighborhood meetings throughout the summer.
A PUBLIC INVOLVEMENT STRATEGY 
DEVELOPED FOR THE 
FEMA MIDWEST HAZARD MITIGATION PROGRAM

Ann Terranova
Woodward-Clyde Consultants

Catherine Tice
Woodward-Clyde Federal Services

Introduction
From June through August 1993, small towns in the Midwest along the Mississippi and Illinois rivers witnessed the worst flooding in their history. Many hydrologists consider the 1993 flood to be greater than a 100-year event; many of the homes and businesses along the river were located within the 100-year floodplain and sustained substantial flood damage.

Woodward-Clyde Federal Services was selected to assist the Federal Emergency Management Agency (FEMA) in conducting environmental assessments (EA) under the National Environmental Policy Act (NEPA) in a number of Illinois communities that had been ravaged by the flood. The communities were Grafton, Valmeyer, Keithsburg, Evansville, Hardin, Fults, Monroe County (unincorporated), and Kaskaskia Island, and each had suffered devastating losses of property. Almost 90% of Valmeyer had been destroyed, and the impacts to Grafton were almost as severe. Woodward-Clyde developed a fast-track approach to NEPA compliance, which was necessary before funds could be released for rebuilding and relocation activities. By the time Woodward-Clyde was under contract and began work, some residents had been living in temporary quarters outside of their communities for as long as eight months.

Public Involvement Strategy
As part of the NEPA compliance process, Woodward-Clyde worked with FEMA to develop a public involvement strategy that would allow maximum public participation during the environmental review process without affecting the sensitive schedules for completing the NEPA documents. One of the biggest challenges that the public involvement staff faced was educating the public about the NEPA process and its importance relative to the funding
process while at the same time soliciting and receiving the affected public's comments on the draft environmental documents. Affected residents were understandably impatient to pick up the pieces of their lives dispersed by the floods and did not understand the need to engage in what they perceived as a cumbersome compliance process. In the cases of Grafton and Valmeyer, local residents worked for months to develop a flood recovery plan, the implementation of which was dependent on funding from FEMA. While the relocation plans intended to meet FEMA's objectives of reducing the risk of future flood loss, minimizing impacts to human health and safety, and preserving the natural resources and function of the floodplain, nevertheless an environmental review of the potential impacts from proposed relocation and property acquisition alternatives had to be completed.

Public Involvement Plan

Despite the accelerated schedule, FEMA was committed to facilitating the public review and comment process for the draft EAs. Since the NEPA documents were being prepared on a very fast track, the time for public review was often as short as five days. Hence, Woodward-Clyde's public involvement strategy was driven by the need to get relevant information to affected people as quickly as possible. The plan had three objectives:

- To provide background information and an explanation of the NEPA process, in general and specifically how it was being applied to individual communities;
- To provide information on the status of the EA, the alternatives, impact mitigation strategies and to summarize the document; and
- To take comments and answer questions about the NEPA process, the alternatives, and the status of the FEMA response.

Since the team would have to move into action very quickly in each of the communities, Woodward-Clyde developed a template approach to achieving the public involvement objectives which, upon review by FEMA, met with their approval. Once the basic elements of the plan were established, FEMA had a roadmap for incorporating public involvement activities into the NEPA compliance process. This basic plan was then tailored to meet individual community needs. In each situation, Woodward-Clyde prepared a site-specific schedule for public involvement activities. The main public involvement elements were:

- **Conduct on-site and telephone interviews** with local government representatives and interest groups to establish communications and learn about local issues and concerns. This information helped in planning for information dissemination and public meetings.
- **Develop background information** to help the public understand the NEPA process and prepare a summary of the community's draft EA to further facilitate public review. A general NEPA Fact Sheet was
developed that was not site-specific, but described more generically the overall NEPA compliance process that was being followed for all hazard mitigation projects in Illinois. This enabled community members to gain a perspective on the necessary steps and procedures for conducting an EA prior to distribution of draft documents.

- **Prepare a site-specific summary of the draft EA** to help community members with review of the document. For each community, a two-page summary was prepared that highlighted the relocation and/or acquisition alternatives, related impacts, and the mitigation strategies for reducing or eliminating impacts altogether.

- **Ensure adequate public notification** of availability of information materials, draft EA, and date, time, and location of public meetings. A template public meeting notice was prepared for FEMA's approval. Once meeting dates, times, and locations were identified, the template was quickly modified and sent to local newspapers and radio stations for publication and/or announcement.

- **Provide a facilitated public forum** where people could ask questions, make comments, and talk to FEMA and other agency personnel before finalization of the EA. Public meetings were held in an informal "town meeting" setting. Brief presentations reiterated the FEMA mitigation and NEPA processes; environmental professionals discussed the draft EA; and qualified FEMA, state and local agency, and contractor staff were on hand to answer questions. A standard meeting included overheads and handouts explaining the meeting objectives and expected outcomes, ground rules, and information packets. Comment forms were also provided so meeting participants could express their concerns in writing. Maps, site plans, and photographs were mounted on display boards for the meetings.

With all the pieces in place, the FEMA/Woodward-Clyde team embarked on a whirlwind schedule of public meetings in April and May of 1994.

**Lessons Learned**

The following are highlights of several of the EAs conducted by Woodward-Clyde. Some successes are the direct or indirect result of the implementation and follow-through of the public involvement strategy described above. In other instances, limitations encountered by the public involvement team are described. These encounters often served as "lessons learned" for consideration in developing subsequent public involvement programs.

**Valmeyer, Illinois**

The residents of Valmeyer spent three intensive months working with the Southern Illinois Planning Commission and other federal, state, and local agencies to develop a flood recovery plan. Most people had been displaced since the flood and were eager to establish a new community on a nearby site
that was out of the floodplain. Most residents actually viewed the NEPA process as a potential roadblock to relocation and were reluctant to participate in any way that might send a message to FEMA that they had comments on the EA which would need to be addressed, thus slowing the process. In contrast to some situations where public interest is high and there is much demand to be involved in the decisionmaking process, the residents of Valmeyer did not want any involvement—they simply wanted the process to be completed so funds could be released and they could move on with the process of rebuilding their community. Nevertheless, the public involvement team announced the meeting, distributed the EA summaries, placed the draft EA in the repository at City Hall and held a town meeting.

**Hardin, Illinois**

At the outset of the project, the flood recovery plan was not clearly defined by the community. Therefore, analysis of the alternatives including the identification of impacts and mitigation strategies was extremely difficult. To a great extent, the community was unaware that the burden of developing the flood recovery plan was their responsibility. The community lacked an overall understanding of the process by which funds could be released for their rebuilding efforts. Information obtained during the public involvement process did, however, help shape some of the alternatives considered by the community in their flood recovery plan. A waste water treatment lagoon was relocated because of concerns expressed by a neighboring property owner during the public meeting. With the displacement of low-income housing resulting from the flood, it became evident that any plans for relocation would need to include a low-income housing component. This was reiterated through the public comment process, which resulted in assurances by the local government that equal opportunities would be provided for all income levels to participate in the housing relocation program.

**Kaskaskia Island**

After the 1993 flood, the residents of Kaskaskia Island faced an impossible dilemma. The closely-knit community did not want to leave homes that had been in their families for generations. Yet, meeting the National Flood Insurance Program (NFIP) requirements or building levees was prohibitively expensive. The community lacked complete information about the flood recovery process; what they did know and the flood recovery options presented to them did not allow for rebuilding on the island. The public meeting to discuss the results of the draft EA proved to be a contentious one. With more public involvement earlier in the process, including working with the community to develop flood recovery alternatives, some of the ill-will between the community and the officials and agencies could have been avoided by creating a more cooperative working relationship.
BEAR CANYON CREEK: WINNING NEIGHBORHOOD SUPPORT FOR CONSTRUCTION OF A SUPERCritical CHANNEL AND BIKEPATH THROUGH BACKYARDS IN BOULDER, COLORADO

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City of Boulder, Colorado

Introduction
In 1990, the City of Boulder desired to construct approximately 800 linear feet of channel improvements through the backyards of a one-block reach of an established residential subdivision. The constructed channel improvements would remove 78 homes from the 100-year Federal Emergency Management Agency (FEMA) floodplain. A bikepath/maintenance trail would be constructed as a part of the proposed project, which would connect a school and a neighborhood park with the existing downstream path improvements and to the city’s extensive Boulder Creek trail system.

An initial neighborhood meeting was held in 1990. Although the public supported the concept of containing the 100-year discharge within a channel, they did not want to have their privacy infringed upon nor lose a critical wildlife habitat that thrived in the overgrown five-year capacity channel. The property owners were also concerned that the bikepath would lower property values, increase noise levels, and increase the potential for vandalism. This paper describes how neighborhood support was gained for this project.

Project Description
The city and the Urban Drainage and Flood Control District (UDFCD) pursued this project to increase the flood carrying capacity, to remove homes from the regulatory floodplain, and to provide maintenance access which has not been available for the reach of Bear Creek Canyon between U.S. 36 and Martin Drive. The existing channel within this reach is heavily vegetated, has several rock-gabion drop structures, and portions of the reach have gabion walls as the edges of the low flow channel. The existing box culverts are not
capable of conveying the 100-year storm and cannot accommodate maintenance equipment. Proposed improvements consist of a 10-foot wide concrete maintenance and bike path, a boulder-lined low flow channel with a buried riprap invert, concrete-reinforced boulder drop structures, and grouted stone walls along the 40-foot wide channel right-of-way. Two 24-foot by 8-foot concrete box culverts are proposed at the crossings of Moorhead Avenue and Martin Drive. These box culverts were hydraulically designed to convey the 100-year flood with no street overtopping (assuming no debris blockage), while providing a pedestrian, bicycle, and maintenance equipment underpass.

The flow hydraulic regime through this reach is unsteady and undulates between subcritical and supercritical states. The design of the channel improvements are based upon erosion resistance of the 100-year supercritical flow velocities which range from 10 to 22 feet per second (22 fps at a box culvert). The proposed regulatory water surface profile depicts the subcritical flow regime.

**Winning Neighborhood Support**

Due to the various concerns voiced above, the project stalled until late 1993 when the city tried to revive the project under the direction of Gary Lacy and Debbie Ritter, the city’s Tributary Greenway co-coordinators. The first order of business was to gain the confidence of the neighborhood. This was achieved by mailings, holding a series of three public meetings, and one-on-one work sessions with individual property owners. In February 1994, the city issued a letter to the neighborhood, which informed the people of the city’s desire to construct the project. The letter described the project, and solicited input from the people. Included with the letter were conceptual design drawings and an illustration of the completed project. Within one week, the city knew who was currently for or against the project. By the end of February 1994, the city had contacted most people either by phone or in person.

The first neighborhood meeting was held on March 2, 1994. Citizens voiced concerns about privacy, property values, crime, and wondered how a public trail could be constructed in a drainage easement. On-street public trail alignments were also suggested. We explained at this public meeting how the UDFCD has a policy requiring gravel maintenance roads along constructed flood control channels (which are allowed in drainage easements) and that the drainage easement description would be expanded to include a public trail. Also, a publication on Seattle, Washington’s Burke-Gilman Trail’s effect on property values and crime (Puncochar, 1987) was made available at the public meeting. This publication states that the Seattle trail system increased property values and decreased crime.

Once the individual property owners were convinced that the bikepath might actually increase property values and decrease vandalism, the project was off and running. However, the city had to make two agreements with the neighbors. First, the channel was to be aesthetically pleasing and second, it must be environmentally sensitive. The bikepath/trail had to afford some
privacy to the homeowners and thus the path was designed to be four feet below the grade to minimize both visual impacts and noise generation from the trail. One issue continued to be voiced by the property owners: they were unwilling to contribute any additional land for the project and the flood control channel would have to be constructed within the existing 40-foot-wide drainage easement. This meant that the 100-year discharge of 2,210 cfs would have to be conveyed within this narrow width. An additional design issue that had to be addressed was the city’s newly adopted wetland ordinance, which requires that any wetlands destroyed by the channel construction had to be mitigated on-site or re-created in another location.

The design solution was construction of a supercritical flow channel which was completely hard lined. The lining consisted of grouted, hand-placed rock walls, a concrete bikepath, and a boulder-lined low flow channel with a buried riprap invert. Replacement wetlands were constructed on shallow fill placed above the riprap lined flow channel invert. These wetlands are designed to wash out during major flood events. If the wetlands do wash out, they will silt in again and be regenerated naturally.

A second public meeting was held on the site in June 1994, and the project was walked and described in the field. The third public meeting was held at the home of one of the project supporters. An appraiser was hired by the city and the city agreed to pay $3 per square foot for the addition of a public trail usage to the existing drainage easements (approximately $4,200 per homeowner).

Of the 21 affected landowners, all but three signed off on the project at the end of the second public meeting. One of the three wanted more money. This person found out that the city did not have an easement for a sanitary sewer that ran along his lot line (a mistake was made on the original subdivision plat approximately 30 years ago). When this person was offered additional compensation for the sanitary sewer easement, he became a supporter of the project. The last two holdouts joined the supporters after a lot of hand holding and reassurance.

In order to keep the public support of the project during the construction, the city’s on site inspector, Casey Crow, went door to door, introduced himself, and gave each homeowner one of his business cards with his city and home phone numbers on it. Casey made himself available to explain the construction process and scheduled meetings to answer questions to keep the communication link open. The construction began on the project in August of 1994 and is now nearing completion.

References

Puncochar, Brian and Peter Lagerwey
Section 4

Acquisition and Relocation
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Act I—Setting the Stage, a Historical Introduction

Since 1981, the State of Illinois has been preaching flood mitigation, specifically acquiring homes and floodplain property and turning it into public ownership. After nine major floods between 1978 and 1987 including floods on the Mississippi and Illinois rivers, the acquisitions totalled slightly more than 300 homes in 12 years. But the power of the Mississippi along her 581 miles on the western boundary of Illinois was extremely underestimated. In the summer of 1993, Illinoisans and the entire country were shocked at how mighty the river could be.

The drama of Mother Nature’s fury was played out again and again when water inundated small riverside towns, communities behind breached levees, and rural farmsteads. The devastation was widespread and overwhelming, and generations of floodplain dwellers were ready to "pull up roots." The Mississippi and Illinois rivers had embraced their floodplains and won, pushing away those who loved the rivers. Individuals who had experienced previous disasters and rejected acquisition were now willing to discuss alternatives to living on the floodplain. The President, the Congress, the Governor, and the Federal Emergency Management Agency were ready to discuss alternatives, too.

Act II—The Cast, the Investors, and the Audience

An Interagency Mitigation Advisory Group made up of 22 agencies provided the basis for a federal/state partnership with technical expertise and the ability to select projects and recommend funding sources. Even before the water receded, one knew substantial funding would be needed. Along came the Volkmer Bill and the Northridge earthquake, which enabled more monies to flow into the Midwest and increase the number of mitigation opportunities in Illinois.
For the past 22 months, the mitigation team has been working with 37 jurisdictions with acquisition projects, plus the relocation of one entire community and portions of four others. There are also 109 infrastructure projects, many of which will provide the streets and utilities for the relocation sites. Currently there are more than 1,800 voluntary participants in the acquisition program. The buyout structures are mostly primary homes with some businesses, churches, secondary homes, vacant lots, and farm residences. With the latter, we will acquire development rights on nearly 20,000 acres of agricultural land in the floodplain. The mitigation mission has gone fairly smoothly, but like any large-scale production, there have been a few glitches.

An appraiser, hired by the local jurisdiction but paid for with grant funds, provided a pre-flood fair market value appraisal for each structure. In many cases, the appraiser had to resort to photos, interviews, tax records, and imagination. It is not surprising that included in the cast of homeowners were many who had brand new cabinets, beautiful landscaping, and a perfect house before the flood. One elderly woman insisted that her carpet was brand new even though it was purchased in 1972; to a person 89 years old, it was brand new! A little comedy was refreshing. Individuals who believed their appraisal was unsatisfactory had the option of paying for a second appraisal. All appraisals were reviewed and certified by a state reviewer.

The decision to acquire both insured and non-insured structures to avoid a "patchwork-quilt" effect of non-contiguous land created a stir as did the prohibition on salvaging items that may have been contaminated. In the latter case, the jurisdictions did not want to be liable for some unknown disease or respiratory condition, or having to deal with a potential lawsuit down the road. A decision not to buy property with an underground storage tank until it was removed was acceptable and, so far, has not caused any concern. The environmental process was handled by our FEMA person, and even the needs of the state historic preservation office were taken in stride.

The State of Illinois decided at the onset that farm families who had lost homes to the flood would be eligible for acquisition. With rural residences in the buyout, county governments were concerned about their responsibility to maintain isolated pieces of property. The FEMA Office of General Counsel worked with the Illinois Attorney General's legal counsels and developed "easement" language that allows the purchase of development rights while enabling the farmer to retain ownership of the land and use it strictly for agricultural purposes.

The greatest financial barrier has been the mixing of funds from many different agencies, which has been a nightmare for local governments who are not familiar with the bureaucratic "red tape." A very small amount of National Flood Insurance Program (Section 1362) buyout funds was used entirely in one project, a move that eliminated one source of funding for the other projects. Communities with relocation projects including infrastructure had to deal with numerous agencies—all with their own set of rules, regulations and forms.
Despite routine and repetitive training for the elected officials, regional planners, appraisers, politicians, preservationists, and rural leaders, a total of 31 joint-policy memos have been developed to address unforeseen situations. One must anticipate that with a cast of more than 1,800 participants, the script may need adjustments. Yes, we are writing the manual, or defining the rules more clearly, as we proceed.

**Act III—The Show’s a Sell-out**

On the bright side, of the first 1,600 structures approved for acquisition, 94% (1,500) have had their local appraisals certified by the state reviewer; 87% (1,389) have had offers; 60% (966) have accepted; and 48% (769) have closed. All this has happened in 15 months since we received our first group of approved acquisition projects.

The political overtones have been virtually non-existent. The mitigation staff coordinates regularly with the Congressional and legislative representatives, and the Governor’s representative plays an important role on the federal-state team.

**Act IV—A Twist in the Main Plot**

In Illinois, 39 counties were declared major disaster areas, however, in one of these instances the flood was caused by an aquifer which rose to the surface and created similar, yet different, types of flood damage. The water moved swiftly over the ground following the contours of the surface similar to riverine flooding and ponded in low spots. These events left entire neighborhoods inaccessible to emergency vehicles and caused damage to streets, roads, and sewer systems. The water also filled every available void, which resulted in up to five feet of stagnant water in basements for as long as five months because the water had nowhere to go. Because of the environmental and health conditions, a buyout was conducted in one area where there were 20 willing sellers with contiguous property.

With the assistance of orthophoto mapping, the Illinois State Water Survey has recently determined the 100-year groundwater flood frequency, which has been mapped similarly to the river floodplain. Prior to these maps, we had serious reservations about acquiring someone’s property and having the individual relocate to another home which could result in another flood because of the ubiquitous nature of the aquifer. The maps will provide the communities with the necessary data to amend their floodplain ordinances and include the prohibition of basements in the 100-year groundwater floodplain. It is next to impossible to apply the same philosophy for a river floodplain to a groundwater floodplain, so developing a mitigation plan with some viable options is the next challenge, or the final act, for federal, state and local teams.
The Finale

For future mitigation endeavors, the mitigation team believes the state should require counties and communities to adopt a mitigation plan, covering not only a flood, but other hazards as well. Through the entire recovery effort, the need for local comprehensive plans to be in-place prior to funding became more and more apparent. The undertaking of plan development with assistance from the state and FEMA has begun and will be the subject of a sequel to this performance. It is important in this planning effort to address potential future funding sources, because there will not be the massive source of funding to do large-scale mitigation as there was after the 1993 flood. Many of the town fathers know this also but have become staunch proponents of mitigation. The only tragedy with the current production is that there are limits in authority, even with a voluntary program; and not every floodplain dweller can be helped. The state and federal agencies can only take mitigation so far, and communities must carry on with land use planning and enforcement of floodplain regulations. We are confident, though, that the next time the Mighty Miss reclaims her floodplain, many communities will say, "I’m glad we participated in Clearing the Floodplain back in the mid-nineties."
The work of the National Park Service (NPS) with communities damaged by the floods of 1993 is very much in keeping with the conference theme—Developing Local Capability. For the last year and a half, through a Mission Assignment with the Federal Emergency Management Agency (FEMA), NPS Rivers, Trails and Conservation Assistance staff have been helping a handful of Iowa communities convert flood buyout properties to public open space. (Land that local governments acquire from homeowners in buyout projects must, by law, be used as open space.)

The FEMA-NPS partnership is an unusual integration of conservation assistance and disaster assistance, with a goal to help institute at the local level changing policies affecting floodplain land use. FEMA recognized that towns had many questions about the open space requirements associated with a buyout—and extended disaster-recovery services to include help from NPS.

In purchasing flood-damaged properties and removing structures from floodplains, local governments are helping people move on with their lives. They are also increasing floodwater storage capacity and reducing damage costs of future floods. But converting floodplains to open space can also bring benefits unrelated to floods—such as increased wildlife habitat and new recreational opportunities. Those are the types of benefits that seem to get people most interested in open space use of buyout areas.

Helping Communities Plan their Own Futures

NPS Conservation Assistance staff have taken the same approach to working with communities in the post-disaster situation as we do with all of our projects, emphasizing "bottom-up" planning and local ownership of projects. We have not told communities how they should use their floodplain as open space. Rather, we have facilitated local leadership and decision-making. While each buyout community has different needs, opportunities, and
resources to bring to an open space initiative, there are some standard steps you can follow to plan and implement a locally-driven project.

1. Learn about the Community You are Working With

Of course, it is important to be familiar with the buyout area itself. But with a grassroots approach, you need to take into account a number of other factors as well. Among them:

- What is the local political organization and who is administering the buyout project? Has the community been supportive of the buyout? Such factors influence who you work with, the issues you will need to address, and the local process to follow to have a plan officially endorsed.
- Who are the community leaders and opinion-shapers? What private organizations and public agencies support community development, local conservation, recreation and civic affairs? They have important information to contribute and can help move an initiative forward.
- Are there any plans, zoning ordinances, or policies on record that lay groundwork for open space planning? If so, build on that groundwork. For example, the City of Nevada, Iowa, had a Strategic Plan on the books that stated a goal of developing a trail-greenbelt along Indian Creek, the source of flooding. Thus, Nevadans had already set a direction for open space use of the Indian Creek corridor, including the buyout property.
- Are any other plans or initiatives underway that could relate to buyout open space planning? If so, build upon them or incorporate them. In Audubon, Iowa, the County Conservation Board, Iowa Natural Heritage Foundation, and a group of area residents was pursuing trail development on an abandoned railroad. The buyout area was on the path of this trail—a consideration which spurred local enthusiasm for using the buyout area as open space.

2. Identify a Local Sponsor for the Open Space Initiative

By definition, a grassroots initiative must originate at the local level and have broad-based participation of area residents. One of NPS's first tasks in assisting a community is to identify a local sponsor who will take the leadership role. We also make sure that NPS is officially "invited in" to assist the sponsor group.

The appropriate group to provide local sponsorship varies from one community to another. In Nevada, the City Parks Board was the logical sponsor: it had been charged, in the Strategic Plan, with developing a trail-greenbelt system. Additionally, the Parks Department manages city-owned open space, so the Parks Board is concerned with future use of the buyout area.
Other Iowa buyout communities had no single organization that would naturally assume responsibility for an open space initiative. Audubon, for example, has only 2,500 residents and no paid city parks or planning staff. NPS helped Audubon form a committee to serve as local sponsor and coordinate with city officials. The committee represents property owners participating in the buyout, adjacent landowners, and business, conservation, education, and recreation interests. A similar committee was formed to lead an open space initiative in the City of Cherokee.

3. Involve Area Residents in Discussion and Decision-making

Local residents need to be involved in decisions about future use of the flood buyout area—and help in developing an open space plan. Community workshops are an excellent format for identifying local ideas and concerns. NPS has helped organize and facilitate locally sponsored buyout open space workshops for four Iowa communities: Nevada, Cherokee, Audubon, and Maxwell. NPS’s role in the workshops has been, first, to provide guidance on how to structure the workshop and get participation, and second, act as a neutral “facilitator” at workshop sessions. The local sponsoring organization gets three products from the workshop that serve as raw material for a buyout area open space plan:

- A list of ideas on how residents would like to see the buyout area used for open space.
- Working maps (prepared by groups of up to 10 people) that show specific locations for suggested open space uses.
- A list of issues that need to be addressed in the course of plan development.

A workshop is much more conducive to idea-exchange and consensus-building than is a formal public hearing on an already-crafted plan put before people for review and approval. By actively involving people in decision-making, you give them opportunity to have ownership. Individuals can see how their own ideas become part of a broader vision for their community.

NPS has continued to work with the local sponsor after the workshop, advising on how to consolidate the information and develop the open space concept plan. Many communities have at least one follow-up workshop to get feedback on the plan as it is being developed and to address issues that need resolution.

Workshops are not the only mechanism for getting public discussion. Others include:

Open houses—Cherokee has held a number of open forums to provide information to buyout participants, adjacent landowners, and other interested residents at key stages in the buyout project. This has been a very effective method of preventing the spread of misinformation about the buyout project in general. It also has provided the city early
indication of issues, so they could be addressed before becoming obstacles.

Classroom projects—"Talented and gifted" classes in Cherokee devoted a semester to the study of floodplain ecology and land use. NPS staff worked with the teacher to develop this curriculum. Each class developed a model of how it thought the buyout area should be used as open space. The classes presented their models at the public workshop, and students joined the town’s adults in workshop sessions. In the course of being educated themselves, the students taught the larger community about appropriate floodplain land use and sparked support for open space.

Media coverage—This might include newspaper feature articles, editorials, and letters to the editor as well as radio and television interviews and coverage of workshops.

4. Make a Technical Assessment of Ideas for Open Space Use

This helps determine their feasibility and appropriateness. There has been a great deal of consistency in the open space ideas generated at workshops in Iowa. Every community NPS has worked with has voiced interest in:

- creating or restoring habitat (prairie, wetland, woodland),
- developing trails (pedestrian, bicycle, equestrian), and
- environmental education (outdoor classrooms, nature trails, interpretive signing).

These are low-impact uses that are consistent with appropriate floodplain land use and National Flood Insurance Program regulations. Communities also want to minimize costs of maintaining open space—another factor supporting establishment of natural areas with few facilities.

To proceed further with their plans, most communities need help with technical evaluations to determine whether specific sites within a buyout area are suitable for a particular use (such as a restored prairie or wetland). They also need guidance on design and engineering requirements (information essential for cost estimates, funding requests, and on-the-ground work).

5. Take Action to Start Implementing Plans

In order to maintain momentum with a planning initiative, it is imperative to take action to bring the plan to life. NPS’s goal in working with the Iowa buyout communities has been to help them get open space developed in their buyout areas—not to produce lengthy planning documents. Taking action to implement is particularly important with buyout projects, because it can take several years for a town to decide it will pursue a buyout, develop the project proposal, get the hazard mitigation grant approved, negotiate with individual property owners, and get the necessary project reviews and approvals—all of which must be done before houses can be moved or demolished. By the time a buyout area is vacant, adjacent property owners and others in town are
concerned that it will be an eyesore, a dumping ground, weed field, party spot, or worse.

Three ways NPS has helped communities get started with implementation are:

- Linking towns with partners (other agencies, organizations, and individuals) who can provide needed technical expertise and other essential resources.
- Focusing on a do-able "demonstration project" that will result in visible progress.
- Identifying and going after sources of funding.

The Results

Here are the results to date of this type of grassroots approach to buyout open space initiatives in Nevada, Cherokee, and Audubon, Iowa.

Nevada

Nevada residents broadened their floodplain open space plan to address the entire Indian Creek corridor through town, not just the 11-property buyout area. The plan calls for development of a greenbelt with primarily natural vegetation, linkages of existing parks and public spaces, and opportunities for recreation and nature study.

The Parks Board has successfully pursued two sources of funding to begin "Phase 1" of greenbelt development: restoring 15 acre in the buyout area and adjacent city park land to native prairie, developing a trail through the buyout area (with amenities such as benches and bike racks), planting trees in some areas, replacing a footbridge that washed out in the 1993 flood, building an open-sided shelter, and acquiring 25 additional floodplain acres to expand the greenbelt. The habitat restoration will be accomplished through a cooperative project with U.S. Fish and Wildlife Service. The remainder of the improvements and the land acquisition are funded through a "Resource Enhancement and Protection" (REAP) grant from the Iowa Department of Natural Resources. Story County Conservation is providing technical support.

Cherokee

Cherokee's buyout is the largest in Iowa—187 residential properties (more than 60 acres) along the Little Sioux River. The town has developed a Green Spaces Plan that includes trails, river access points, natural area restoration and enhancement, interpretive sites for outdoor education, playgrounds, picnic and camping areas, and a community garden.

The U.S. Fish and Wildlife Service has approved a cooperative project for restoration and streambank stabilization. The Natural Resources Conservation Service is assisting with restoration as well as landscape design. Siouxland Interstate Metropolitan Planning Council and the Iowa Department of Natural Resources-Forestry are also providing technical support. Many
private groups are contributing, too, such as businesses and conservation, sportsman’s, and recreation clubs.

**Audubon**

Audubon’s buyout open space plan addresses reuse of 25 properties along Bluegrass Creek. The plan calls for habitat restoration, an outdoor classroom, a creek access area, a community garden or arboretum, and recreational facilities (an ice rink, picnic shelters, playground, half-court basketball, and horseshoe pits). Audubon will start habitat restoration in the coming year through a U.S. Fish and Wildlife Service cooperative project.
KEYS TO SUCCESS: POST-FLOOD ACQUISITION IN TULSA, OKLAHOMA

Rita J. Henze
City of Tulsa

Introduction

After two floods in 1994, the City of Tulsa set out to acquire 5 to 11 flooded houses quickly enough that residents could choose to sell their flood-damaged houses instead of repairing the damage. The city accomplished this by acquiring seven flood properties for $525,000 within one week to just a few months after the flood. This was a voluntary acquisition program and all properties were purchased at the fair market value. Property owners received modest relocation benefits and moving expenses. This program was funded and administered by the City of Tulsa with no state or federal assistance.

Tulsa’s experiences in planning and implementation are presented in this paper in order to assist other communities, and the state and federal government in the future.

The 1994 Floods

Shortly after dawn on Memorial Day weekend, May 29, 1994, a thunderstorm passed through Tulsa, Oklahoma. Official records show that as much as 3.39 inches of rain fell in four hours; one area, Hager Creek, experienced the equivalent of a 25-year event. The flash flooding resulted in impassable streets, stranded residents, and flooded houses. The flood waters hit in a wave with only a few minutes warning. Several days later, water was still ponding in some low areas as residents tried to clean up their flood-damaged properties.

In 1988, the city had developed the Hager Creek Basin Drainage Study, which identified significant flood problems (up to five feet of water during a 100-year event) in the area impacted by the May storm. This plan recommended the acquisition and removal of 10 floodprone houses as the most cost-effective solution.

On July 14, 1994, a second heavy storm passed through Tulsa and resulted in localized flooding in one of the older parts of the city. Water from the storm pooled outside one home and then rushed into the basement through a sinkhole from a nearby storm sewer. Massive structural damage resulted.
Because of the age of this part of the city, the entire drainage basin had been storm sewered with structures inadequately sized for a fully developed basin during a 100-year event. The basin drainage study developed in 1988 recommended detention facilities and upgrades to the existing storm sewer system. The cost of these improvements had been ranked as low priorities city-wide and, therefore, had not been implemented.

**Planning**

After the Hager Creek flood, a flood hazard mitigation team consisting of upper management, floodplain managers, key financial persons, public information staff, engineers, planners, and acquisition staff was convened. The team quickly viewed the damaged area, reviewed the basin study recommendations, and considered the available funding sources. Four days later, the team submitted a proposed acquisition program with priorities and a budget to the mayor. Acquisition priorities were based upon actual flood depths, if the property were recommended for acquisition in the basin study and hardship. On June 9, 1994, the City Council approved unanimously the recommended plan.

During this time, staff worked diligently soliciting turnaround times and fees for appraisals, abstract updates, and title opinions from local consultants. The acquisition staff also developed a set of Flood Mitigation Voluntary Acquisition Policies and Procedures based upon existing city acquisition policies and previous acquisition programs. The stage was set for immediate implementation upon approval of the plan.

A unique opportunity presented itself during this time. Four of the properties recommended for flood acquisition were also part of a city water line acquisition project initiated in April 1994. As a result, staff was able to coordinate the appraisals, title opinions, and acquisition of these parcels for efficiency and cost-savings to both projects.

**Implementation**

On June 10, 1994, staff received authorization and funding to acquire initially five properties, and up to 10 properties, based upon available funding. Staff immediately authorized all contractors to begin work. Appraisers were instructed to value the houses as of the day before the flood but located in a floodplain. Within 18 calendar days of the event, all abstracts had been updated and site visits made to the first five properties by the appraisers. All title opinions and appraisals were completed by June 27, 1994. Exactly 29 days after the flood, the first offer was made and accepted. Staff had the check to this single mother with two children 42 days after her house had been flooded with 8 inches of water. The other four offers were made within the next two days. Before the end of three months, all offers had been accepted and the residents had received their checks. Residual funds and non-participation by one elderly resident allowed the city to acquire six of the original 10 approved properties.
During the Hager Creek acquisition, the second storm hit Tulsa. By this time, staff had in place the procedures and contacts necessary to acquire this property and deliver the check to the sellers seven calendar days after the storm.

All residents were entitled to actual moving expenses or a fixed moving expense based upon the number of rooms up to a maximum of $1300. Residents were also entitled to $1000 in relocation benefits if they purchased another house outside the floodplain. A requirement of the purchase contract was that the seller turn over to the city any flood insurance payments received for structural damage. Sellers were also allowed to buy back any improvements at cost as long as they relocated the improvements outside the floodplain.

After acquisition, salvageable houses and improvements were advertised for sale by closed bid for removal. Some of the properties had some improvements sold to private bidders and were moved at their cost. This reduced the overall cost of the site clearance and was a cost savings to the project. Any remaining improvements were then demolished and the land restored to a maintainable condition.

**Keys To Success**

The city set for itself an ambitious goal to acquire 5 to 11 properties voluntarily in as short a time as possible before the owners could rebuild. This goal was accomplished quite successfully for several reasons.

**Funding Availability**

The most important key to the success of this program was immediate funding availability. In 1990, the city had earmarked $600,000 for voluntary acquisition as a part of a sales tax funding package approved by Tulsans. This funding allowed Tulsa to respond effectively and quickly to the disaster.

**Local Initiative**

Local initiative to proceed without assistance from other governments was critical to the program’s success. Eleven months after the event, the city still has not received any state or federal assistance despite numerous assurances regarding residual 1994 funding. A quick response by other governments may be difficult, especially in non-federally declared disasters. As a result, communities must be prepared to act quickly and independently while pursuing other avenues of assistance.

**Existing Basin Drainage Study**

A completed basin study provided the city invaluable information on existing conditions and recommended solutions. With this, the most cost-effective approach and the projected costs were easily available to the city’s decisionmakers.
Flood Hazard Mitigation Team
The use of the flood hazard mitigation team allowed the city to pull different resources and knowledge together quickly and easily. As a result, information could be collected individually, brought to a team meeting for discussion with upper management, and important decisions could be made in a brief time span.

Experienced Acquisition Staff
Having an experienced in-house acquisition staff was critical to this program. Without the contacts with outside contractors and an understanding of the city's internal bureaucracy, timeliness and responsiveness would have been difficult.

Responsive Consulting Community
The city would not have been able to acquire these properties in such a short time without the full cooperation and response of its professional community of appraisers, abstract companies and title attorneys.

Lessons Learned
In the case of disasters, federally-declared or otherwise, communities must be prepared with adequate flood studies, funding, and staffing in order to be responsive to the immediate needs of their citizens. Funding to offer residents an alternative to rebuilding in the floodplain may be available from other sources in the long term but may not be timely or responsive enough in the short term.
OUT OF THE FLOODPLAIN:  
A PARTNERSHIP THAT WORKED—  
THE FORT FAIRFIELD, MAINE,  
ACQUISITION/RELOCATION INITIATIVE

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Background

On April 16, 1994, a major ice jam transformed the main street of Fort Fairfield, Maine, into a river of rushing flood waters and large chunks of ice. The town’s commercial center sits about 100 yards south of the Aroostook River, which, on that day was jammed with ice, sending its waters out into the adjacent floodplains. On the north side of the river, raging flood water and cascading blocks of ice devastated a neighborhood containing about 30 homes and several businesses.

Fort Fairfield, located in northern Maine adjacent to the Canadian border, is no stranger to the ravages of the Aroostook River. Damaging floods have occurred with alarming regularity, most recently in 1994, 1993, 1991, 1990, 1989, and 1988. On April 20, 1994, the Governor of Maine requested that a major disaster be declared for Fort Fairfield and Aroostook County. On May 13, 1994, the President granted the governor’s request, declaring that a major disaster had occurred in Aroostook County.

The Federal Emergency Management Agency (FEMA) and the Maine Emergency Management Agency (MEMA) established a Disaster Field Office (DFO) in Fort Fairfield shortly after the May 13 disaster declaration. FEMA and MEMA also established a Disaster Application Center (DAC) to provide human resources assistance such as temporary housing, minimal home repair funds, and Small Business Administration loans. FEMA and MEMA staff
provided hazard mitigation counseling at the DAC, providing technical information on flood retrofitting, the elevation of homes, and information on a possible property acquisition program. DAC mitigation counseling tables are often the first opportunity to provide disaster victims some education on the benefits of mitigation measures.

The establishment of the Disaster Field Office in Fort Fairfield’s town center and its continued operation over a period of 3-4 months turned out to be an important component of the recovery process. Because key FEMA and MEMA staff were continually present in the community over several months, Fort Fairfield citizens and officials had an excellent opportunity to get to know and learn to trust FEMA and MEMA staff. FEMA and MEMA staff held the view that to empower local government to make sound choices for its disaster recovery, some effort must be made to overcome built-up distrust that often exists toward the federal government and to a lesser extent, state government.

Once the flood waters and ice receded, the town realized that its flood problems were concentrated into two distinct areas. The first involved residences and businesses in the floodplain on the north side of the Aroostook River. It became clear that the recent series of damaging and dangerous floods were motivating many property owners and households in this area to consider moving out of the floodplain and on to higher ground.

The second area centered on Main Street commercial buildings in downtown Fort Fairfield. As it became clear that a possible U.S. Army Corps of Engineers dike to divert water and ice from this area was not economically feasible, local, state, and federal officials initiated a search for other mitigation solutions. The recovery program included concentrated efforts to acquire floodplain properties on the north side of the river and to provide relocation assistance and site location to households voluntarily choosing to sell their flood-prone properties and move out of the floodplain to higher ground. Since relocation was not deemed to be a feasible mitigation solution—at least in the short term—for the Main Street properties, a program of assistance for mitigation-in-place measures for these properties was developed.

Successful Outcomes

By the end of 1994, 15 homeowners had agreed to sell their property to the town. Twelve property acquisitions were complete and 6 families had moved into their new permanent housing. Three relocations involved moving existing housing and three involved new construction. As of April 13, 1995, 21 written offers were accepted and 14 acquisitions were completed. Six additional relocations were scheduled for the spring construction season. The remaining 15 single family units are expected to be acquired by October 1995. Each acquisition case may involve as many as six sources of funding to complete the project.

The extension of infrastructure in the town-owned subdivision, a primary relocation site, went to bid in mid April with bid opening in early May. It is
expected that infrastructure construction will be completed by July 1995. This project is funded by a grant from the Maine State Housing Authority, making available about 20 new lots to support affordable housing. Demolition and site preparation of acquired properties will create open space to be used for both summer and winter recreation. An open space planning effort has already begun and Fort Fairfield has been designated as the entry point of the Appalachian Trail into Canada. The year-round recreational opportunities are changing the Aroostook River’s floodplain from a liability to a community asset.

Ingredients for Success

A variety of factors combined to make the project a success, primarily the following:

- A **teamwork approach** taken by FEMA, MEMA, and the community, which empowered the local community and its officials to develop and direct the relocation/acquisition recovery effort;
- **Development of community trust**, early in the process, that federal and state agencies were not going to dictate or take over the local recovery effort;
- **Provision of technical assistance**, arranged through FEMA, to aid the recovery effort;
- **Rapid availability of funding** from FEMA and others to allow the project to commence quickly; and
- **The availability of town-owned land** for ready use as a relocation site.

A Teamwork Approach

**Participatory IHMT Meeting and Report**

On May 19, 1994, FEMA conducted a meeting of federal, state and local agencies to develop a set of flood recovery and hazard mitigation options and recommendations for Fort Fairfield. Particular care was taken to ensure that appropriate Fort Fairfield officials played key roles in this meeting. The meeting was carefully structured, using heterogeneous working groups to first brainstorm about alternatives, then present recommended measures to the larger group. Four major recommendations emerged from the Interagency Hazard Mitigation Team meeting, all of which have been fully implemented: 1) town hiring of a full-time Flood Recovery Coordinator; 2) Development of a voluntary program to acquire and/or relocate flood-damaged residences; 3) Activation of FEMA’s stand-by technical consultants to help develop a technical floodproofing program for the commercial business located on Main Street; and 4) Computation of a new 100-year flood elevation based on actual flood levels from the April 16, 1994 flood by the Corps (with FEMA and the U.S. Geological Survey). FEMA and MEMA staff made special efforts to
ensure that the spirit of teamwork among federal, state, and local officials continued through the recovery effort.

Early Development of Community Trust

If the IHMT meeting was the step in the recovery process that identified actual recovery and mitigation options, the "community supper" was the step that both allowed residents to receive more detailed information on the various options and that brought about realization on the part of Fort Fairfield officials that FEMA and MEMA staff really meant what they said about local empowerment to manage the recovery process. On July 7, 1994, a community workshop on the flood recovery program took place in Fort Fairfield, with break-out sessions held separately for flood-affected residents and flood-affected businesses. A major attraction of the workshop was a community supper, provided locally with assistance from the American Red Cross. The supper helped to create an atmosphere of conviviality and community and, combined with clear information provided in the workshop about the recovery effort, greatly helped to dispel negativity and suspicion built up in the community about what was going to happen. While FEMA staff did much of the organization and preparation for the workshop, the event was sponsored by the local Chamber of Commerce, with the major workshop presenters being town officials, rather than federal and state officials. This event was a turning point in building community trust and in convincing residents that workable and sensible flood recovery options existed.

Rapid Availability of Funds

About $700,000 in pre-existing Hazard Mitigation Grant Program (HMGP) funds remained available for use in Aroostook County from prior disaster declarations. MEMA made a decision shortly after the April 16 flood to direct all of these funds for use in Fort Fairfield. Shortly after the July 7 community supper, the town began preparation of its application for HMGP funds (Section 404 of the Stafford Act). MEMA and FEMA, when informed that the application process was underway, developed an expedited grant approval strategy. The intention of the strategy was to reduce the normal six-month approval process to less than one month. A key aspect of the strategy involved FEMA on-site staff who assisted town officials on a daily basis in developing the town's HMGP application. Once the scope of the town's proposed program became known, FEMA was able to prepare an environmental assessment in anticipation of the receipt of the town's formal application. As a result of a cooperative effort between the staff of FEMA's Fort Fairfield DFO, FEMA's Region I Office in Boston and FEMA Headquarters in Washington, D.C., all HMGP approval steps had been taken by the time the actual written grant application was received by FEMA. HMGP funds were obligated and put to use by Fort Fairfield within 30 days of FEMA's formal receipt of the HMGP application.
In its work directing the 1993 flood recovery effort in Iowa, the FEMA Region I office had developed a strategy for disaster recovery nicknamed the "patchwork quilt" approach. This approach weaves numerous strands of financial and technical resources into a coherent and comprehensive mitigation effort, essential in a flood recovery relocation/acquisition project. A patchwork quilt recovery program might involve such resources as federal and state funding; in-kind services; volunteer labor; donated funds and materials; tax refunds, credits, and incentives; and technical assistance. FEMA, MEMA, and town officials used the patchwork quilt approach to garner resources for the Fort Fairfield recovery effort.

**Provision of Technical Assistance**

**Hiring and Training a Local Project Coordinator**

Shortly after the disaster declaration, the Town of Fort Fairfield hired a full time "flood mitigation coordinator" using administrative funds provided by the HMGP and other funding programs. A positive working partnership soon developed between FEMA and MEMA staff and the town’s flood recovery coordinator. The importance of choosing a locally known and trusted individual to be responsible for all aspects of the flood recovery cannot be overstated. Once hired, it is vital that the local coordinator be involved in key recovery and mitigation decision making, as was the case in the Fort Fairfield recovery effort.

**Deployment of Stand-by Mitigation Contractor**

After Presidentially declared disasters, FEMA has the capability to call upon a variety of "stand-by" technical assistance contractors to perform specific assignments. In June, 1994, FEMA’s technical contractors, Dewberry & Davis (an engineering firm) and French Wetmore (a hazard mitigation consultant) came to Fort Fairfield to provide floodproofing technical assistance to business and commercial building owners in downtown Fort Fairfield. These experts developed conceptual floodproofing plans for interested building owners and produced a report for use by the owners and town officials.

**Technical Assistance on NFIP Permit Requirements**

FEMA Region I office staff, with FEMA DFO staff in Fort Fairfield, provided technical assistance to town officials in the enforcement of National Flood Insurance Program (NFIP) floodplain ordinance provisions, following a difficult monitoring and evaluation site visit to Fort Fairfield by NFIP staff. FEMA's Federal Coordinating Officer (FCO) for the Fort Fairfield recovery effort was instrumental in bringing a balance to the difficult dual roles of FEMA as enforcer of NFIP requirements and at the same time advisor and helper for development of local mitigation initiatives.
Conclusions

The flood recovery effort successfully carried out in the Town of Fort Fairfield offers a model for other recovery initiatives involving local, state, and federal government partnerships. A high degree of independence and skepticism about the federal government exist in rural areas and small towns. A recovery plan or mitigation strategy that is dictated by federal and state agencies is likely to fail. A more appropriate role for federal and state agencies can be to assist local officials and citizens in clearly identifying recovery options and the benefits and costs of each. Once appropriate options are selected, it can be useful for federal and state agencies to act as facilitators to help ensure that the program chosen is implemented in a timely manner. Required enforcement of NFIP regulations can be facilitated through technical assistance and a sincere attitude of "we're here to help."

The aftermath of a particularly destructive disaster can be a good time to increase a community's awareness of floodplain management and hazard mitigation opportunities. It is a time of heightened awareness of disaster risk and also a time when funding resources and outside assistance are more readily available and mobilized. Local capabilities and positive working relationships among federal and state officials and the local community can be developed by taking the time to establish a professional, respectful working relationship with local officials and community leaders. Federal and state officials need to try to understand the unique set of pressures and constraints that face officials of small, rural communities. It may take more time initially to allow the slow process of local empowerment to germinate. In the long run, however, the time is well spent if local capabilities to manage hazard-prone areas are improved as a result.
BEFORE THE STORM: PRE-FLOOD MITIGATION PLANNING IN TULSA, OKLAHOMA

Ann Patton
City of Tulsa

Introduction
The best time to stop a flood—or at least to cut your losses—is before the storm. That’s why the City of Tulsa, Oklahoma, is doing its flood hazard mitigation planning now, before the water rises again.

Flood hazard mitigation has many current shades of meaning. As used in the Tulsa program and this paper, flood hazard mitigation is defined as "acquisition, relocation, floodproofing, and related actions taken before, during, and after a flood to reduce future danger, damage, trauma, and loss." It is also called "nonstructural mitigation."

Tulsa’s update of its mitigation plan is founded on citywide master drainage plans and seeks to capitalize on nonstructural mitigation opportunities, an area only partially explored in the older master drainage plans. The updated mitigation plan focuses on acquisition and relocation, rather than floodproofing, because Tulsa’s city attorney has ruled that existing state law precludes the city from spending public funds on individual private properties.

The planning is under direction of the Tulsa Mitigation Team (TMT). The TMT has found few model plans from other communities, although emerging federal policies tout the benefits of pre-disaster planning and nonstructural mitigation. This paper highlights the Tulsa mitigation planning process, progress, and lessons learned, which we hope may prove useful to others.

Background
Tulsa was settled 100 years ago on the banks of the Arkansas River in Indian Territory. The town boomed after oil was found around 1900, prompting the community to dub itself the "Oil Capital of the World." Tulsa today covers 200 square miles, contains 375,000 residents, and has a diversified economy.
Flooding problems have haunted Tulsa throughout its history. It lies in the infamous "tornado alley," where capricious, colliding weather systems often produce spectacular thunderstorms, most treacherous in the spring and fall. The town was built on the banks of a major river, on rolling terrain networked with floodplains. Extensive floodplain development aggravated flooding problems.

By the 1980s, Tulsa County had received nine federal flood disaster declarations in 15 years, the worst record in the United States at that time. Some were calling Tulsa the "flood capital of the world."

The city's record was transformed from worst to best after a flash flood on Memorial Day 1984 killed 14 and left $180 million in damage. Leaders launched a comprehensive stormwater management program. In the past decade, the city has completed master drainage plans for all its watersheds and has under way or complete some $200 million in both structural and nonstructural projects. Since 1993, Tulsans have enjoyed the lowest flood insurance rates in the United States, because the Federal Emergency Management Agency (FEMA) has rated the city's floodplain management program first in the nation.

Nonstructural mitigation is one component of the city's overall program. Tulsa has cleared more than 900 floodplain buildings over the past 15 years. The largest floodplain clearance project was enacted after the 1984 flood, when 300 homes and 225 mobile home pads were acquired and cleared. Working slowly but steadily, we are developing an ongoing nonstructural mitigation program, which we hope will be completed before our next flood—for leaders know full well that, inevitably, Tulsa will flood again.

A Mitigation Tool Kit

As the TMT hammers out consensus on point after point, we are developing a mitigation tool kit that we hope can be readily available when needed. Here are some highlights.

Mitigation Team

The 1993 Midwest floods did not harm Tulsa, but they reinvigorated our determination to make the most of nonstructural opportunities. In late 1993, we recreated our flood hazard mitigation team, which had worked well in previous post-flood acquisition projects. This time the TMT is ongoing, with seven standing members plus others on call as needed. TMT chairman is Charles L. Hardt, the city's public works director and chief operations officer.

Floodplain Inventory

The first job was to update the city's inventory of floodplain buildings. The completed inventory identifies about 10,000 floodprone buildings throughout the city, by address and other pertinent data.
Goals
As meetings progressed over subsequent months, we continued to refine goals. We emphasize safety first, followed by damage reduction and other community aims.

Major Plan Elements
The plan is intended to cover the elements needed for a quick-response post-flood or pre-flood nonstructural mitigation program. Here’s the current report structure, which continues to evolve during our planning process.

Baseline Information
- Floodplain buildings inventory
- Identification of problems and opportunities
- Historical and other background data

Guidelines
- Goals
- Objectives
- Policies
- Procedures
- Guidelines for setting priorities
- Methods for analyzing costs and benefits

Project Candidates
- Master drainage plan recommendations
- Recommendations from other community plans
- Multiobjective management possibilities
- Pre-flood possibilities
- Post-flood possibilities
- Nonstructural acquisitions
- Right-of-way for structural projects or other infrastructure

High-Priority Project Recommendations

Implementation
- Funding
- Scheduling
- Implementing ordinances, resolutions, etc.

Quick-Reference Materials
- Federal, state, and city laws and regulations
- Emergency plans
- Maps and other planning tools
Policies and Procedures
This section will detail steps to be followed to carry out a nonstructural mitigation program, with emphasis on mitigation procedures during and after a flood.

Candidate Buildings
From existing master drainage plans, we have identified 162 buildings that are recommended candidates for floodplain acquisition or relocation. Some older plans do not identify acquisition recommendations, so the numbers will continue to grow as we analyze additional data.

Priority Criteria
We have identified more than a half dozen systems for setting priorities for floodplain acquisition projects. At present, we are leaning toward a fairly flexible system, that includes

- Plan—Is the building in a city plan (master drainage, urban redevelopment, park, open space, other infrastructure, etc.)?

- Acquisition Category—Is it identified for acquisition, either nonstructural acquisition (first priority) or right-of-way for a structural project?

- Use—How is the building used? First priority goes to places where people sleep—single-family or apartment, mobile homes, motels, critical facilities, commercial, industrial (toxic, non-toxic), and other uses.

- Location—Is it in a floodway, repetitive loss area, or regulatory floodplain?

- Depth—Is it substantially damaged or subject to more than 5 feet of flooding; or 3-5 feet, 1-3 feet, 0-1 foot, or less?

- Insurance—Does the owner have flood insurance? High priority would go to those who also have mitigation insurance, when available.

- Other Factors—Are the buildings in a contiguous project area, suitable for community reuse and/or open space? Would the project meet other public objectives (including local, state, and federal goals)? Does it merit special consideration because of poor access during flooding, isolation, hardship, or other factors?

Hager Creek Pilot Acquisition Project
Long before we were ready, our system was tested again, in a localized flood on Memorial Day 1994. Flooded were a few houses in a lush, floodprone,
rural pocket along a creek named Hager. We knew those houses well, because they had flooded or been surrounded by water often before. They were built across the creek from a county levee around an old airport. The master drainage plan recommended that the houses be cleared. Acquisition was far cheaper than building a channel or upstream detention basins.

Within a hour or two after the flash flood, the TMT toured the area. We suggested to owners that they delay rebuilding if they were interested in voluntary acquisition. Before the week was out, we completed most of our analysis and recommended voluntary acquisition of the 10 houses slated for clearance in the master plan. We recommended using the $550,000 in city funds that had been allocated for floodplain acquisition—plus FEMA funds through the state, if any could be made available in this localized, nondeclared flood. The City Council approved the project unanimously and enthusiastically, and we geared up to move fast. The first offer was made before the month was out.

Our estimates showed that acquisition of all 10 homes, plus their large lots and extensive outbuildings, would cost $822,500. If the houses were acquired, we would not need to build other flood control works in the area, so we were able to include averted costs in our benefit calculation. We estimated total benefits of $3,243,800, giving us a benefit-to-cost ratio of 3.94. To date, the city has bought and cleared six homes from the Hager area; two other owners have declined our offers. We have spent most of our money, and our application for FEMA help has not yet produced funds. We expect to leave the area as a wilderness or open space preserve.

Lessons Learned

One way or another, Tulsa has been conducting floodplain acquisition projects since 1979, most of them small. We have learned hard lessons, a flood at a time.

Nature's Way

The most natural way is best: when it's feasible, preserve or clear floodplains and give the flood the right of way.

Quick Action

People begin to rebuild very quickly after a flash flood, sometimes within hours. Post-flood mitigation must move rapidly to seize opportunities and reduce hardships. Locally, we can probably move more quickly than the state or FEMA, if we have funds. We would like to see a joint planning process with FEMA, under which we would front-end acquisition projects through a revolving fund; if FEMA later certifies the project and reimburses us for a portion of the costs, the FEMA funds would go back into the revolving fund for future projects.
Flexibility
Our goal is to provide a mitigation program framework, but we want to keep our hands as free as possible to take advantage of opportunities as they arise.

Simplicity
The easier our program is to operate, the more often it can be useful. Maybe someday, for example, we will do an all-hazards plan, but for now we have our hands full with just flooding issues.

Multiobjective Management
The more goals our program meets, the more effective it can be, and the broader its constituency.

Ongoing
One-shot programs after major disasters are valuable, but we would prefer to take back the floodplain in a series of small projects, which allow us to work one on one with floodplain occupants.

Tenacity
Hazard mitigation is not for the faint-hearted. It's a job that can extend over generations. Try to get ahead of the storm. The period after a disaster can bring rich, but fleeting, opportunities to recreate portions of a community. You will need to have your mitigation tool kit ready to make the most of them. But when it is feasible, it is far better to get ahead of the game and mitigate in conjunction with small floods or, even better, no floods—before the storm.
Introduction

Tulsa, Oklahoma, is close to the middle of America. Geographically it is almost halfway between coasts and demographically its citizens reflect the typical American in the average American community. This makes us a natural test market for most American products. However, we never dreamed it would make us a candidate for disaster with a capital "D."

Tulsa is located in the middle of "tornado alley," where colliding weather systems make the city vulnerable to violent thunderstorms, particularly in the spring and fall. Annual rainfall is 37 inches, but storms have produced as much as 15 inches of rain in a few hours, with little or no warning.

The city has 375,000 people and extends across 200 square miles in northeast Oklahoma. Tulsa's geographical crossroad is also a weather junction, with a hot, arid zone to the west, temperate climate to the north, and a hot, humid zone to the south. Its riverfront site also helps make Tulsa flood prone; an estimated 10-15% of the community is in the floodplains. A national study shows that Tulsa at one time led the nation in number of federally declared flood disasters, with nine in 15 years.

Background

After the Mother's Day flood in 1970, Tulsa joined the National Flood Insurance emergency program. Ordinances were drafted, and in 1971 Tulsa joined the regular program. This was only the beginning.

Things rocked along until 1974 when Tulsa experienced a damaging flood accompanied by three wet tornados. A decision was made that it would be worthwhile to take a longer look at the various watersheds within the city. Mingo Creek was targeted for a small acquisition project; 18 houses along the east boundary of the channel were relocated and a $6 million channel widening was started along three miles midstream. In addition, master drainage plans were begun. The first, "Vensel Creek," was completed in 1978. It would be another 10 years before plans for the entire city were finished.
In 1976, another devastating flood, worse than 1974, occurred—almost two years to the day from our last "100-year flood." We took another look at our ordinances and made some changes. City Commissioners approved a change in the channelization project on Mingo Creek. Instead of the original three miles of channel, they authorized purchasing and moving 38 houses upstream of the 1974 acquisition site. These structures were removed and a 70-acre detention pond was excavated in their place. Everything looked pretty good, again.

But, along came 1984 and it only got worse. This one was the "flood of record" for Tulsa. In other words—the worst goldarn flood we ever had seen. After it was over, we counted 14 dead and $180 million in damage. After all that time and hard work—well, here we go again.

City leaders decided to put all their eggs in one basket: form the Department of Stormwater Management, put all the responsibility for drainage and flood control into one entity, and tell the whole world about it—so if we failed to perform we were "dead meat." They also approved a $2.00 monthly drainage fee on each residential property's water bill. Commercial and industrial costumers paid $2.00 for each equivalent service unit, 2,650 square feet of impervious ground cover on their property. As luck would have it, if you're going to have a toadstrangler (that's raining cats and dogs to cityfolk), it is fortunate if you happen to have a surplus in the current capital improvements sales tax fund; and if you have elected officials with the commitment to allocate it for acquisition of flood-damaged structures.

Tulsa began the largest floodplain clearance project in our history. With 6,000 damaged structures, a decision was made to look at removing homes in high hazard areas, or where houses were located in a drainageway that carried sufficient volumes of water to cause damage. Removing these homes would open up sufficient space to pass the regulatory flood. Within two years, approximately 300 homes were purchased on a voluntary basis, and a mobile home park with over 200 pads was closed, and after some legal transactions, the city acquired title to the land.

This got us to thinking. When we reviewed our 15+ years of floodplain management, we determined that our most effective projects included acquisition and a combination of structural and nonstructural solutions. The most popular ones also included multi-use facilities: a park-like atmosphere with jogging trails, small 5-acre lakes, new trees, and some recreational amenities. We had it all!

It became apparent that many of these projects had been accomplished without a federally declared disaster. So, we started a Flood Hazard Mitigation Task Force to develop plans for implementation as annual allocations of funds were identified, and also to develop grant applications for any mitigation funds available to assist with local programs. The task force documented a number of floodplain houses the city had acquired annually, for project right-of-way, others as a result of damage from storm sewer collapse or overland flow problems. But, it proved that a mitigation program can be implemented numerous ways. The most important ingredient was
documentation of the problem and seizing mitigation opportunities as they arose. Fresh on the heels of this discovery, we had another flood.

On May 29, 1994, Hager Creek in far southwest Tulsa flooded. Tulsa’s mitigation team seized the opportunity to develop a mitigation plan for this area. The first thing was to review existing plans and see what they recommended. The city’s master drainage plan and the Corps of Engineers’ 1982 report both recommended acquiring the sparsely populated floodplain. Hager is a small downstream tributary of Polecat Creek, a large watershed extending westward upstream into Creek County. Because of the vast amount of flooding along Polecat, backwater threatened the structures along Hager Creek often. Due to its largely natural floodplain, the 10 structures could be easily relocated and the site could be restored to its natural condition. Charles Hardt, Tulsa’s Public Works Director and leader of the mitigation task force, took the proposal to Mayor M. Susan Savage, and later to the City Council for approval. He identified $500,000 in existing sales tax revenue that had previously been earmarked for floodplain acquisition.

Prior to seeking approval from the elected officials, Director Hardt and the mitigation task force met with the affected homeowners and discussed their recommendation. It was explained to them that the project would be entirely voluntary on their part, and they would have the opportunity to accept or reject an offer based upon fair market value the day before the flood. The majority of flooded homeowners agreed with the proposal; their number one question was, "how long will we have to sit in our flooded homes?" Director Hardt told them if the Council agreed, the city would have appraisers assigned to their property within a week.

It was apparent from the beginning that the city funds would not be sufficient to purchase all of the properties. The task force applied to the State of Oklahoma for additional funds to complete the project. A grant application was submitted to the Office of Civil Emergency on June 6, only eight days after the flood. Albert Ashwood, State Mitigation Officer, agreed to review the application and look for post-flood funding opportunities.

Within 45 days after the flood, an offer was made to the first homeowner. She accepted the offer and the city closed on the sale July 11, 1994. Because of the condition and location of the home, no bids were forthcoming to purchase and relocate the residence. The structure was demolished and the city restored the site to its natural condition. The Park Department is investigating using the property as the site for a future park planned for this area. Until a reuse plan is developed, the city is considering renting out the pasture land for grazing animals or planting crops.

Previous projects in other areas of town have been successful in meeting a variety of needs within the community. An existing city park was excavated and recreational facilities restored to better than existing conditions. This has provided the neighborhood with an upgraded park facility that otherwise would have been financially impossible. Homes along Mingo Creek that had been flooded up to 10 times were sold and relocated, making a natural parklike setting for remaining homes, while providing improved conveyance and storage for floodwater. A depressed neighborhood along the west bank of
the Arkansas River was purchased after the 1986 flood. This neighborhood was surrounded by a refinery, large industrial development, and the river, making access difficult and reducing property values. The land is currently being maintained as open space until a reuse plan is developed. Some limited use for redevelopment as part of the existing industrial park could be feasible if it can be developed safely and in compliance with all local floodplain regulations.

Tulsa has developed a comprehensive floodplain management plan. This makes it possible to utilize these opportunities to enhance surrounding land uses and mitigate existing problems at the same time. As a result of this approach Tulsa has received numerous awards and recognition from around the country. The Federal Emergency Management Agency has approved a class five designation for Tulsa as part of the Community Rating System, thus giving flood policyowners within the city the lowest flood insurance premiums in the nation. After the Midwest floods of 1993, numerous national publications and media descended upon Tulsa to investigate our floodplain management program. Both CBS and ABC produced segments for their nightly news broadcasts portraying Tulsa’s program as a good example for the rest of the nation.

Summary

In summary, it seems the long journey is finally over. Tulsa has been through a long period of flood and recover and flood again. After each event we seem to have learned just a little more. By changing and adjusting and massaging our program it has become a very effective tool for managing this valuable resource. Floodwaters do not have to be an enemy—if you simply respect their existence, they can work for you and make your community a more enjoyable place to raise a family.

Good floodplain management requires local responsibility and commitment to succeed. Plan what is best for your town and then start telling everybody about it. Don’t be shy—the only way to solve a problem is to let the community know what you plan to do and then work to gain their support. Make sure you include the needs of both hilltop and lowland dwellers. Find out what they will support and make your program grow to fit those needs, if possible. Let them know it is in everybody’s best interest to have a liveable community, to grow and prosper, to be proud to tell other communities about your town, and to never let an opportunity go by that could have helped make your hometown a better place to live. After all, it is for all of us, and if not us, who? If not now, when? Remember that a journey of a thousand miles begins with a single footstep.
Section 5

Multi-Objective Management
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ESTES PARK: FROM DESTRUCTION TO ECONOMIC SUCCESS

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Introduction

Flood mitigation projects can be used successfully to provide and improve community image. The Estes Park, Colorado, story illustrates how the Big Thompson River and Fall River, long the ignored back door of the community, have been reconstructed to become an example of flood mitigation as well as an economic development tool and community asset. The events and processes involved in this change will be described.¹

Location

Estes Park, Colorado, is 75 miles northwest of Denver. It is located in a mountain valley (called a park) surrounded by the Rocky Mountains to the west and the foothills to the east, north, and south. At the time of this flood, the town had a population of approximately 2,900 and a surrounding valley population of 4,300. It is a tourist-oriented community with Rocky Mountain National Park, located to the west and north of the town, receiving approximately 2.5 million visitors each year. The Big Thompson River starts in the central region of Rocky Mountain National Park and flows through the middle of the valley and enters downtown Estes Park from the southwest, joining Fall River in the center of town.

¹I want to acknowledge the efforts of Don Brandes, Principal of Design Studios West, Inc., Denver, Colorado, and his excellent design team that created the Riverwalk and River Plaza image and design. The efforts of Wright Water Engineers are appreciated, for they saw the benefits of the aesthetic improvements and integrated them with the flood models. I thank the Estes Park Urban Renewal Authority for allowing me the opportunity to plan, manage, and enjoy this great project.
In the early 1900s, communities and irrigation companies located on the eastern plains of Colorado established irrigation and water supply reservoirs by damming streams high in the mountains. These reservoirs and earthen dams continued to exist after Rocky Mountain National Park was established in 1915. One of these private reservoirs was Lawn Lake, at an elevation of 10,789 feet, created by damming the lake outlet to the Roaring River. The lake was located about 3,260 feet above the Town of Estes Park. Roaring River flowed into Fall River in a broad glacial valley inside the national park.

Both rivers are subject to spring runoff with high flows in May, June, and July. To the east of the Big Thompson/Fall River confluence, the Big Thompson regularly overflowed its banks during periods of high spring runoff. Several buildings along the river were located within the 100-year floodplain. Sandbagging the river to keep its flow within its banks during the runoff period was a common occurrence.

What Happened

Early on the morning of July 15, 1982, the gate valve on the Lawn Lake earth dam failed, quickly releasing 817 acre feet of water down the Roaring River. The rushing water moved boulders the size of automobiles down the streambed and the water joined Fall River, creating a large alluvial fan. The water spread over the entire valley floor, thus dispersing the flood energy. The flood water again gained momentum as it left the valley and caused the breaching of a small hydroelectric dam, originally built by F.O. Stanley of Stanley Steamer Car fame and The Stanley Hotel in Estes Park. The raging torrent followed the Fall River channel, dropping another 1,000 feet when it entered the west edge of town about three and a half hours after the dam break. It passed through a mobile home park, picking up and carrying those vehicles until they formed a dam and forced the water down Elkhorn Avenue, the main street of downtown, as well as filling the Fall River channel.

The water now had the consistency of syrup due to carried solids, and it flooded the entire length of downtown and re-entered the Big Thompson channel at the east end of town. Because of adequate warning, the motel accommodations along the Fall River, the mobile home park, and all downtown businesses had been evacuated. No lives were lost in this area, but three lives were lost in the National Park when a campground was inundated. The community damage was severe: 108 residences and 177 businesses were damaged or destroyed. Flood damage was estimated at $30.7 million.

The flood occurred as the community was in the midst of an economic downturn. Downtown sales, adjusted for inflation, had fallen steadily since 1976 due to competition from other summer tourist programs, created by the mountain ski communities. The Lawn Lake flood caused the Estes Park community to realize that flood recovery efforts must be based outside the usual political process.
Downtown Revitalization

The mechanism selected to create community change was an Urban Renewal Authority. It was selected because, under Colorado statutes, its members are appointed for 5-year terms from the entire community (not just the town limits) and are outside the political process, and because of the financing tool of tax increment financing (TIF). TIF allows an urban renewal authority to benefit from growth in sales and property tax created by the improvements constructed by the authority. It is a bootstrap-type operation that can fund change without additional taxes. The Estes Park Urban Renewal Authority (EPURA) was established in the fall of 1982, three months after the flood, and the first citizen board was appointed with the adoption of the Estes Park Downtown Revitalization Program in May 1983. EPURA moved quickly to implement the program and thus create community support since the town had a history of doing studies but not implementing them.

The first constructed projects were streetscape infrastructure improvements which included new curbs/gutters, widened sidewalks, specialty streetlights, street trees, planters, pedestrian seating areas, intersection neckdowns, and storm drainage improvements. In 1986, a Master Plan for the river was developed and in 1987 the first river construction began. Both rivers were dechannelized and provided larger flow channels. River bottom obstructions, such as a concrete sewer line, were relocated from the point of confluence.

At the confluence of the Big Thompson and Fall rivers, Riverside Plaza was created between the river and the existing buildings facing Main Street. This area presented a naturalistic environment with a large grassy raised area facing the walkway next to the river that can be used for musical performances. The river was brought back into the plaza by pumping water to create a water feature and safe access to the water for children and adults (and elk) to play in. The surrounding property owners responded by rebuilding their retail spaces and thus creating a unique space for residents and tourists. This project allowed pedestrians, for the first time, to approach and appreciate the beauty of a rapidly moving mountain stream.

The next phase of the project extended the plaza design details to the east approximately 2,500 feet. This is the area that flooded during high spring runoff. The river channel is contained on the south side by the rock base of Little Prospect Mountain. Years ago the river channel had been forced by early residents to this side of the valley floor to allow development of Elkhorn Avenue. The north bank was concrete debris, rock, and dirt fill dumped as buildings and parking lots encroached closer to the river. Several buildings were built to the river channel edge. It was a challenge to get room for a 10-foot walkway.

The first phase of this project involved deepening the river to increase flow capacity and rebuilding the riverbanks with natural river rock. The armoring on the river bottom was removed and the river dredged and deepened and armoring replaced. In one area, bedrock was encountered which necessitated that the bottom be blasted and excavated for a distance of
about 150 feet. All construction work was based on a hydraulic model constructed of the river by Wright Water Engineers of Denver. The north river bank was next armored using varied-sized round river boulders recovered from the flood area west of town.

The second phase of the project involved the construction of the riverwalk infrastructure improvements, such as the walkways, running primary and secondary electric service underground, telephone and cable television, cantilevering around buildings, and landscaping. This construction was all done in the winter to minimize the impact upon the tourist economy. All property along the east riverwalk was given to the town in the form of easements at no direct cost; however, improvements were provided to building owners to offset loss of property. Part of the river recontouring were several new drop structures creating trout fishing pools, which are appreciated by the local fishing enthusiasts. Local residents have adopted the riverwalk as an exercise trail and many use it daily.

The riverwalk project removed the surrounding buildings from the threat of spring runoff and contained the 100-year flood within the riverbanks. It created the opportunity for new business development, as well as redevelopment. The riverwalk project cost approximately $400 per lineal foot for all construction, including running utilities underground.

What We Learned

Water is an attraction for young and old. Those communities that have that asset should capitalize on it. The river edge should be made accessible and the actual river safely accessible for all.

Flood mitigation projects can be an economic development tool. Those communities facing recovery after flooding should consider all alternatives when rebuilding. The natural desire of a community is for everything to be returned to the status quo immediately. Fight that urge, and look to see what can been done to boost local pride and capture tourists and visitors by the construction of an aesthetic project in coordination with flood mitigation. It can be done.
TRINITY RIVER COMMON VISION: INTEGRATED PARTICIPATION IN DEVELOPING REGIONAL MOM PROJECTS IN THE DALLAS-FORT WORTH METROPLEX

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Introduction
Recent efforts to minimize the potential for flood damage and to enhance the environment in the Dallas-Fort Worth (DFW) Metroplex have motivated citizens, federal, state, and city government officials and staff, business people, private-interest groups, and others to rediscover the Trinity River. Together, they are arriving at the realization that the river corridor also holds valued community assets such as wetlands, fish and other wildlife habitats, historic sites, and recreational opportunities. The vision for a "world-class" Trinity River Greenway, which follows the river through nine cities in the Dallas-Fort Worth Metroplex, anticipates conservation of these assets through public and private partnerships. The Upper Trinity River Corridor encompasses approximately 240 square miles of floodplain land, over which the political jurisdictions of nine cities, three counties, and numerous special districts in the DFW area are superimposed (Figure 1).

Proposed World-Class Trinity River Greenway
Work toward these ends will be ongoing, and partnerships among federal, state, and local governments and the private sector will be critical. This paper addresses why integrated participation is so essential, how it can be generated, and cites examples of how it has been successfully coordinated in the DFW Metroplex.

Why Bother with Integrated Participation?
Although many of the projects associated with the Trinity River Greenway will be developed at the local level, regional coordination and information-sharing on other broader issues is crucial. Building a strong network of
broad-based support for multi-objective projects yields the following benefits:

- Projects are eligible for a broader range of funding opportunities.
- Innovative mechanisms for facility operation and maintenance are more likely (e.g., involving developers, corporations, volunteers, etc.).
- Public support is more likely during bond elections and related campaigns.
- Diverse expertise and resources during planning and coordination are naturally incorporated into the process.
- Community spirit and purpose are revived due to a sense of ownership in the project, vision, and process.
- There is a better chance for continued collaboration in the future between the private and public sectors.

Incorporating integrated participation into the planning process does not, of course, guarantee smooth sailing throughout the life of the project. However, the alternative, a single-purpose planning approach, has weaknesses—with fewer mitigating assets. The latter approach tends to require an inordinate amount of time and energy for consensus-building and sustaining project support. With integrated participation, however, the extra
time spent reaching consensus is compensated for when people and agencies pool resources and coordinate efforts to implement their common vision.

Generating Integrated Participation

The DFW Metroplex is home to numerous private-interest groups, homeowner associations, developers, businesses, and government staff and politicians working for a cleaner environment, a better quality of life, and safer communities. As long as interest groups and institutions work autonomously and do not coordinate or collaborate with groups sharing similar goals, the effectiveness of this disparate work is constrained by a narrower resource base and the inefficiency of duplicated efforts.

The following examples demonstrate how broadening the scope of, and participation in, a project can embue even a small neighborhood project with a larger, regionwide purpose enjoying access to regional resources, experience, and opportunities.

The Trinity River COMMON VISION

The COMMON VISION was an outgrowth of the Upper Trinity River Feasibility Study carried out cooperatively by the U.S. Army Corps of Engineers (USACE) and 14 local governments represented by the North Central Texas Council of Governments (NCTCOG). This study is, in the fifth year of six, the largest cooperatively cost-shared, multi-objective effort ever undertaken by the USACE. Its focus is on reducing the potential for flooding, preserving the river's water quality, providing recreational opportunities, and restoring the environment. The National Park Service’s Rivers, Trails and Conservation Assistance Program became involved in the study in 1991, and is continuing to provide technical assistance on recreation-planning and community support-building for river-related plans.

The vision for a safe, clean, enjoyable, natural, and diverse Trinity River evolved through the integrated participation of citizens, interest groups, businesses, schools and universities, and governmental staff and politicians at all levels. Current proposals for a world-class Trinity River Greenway include plans for parks, preserved open space, nature centers, environmental learning laboratories and research facilities, off-road trails, wetland development, structural and nonstructural flood damage reduction projects, environmental restoration projects, and integrated transportation corridors.

Why is the Trinity River COMMON VISION Successful?

First, the study partners have demonstrated their commitment through cost-sharing and work-in-kind. Second, all the partners share such common goals like reducing the potential for flooding, improving water quality, restoring the environment, and providing safe recreational opportunities. Third, the study was designed so that power was shared, but leadership and roles were clearly defined. The study was guided by a steering committee of elected officials and a task force of government staff from each of the local partners. The
NCTCOG serves as the facilitator, representing the interests of the local partners. Finally, citizens, interest groups, businesses, and educational institutions have been involved throughout the study, offering feedback and rallying support for many of the proposed plans.

**The Trinity River Corridor Citizens’ Committee**

The Trinity River bisects the city of Dallas. The river has previously been perceived as a barrier that separates races and economic classes. Dallas has struggled with a long history of flooding, as well as with the resulting need to reach consensus about the river corridor’s future. A committee consisting of interested citizens, city staff, businesses, and property owners recently completed an eight-month-long master-planning process. Four hundred people, representing varied ethnic and economic backgrounds, interests, talents, and professions, were involved in the planning process. Each committee member volunteered to serve on one of five functional committees, as well as on one of three area committees. This intensive, citizen-based planning effort resulted in policies and project recommendations for flood damage reduction, recreational and open space, transportation, environmental preservation/restoration, and economic development. As a result of this committee’s work, the citizens of Dallas are expected to approve, through a bond election, the expenditure of $7.3 million to begin implementing the citizens’ plan. City funds will be augmented by private and public cost-share partners.

**How Was the Citizens’ Committee Process Successful?**

First, the process functioned within a well-defined structure, with committee-selected goals and committee-elected leaders. The committee structure was set up to empower committee members, throughout the process, in voicing their opinions, concerns, and dreams about the river corridor. City staff from many departments were on hand to provide technical assistance at the request of the committee members.

Second, the committee members understood their involvement in this process to have direct impacts on their individual lives and future prosperity. Motivation for becoming involved in the citizens’ committee work varied among individuals. Property owners sought ways to protect themselves from flooding; families sought safe places to recreate and an improved quality of life; environmentalists sought the preservation and restoration of natural resources; and businesses were interested in new economic development opportunities.

In addition, the committee comprised committed citizens whose backgrounds were diverse from the standpoint of race, economics, education, expertise, and profession. The committee was thus able to draw upon a wide range of experiences and resources from which their plan evolved.
Conclusion

Floods in the DFW Metroplex as recently as 1989, 1990, and 1991 are reminders of how critical regional partnerships are to managing the Upper Trinity River Corridor. Integrated participation in developing multi-objective management projects has become an extremely useful tool in developing consensus on the use and management of river corridors. The process is designed to involve all interested parties in ensuring that the region's needs and goals are met. The Trinity River COMMON VISION Program and the Trinity River Corridor Citizens' Committee can attribute much of their success to broad-based collaboration in the pursuit of an integrated, multi-objective management approach. Instead of having a single-purpose flood conveyance channel be the only focus of regional floodplain efforts, the pursuit of an integrated planning approach has raised awareness of the wonderful possibilities of the Trinity as a world-class Trinity River Greenway.
A MULTI-OBJECTIVE FLOOD HAZARD MITIGATION PLANNING PROCESS FOR THE VERMILLION RIVER BASIN, SOUTH DAKOTA

Bob Cox
Sherryl Zahn
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Duane Holmes
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The Multi-objective Concept

Multi-objective planning is a process with five essential components:

(1) Multi-objective planning addresses numerous issues and goals simultaneously. Each is approached with the best technical information available, resulting in a multi-disciplinary effort.

(2) Multi-objective planning is based on an appropriately delineated planning area that incorporates an entire ecosystem, watershed, basin, political jurisdiction, or other appropriate unit.

(3) Multi-objective planning is locally based and is initiated by and driven by individuals, groups, and local government bodies within the planning area.

(4) Multi-objective planning uses existing resources to the maximum extent possible rather than proposing new projects or programs.

(5) Multi-objective planning uses a comprehensive partnership that includes all levels of the public and private sectors, non-profits groups, and individual citizens.

The multi-objective planning process has numerous advantages. It allows a common vision of an area's future to be developed among both the local public and government personnel. A large number of individuals and organizations working together on a plan makes the work go more quickly
and the plan more comprehensive. Consequently the people, be they private landowners or government employees, are more enthusiastic about working to carry out projects that they have helped plan themselves. This brings about a sense of ownership that generates a desire to see the plan fulfilled and a sense of responsibility for it, too.

A New Concept—Implementing Hazard Mitigation by Using the Multi-objective Process

One of the new ways of approaching this old problem of flooding is "multi-objective planning" for hazard mitigation. Although the various components of this process have been around for some years, the way in which they are brought together to create a locally based, economical plan for mitigating future hazards is a new and innovative concept. The process is highly adaptable, making it applicable to a possibly unlimited range of local situations. It is flexible, enabling numerous issues to be considered and incorporated into the planning process. It makes it easier to see what effects human activities have on the local natural environment, and vice versa. It combines the goal of mitigating future disasters with other local needs and goals so they all can be dealt with in a more efficient, comprehensive manner. Specifically, multi-objective hazard mitigation is a process to:

- Utilize existing programs, studies and funding;
- Build on those public and private resources that already exist;
- Focus on chronic flooding problems within a single water related geographical unit;
- Utilize a multi-disciplinary, multi-objective, multi-agency, bottom-up partnership for mitigation; and
- Build on local consensus, local citizen involvement and commitment, and local government cooperation to solve a common problem.

Multi-objective hazard mitigation is not designed to:

- Replace existing interagency hazard mitigation teams or their activities;
- Create new top-down, single-purpose or single-dimension programs;
- Create new top-down federal or state regulations; or
- Create new single-agency multi-purpose projects.
The Setting

The Vermillion River Basin lies entirely within the southeast corner of South Dakota. The basin is approximately 2,185 square miles, making it a little larger than the State of Delaware. It runs through 10 South Dakota counties providing for a 20-mile-wide drainage corridor that empties into the Missouri River. About 95% of the land in the basin is in agricultural use. Flooding in the southeast portion of South Dakota is both acute and chronic. These floods have inundated farmlands, damaged roads, flooded homes and businesses in the small farm support communities, and have caused millions of dollars of economic loss throughout past decades. As part of the 1993 Midwest floods, all of the counties within the Vermillion River Basin were included in the Presidential disaster declaration. The basin encompassed about one-fourth of all South Dakota counties declared in that disaster.

The Planning Workshop

In response to the most recent floods in the basin the Federal Emergency Management Agency (FEMA) Region VIII Mitigation Division and the Rivers and Trails Conservation Assistance Program of the National Park Service entered into a partnership to develop a multi-objective flood hazard mitigation plan for the Vermillion Basin. The process for developing the plan involved a five-day planning workshop during the week of June 20-24, 1994, in Parker, South Dakota. About 150 people participated: a third of them were representatives of local state, and national organizations with expertise in planning, flood hazards, engineering, wildlife management, economic development, historic preservation, and the like. The rest of the attendees were residents from all over the Basin who came to share their concerns, suggestions, and energy. The workshop used a consensus building team process that focused on:

(1) Identifying the flooding problems;
(2) Listing sensible ideas for solving each problem;
(3) Identifying ways to reach other Basin goals that coincided with or complemented the potential solutions to the flood problems;
(4) Identifying specific sources of technical assistance and funding for each potential solution and how and where to obtain it.

During the week-long workshop attendees participated in field trips to visit specific sites in the Basin and a two-hour public radio call-in show was used to get input from individuals that could not participate in the workshop. On the fifth day of the workshop, the draft multi-objective hazard mitigation plan for the Basin was presented to the workshop participants. This draft plan then went out for agency review and then into final production. The plan now serves as a blueprint for the people of the Basin to formulate their priorities, carry out activities to avoid future flood disasters, and improve and preserve their quality of life. This includes flood control, economic development, fish
and wildlife habitat, recreation, water quality and cultural resources. The recommendations contained in the plan do not vary greatly from those in other such plans. The differences are the manner in which the plan was formulated using the consensus of the people who live in the basin, and the integration of multiple objectives in the overall process of flood loss reduction.

The Products

This project resulted in

- A multi-objective flood hazard mitigation plan for the Vermillion River Basin.
- A 17-minute video describing the process.
- A catalog of funding sources for implementing this and similar multi-objective hazard mitigation plans.
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Section 6

Watershed Management
INTEGRATING ENVIRONMENTAL AND ECONOMIC OBJECTIVES THROUGH A WATERSHED APPROACH

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World Wildlife Fund

Introduction

Society has essentially two approaches to reducing flood damage. One is to maximize the conveyance rate of stormwater downstream, structurally alter river channels, and construct levees to protect adjacent communities from short, but immense, flood peaks. Largely because structural flood control measures encourage behaviors that increase risk (federal drainage projects increase opportunities for farmers to drain private agricultural fields; dams and levees are thought to provide a "false sense of security" that encourages floodplain development), the structural approach has not reduced national flood damage over time. The second approach is to hold the water where it falls on the landscape through natural means, thus prolonging but minimizing the flood peak. Under this approach, floodplains are used largely for storing and conveying floodwaters, as well as for their natural values. This is referred to here as the "natural storage" approach. The World Wildlife Fund (WWF) is working with communities and federal agencies to implement this approach on small watersheds in the upper Mississippi River basin and to assess its potential for integrating environmental objectives, such as wildlife habitat and water quality, with economic objectives, such as flood damage reduction and increased agricultural productivity.

Increasing Flood Trends

Floods annually cause greater damage and result in more Presidentially declared disasters than all other natural hazards combined. Nationwide, annual flood damage has been steadily increasing over the past century despite increases in flood control expenditures. Data collected by the National Weather Service shows an increase in average annual flood damage between 1916 and 1985 of 268% after adjusting for inflation. Per capita flood damage was 2.5 times as great from 1951 through 1985 as from 1916 through 1950 after adjusting for inflation (L.R. Johnston Associates, 1992).

A trend towards increased flood frequency is evident in the upper Mississippi River basin. Data analyzed by the Midwestern Climate Center of
the Illinois State Water Survey (Chagnon et al., n.d.) showed an upward trend in flood events and intensity from 1921 through 1985 across Minnesota, Iowa, and northern Illinois. There were also significant upward trends in cold season floods in northern Illinois, Minnesota, Iowa, and Missouri.

Flood severity on the upper Mississippi is also increasing. At St. Louis, the relationship between Mississippi River stage and river flow was relatively stable and predictable from 1861 to 1927. The relationship fluctuated increasingly after that, with low flows becoming lower and high flows higher. As a result, for any above-average volume of river flow, the flood stage is generally higher than it was between 1861 and 1927 (Belt, 1975).

Many factors, including trends towards increasing precipitation and channel constriction by levees, could contribute to increased flood frequency and severity in the upper Mississippi basin. This paper focuses on watershed management as a major influence on the magnitude of flood damage.

Watershed Restoration for Multiple Objectives

Post-settlement changes in the natural hydrology of the upper Mississippi River basin probably contribute substantially to increased flood peaks. Partial restoration of pre-settlement hydrology through wetland restoration and the installation of soil and water conservation practices could provide significant flood damage reduction benefits in many parts of the basin. This type of approach could provide other environmental and economic benefits, as well.

Wetland Restoration

Before the upper Mississippi River basin was settled by Europeans, it was characterized by morainal wetlands, common in glaciated regions because of abundance of undrained depressions. The hummocky land surface left by retreating glaciers markedly retarded runoff and enhanced ponding (Winter, 1992). Prairie ecosystems, dominated by perennial grasses, ranged from mesic to wetland communities in a gently rolling landscape. Defined stream channels were rare and marshy swales conveyed water downstream. The probable pre-settlement extent of wetlands is indicated by the over 40 million acres of hydric soils in the upper Mississippi basin (including the Missouri) (Hey and Phillipi, 1994). Less than half that many wetlands remain.

Wetlands temporarily detain floodwaters and attenuate flood peaks. Watersheds with a large percentage of their area in wetlands generally have lower high-magnitude flows than those with less wetland area (Hollands et al., 1986). Wetlands also desynchronize flood peaks. In a watershed with a variety of water retention systems, including wetlands and ponds and upland areas maintained in native vegetation, each area of retention releases its water at a different rate. In contrast, a watershed designed to pass water quickly off the land and into a receiving stream will release most of the water virtually simultaneously, resulting in a larger flood peak or crest. Wetland losses can result in the loss of flood storage and can increase downstream flood profiles and downstream flooding (Larson, 1987). Past research has shown mixed
results regarding the impact of wetlands on flooding in specific regions, however (Demissie and Kahn, 1993). Depending on the extent of the wetland, its geographic location, storm intensities and durations, and seasons of the year, the influence of wetlands on streamflow varies with the region and with the specific wetland type (Faber and Hunt, 1994).

Results of models run on upper Mississippi River subbasins in 1994 show that wetland restoration could significantly reduce peak flood flows. A study of the Redwood River in Minnesota indicated that restoration of all depressional hydric soil units in the subbasin to wetland (roughly 19% of the watershed), and prevention of surface water discharge during storms from half of them would reduce the 100-year flood peak at the river mouth by at least 16% (Cooper, 1994). We believe that these results underestimate total potential storage because the topography of the deeply incised wetlands and lake basin that dominate this landscape has not yet been mapped.

In addition to the reductions in peak flows, wetlands can reduce flood damage by removing flood-prone land from production. The U.S. Army Corps of Engineers (1995) estimates that at least 80% of agricultural damage compensated by the federal government after the 1993 floods was caused by saturated or ponded soils, not by overbank flooding. Data compiled by the Clinton Administration’s Scientific Assessment and Strategy Team indicates a close correlation between Mississippi River basin counties that received the highest crop insurance and disaster assistance payments after the 1993 flood and those parts of the basin with extensive converted wetland area, as indicated by extent of hydric soils.

Wetlands can improve water quality—an important consideration in the restoration of the upper Mississippi watershed. Forty-two percent of the nitrogen fertilizer and 37% of the phosphorus fertilizer used annually in the United States from 1981 to 1985 was applied in states partially or entirely within the Mississippi River basin. The mean annual concentration of nitrate in the lower Mississippi River has doubled since the mid 1950s (Turner and Rabalais, 1991). These riverine inputs of nitrate are linked to seasonal periods of hypoxia (oxygen deficiency) in the Gulf of Mexico off the Louisiana coast (Justic et al., 1993). Hypoxia results in declines in benthic invertebrates in bottom waters and fish and other invertebrates in the water column. When these populations decline, the commercially important fish species that feed on them are also threatened (Coleman, 1992). The load of nitrate transported to the Gulf of Mexico from April through August 1993 was 827,000 metric tons, 112% higher than in 1992 (Goolsby et al., 1993). The flood water draining into the Gulf of Mexico from the Mississippi River in 1993 doubled the size of the hypoxic zone compared to previous years.

Treatment of nitrate-laden stormwater by wetlands throughout the upper basin could significantly decrease the total loads transported to the Gulf. The anaerobic, or oxygen-deficient, soils characteristic of wetlands catalyze denitrification, or the loss of nitrogen as it is converted to gaseous nitrous oxide and molecular nitrogen (Mitsch and Gosselink, 1986). Wetland plants also store excess nutrients, including nitrogen, in standing biomass. Kadlec and Kadlec (1979) reported that above-ground standing wetland plants store
INTEGRATING ENVIRONMENTAL AND ECONOMIC OBJECTIVES

40 to 460 kilograms of nitrogen per hectare (a mean of 207 kilograms per hectare). Thus, wetlands are important in removing nitrogen from water.

The wetlands of the Mississippi River basin also support an important component of North America’s biological diversity. The river is a major flyway for migratory birds, including up to 40% of North America’s ducks, geese, swans, and wading birds. Approximately 60% of the bird species in the contiguous United States may be observed in the Mississippi River flyway. The Upper Mississippi National Wildlife and Fish Refuge supports approximately 300 resident and migratory bird species, including bald eagles and tundra swans. Other wildlife that use the river’s channel, bluffs, and bottomlands include 50 species of mammals, 45 species of reptiles and amphibians, and 37 species of mussels. After over a century of rapid wetland destruction, restoration efforts are being concentrated in the basin. The prairie potholes and other midwestern wetlands historically provided extensive wildlife habitat, particularly breeding habitat for waterfowl. Much of this habitat has been lost as a result of agricultural conversion, leading to drastic declines in populations of ducks and other species.

**Soil and Water Conservation Practices**

The conversion of prairie communities to cultivated acreage in the upper Mississippi River basin had a number of impacts on hydrology. First, under conventional tillage practices, soil may remain unvegetated and unprotected from erosive forces for large portions of the year. This results in rapid stormwater runoff and high soil erosion rates. The top few inches of the soil, which contain the highest organic matter content, are the first to erode. Thus, the soil loses much of its moisture retention capacity. Organic matter is replaced much more slowly by annual crops, such as corn and soybeans, which are harvested after every growing cycle, than by perennial grasses, which build root systems over many years. According to Soule and Piper (1992), soil erosion leads to and exacerbates flooding by diminishing the landscape’s capacity to hold water.

Soil and water conservation practices that involve increasing the density of vegetation cover in a watershed (conservation tillage, no-till farming, intercropping, and short and long term acreage set-asides, for example) can lower hydrographs by retaining water on the landscape. Such practices reduce flood peaks by intercepting falling raindrops, increasing soil carbon, facilitating greater infiltration into groundwater, and protecting against surface sealing (Baker, 1987; Mannering et al., 1987; Langdale et al., 1992). Like wetlands restoration, soil and water conservation provides benefits beyond flood damage reduction, including enhanced wildlife habitat, water quality (Login et al., 1987; Ribaudo, 1989), and agricultural productivity.

**Conclusion**

Many communities around the country are working cooperatively with local, state, and federal agencies to develop watershed management plans that
integrate economic concerns with natural resource restoration and protection. Successful models are under development at a variety of scales in places as different as south Florida, the Iowa River corridor, the Chesapeake Bay, and West Eugene, Oregon. The common factor among these diverse processes is a willingness on the part of the public sector to use existing programs creatively to achieve objectives set by local communities.

WWF is currently working with basin communities and decisionmakers at federal, state, and local levels to demonstrate the benefits of a natural storage approach to flood damage reduction through a series of restoration projects in the upper Mississippi watershed. Because this approach is more hydrologically and politically complex than a structural one, it presents new challenges to federal water resource agencies used to working with a great deal of autonomy. Recent publications by the federal agencies regarding flood damage reduction in the upper Mississippi River basin suggest that they are ready and willing to work collaboratively with each other and with state and local governments. One example is a study by the Corps of Engineers (1995):

A realistic approach to upland retention [in the upper Mississippi River basin] would likely consist of several programs that consider conservation practices, detention ponds, wetland restoration, etc. to attain significant upland storage. Programs of [CRP's] magnitude would be required to meet runoff reduction targets, but when viewed in the context of the recent emphasis on ecosystem management and inter-agency partnerships and goal setting, benefits beyond simple flood storage could make such programs feasible. Costs would be high, but benefits also would be high.

We look forward to implementing such an approach and monitoring the results.

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Winter, T.C.
PROACTIVE WATERSHED PROGRAM DEVELOPMENT

Ward S. Miller
Lake County Stormwater Management Commission

Introduction

The great Midwestern flood of 1993 prompted review and redevelopment of federal policies and programs related to stormwater management. This paper offers a local government perspective and "lessons learned" during the development of a small, but proactive, countywide watershed management program with modest local government investments in anticipation of federal initiatives in the near future.

In 1988, the Lake County (Illinois) Stormwater Management Commission (SMC), consisting of six mayors and six county board members, was created and began developing a comprehensive stormwater management plan. The plan, adopted in 1990, set the stage for program development, watershed management-based goals, institutional organization and roles, and a four-year financial/action plan. Nine staff members were hired in late 1991 and early 1992.

The state enabling legislation established property taxes as the primary funding mechanism. SMC's plan recommended that the legislation be amended to allow service charges as the primary source of funds. However, property tax "cap" legislation in 1991 and lack of approval for the amendment basically froze SMC at about $550,000 in property tax revenue rather than the envisioned $5 million a year program. Although the initial four-year action plan was not fully realized, there was very important work to be done. In fact, attempting to "do more with less" has actually positioned SMC to take full advantage of new federal initiatives.

National Policy Shifts and SMC's Endeavors

Federal, State to Local

Summaries of Sharing the Challenge: Floodplain Management Into the 21st Century, National Flood Insurance Program (NFIP) reform legislation, and "National Policies in Review—1994," a paper by the Association of State Floodplain Managers (ASFPM), all point to revised federal and state programs to focus on local efforts and funding. As Peggy Glassford commented in the August 1993 issue of Environment and Development,
"Those of us involved in area local governments began with the hope that somebody else would provide a quick fix and lots of money. Our reality has been a process of self-help and intergovernmental cooperation with very little funding. Our story is a series of multi’s—multi-community, multi-agency, multi-objective." I believe the most important national policy shift is an acknowledgement of this and, in fact, the shift to local participation has begun in Lake County.

Over the past two years, SMC has implemented $500,000 in various Clean Water Act grants toward our incremental (basin by basin) watershed management planning efforts. These grants brought together local shareholders and provided forums for informing municipalities and the general public as well. SMC’s local stakeholder approach to the grants was the basis for entering into partnerships with the Federal Emergency Management Agency (FEMA) on local floodplain remapping projects and the Corps of Engineers on two major flood management feasibility studies for the county. Our efforts have also resulted in the establishment of mutually beneficial working relationships with the U.S. Fish and Wildlife Service and the Natural Resources Conservation Service (NRCS) in their urban initiatives, and has established SMC’s coordination role in the county.

Fragmentation to Integration at the Local Level

Edward A. Thomas, Director of Response and Recovery Division of FEMA Region I, has developed a very effective presentation on the concept of a "patchwork quilt." The fragments are brought together in a cohesive manner at the local level. The quilt provides more effective stormwater management coverage than the sum of its parts. I believe that a governmental organization dedicated exclusively to comprehensive stormwater management with at least countywide jurisdiction could be the thread that unifies the fragments.

SMC’s emphasis has been on identifying the mutual goals of groups and coordinating those resources on specific local projects. For example:

- Watershed Development Ordinance—Lake County has 53 municipalities, many of which had only minimum floodplain regulations to participate in the NFIP. To preclude developers' shopping around for the best deal, in 1992 a unified and comprehensive set of development regulations was enforced countywide. To date, 40 communities have been certified to enforce ordinance standards within their jurisdictions. SMC enforces the ordinance in other areas and has been delegated by the state to enforce state floodway and floodplain regulations. We will continue to pursue our long-term goal of "one stop" permitting by obtaining a general permit from the Corps of Engineers for partial 404 wetland permitting. A Technical Advisory Committee was established to develop the ordinance. Its membership includes developers, consulting firms, environmental groups, and municipal and county engineers. The ordinance was recently amended to clarify and strengthen the responsibilities of the certified communities. The two-
year consensus building process was sometimes painful, but worth it. SMC staff provides technical assistance, training opportunities, enforcement officer forums, and newsletters to continue the "translation" of the written work to actual field practices.

- Best Management Practices (BMPs)—One of SMC’s primary roles is to work with other interested parties to develop curricula and co-sponsor training and public information workshops. For example, we worked with our regional planning agency (Northeastern Illinois Planning Commission) to develop a workshop on practical, cost-effective applications of BMPs in site designs. The staff worked with the local Soil and Water Conservation District and NRCS to develop and hold three workshops for site planners and engineers, development officials, field inspectors, and contractors. We are working with the professional engineering organizations and NRCS to develop a workshop on "Integrating Natural Resources into Site Plans."

- Round Lake Area Stormwater Management Plan—Four adjacent villages suffered flash flood damage and traffic/economic disruption in a June 1993 storm. The County of Lake’s Planning and Environmental Quality Department and SMC worked with the four village presidents and their engineers to develop an intergovernmental agreement and scope of work for a unified stormwater management plan. Community Development Block Grant (CDBG) funds are being used for the acquisition of new contour maps. SMC staff will develop the hydrologic and hydraulic model and subsequent "regional-scale" management plan.

**Structural to Nonstructural**

SMC’s bias toward nonstructural solutions has been reflected not only in our plan but also in our ordinance, which encourages more natural and less "hard" elements of new development. In addition, we have completed management plans for three sub-watersheds using funds from the Clean Water Act. Although the major focus of these plans was on surface water quality, we integrated flood management considerations into every plan, emphasizing the costs and benefits of preserving, restoring, and enhancing wetland complexes and natural floodplains as part of the strategy.

SMC has coordinated the resources of several stakeholders for wetland restoration and bioengineered stream bank stabilization projects primarily funded by U.S. Environmental Protection Agency 319 grants. In all of these filed projects, "real life" cost-benefit data can help us market the advantages of nonstructural solutions.

SMC does have a modest drainage system improvement incentive program. This year, our Watershed Management Boards used $135,000 to leverage co-sponsored projects totalling more than $400,000 with four municipalities, two townships, three drainage districts, and two non-profit organizations.
Single-Purpose Function to Multi-Objective, Holistic

The *Sharing the Challenge* report concludes that every "flood control" project, whether it is structural or nonstructural, will need to serve many community objectives so that each tax dollar buys multiple functions or community benefits. The most popular components of the Third Lake and Flint Creek watershed plans are the stream corridor greenways, which combine the objectives of flood management, water quality, open space, recreation, habitat, and aesthetics. Near-future federal grants will favor holistic, ecosystem, watershed-based plans and programs. It is my opinion that local governments in partnership with grass-roots organizations are in the best position to identify specific opportunities for multi-community objective projects.

Flood Reaction to Flood Mitigation Planning

The "boom and bust" cycle of bailing out damaged communities after a flood and then ignoring the problems and the drainage system in the drier years is over. All three of the new documents referenced above emphasize proactive flood hazard mitigation planning at the local level. Grants and technical assistance will soon become available for plan development. For example, the recently adopted NFIP Reform Act earmarks $20 million a year for flood mitigation assistance grants. Communities with plans will probably be given "favored status" in allocation decisions before and after floods. It is likely that local cost-share requirements for federal projects and disaster assistance could be reduced if you have a plan.

SMC is just beginning a county-wide flood mitigation planning effort. The plan will prioritize action to (1) reduce future flood damage and prepare for the next flood, (2) provide emergency response and documentation during the event, and (3) identify major, ready-to-implement projects such as floodproofing and floodplain building relocation to take full advantage of public awareness, political support, and funding availability (during that brief "window of opportunity").

General Fund to Stormwater Utility

One trend not discussed as part of the national policy evaluation is the shift from sporadic general fund/public works stormwater management activities to dedicated funding of permanent, holistic stormwater management institutions. These stormwater "utilities" perceive drainage as a complex system of natural and human-made, interrelated components in need of sustained improvement and maintenance, funded by service charge (not tax) revenues from public and private property owners who use the system for the stormwater runoff they produce.
Conclusion

As a whole, I believe SMC's first three years of experience has prepared us well for taking full advantage of near-future federal and state initiatives resulting from the shifts in national policy. What is your role in the development of a vision, a plan, a program to position your organization for these shifts in national policy? Doug Plasencia, former Chair of the ASFPM, offers the following questions you can use to evaluate where you are and need to be:

(1) Are authorities in place to allow the development of local districts or utilities dedicated to flooding and stormwater issues?
(2) Are community-based, multi-objective planning procedures being considered or supported?
(3) Do your programs consider conservation of natural resources and beneficial functions?
(4) Is there a vision or plan for where local programs should be heading?

Plasencia has stated that "Leadership and responsibility for floodplain (stormwater) management need to be cultivated at the state and local levels of government." The federal government is now positioned to increase its support to local governments.
Introduction

The selection of a design rainfall event and an allowable release rate for detention by most developing communities is, too frequently, made at random. The decision may be influenced by the detention policy used by a neighboring community or could be the result of simply selecting overly restrictive criteria. The random selection may be counterproductive to the community’s stormwater and floodplain management needs and could lead to unforeseen future challenges.

A study of the alteration of natural watershed response by the introduction of stormwater detention in an urbanizing area was undertaken for the City of Bettendorf in southeastern Iowa, along the Mississippi River. The city encompasses approximately 39 square kilometers (15 square miles) of land area and 12 individual watersheds. Hydrologic computer modeling of a range of alternative detention scenarios formed the basis of the research. Detention in the form of on-site detention basins, as typically constructed in urbanizing communities, was selected. Sensitivity analysis was performed with two representative watersheds in the city to examine the performance of alternative detention scenarios. The sensitivity analysis significantly reduced the computer modeling effort by limiting the detailed analysis of the full range of alternative scenarios to the two watersheds otherwise necessary for the entire study area. The most suitable alternatives selected from the sensitivity analysis were tested on a city-wide basis to ensure that the trends exhibited by the individual watersheds in the sensitivity analysis were, in fact, valid for other areas. The analysis also verified that the selected detention scenario would be effective when applied across the city.

Evaluation and Selection Criteria

The selection of an appropriate detention policy from the available detention alternatives was made in accordance with the following considerations:
(1) Detention policy should be based on the hydrologic characteristics of the watersheds in the city, and yet be uniformly applicable to a large percentage
of the city area; (2) the policy should provide a sufficient level of protection for the area residents without imposing undue burden on the land developers. The peak discharges for a range of storm events (5-year to 100-year), as expected under existing land use conditions, should not be exceeded after development; (3) the policy should be compatible with the city's infrastructure design and maintenance criteria; and (4) the policy should be implementable by the city engineering staff.

Hydrologic Analysis

The analysis was performed with the U.S. Army Corps of Engineers HEC-1 computer program. The watersheds and subbasins used for the computer modeling are shown in Figure 1. The Hopewell Creek watershed has a classic dendritic shape, whereas the West Pigeon Creek watershed is comparatively long and narrow. The following alternative detention scenarios were modeled. All of these assumed that detention will be provided for individual development sites, as development occurs.

Scenario 1 - No detention for future developments.
Scenario 2 - Detention to restrict the 100-year post-development flow rate to the 5-year pre-development flow rate.
Scenario 3a - Detention to restrict the 5-, 10-, 50-, and 100-year post-development flow rates to the respective 5-, 10-, 50-, and 100-year pre-development flow rates.
Scenario 3b - Detention to restrict the 100-year post-development flow rate to the 100-year pre-development flow rate.
Scenario 4 - Detention to restrict the 100-year post-development flow rate to the 50-year pre-development flow rate and the 5-year post-development flow rate to the respective 5-year pre-development flow rate.

Results

The computer modeling results for the sensitivity analysis are summarized in Table 1. These and other results are summarized below:

1. The shape of the watershed affects the overall effectiveness of detention. In a watershed that has a "classic" dendritic shape, post-development peak flows along discrete locations in the watershed can be maintained to pre-development levels with on-site detention. The effectiveness of detention decreases as the watershed shape changes to long and narrow.

2. Control of peak flow for a given design event (e.g. 5-year) through on-site detention, yields greater than desired flow in the receiving channel, as discharge from individual detention basins accumulates, in a downstream progression.
Figure 1. Study watersheds.
Table 1. Results of hydrologic analysis.

<table>
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<th>Location</th>
<th>Rainfall Frequency (year)</th>
<th>Pre-Developed Conditions</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3a</th>
<th>Scenario 3b</th>
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</table>
3. Control of multiple storm release rates through a multi-level outlet structure to respective pre-development levels may provide an optimum "across the board" protection. However, it is impractical to design and construct a detention basin and an outlet structure for more than two design storm events.

4. The performance of a four-level outlet structure to control four design storm events can be significantly reproduced by controlling one high and one low frequency (5- and 50-year) design storm event with a two-level outlet structure.

5. On-site detention in only the upper half of a watershed can produce peak flow attenuation comparable to that realized by detention over the entire watershed (results not presented in Table 1).

6. Indiscriminate use of overly restrictive on-site detention can lag the peak runoff from tributary watersheds to the extent where peak flows and stages in a receiving stream may be adversely impacted (results not presented in Table 1).
HICKORY CREEK WATERSHED: A RECIPE FOR SUCCESSFUL FLOODPLAIN MANAGEMENT

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Natural Resources Conservation Service

In the November 1994 issue of Erosion Control, Sean Daly wrote an article entitled "Watersheds—A Look At The Big Picture." Daly interviewed watershed planners and resource professionals from California to West Virginia. He found some common denominators for successful projects and summarized them in a sidebar titled "Recipe For Success."

We read the article as we were completing work on a plan for Hickory Creek watershed in southwest Missouri. We found striking similarities with the experiences of the planners interviewed by Daly. We made no profound discovery of the hidden secret to successful watershed planning. We wrote this paper to add our affirmation of the simplicity of the "Recipe" for successful projects. We also want to stress the simple fact that each ingredient in the recipe is absolutely essential.

Hickory Creek is a spring-fed stream in southwest Missouri that flows through the community of Neosho, population 9,250. The watershed encompasses 24,600 acres. The first settlers of Neosho were obviously attracted by the beauty of the clear, clean Ozark streams. However, the first flash flood should have been a clue of what was to come. As for thousands of communities, the costs of the occasional flood were low in comparison to the benefits of proximity to water for power generation, drinking, washing, fishing, livestock use, and just plain peaceful living. Today, 169 years later, it is a different story. Neosho is a thriving trade center for the surrounding agricultural area. But unplanned and uncontrolled growth has taken its toll. Much of the floodplain is completely developed. There is little available capacity for storm runoff. Average annual damage from flooding is now estimated at $995,000.

In 1987 the city teamed up with the Newton County Soil and Water Conservation District to try to solve the flooding problems. Assistance was requested from the Soil Conservation Service to conduct a floodplain management study. Much of what followed was plain vanilla watershed
planning, but a few new twists were added. Let me return to Daly's recipe for successful projects and illustrate how we adhered to these essential ingredients.

Let's begin with local support. Daly reports local support as the single most important ingredient. Let me add a resounding amen. Local ownership of the Hickory Creek project began when a citizen planning committee was established by the city. Members included representatives of as many of the affected shareholders as we could identify—civic leaders, floodplain home owners, floodplain business owners, city council members, the high school principal, a newspaper editor, the city administrator, and the public works director. Note the absence of elected officials. We have learned that the support of elected officials is essential. However, we all know that these positions change, sometimes unexpectedly. Jim Cole, the current city administrator, was public works director when we started working with Neosho. Because Jim was involved from the inception, the transition to working with a new administrator went virtually unnoticed by agency planners. As my presentation continues you will learn that the Hickory Creek project has widespread community support. That support must be credited to the leadership, commitment, dedication, and people skills of Jim Cole. His excellent working relationship with public works director Malcolm Mosby, elected officials, citizens of Neosho, and agency planners has, and continues to be, a model for others.

Essential step number two is coordination among agencies. Daly recognized that projects often have many participating state and federal agencies. He wrote, "Inter-agency rivalry exists, but the stakeholders and sponsors of the directive must work side by side amicably." The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service, has developed memoranda of understanding with our key agency partners. We honor the commitments in those agreements. We begin the cooperation process internally. NRCS technical assistance to local people and organizations is channeled through our county office. The office is staffed with a supervisor called a district conservationist, "DC" for short. The DC has the responsibility to establish and maintain communication with local project sponsors. The DC is our inter- and intra-agency facilitator. He or she is the single point of contact between the local sponsors and all participating agencies. Without exception, all projects we consider successful have had an outstanding DC. District Conservationist Lynn Jenkins is the hub of the agency coordination wheel in Hickory Creek.

What about coordination and cooperation between agencies? Yes, there are sometimes overlapping responsibilities, potential turf battles, and sometimes conflicting agency missions. Our experience in Hickory Creek illustrates that inter-agency coordination at all levels is possible. The Federal Emergency Management Agency was contacted to confirm that Neosho was in good standing with the National Flood Insurance Program. Our tri-agency biology team led the environmental assessment. Individual participants differ from project to project but always include representatives from the U.S. Fish and Wildlife Service, Missouri Department of Conservation, and NRCS. A
forester from the U.S. Forest Service routinely joins the team as a fourth member. What began as a narrowly scoped flood prevention study evolved into a multiple-objective plan with special features for recreation and fish and wildlife development. The restoration of the degraded Ozark stream became the focal point of the recreational plan. It was made possible by the collective involvement and expertise of discipline specialists from five agencies.

Let's look at technical support, another essential for successful projects. I will say the least about this ingredient because it has been the easiest to provide, not because it is least important. Most of us in NRCS and our partner agencies are "technocrats" of one sort or another. We rigorously collect and analyze relevant data, develop alterative solutions, and evaluate and display effects. We seem to have little difficulty in getting timely and accurate technical support. Daly, too, was brief in discussing this element. He points out that taking advantage of available expertise is imperative. Suffice it to say that good technical support is out there in a host of state and federal agencies and consulting firms. Communities interested in watershed planning and floodplain management need only request it or contract for the work.

Our fourth essential is education. Daly found that teaching producers soil and water conservation techniques usually tied in directly to the watershed enhancement goal. He noted also that the local population needs to get involved and stay involved long after the team of technicians and project leaders have left. We found that the more local people understood the cause and effect relationships between unplanned development in the watershed, stormwater runoff, and flood damage, the more comfortable they were in making pro-active decisions. This, too, was no new revelation. Dr. George Gallop is purported to have said, "The collective judgement of the people is as sound as the opinions of the experts." There is a critical need to inform and educate all affected shareholders. This applies to inter-agency partners and local people. Agency staff must understand local needs and concerns to help formulate effective and acceptable alternative solutions. Similarly, local decision-makers must have a good grip on the facts to minimize decisions based on perception and emotion.

We used all the information and education tools in the toolbox in Hickory Creek. The newspaper editors were great allies! They were members of the local planning committee and ensured that newsworthy decisions and progress were reported quickly and accurately. We developed a video to help the local people visualize potential alternatives. The technology known as image processing was used to illustrate what the floodplain could look like with a project in place. The visual quality was not the greatest, but we believe it helped. Other more commonly used educational and informational methods were also used. These included public meetings, talks to civic clubs, radio interviews, and news releases.

The fifth and final ingredient is mandatory—money. Daly concludes, "Access to state and federal money is almost always essential unless the watershed is exclusively on private land." Few would argue that funding is nearly always a limiting factor when planning and implementing projects.
However, funding limitations are often overestimated by local project sponsors. Securing the money to implement a project is the final step. Once a plan has been formulated it becomes much easier for a community to go shopping for implementation funds because the amount, purposes, and time frame for implementation are all known. Neosho City Manager Jim Cole used the Hickory Creek Floodplain Management Study to obtain funds from several sources even before the final Public Law 566 watershed implementation plan was completed. He used the study to demonstrate to several potential funding organizations that Hickory Creek was a project worthy of funding. Jim was able to secure $1.1 million from the state through Community Development Block Grants, and $1.2 million from state and federal emergency management agencies (SEMA and FEMA) to begin evacuating the floodplain. These funds are in addition to the $6.1 million committed from the P.L. 566 Watershed Program, U.S. Forest Service, and Missouri Department of Conservation. The key point we wish to leave you with is that money is available for projects from a variety of sources.

In conclusion, the recipe for successful projects is far from profound. Our experiences in Hickory Creek remind us to stick to the five obvious and simple basics. First, be sure the local people are committed to the project; second, strive to build teamwork among participating agencies; third, use all the tools necessary to educate shareholders and keep them informed; fourth, solicit help from a variety of agencies with competent technical staffs; and fifth, the money is out there. Go after it. If you don’t Jim Cole will!

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IMPLEMENTATION OF THIRD LAKE WATERSHED ASSESSMENT AND CORRECTIVE ACTION PLAN

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Introduction
Third Lake, located in Lake County, Illinois, is expected to exhibit worsening water quality as development occurs within its watershed. Historic pollutant sources and runoff from ongoing construction are impairing recreational uses and lake aesthetics by causing nuisance plant growth and turbidity, and depleting dissolved oxygen in the lake. Development of most of the agricultural lands (the proportion is now 78% urban and only 16% agricultural) is expected to exacerbate existing water quality problems. A nonpoint source watershed assessment and corrective action study identified best management practices (BMPs) for reducing stormwater pollutants in runoff from the watershed to the lake.

This study was funded under the Illinois Environmental Protection Agency’s Clean Lakes Program with the Lake County Stormwater Management Commission (SMC) and the Village of Third Lake. SMC was the lead agency responsible for the Third Lake study. While the watershed was being studied, the Lake County Health Department (LCHD) initiated an in-lake water quality assessment. The results of those two studies will be reviewed before appropriate corrective actions are determined.

An existing ARC-Info GIS (geographic information system) database (Thum and Stowe, 1993) of Third Lake watershed features was obtained from SMC to create a GIS-based nonpoint source loading model for estimating annual stormwater pollutant loadings to the lake. The Simple Method (U.S. Environmental Protection Agency, 1992) for estimating stormwater pollutant loads was programmed into the GIS model. This method requires the use of event mean concentrations, which were obtained from the Northeastern Illinois Planning Commission (Price, 1993). The GIS model calculated and displayed stormwater pollutant loading intensities (pounds of pollutant/drainage subbasin) for each subbasin. The GIS model output
included composite maps of spatial information including subwatershed boundaries, drainageways and wetlands, and unit-area loading maps.

**Stormwater Management Goals**

The stormwater management goals for the Third Lake watershed were presented to the Third Lake Technical Advisory Committee (TAC). TAC members included staff from SMC, LCHD, the villages of Grayslake and Third Lake, Avon-Fremont Drainage District, and other potentially affected entities. The TAC was established to build consensus for the methods and priorities for implementing watershed-wide BMPs.

Stormwater management goals included reducing nutrients to minimize the causes of algal and macrophyte growth, reducing sediment in stormwater runoff to reduce sediment deposition in the lake, minimizing potentially toxic effects of metals by reducing sediment loads in stormwater runoff, and restoring the natural hydrologic regime within the watershed to reverse the effect that urbanization has on elevated water temperatures, soil erosion, reduced groundwater recharge, and impaired aesthetic conditions.

**Corrective Action Plans**

Five corrective action plans consisting of combinations of BMPs were developed to address stormwater loads based on future land use conditions. The pollutant loads for each plan were compared to existing conditions as a way of measuring how well each plan would prevent additional degradation of lake water quality caused by stormwater runoff. A spreadsheet nonpoint source load reduction model was developed using loads based on existing land use conditions generated by the GIS and pollutant removal efficiencies applicable to northeastern Illinois (Price and Dreher, 1994).

The "No Action Plan" assumed existing drainage facilities would remain in their current conditions and future stormwater management would occur in accordance with SMC’s existing Watershed Development Ordinance. The ordinance and its technical reference manual require the use of filter basins to detain stormwater runoff draining into a pond, lake, or wetland.

"Plan A" focused on new institutional BMPs and currently identified village projects in addition to existing ordinance requirements for stormwater quality management. Plan A added the following to the No Action Plan:

- Stormwater drainage projects identified in the Village of Grayslake’s capital improvements program would be reviewed and modified, where possible, to include water quality enhancement features. Enhancement features would include replacing storm sewers with grassed swales, providing outfall protection, and constructing sediment traps.
- Programs including technical training, public education, enforcement, street sweeping/catch basin cleaning, and illicit disconnection and pollution prevention planning.
• Agricultural BMPs for remaining agricultural lands including conservation tillage; crop rotation; manure, fertilizer, and pesticide management; buffer strips; and grassed waterways.

"Plan B" expanded Plan A by increasing ordinance requirements for stormwater quality management for future development. These requirements could also be implemented through local subdivision ordinance modifications requiring more stringent stormwater quality management. Ordinance revisions could require developers to preserve buffers along the Avon-Fremont ditch and preserve land for constructing regional water quality management initiatives. Plan B added:

• No direct connections of storm sewer discharges to the Avon-Fremont ditch or its tributaries without prior stormwater treatment using BMPs.
• Construction of a greenway along the Avon-Fremont ditch or its tributaries requiring land acquisition, ditch improvements including flatter side slopes, wetland features, and other aquatic or riparian features, dedication and preservation of buffers along either side of the ditch, and storm sewer outfall protection.
• Use of existing or historic wetland sites for stormwater treatment. Pretreatment using settling basins would be required prior to stormwater discharge into wetlands. Plan B would use larger wetland sites to provide regional stormwater treatment.

"Plan C" expanded Plan B by modifying the ordinance to require onsite pollutant load reduction in addition to regional techniques for future development. Plan C added:

• Future development would limit construction of impervious surfaces, disconnect impervious surfaces, integrate the concept of the BMP treatment into all new neighborhoods, and preserve sensitive areas—highly erosive areas, wetlands, wooded tracts, and riparian zones—using setbacks and buffers.
• No stormwater discharges from new commercial, industrial, or institutional property without prior stormwater treatment using BMPs. BMPs would require implementing a BMP treatment train to minimize or disconnect impervious surfaces, use depressed vegetated medians in parking lots rather than raised medians, use vegetated swales, and detain stormwater onsite (partially flooded parking lots are permissible).

"Plan D" expanded Plan C to require retrofitting of existing drainage and flood control facilities. Plan D added:

• Rehabilitate and retrofit detention ponds by converting dry ponds to wet ponds; adding risers for extended detention; planting wetlands
vegetation; providing sediment traps/forebays; and draining, regrading, reshaping, and removing sediment. Rehabilitate and retrofit filter strips and buffer zones.

- Preserve smaller onsite wetlands to provide "polishing" effect on pretreated stormwater discharges (no direct discharges to wetlands would be allowed).
- Disconnect impervious surfaces (roofs) in older development. (Most newer development has been constructed with roof drains that discharge to the lawn and with short driveways). Replace storm sewers and raised medians with grassed swales and vegetated depressed medians, respectively.
- Construct sand filter inlets where stormwater collects on smaller impervious lots (<5 acres).

Potential Actions Necessary for Plan Implementation

Each of the corrective action plans described in the previous section offers potentially effective technical methods for reducing nonpoint source pollution. The plans are progressively more comprehensive and correspondingly more costly as each plan builds on the previous one by adding more techniques. A technically sound plan, however, does not ensure implementation.

For the Third Lake planning project, a steering committee was represented by SMC, the villages of Third Lake and Grayslake, the Avon-Fremont Drainage District, the College of Lake County, the Vocational-Technical School, and the Lake County Forest Preserve District. At steering committee meetings, it became evident that some misunderstanding and mistrust exists among the stakeholders about "who will pay and who will benefit" from nonpoint source pollution controls. The following actions would help overcome this misunderstanding and mistrust by sparking interest, generating enthusiasm, and facilitating cooperation.

Further Explanation of Water Quality Impairment

The Lakes Management Unit of the LCHD is completing its in-lake water quality assessment. These results will enable better identification of the causes of water quality impairment in Third Lake. The results should be explained to the stakeholders to convince those who most affect the lake's water quality what can be done to and why their involvement is needed. The LCHD should also publicize its wet-weather sampling results as a means of generating concern over the potential sources of nonpoint source pollution and to draw attention to the need to reduce those sources.

Preparation of Achievable Action Plan

A specific short-term (2- to 5-year) action plan should be developed to describe the preferred role of each stakeholder and list suggested responsibilities for each. These stakeholders were involved in the initial planning process and must continue to be involved in implementation. Some
one-on-one outreach by SMC to stakeholders will be necessary to continue to emphasize how each stakeholder is part of the problem and must participate in solutions to improving lake quality. The action plan should be developed upon completion of the LCHD's conclusions mentioned above. Initial action plan items should be relatively low cost, jointly funded, aesthetically pleasing, involve minimal permitting hassles, generate positive media coverage, and be visible to many stakeholders. The action plan should identify a regional demonstration project as discussed below.

**Implement Regional Demonstration Project**

A demonstration project would serve as a catalyst for other projects by showing successful action. It would also provide an educational tool for local schools, elected officials, homeowners, and developers. The Third Lake watershed offers several potential demonstration projects including converting an old agricultural drainage ditch to a multi-use greenway corridor and restorating wetlands at the lake's inflow and headwaters.

**Identifying Funding Mechanism**

Many of the stakeholders are probably not aware of grant application opportunities that could lead to funding of stormwater management improvements. The identification of funding sources would enable the Village of Third Lake to participate in jointly funded in-lake treatment and/or watershed management projects. Funding would also provide an incentive for Grayslake to participate. The final recommendations for the Third Lake watershed should be expanded to identify the more likely funding source(s) for each plan recommendation. Those recommendations with more viable funding sources should be given a higher priority, especially where significant improvement in water quality will result for the investment. The villages could use this information during their annual budgeting process to fund projects that would otherwise be lower priorities.

**Expanded Public Education and Information Programs**

The general public in the Midwest does not perceive stormwater runoff to be a significant cause of water quality impairment. This trend has been reversed in many regions around the country, especially where economic markets have been affected by urban runoff. Public education and information programs, as described under Plan A, would include technical training, public education, and pollution prevention planning.

**Summary**

It is likely that a combination of in-lake strategies and watershed management BMPs will be needed to achieve the desired goals for Third Lake water quality. The combination will be determined after the results of the LCHD's in-lake water quality analysis are finalized. The four corrective action plans
prepared for the assessment study offer progressively more comprehensive and site-specific BMPs. Organized this way, the water resources decision-maker can choose the level of watershed management that, combined with in-lake treatment, achieves the desired water quality. As this paper notes, however, the ability to implement any water quality improvements will require that SMC continue to build understanding and trust, and demonstrate the need for inter-jurisdictional cooperation with the stakeholders who benefit from Third Lake.

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Section 7

Natural and Cultural Resources and Environmental Compliance
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HISTORIC RESOURCES
COMPLIANCE AND MITIGATION
IN MISSOURI’S FLOODPLAINS

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While well-known flood-damaged historic buildings and historic districts—such as the French Colonial settlement of Ste. Genevieve, Missouri, just south of St. Louis—have received the most attention by the media, the historical significance of most flooded properties in Missouri has not been previously assessed. This paper addresses the importance of historic resources compliance in floodplain management by focusing on the identification and documentation of historic architecture in parts of Missouri affected by the 1993 Midwest floods.

The documentation was conducted for the Federal Emergency Management Agency (FEMA) as part of its general disaster assistance program. Missouri has the most participants of all Midwest states in FEMA’s Hazard Mitigation Grant Program, designed to assist local homeowners in relocating out of floodplains by acquiring, and in most cases demolishing, buildings which have become health and safety hazards. Consultants for this ongoing Missouri work are Greenhorne & O’Mara, Inc., working in cooperation with Woodward-Clyde Federal Services, the prime contractor.

Historic resources identification, evaluation, and mitigation are required for FEMA to comply with the National Historic Preservation Act (NHPA) of 1966, as amended. Section 106 of the NHPA requires federal agencies to take into account the effects of their actions on properties included in, or eligible for, the National Register of Historic Places. If effects are determined to be adverse, federal agencies are required to consult with the State Historic Preservation Officer to explore ways to avoid, minimize, or compensate for adverse effects. (While the effects upon archeological resources must also be considered, this paper is concerned solely with historic buildings.)

Throughout 1994 more than 450 properties, located in 13 counties in the floodplains of the Mississippi and Missouri rivers, were photographed and evaluated for historical significance. Although the Missouri State Historic Preservation Office has completed systematic historic architecture surveys in some counties, most buildings in areas affected by the flood had not yet been
evaluated for historical and architectural significance. This progress in inventorying historic properties is typical of most State Historic Preservation Offices, whose systematic surveys on a county-by-county basis are far from complete.

FEMA's Missouri field investigations were conducted by multiple teams working concurrently in several locations, with team experience in Missouri history and vernacular building types. The vast majority of the 450 properties were vernacular (i.e., non-architect designed) buildings ranging in date from circa 1850 to 1940. To date, fewer than 5% of the total have been determined eligible for the National Register. Eligibility for the National Register requires structures to be at least 50 years old and important for their design or association with significant persons or historical events. Most eligible buildings were found significant as good examples of their type or style, while others were important for their association with locally important persons and community history.

The survey and mitigation phases documented buildings whose local importance was previously known, such as the circa 1858 Greek-Revival-style house of merchant Andrew Maxwell in the town of Alexandria, while also recording lesser-known traditional building types in both rural and small-town environments. Much of Missouri between the Mississippi and Missouri rivers was settled by pioneers moving westward from Virginia, the Carolinas, and Kentucky, and its landscape contains traditional house types also found in those states. Traditional houses in this inter-river region are dominated by one- and two-story houses whose first-floor plan consists of two rooms, sometimes divided by a central hall (Marshall, 1981, 1994). Two-room versions include the English hall-and-parlor plan as well as a type with two front doors, reflecting a characteristic also found in the Lowland South region and the Pennsylvania-German Mid-Atlantic region (Glassie, 1968). One visually similar but little-known local type documented for FEMA was a circa 1855 duplex tenement built as rental housing in working-class South Hannibal (Figure 1).

Properties determined eligible for the National Register by the Missouri State Historic Preservation Officer were recorded in greater detail as a mitigation measure before their demolition or relocation. Due to the extent of physical damage and the impracticality of rehabilitation and relocation, the vast majority of buildings are being demolished. Mitigation recordation included large-format photographs and measured floor plans executed according to the standards of the Historic American Building Survey. Site-specific historical information as well as local/regional contextual histories were also written to fully document the importance of each building. Salvageable architectural elements, such as mantels and trim, were also noted for possible removal prior to demolition; in many cases, however, these elements had already been removed either by the owners or local scavengers (Figure 2). As part of the agreement between FEMA and the Missouri Department of Natural Resources, copies of mitigation recordation materials will be deposited at Missouri Office of Historic Preservation.
Could historic resources compliance in Missouri have been achieved more quickly if the flooded areas had already been surveyed by the state? Yes, but completed surveys do not guarantee the ability for rapid recovery from natural disasters. In commenting on the 1989 disasters caused by Hurricane Hugo and the Loma Prieta earthquake, Jerry Rogers, former associate director of the National Park Service, noted that "inventories of historic resources—a key component of state and local government preservation work—were not fully effective planning tools," which were "in many cases inadequate to assist decision makers in responding rapidly in these emergency situations" (Nelson, 1991). Primary reasons for this inefficiency are the lack of computerized data retrieval systems and the need to individually document all buildings within historic districts before disaster strikes.
The scope of historic resources identification, protection, or compensatory recordation mitigation can be predicted early in the recovery process by including historic architecture specialists and local history specialists in preliminary damage assessment teams. Along with ensuring compliance with federal environmental laws, one of the main benefits of mitigation recordation projects for local floodplain managers and planning departments is the identification of resources that have either not been previously recorded or whose importance is not fully recognized. While severely damaged or threatened historic buildings may be demolished or

Figure 2. This circa 1920 Craftsman-style mantel was recommended for salvage from a house in New Franklin, Missouri. [Photo by Scott Myers]
relocated as part of a larger recovery plan, resulting recordation information can be used by local governments to better interpret and preserve historically significant properties.

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CULTURAL RESOURCES MANAGEMENT: FEDERAL AND STATE OBLIGATIONS

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Introduction

The Midwest flood of 1993 created many challenges and provided ample opportunity to refine the application of cultural resources management in the wake of a disaster. One challenge, for example, was to ensure that agencies involved in response and recovery recognized properties that are included in or eligible for inclusion in the National Register of Historic Places (NRHP). However, all challenges bring with them opportunities. In this case it was the opportunity to forge a cooperative working relationship among the Federal Emergency Management Agency (FEMA), the Advisory Council on Historic Preservation (ACHP), and the state involved in the 1993 disaster. The cornerstone of that relationship is a Programmatic Agreement (PA) that defines the responsibilities and obligations of FEMA, the ACHP, and the state with regard to satisfying the requirements of Section 106 of the National Historic Preservation Act (NHPA).

This paper describes the purpose of the PA that is currently driving the consideration of cultural resources in the Midwest and Georgia, and then explores specific aspects of that agreement in more detail. Included among those details are the following:

- State and federal obligations with regard to cultural resources and recovery,
- The concept of "area of potential effect" as considered with respect to an "undertaking," and
- The intent and mechanics of the program to release acquisition monies before completion of the Section 106 compliance process.

Programmatic Agreement

In the wake of the 1993 Midwest flood, FEMA and the ACHP developed a PA that defines federal and state responsibilities with regard to satisfying the requirements of the NHPA. The primary purpose of the PA, which remains in force today, is to define the responsibilities of the state and the federal
entities involved in disaster assistance programs, which includes the Hazard Mitigation Grant Program (HMGP). The PA is a road map of sorts that provides guidance to the affected state and regional FEMA offices navigating through the esoteric of the Section 106 maze.

Section 106 compliance requires that the ACHP be afforded the opportunity to comment on federally assisted or licensed undertakings that may have an effect on properties listed on or eligible for the NRHP. The PA establishes the ground rules for identification of register-eligible properties and sets forth the procedures to identify and evaluate the effects that federal actions will have on those properties. Creating a PA document common to each of the nine Midwestern states affected by the flood was a way to bring consistency and order to the Section 106 implementation process.

State and Federal Obligations

The Midwestern PA was somewhat of a departure from the common compliance process. The Midwestern PA identified the State Historic Preservation Office (SHPO) as the party responsible for identifying properties affected by an undertaking, even though that responsibility usually falls to the lead federal agency. This departure from typical practice was brought about by several factors, among them expediency and recognition of the prior and continuing efforts of individual states to identify and preserve their heritage resources. To confirm the acceptance and involvement of the individual states, the SHPO and the state office that would receive assistance from FEMA were parties to the agreement. To assist the states, FEMA has provided consultants through existing technical assistance contracts and assumed the responsibility of lead agency for Section 106 compliance.

Nonetheless, the limits of FEMA’s federal responsibility, the state interpretation of that responsibility, and related recovery often requires clarification. To some extent the confusion regarding the limits of FEMA’s Section 106 responsibilities derived from FEMA’s role as a disaster response and recovery agency rather than as a land management agency. An example helps illustrate the point and provides an opportunity to address the concepts of "undertakings" and "area of potential effect" as well.

Undertakings and the Area of Potential Effect

In a flood-affected southern state, a storm and related flood destroyed some 38 earth dams. Receding flood waters breached the dams and drained the reservoirs, exposing the previously submerged areas behind the dams. The pool area of one reservoir in particular is known (through a prior cultural resource inventory) to contain numerous prehistoric sites. As part of the FEMA-sponsored recovery effort, the project applicant undertook planning to repair the dam.

On the basis of a preliminary Section 106 review by the SHPO, it was determined that the federal involvement in the repair of the dam, and the subsequent rewatering of the reservoir pool, posed a potential effect on
cultural resources. On the basis of that determination, the SHPO concluded that it was FEMA’s responsibility to inventory and evaluate the resources within the pool area. The argument for this determination was based primarily on the erroneous conclusion that FEMA’s direct involvement in the repair of the dam linked that agency, albeit indirectly, to the rewatering. The SHPO viewed the rewatering as an action that would pose a potential impact to the resources located in the pool area. The SHPO conclusion carried with it the inference that FEMA was responsible for assessing the damage to resources resulting from the dewatering. Thus the SHPO viewed the FEMA "undertaking" as the repair of the dam and the rewatering of reservoir. The "area of potential effect" was considered to be that area that would be disturbed by repair of the dam and the rewatering of the gross pool area. The notion that FEMA must evaluate the impact to resources caused by the dewatering implied that the flood was an aspect of that undertaking.

Two concepts and two issues surface here—the concepts of undertaking and area of potential effect.

- The NRHP implementing regulations define undertakings as "any project, activity, or program that can result in changes in the character or use of historic properties, if any such historic properties are located within the area of potential effects" (36 CFR 800.2).
- The area of potential effect is defined as the "geographic area or areas within which an undertaking may cause changes in the character or use of historic properties if such properties exist" (36 CFR 800.2).

In this example, FEMA’s role as an emergency response and recovery agency includes the repair and replacement of damaged facilities and structures. FEMA acknowledges these actions as undertakings and accepts responsibility for impacts to resources resulting from them. Impacts related to the undertaking could result from activities to repair the dam, the use of new lay downs and/or borrow areas, and the construction of new haul roads. FEMA’s responsibility is limited to the impacts that result from the undertaking of repair and replacement. They do not, however, include the impacts resulting from the phenomenon that required the repairs.

FEMA’s responsibilities with regard to impacts resulting from rewatering were argued with regard to interpretation of the limits of the area of potential effect. Returning for the moment to the concept of undertaking, there is a technical relationship between the repair of the dam and the subsequent rewatering. Thus the SHPO concluded, as defined above, that the area of potential effect included the reservoir pool. However, FEMA maintained that the rewatering was not an agent that would "cause changes in the character or use of historic properties if such properties exist" because the use before and after the rewatering was the same. Therefore, it was concluded that the area of potential effect would include only those areas that would be disturbed by the actual ground-disturbing activity.
Acquisition before Completion of the Section 106 Process

Because many potential participants in the HMGP remain in temporary accommodations or in partially repaired homes, FEMA Region VII studied the overall acquisition program to identify ways to shorten the process. FEMA concluded that the potential for affecting flood-damaged structures generally occurs in the demolition or structure relocation phase, not the acquisition phase. Communication with the OHP confirmed that "effect" did not occur at purchase but rather at demolition or relocation.

FEMA specifically identified its undertaking with regard to Section 106 as the actions following purchase of the flood-prone structures and would not include the acquisition itself, as long as adequate measures to protect potentially historic properties are put in place. In January 1995 the ADHP concurred with FEMA’s interpretation.

This expedited process is not, however, without its stipulations. If the Section 106 process is not complete when the subgrantee obtains title to the property, it is the subgrantee’s responsibility to protect and secure the property until the determination of eligibility and effect are complete. Notice of the requirement for protection and security is included in the notification to the subgrantee that funding can be obligated prior to the completion of the process. In Missouri the purchase of properties with HMPG funds may proceed only if the subgrantee agrees to the following conditions:

1. Acquired structures may not, under any circumstances, be demolished before and until the Missouri State Historic Preservation Office has provided written authorization.

2. The subgrantee shall ensure, to their best ability, that acquired structures scheduled for Section 106 review shall be physically protected against illegal entry and damage by pursuing, undertaking, and enforcing the following actions:
   a. All exterior entrances of acquired structures shall be locked and posted with a "NO TRESPASSING" sign.
   b. Exterior protective measures shall be employed, whenever necessary, to abate the risk of further weather damage.

Successful implementation of the expedited acquisition process requires substantial front-end coordination among FEMA, the SHPO, and the cooperating state agencies. The need for that coordination derives primarily from the alternatives to demolition (rehabilitation and relocation, for example) provided by the PA.

In some cases the subgrantee and the state emergency management agencies have become concerned that they may be required to secure structures for long periods until the final disposition has been determined by the SHPO. In other cases the SHPO has viewed the expedited acquisition process as a procedure that would limit the disposition of a structure to recordation and demolition.
In Missouri, 516 structures in 19 communities or areas have been evaluated. Of those, 40 structures have been determined to be eligible for the NRHP. Each of those contained elements or materials that warranted salvage, and none has required prolonged periods of care. None has been relocated.

A subsequent review of the expedited acquisition process with regard to the possibility of relocation has revealed the need for an additional stipulation in the notification provided to the municipality. This is the result of two related issues. The first is the potential for the subgrantee, having chosen to participate in the expedited acquisition, to opt for relocation of a structure after the Section 106 review. The second issue is that, to complete the cost/benefit analysis and determine the amount of funds that must be obligated, FEMA uses pre-flood fair market values and assumes that the structure will be demolished. Changing the disposition of the structure from demolition to relocation, however, can invalidate the cost/benefit analysis. To avoid such a circumstance, the subgrantee must assume responsibility for any mitigation or treatment beyond the standard mitigation of recordation.

Documents currently being framed for distribution in Region IV will inform the subgrantee that local government must bear the costs of any extraordinary historic preservation measures, such as relocation of the structure. Rehabilitation of the structure in place is strictly prohibited, because the HMGP requires that structures be removed from the floodplain. Additional information pertaining to the program can be obtained from FEMA Regions IV and VII.

Conclusion

The need for addressing the requirements of Section 106 of the NRHP in post-disaster Georgia and the Midwest has enhanced the cooperative relationship between FEMA and the ACHP, promoted cooperation between FEMA Regional Offices, State Historic Preservation Offices, and related state emergency offices, and contributed substantially to the preservation of heritage resources otherwise lost or damaged by the disasters that occurred in those states. The early acquisition process described above exemplifies the efforts on behalf of all participants to preserve the heritage resources of the affected regions, while furthering FEMA's goal of removing people from harm's way.
HAZARD MITIGATION LESSONS FROM THE 1993 MIDWEST FLOOD: ENVIRONMENTAL COMPLIANCE ISSUES

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Introduction

One of the important lessons to come out of the hazard mitigation activities associated with the flood recovery efforts in the Midwest is the need to incorporate environmental compliance efforts early in the recovery process. The extent of substantial damage to residential structures and the number of communities requesting Hazard Mitigation Grant Program (HMGP) assistance emphasized the need to streamline the National Environmental Policy Act (NEPA) process to enable the release of federal funds and to allow program implementation. The range of HMGP projects included acquisition of flood prone structures, relocation of affected residents to selected sites outside of the floodplain, infrastructure improvements such as flood-relief roads, new wastewater and water treatment plants, and structural flood mitigation projects such as improved bridge crossings, culverts, drainage ditches, and levees.

Woodward-Clyde Federal Services is the principal contractor to the Federal Emergency Management Agency (FEMA) for providing NEPA compliance services in response to the Midwest flood recovery efforts. The 26 task orders under the Midwest contract addressed a wide range of NEPA compliance services associated with implementing hazard mitigation projects. However, these services generally fell into three broad categories: environmental assessments (12 task orders); Phase I and II Environmental Site Assessments (4); and cultural resource investigations, including both historic preservation and archeological studies (10).

The HMGP is authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Act (P.L. 93-288, as amended), commonly referred to as the Stafford Act. The Stafford Act and FEMA’s HMGP guidance places a reliance on state and local government to identify and prioritize hazard mitigation opportunities. Local governments need to understand the implications of receiving federal funds. For better and for
worse, NEPA compliance is a requirement that has both cost and time implications to implementing hazard mitigation projects.

The Relationship of NEPA to Hazard Mitigation Projects

The National Environmental Policy Act of 1969 (P.L. 91-190, as amended) was one of the broadest and most significant pieces of environmental legislation enacted in the United States. NEPA is the basic national charter for the protection of the environment; it is a procedural law that affects how federal agencies conduct their planning and decisionmaking processes. The law helps public officials make informed decisions regarding the environmental effects of implementing their decisions. NEPA requires federal agencies to provide environmental information about their proposed action to other public officials and to the larger public audience who may also have a stake in the planning and decisionmaking process.

NEPA comes into play in the implementation of hazard mitigation projects when one or more federal agencies funds specific components of the recovery project. For most of the larger projects, FEMA has been designated the lead federal agency, providing a coordination role for addressing environmental concerns. For these complex projects, many other state and federal agencies are involved, either as funding agencies for specific elements of the acquisition and relocation effort, or as reviewing agencies to ensure that all potential NEPA compliance issues have been adequately addressed. It has been the goal of FEMA, as the lead agency, to expedite the preparation and review of NEPA documents to be responsive to the needs of the Midwest communities devastated by the 1993 flood, while meeting the intent of NEPA and complying with all NEPA provisions. To achieve this goal, FEMA has involved both funding and review agencies from the onset of the NEPA compliance process.

The NEPA process can be described in three phases. First, the federal agency must determine whether the proposed action is categorically excluded or otherwise exempt from NEPA provisions. Many of the straightforward acquisition projects without hazardous waste or historic structure concerns were categorically excluded from NEPA by FEMA. Secondly, for hazard mitigation projects not categorically excluded or exempt, the federal agency must determine whether the proposed action may "significantly affect the quality of the human environment." This step generally involves preparing an environmental assessment (EA) to determine if the proposed action would result in any significant environmental effects. The third phase of the NEPA process involved the preparation by FEMA of a "finding of no significant Impact" (FONSI) or an environmental impact statement (EIS). A FONSI is prepared if the agency determines that no significant adverse effects would occur from implementing the selected alternative. An EIS is prepared if FEMA determines that the proposed action may have significant effects on the environment. All of the FEMA EAs prepared by Woodward-Clyde to date have resulted in FONSIs. In several cases, fully mitigated EAs were required to allow FEMA to prepare a FONSI for some of the larger, more
complex hazard mitigation projects, such as the Valmeyer, Illinois, relocation project.

A Hazard Mitigation Case Study

The Village of Valmeyer, Illinois, was almost completely destroyed by flooding on August 2, 1993. Approximately 343 homes, businesses, and public buildings sustained damage; 90% of the structures received damage that exceeded 50% of market value. Although the village had experienced periodic flooding in the past, the severity and length of time that the village was flooded focused the residents to address the long-term prospects for the town's survival. The residents overwhelming indicated a desire to relocate the entire community during public meetings in the fall of 1993. The relocation site for the new village is located 1.7 miles east of the village and the site comprises approximately 500 acres of existing cropland and woodland. It is located on a limestone bluff overlooking the Mississippi River floodplain.

At first glance one might consider that relocating an entire community outside of the 100-year floodplain would require an EIS, and as the NEPA compliance process unfolded, it remained a distinct possibility. An EIS would have destroyed any opportunity to keep the community intact, owing the length of time required to conduct an EIS. Woodward-Clyde worked closely with FEMA, the local community, engineering consultants, the regional planning commission, and numerous state and federal regulatory agencies in drafting complex mitigation requirements necessary for FEMA to prepare a FONSI. The following NEPA compliance issues were evaluated and mitigation measures described in the Valmeyer EA.

- The potential presence of a federally endangered species, the Indiana bat, required prohibitions on the timing of clearing mature forest.
- An extensive geotechnical evaluation of the potential for future sink-hole development in the karst topography found at the relocation site was required.
- Development constraints on loess soils (erosion, subsidence, and slope failure) necessitated modifications to the original site plan and required best management practices (BMPs) to address sediment control and stormwater management concerns.
- Initial archeological fieldwork uncovered an intact Mississippian indian village site. Mitigation for this unanticipated find necessitated a full Phase III archeological investigation which quite literally was conducted in the shadow of the bulldozers.

The end result of this effort was that the final EA and FONSI were prepared in less than three months and today a new community is taking shape as residents and businesses rebuild.
Fast-Tracking the NEPA Compliance Process

At the outset of the NEPA compliance studies for the Midwest disaster, there was considerable pressure from local, state, and federal levels of government and from the affected communities to address environmental compliance issues quickly. In communities where a high percentage of structures was substantially damaged, the displaced residents had been living in FEMA trailers or with friends and relatives for extended periods of time. FEMA Hazard Mitigation Officers from the nine-state region and, particularly in Illinois, where eight EAs were conducted, were developing innovative approaches to streamline the NEPA compliance process. Woodward-Clyde worked closely with the FEMA Disaster Field Office staff, FEMA Headquarters Mitigation Directorate staff, and state and local government representatives to facilitate compliance with all applicable environmental regulations. The urgency for fast-tracking the NEPA compliance process was that grant funds could not be released until the FONSI. The following recommendations for streamlining the NEPA compliance process reflect a cooperative effort of all involved parties and are "hard-won" lessons learned in the trenches.

- Initiate the NEPA compliance process as early as possible. Inform local communities that an EA is likely when hazard mitigation projects such as a formal relocation are first proposed. The local community should develop a consistent process for identifying alternatives and should use objective criteria for evaluating potential relocation sites.
- When evaluating hazard mitigation alternatives, local communities should consider strengthening their floodplain regulations, zoning, and long-range comprehensive plans for the floodplain.
- For hazard mitigation projects using several federal funding sources, establish the lead agency role quickly, and seek concurrence among the funding agencies on the lead agency's NEPA compliance process, timeframes for review, FONSI preparation, if applicable, and approval of grant funds.
- Although not required for EAs, incorporate scoping meetings early in the NEPA compliance process for large, complex EAs so that state and federal review agencies can identify potential "red flags" or controversial issues that can be addressed before preparation of the draft EA. Use conference calls to obtain timely agency input on draft documents.
- Utilize Memorandum of Agreements and Programmatic Agreements to address substantive cultural resource issues. These techniques allow an EA to progress to a FONSI while detailed historic structure evaluations or archeological investigations are underway. In this way, time-consuming cultural resource investigations do not necessarily need to slow the NEPA process, but compliance with Section 106 of the National Historic Preservation Act is still ensured.
Develop focused public participation strategies to ensure effective and timely input from the residents and businesses. Make the community aware of its role in the EA process. For the Midwest EAs, Woodward-Clyde used public information meetings, NEPA fact sheets, direct mailing, and project-specific draft EA summary descriptions to tailor public involvement to meet the needs of each specific EA.

Use innovative approaches to describe how mitigation measures will be addressed in the EA. In many cases, detailed engineering designs for the relocation were not available when the EAs were being prepared. For complex relocation EAs, Interagency Mitigation Monitoring Teams, composed of local, state, and federal agency representatives, were proposed to review and approve relocation site plans, stormwater management, and sediment and erosion control plans, to ensure that mitigation measures identified in the final EA were carried out by the local jurisdiction after the FONSI.

Conclusions
The first impulse felt by local officials after a major disaster affects their community is to get the affected residents back into their homes as quickly as possible. There is a window of opportunity at this stage, however, to evaluate a broader range of hazard mitigation alternatives such as acquisition and formal relocation. Although formal relocations require a more extensive NEPA documentation effort and more lead time than straightforward "buy-outs," relocation hazard mitigation projects can provide substantial benefits such as maintaining the integrity of the community and providing affordable building sites for displaced residents.
On July 19, 1994, the Pima County Board of Supervisors (Board) adopted the Watercourse and Riparian Habitat Protection and Mitigation Requirements Ordinance 1994-FC2. Its intent is to protect valuable riparian habitat areas and natural watercourses from the pressures of urban growth. The protection requirements were adopted under two ordinances simultaneously, which amended the Floodplain and Erosion Hazard Management Ordinance (FPMO) and the Pima County Zoning Code. The main provisions for the protection of riparian habitat are placed under the authority of the FPMO. A companion Zoning Code text amendment offers flexible development standards in exchange for minimizing the disturbance of riparian habitat.

A definition and classification system of riparian habitat that was specific to the arid nature of Pima County was developed by SWCA, Inc. Environmental Consultants. Riparian habitat was defined simply as plant communities occurring in association with a watercourse, surface, or subsurface, through which waters flow at least periodically. These habitat areas are generally characterized by an increase in the plant size, variety, or density of vegetation as compared to adjacent areas, representing a continuum of plant species' response to available moisture (SWCA, Inc., 1993).

The ordinance applies to all parcels in unincorporated Pima County that are entering the county's rezoning, development plan, or subdivision process, and to Pima County government projects. The ordinance was structured to encourage the avoidance of riparian habitat, but does not prohibit development in those areas. If a developer chooses to impact riparian habitat then mitigation is required. Onsite mitigation to provide continuity of habitat is preferred but offsite mitigation and mitigation banking options are available.

Pima County is located in the south-central portion of Arizona within the Sonoran Desert and encompasses 9,241 square miles, approximately the size
of New Hampshire. This is an arid region receiving an average annual rainfall of 12 inches. Riparian ecosystems are among the most significant and valuable natural resources in Pima County, providing water quality protection, groundwater replenishment, soil stabilization, flood prevention, historic and archaeological values, open space, recreational opportunities, education, and wildlife habitat and production. Southwestern riparian ecosystems comprise only a small portion of the native landscape when compared to upland areas. During the past 100 years, a significant portion of Arizona’s riparian ecosystems have been destroyed, altered, or impaired by such human activities as grazing, agriculture, groundwater pumping, and urban development. This ordinance helps to protect and minimize impacts to the remaining valuable riparian habitat for future generations.

Ordinance Development

While the FPMO philosophically addresses natural wash protection, there was no regulatory component to execute this policy within the ordinance itself. Development of riparian habitat protection regulations began when the Board directed staff to draft an ordinance in November 1991. The effort was initiated in response to the community’s desire to protect the remaining riparian habitat in its natural state, particularly in the face of rapid urban growth experienced in the Tucson area. The process of developing the two interrelated ordinances involved 1) obtaining public input on the framework and content of the ordinance, and 2) performing the technical studies and habitat inventories necessary to develop a database of the amounts and types of riparian habitat in the county and to map it.

Several public meetings were held during development of the ordinance to obtain the community’s views on the value of riparian habitat, what types needed protection, and the process for adoption of the regulations. A lack of consensus on several key components of the draft ordinance required the Board to appoint a broad-based citizen’s committee to address the major issues. The nine-member committee consisted of representatives from the environmental community, developers, builders, attorneys, private property rights advocates, and the engineering and planning community. The committee reached consensus on the level of habitat protection, need for incentives, mitigation banking, and other issues that were critical in the adoption of the two ordinances.

The citizen’s committee also helped develop the mitigation standards. It met with members of local, state, and federal resource agencies and conservation organizations with an interest in riparian habitat to determine the appropriate level and type of mitigation needed. The mitigation standards were tailored to complement Section 404 permit mitigation requirements.

Key Ordinance Features

The main provision of protecting riparian habitat is under the authority of the Flood Control District (District) through the FPMO. The companion Zoning
Code Amendment allows for flexible development standards that encourage avoidance of riparian habitat areas. Preservation of habitat in place was determined by the committee to be the most desirable approach to maintaining riparian habitat. The ordinance provides numerous incentives for developers to avoid disturbing regulated riparian habitat areas. The ordinance requires mitigation of disturbed habitat over a threshold amount (10% or one acre of regulated habitat on a site, whichever is less) for projects entering the development plan, subdivision, or rezoning process.

If a developer demonstrates that on-site mitigation is not possible, mitigation banking is allowable with Board approval. In these cases, the developer can make a contribution to a mitigation bank. The funds collected will be used to purchase high-resource-value riparian habitat. Priorities for acquisition of that habitat will be based upon regional significance of habitat. The District is identifying priority acquisitions with assistance from local natural resource agencies and organizations. Mitigation bank funds may also be used to restore degraded riparian habitat already in public ownership.

The companion zoning code regulations provide for flexible development standards that can be implemented in exchange for avoidance of riparian habitat. Flexible standards available to developers who chose to avoid regulated riparian habitat areas include lot size reductions, off street parking modifications, building setback reductions and height variations, cluster subdivision development options, and reduced landscape buffer yard requirements. The reduced buffer yard option allows reduced amounts of required landscape plantings where an equivalent area of riparian habitat is preserved. The lot size reduction includes the option of combining regulatory riparian habitat areas with connected undisturbed upland areas to create the preserved area used to calculate the reduced lot size.

Habitat Definition and Classification

Riparian habitat is defined in the ordinance as plant communities occurring in association with any spring, cienega, lake, watercourse, river, stream, or other body of water, either surface or subsurface, through which waters flow at least periodically. Riparian habitat is generally characterized by an increase in the size, variety, or density of vegetation compared to upland areas. These plant communities represent a continuum of plant species' response to available moisture.

The major considerations in developing the classification system included desired complexity, ease and cost of implementation, mapping scale, and the relative nature of occurrence of riparian habitat in nature. Riparian habitat was divided into classes including Hydro- and Mesoriparian, and Xeroriparian Classes A-C. Hydroriparian and Mesoriparian habitat are associated with perennial or intermittent watercourses or shallow groundwater levels. Plant species include preferential wetland vegetation, such as cottonwood, willow, and sycamore, as well as species also found in drier habitats such as mesquite. Xeroriparian habitats are associated with ephemeral watercourses. Plant species include those typically found in adjacent upland
habitats, such as mesquite, palo verde, and acacia, but are typically larger and occur at higher densities than in the surrounding upland area.

SWCA, Inc., Environmental Consultants divided xeroriparian habitat into four subclasses based upon total vegetation volume (TVV). The subclasses are 1) xeroriparian class A having a TVV greater than 0.85 m³/m², 2) class B, TVV between 0.85 m³/m² and 0.675 m³/m², 3) xeroriparian class C, TVV between 0.675 m³/m² and 0.500 m³/m², and 4) xeroriparian class D, TVV less than or equal to 0.500 m³/m². The lowest value category, xeroriparian class D, was used to represent the vegetation volume of the upper limits of typical Sonoran Desert Scrub and Semidesert Grasslands Biomes which cover most of undeveloped portion of Pima County (SWCA, 1993).

Mapping Methodology

The riparian habitat mapping area included all of unincorporated Pima County (over 2,600 square miles or 30% of the county's land area). State land, private land, and land in county ownership (except parks and preserves) was included. Land excluded from the habitat mapping consisted of incorporated areas, Indian Nations, and federal lands such as wildlife refuges, national parks, national forests, etc.

The most practical and cost effective method for mapping such a large area was using remote sensing techniques. The University of Arizona, Advanced Resource Technology Program found that sample area TVV measurements correlated well with reflectance values of Landsat TM satellite imagery. The Riparian Habitat Boundary Maps that accompany the ordinance were generated from Landsat TM satellite data. Lateral and internal boundaries based upon the presence of riparian habitat along watercourses were delineated on orthophoto aerial photography. The satellite data (corresponding to the TVV figures) was then clipped using the lateral and internal boundaries with geographic information system (GIS) technology. The satellite data within the boundaries was averaged, producing a classification of riparian habitat for each watercourse delineated (SWCA, 1994). The habitat boundaries were plotted over the assessor's parcel data and street base, resulting in detailed habitat maps at a scale of 1"=1000' from which the habitat location and classification on individual parcels can be determined.

Mitigation Requirements

Mitigation is required for all classes of riparian habitat down to xeroriparian class C; protection of class D is optional. This option offers the developer flexible development standards in exchange for protecting additional habitat, without requiring mitigation for disturbance of xeroriparian class D.

Preservation in place is the preferred approach as stated in the ordinance. The mitigation standards are intended to be stringent enough to encourage the preservation of habitat by establishing specific requirements for mitigation. On-site mitigation requirements are intended to recreate, as closely as possible, the type and volume of the riparian habitat that has been altered. A
list of specific mitigation requirements, including planting and seeding quantities tailored to each class of habitat has been developed based on the size of plants 10 years after planting. Maintenance and irrigation of the plantings are required for a minimum of five years after project construction.

**Mitigation Banking**

Off-site mitigation requirements are provided in the instances where avoidance and on-site mitigation are not possible. In these cases, the developer will make a financial contribution to a mitigation bank. The amount of the contribution directly relates to the amount and type of riparian habitat that will be disturbed. The funds collected in lieu of on-site mitigation may be used to purchase high-resource-value riparian habitat or to restore degraded riparian habitat areas under public ownership.

**Conclusion**

The ordinance and associated maps and mitigation standards meet the needs of expressed community interest in protecting valuable riparian habitat from the pressures of urban growth in Pima County. The ordinance is structured to provide flexibility in allowing development to occur in a manner more acceptable to the community. Riparian habitat protection is an integral component of Pima County's multi-objective floodplain management program. Acquisition of flood-prone land and protection of riparian areas help to protect watersheds and thus reduce the cost and public safety hazards of flooding. Riparian habitat corridors offer the community recreational opportunities, environmental education, and wildlife viewing, as well as less immediately tangible benefits such as flood reduction, water quality protection, and groundwater recharge.

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HEATHERRIDGE DETENTION BASIN: FLOOD CONTROL AND WETLAND MITIGATION WORKING TOGETHER

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The southern part of the City of Tulsa has experienced rapid development over the last 20 years. Along with this development has come traffic congestion and problems with flooding resulting from increasing development.

The City of Tulsa and Tulsa County Major Street and Highway Plan, which was adopted in the late 1950s, recommended a southern transportation loop around Tulsa. Funding for this major thoroughfare was difficult to obtain; however, studies at the Oklahoma Turnpike Authority (OTA) indicated a toll road was feasible. Turnpike bonds were sold, and the project was implemented. The proposed route of the toll road crossed several areas designated as wetlands. In order to obtain a Section 404 Permit, any disturbed wetlands were to be replaced.

The coordination that the City of Tulsa established with OTA provided a unique opportunity for the city to link flood control with wetland mitigation.

Background

After approval of the feasibility study, OTA began developing the preliminary design for the turnpike, which was named the Creek Turnpike. The proposed alignment crossed two of the city’s undeveloped major streets and tied into an existing four-lane major thoroughfare. The alignment also crossed two large watersheds (Vensel Creek and Fry Ditch II) with known flooding problems.

During the design of the 6.9-mile Creek Turnpike, approximately 15 acres of impacted wetlands were identified. The identified wetlands had the following classifications: riverine intermittent wetland, palustrine emergent wetland, riverine lower-perennial wetland, palustrine unconsolidated bottom system, palustrine open water wetland, and palustrine forested wetland.
Approximately 7.8 acres of impacted wetlands were located on the west side of the Arkansas River, with 7.2 acres on the east, primarily within the Fry and Vensel Creek Drainage basins.

In accordance with Section 404 permit requirements, OTA agreed to mitigate the loss of 15 acres of wetlands by creating 45 acres of new wetlands. OTA’s environmental consultant recommended five sites for wetland mitigation—four on the west side of the river and one on the east.

One of the areas OTA considered for wetland mitigation on the east side of the river was an area the City of Tulsa had designated in its Fry Ditch II Basin Drainage Plan as a site for a regional stormwater detention basin, called the Heatherridge Detention Basin. When the city learned that this site was being considered for a wetland mitigation site, it diligently pursued including flood control. Discussions between OTA, City of Tulsa, and the U.S. Army Corps of Engineers revealed that the site could be utilized for the dual purpose of flood control and wetland mitigation. The city recognized the opportunity to implement flood control as part of the construction of the turnpike to offset some of the increased runoff from the new road, as well as reduce some of the existing drainage problems.

Agreement for Streets, Wetland Mitigation, Flood Control

The City of Tulsa was concerned that the construction of the turnpike might not meet its floodplain development and street development requirements. Since OTA is a governmental agency of the state, it only has to meet federal requirements for floodplain development. The City of Tulsa’s standards are more restrictive. Therefore, the city had to negotiate with OTA to reach a compromise to conform to city standards. After months of wrangling and negotiating, the city agreed to construct the Heatherridge Wetlands and detention basin in exchange for work OTA would do on some city bridges and overpasses during construction of the turnpike.

Heatherridge Detention Basin

The Heatherridge Detention Basin is one of four facilities recommended for flood control in the Fry Ditch II drainage basin. It is situated on a 25-acre tract of land. The detention basin was designed for the 100-year frequency storm. The drainage area is 240 acres. Inflow is 1276 cubic feet per second, and outflow will be 38 cfs. The volume of flood storage is 115 acre-feet. The bottom will be a small lake covering approximately nine acres with a normal pool elevation of 679 msl. Water levels will be maintained by an outlet control structure.

The detention facility will reduce flooding to 21 homes and reduce runoff due to urbanization in the watershed, including the turnpike.

Wetland Mitigation

About 15 acres of emergent marsh will be created by this facility. A clay liner to minimize percolation and to keep the water surface elevation stable
An overburden of one foot of organic soil has been placed to support vegetative growth.

Four zones of wetland plants will be planted. Zones one and two are the shallow depth zones, with plantings of prairie cordgrass and switchgrass, soft rush, blue flag iris, common three square, and rice cutgrass. Zones three and four are the mid-depth wetland zones, with plantings of arrow arum, lizards tail, smartweed and soft stem bulrush, arrowhead, pickerel weed, and sago pond weed. To provide a diversity, plants in each zone were randomly mixed. All vegetation will be supplied either bare-root or in 2-1/4" pots planted on two-foot centers.

A buffer zone of hardwood trees will be planted. Two-gallon container nursery stock three to four feet in height will be planted on 10-foot centers in randomly shaped masses around the marsh. Fifteen different types of trees will be planted: green ash, box elder, black cherry, common mulberry, American elm, hackberry, honey locust, Chinquapin oak, northern red oak, shumard oak, sweet pecan, sycamore, black walnut, black willow, and eastern redbud.

A five-year maintenance program will be implemented upon completion of the plantings to assure a successful mitigation effort. Maintenance will include (1) watering on a weekly basis for the hot months (May through September) and watering as needed to keep plants moist in the other months; (2) removal of weeds as necessary; (3) removal of litter and debris as necessary; and (4) replacement of dead plant material annually. The goal of the maintenance program is to have at least 70% of the planted vegetation alive at the end of five years.

The benefits expected from construction of the wetlands and detention basin are (1) sediment control; (2) fishing for area residents; (3) erosion control, particularly downstream from the facility; (4) downstream water quality; and (5) flood control.

Conclusion

From its conception, the turnpike was controversial. Area homeowners believed the roadway would be an intrusion. Others felt their land was being taken unfairly, and some were concerned about increased stormwater runoff. Some environmentalists feared the turnpike would destroy valuable wetlands and habitat. Despite the fears concerning the Creek Turnpike, the end result has been for the most part favorably received.

The unique nature of the Heatherridge Stormwater Detention Basin and constructed wetlands demonstrates that dual purpose projects can benefit citizens and the natural environment.

Protecting our wetlands and natural habitats is important. The cooperative effort between the city and the OTA proves that the needs of a growing city can go hand-in-hand with safeguarding the environment and protecting the resources we have.
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FLOOD CONTROL AND HABITAT PRESERVATION IN THE MOJAVE RIVER, VICTORVILLE, CALIFORNIA

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Background
Victorville, California, was flooded during January and February 1993. Floodwater overtopped and eroded levees. Homes and streets were inundated, highway access ramps were closed, and interstate bridge spread footings were undermined by erosive return flows. Public and private damage totalled about $1.6 million.

Flooding was largely attributed to dense vegetation stands that fill the river channel and increase water surface elevations. The vegetation also traps sediment, forming sand bars that can reach 10 feet in height and redirect flow toward unarmored levees. During January flooding, flows above 16,000 cfs overtopped the left bank. Emergency channel clearing and levee construction was performed at a cost of $390,000.

As a result of this clearing, water surface elevations during February storms were lower than those in January despite higher discharges. Comparatively, water surface elevations were also less severe during the 1969 and 1978 storms which had substantially larger flows (30,000 cfs and 16,000 cfs respectively). At that time the channel was clear of vegetation and the flows were largely contained.

The San Bernardino Flood Control District had historically maintained a 300-ft centerline path through the study reach to convey 23,500 cfs. This clearing had not been performed since the mid 1980s because environmental permits, now required, had not been issued. Since 1987, the District had worked with the U.S. Army Corps of Engineers, California Department of Fish and Game, U.S. Fish and Wildlife Service, Environmental Protection Agency, and the Regional Water Quality Control Board to meet evolving environmental requirements and obtain a permit from each agency.
Previous hydraulic and environmental analysis had not demonstrated historic clearing as the least-damaging practicable alternative, a permitting necessity. After five drought years, the 1992 storm damage renewed the urgency for action. By fall of 1993, disagreement over permit terms, flood control needs, and appropriate analyses had escalated between the District and resource agencies. The District then requested that the Corps prepare a floodplain management plan (FMP) under our Section 22 Program (Planning Assistance to States, which has 50% matching federal funding).

The FMP was to identify the least-damaging practicable flood protection alternative while maintaining the river’s ecological integrity. We were to focus our efforts on the most significant flood risk, the 8000-ft-long reach near Victorville. Additionally, the FMP was to consider evolving environmental concerns and maintenance methods and evaluate flood control and mitigation alternatives.

After much discussion, the resource agencies reached consent that interim, environmentally sensitive flood protection to the high risk area was prudent and agreed to base permits upon study findings. A two-phased approach was to be used: 1) develop an IFMP for the critical reach implementable by the 1994 flood season that also satisfied permitting needs, protected adjacent homes and structures, preserved ecological integrity, and minimized environmental impacts; and 2) develop a long-term FMP that similarly satisfies flood control needs and the river’s ecological integrity.

Study Area

The Mojave River flows northward across 140 miles of desert from the San Bernardino Mountains to Soda Dry Lake (near Baker, California). The upper watershed receives over 40 inches of mean annual precipitation while the lower watershed receives only about 3 inches. Although the river is ephemeral, there is some perennial bedrock flow and continuous subsurface flow. Existing flood control structures include levees composed of sand reinforced by pile and wire revetment, and highway and railroad guide levees constructed to higher design standards.

The 8000-ft study reach near Victorville is divided by the 1-15 bridge. The upper half is primarily urban, containing homes, businesses and a campground; the lower half is primarily open space with some isolated agriculture and recreation.

Environmental Considerations

Environmental Objectives

We jointly developed the objectives with the resource agencies, a procedure that was critical to ultimately obtaining their concurrence on the IFMP. The most significant objective was to avoid clearing vegetation and preserve the rare and diverse habitat in its natural state. The others were to maintain a mosaic of habitat and successional stages; avoid vegetated low-flow areas,
marshes, and mature trees; and where necessary, clear as narrow a swath as possible.

General

Riparian vegetation, especially in desert areas, is an important resource for migratory birds, endangered species, and other wildlife. The most recent survey of the river identified 43 species protected by federal and state laws, with 10 sited or potentially occurring near the study area.

This habitat can provide flood control benefits as well as increase flood risks. For example, if the vegetation is located along banklines, it can provide a buffer zone and protect levees from high velocities and direct flow impingement. Conversely, if the vegetation is located in the channel center, it can block and redirect flows increasing flood damage. Vegetation has adapted to changing flow paths and highly variable annual water availability; frequent scouring yields a mosaic of early to late successional habitat. Some endangered birds prefer and often only use these dynamic systems.

Habitat is declining in the Mojave River, and across California, due to urban and agricultural expansion, off-highway vehicles (OHV), flood and erosion protection, and non-native species competition. OHVs crush vegetation, erode soil, and subject birds to noise. Frequent clearing of a single age-class or species often prevents even early successional vegetation and removes preferred nesting habitat. Non-native wildlife like cowbirds, bullfrogs, and European starlings outcompete native species. Cowbirds parasitize native bird nests, devastating viable populations and preventing recovery. Non-native plants provide virtually no habitat, spreading rapidly and crowding natives. Tamarisk, the most abundant non-native in our study area, secretes salt deposits which inhibit growth and degrade water quality.

Field Methods, Findings, and Priorities

Existing conditions were documented to establish a baseline using field surveys and aerial photographs of the study reach. Contiguous areas were grouped by dominant characteristics, namely habitat type, height class, and density. Tree habitat was categorized by dominant average height and subdivided into 20% increments by upper canopy density. Mojave riparian forest dominates the study area. It consists of willows and cottonwoods with a dense understory that adds species composition and structural diversity.

To determine habitat that could be cleared with the least impact, a series of five priorities were established in conjunction with the resource agencies using the agreed upon environmental objectives (Figure 1).

Priority 1—Non-native vegetation, bare sand, or open water without well-established marshy or herbaceous vegetation.

Priority 2—Monotypic, isolated, small willows not adjacent to high quality habitat or likely to quickly develop under- or overstory, or provide diversity.
**Priority 3**—Small, isolated stands of medium to tall willows and cottonwoods, not adjacent to water.

**Priority 4**—Large expanses of medium to tall cottonwoods and willows not adjacent to the well established low-flow aquatic community, such as the median sandbar and terraces.

**Priority 5**—Well established low-flow and adjacent marsh habitat, dense willow and cottonwood stands of all heights, and native vegetation or sandbars adjacent to water.

Figure 1. Habitat priorities and minimum clearing alternative.
Mitigation

Because traditional mitigation is often unsuccessful and cost-prohibitive, we investigated alternative mitigation strategies. We focused on factors that limit successful habitat generation to determine whether mitigation funds could be used more cost-effectively to replace the lost habitat functions and values. We considered (1) reducing OHV impacts in critical habitat areas, (2) removing non-native plants along with some low-technology native replanting, and 3) removing cowbirds.

To determine the mitigation required, we first rated each habitat priority for the habitat value it provided (on a percentage basis) in terms of specialized habitat usage (endangered or aquatic-dependent species), diversity, and maturity. We averaged these factors to obtain the average habitat value (AHV) provided by each option and then multiplied AHV by the acreage of each priority habitat impacted.

\[
\text{average habitat value} \times \text{acreage} = \text{habitat units impacted}
\]

To determine the mitigation credit, we rated each mitigation option as to habitat improvement factor (HIU) provided. We then multiplied HIUs by acreage to be improved and obtained habitat benefits derived.

\[
\text{habitat improvement factor} \times \text{acreage} = \text{habitat units derived}
\]

Since this was an interim FMP, we included each mitigation option in our mitigation plan to demonstrate the effectiveness of each in terms of habitat improvement and cost. We also provided for monitoring and the subsequent opportunity to revise relative habitat values and mitigation credit based upon observations. Preliminary costs for the 14 acres impacted by the IFMP total $25,000–$40,000. Traditional mitigation costs substantially vary, often between $10,000 and $60,000 per acre.

Plan Formulation

Only flood control measures that could be implemented by the 1994 rainy season were identified. Structural alternatives (levee setbacks, extensive armoring) could not be implemented within that time frame and so were dismissed from consideration. Clearing remained as the most viable alternative for flood protection.

The primary objective was to develop the least-damaging practicable alternative by removing habitat only where necessary, depending upon acceptable flood risk. Residential flooding poses a significant threat to loss of life and property; closure of interstate highways poses significant impacts to residents and the local economy. It was agreed that areas adjacent to these structures required immediate and greater protection. Open space, riparian, or even agricultural flooding poses a lesser threat, and so environmental considerations were weighted higher in these areas.
The priority map was used to determine the least-damaging clearing plan that also restores the channel capacity needed to protect critical areas from flooding. The habitat priorities ranged from environmentally sensitive areas (dense markings on Figure 1) where channel clearing was to be avoided, to less sensitive areas (lightest areas) where channel clearing was less objectionable. The hydraulic analyses indicated that clearing only the low priority areas would not achieve the required capacity and that selective clearing of higher priorities was required in certain areas. We then varied the extent, type, and location of clearing the original proposal to determine the preferred alternative. In many areas, the preferred environmental alternative overlapped the hydraulic performance requirements. This simplified plan selection.

Hydraulic Analysis

The Mojave River is a highly dynamic stream with a relatively flat slope where degradation and aggradation of ± 1.5 (5 ft) occur as long-term trends. At low flows, the planform is braided and at high flows, a single channel exists. A HEC-2 model was developed and used to determine the existing channel capacities and vegetation impacts associated with different floods. The model was adjusted to reproduce high water marks for a discharge of about 15,000 cfs. The geometry was based on recent topography adjusted for the scour and fill during recent flood activity.

Clearing alternatives were analyzed for their relative effectiveness in meeting environmental and flood protection needs for a series of n-year discharges. The effect of various channel clearing alternatives was estimated by adjusting Manning's n-values in combination with the HEC-2 channel improvement routine (CHIMP).

Implementation

Developing an acceptable IFMP required cooperation among agencies and disciplines. With early and continued discussion, we defined mutually acceptable goals, priorities and plans. Engineers and environmentalists developed a greater understanding of respective needs and limitations, compromising where necessary to protect life and property at immediate risk and to conserve environmental resources. Compromise was aided by the understanding that a balanced long-term plan for the river would be developed upon IFMP completion.

We developed the IFMP in four months. The District used it to supplement their Clean Water Act 404 permit and DFG 1601 Streambed Alteration and RWQCB 401 Certification applications, and permits were issued in March and April 1994. Since nesting season was approaching and it was a dry winter, implementation was deferred until September. It was completed in one month for $135,000. Plan effects are being monitored to develop more effective mitigation measures and to provide additional data for model calibration.
We began developing the long-term FMP in October 1994 under a second Section 22 agreement with the District. The draft is scheduled for November 1995. It will be dynamic and will include mitigation and monitoring. The District will submit it with their applications for long-term permits, which are feasible because we will provide the resource agencies an annual opportunity to monitor progress and refine the FMP.

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EVALUATION OF RESTORABLE SALT MARSHES IN NEW HAMPSHIRE

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Introduction

The purpose of the study was to inventory and evaluate non-natural restrictions to tidal flow in the vegetated tidal marshes (salt marshes) of New Hampshire. The study focused on restrictions to tidal flow because the daily flux of seawater is the life blood of a salt marsh. When impediments to tidal flow are created, profound changes take place; marshes may degrade to the point where they no longer provide their characteristic suite of functions and values, such as wildlife habitat or visual/aesthetic quality. If restrictions are severe enough, marshes may be replaced by brackish or freshwater wetlands, usually of lower ecological value.

In New Hampshire, salt marshes are found along the state’s 18-mile Atlantic coast, along the Piscataqua and Cocheco Rivers, and around the Great/Little Bay estuary and its tributaries. A recent estimate by NRCS, based on soil mapping conducted by the NRCS as part of the National Cooperative Soil Survey Program, shows approximately 6,200 acres of salt marsh in New Hampshire.

Although from a distance salt marshes appear to be flat, featureless meadows, this is deceiving. These marshes are, in fact, complex ecosystems...
delicately balanced between marine and terrestrial environments and are the primary grassland ecosystem in the Northeast. They have adapted to a part of the landscape that regularly undergoes dramatic changes in salinity, water level, and temperature.

Salt marshes occupy only about 0.1% of the entire area of New Hampshire. For their rarity alone they are a valuable natural resource, but the benefits derived from these wetlands go well beyond their scarcity. Native Americans regularly hunted and foraged in tidal marshes taking fish, shellfish, birds, and other wildlife. With the arrival of European settlers, salt marsh grasses were harvested for use as hay and animal bedding. Modern day residents benefit from the wildlife habitat, aesthetic quality, shoreline anchoring, and other functions that salt marshes still provide.

Unfortunately, many salt marshes in New Hampshire have been degraded by human activity. Probably the major cause of deterioration has been the construction of roads and other impediments to tidal flow. These restrictions, often coupled with increased freshwater inputs from urban runoff, have resulted in a decrease in soil salinity which, in turn, has resulted in dramatic changes in the plant community of affected marshes. One indicator of this change has been the spread of common reed (Phragmites australis), purple loosestrife (Lythrum salicaria), and narrow leaf cattail (Typha angustifolia) into salt marsh communities typically dominated by salt meadow cord grass (Spartina patens). These invasive species, which have a low value for wildlife, tend to dominate and eventually crowd out the characteristic salt marsh vegetation, reducing the overall value of the marsh.

**Study Methods**

Potentially impaired salt marshes were identified using the digitized NRCS soil survey data for Rockingham and Strafford Counties and the U.S. Geological Survey quadrangle maps of the area. These data were supplemented by the Soil Survey of New Hampshire Tidal Marshes (Breeding et al., 1974) and the mapping associated with the Phase 1 Report of the New Hampshire Coastal Wetlands Mapping Program.

Each site was field visited to evaluate the current status of the plant community. The type of plants present, the degree of encroachment by invasive species, the apparent trend of deterioration, and the dominant surrounding land use were noted.

From the initial inventory of approximately 100 restrictions and their associated marshes, 84 sites were selected for further evaluation. For these marshes an engineering survey relating the size and shape of the opening(s) to the elevation of the marsh was conducted.

A simplistic hydraulic model was developed to analyze the relative restrictiveness of the surveyed openings. The model evaluated an opening’s capability to pass a tide which rises to a National Geodetic Vertical Datum (NGVD) elevation 5.0, a tide which can be expected to occur or be exceeded on about 10 days every month. Where openings and restrictions were in series, a storage routing routine was utilized to evaluate the segments of...
marshes and restrictions as well as the entire system's interactions through the evaluation tide cycle.

From this analysis, 50 openings were found to be restrictive to the passage of the evaluation tide. Recommended corrective measures and associated cost estimates were developed for 39 of the 50 restrictive openings. Of the remaining 11, six were determined to be impractical to modify, four were found to need further study before a recommendation could be made, and the restrictive effect of one site will be offset if an adjacent restriction is enlarged.

A conceptual cost estimate (for comparative purposes only) was developed for each recommended measure based on materials judged to be best suited for each site. The cost estimates assume installation by competitively bid contract and do not include engineering design, contract administration, land rights, utility modification, or monitoring.

Each restriction and associated marsh segment was evaluated with respect to the economic and social factors that might affect its potential for restoration. The evaluation considered two primary elements, flood potential and land rights. The flood potential evaluation considered the probability that a structure (building) located near the marsh would be flooded should the restriction be removed. The land rights evaluation considered known objections by landowners/abutters to the removal of restrictions, the need for structural relocation in order to remove restrictions, and the general probability of induced flooding.

A relational database was used as the repository of the physical and analytical data collected and developed.

Salt marsh restoration maps were produced using digital geographic data from several sources. The salt marsh and coastal layers were derived from the National Cooperative Soil Surveys digitized at Complex Systems Research Institute, University of New Hampshire, from source maps at a scale of 1:20,000. Corrections to the derived salt marsh layer to reflect current land cover conditions and the digitization of restriction sites were done at the NRCS office in Durham, New Hampshire. The USGS provided transportation network data digitized at a scale of 1:24,000. The maps were produced using Geographic Resource Analysis Support System (GRASS) software.

Study Findings and Recommendations

The study found that there are numerous locations in New Hampshire where salt marshes have been degraded, at least in part, due to restrictions to tidal flow. Estimated restoration costs range from less than $100 per acre to over $25,000 per acre. Before any restoration effort is undertaken, other factors not addressed in detail in this report should be considered, including the impacts on flooding from any modifications to the restrictions.

The primary product of the study was a document for use by resource planners that contains digitized maps locating restrictions and tables giving recommended corrective actions, acres benefited, and approximate costs. NRCS plans to provide technical assistance to individuals and towns and
other units of government interested in correcting restrictions to tidal flow in New Hampshire.

The study found that there are 50 locations where non-natural restrictions impact the daily flux of the tide. These restrictions, many of which have been in place for years, affect over 1,300 acres, approximately 21% of the total remaining salt marshes in New Hampshire.

Of the 50 restrictions, 45 are located along the Atlantic Coast and impact approximately 1,214 acres (93% of the total) while five, affecting about 98 acres, are located along the Piscataqua River or within the Great/Little Bay estuary. Hampton and Rye contain the largest number of restrictions and affected acreages.

Town road crossings are responsible for the greatest number of restrictions, 22, although the acreage affected, 366, is much less than that affected by state-maintained highways. The state highway system is responsible for 15 restrictions (583 acres), most of which are located on Route 1A as it winds its way up the New Hampshire coast. There are also several farther inland along the state-maintained U.S. Route 1 corridor.

Railroad crossings are responsible for four of the restrictions (257 acres) with private roads or others responsible for nine (105 acres).

There is still much to learn about the response of salt marsh ecosystems to restoration, and because it takes time for marshes to recover from the effects of tidal restriction, it is essential to monitor restored sites over the long term. At a minimum we suggest that data be collected before the restoration project and in years 1, 5, and 10 after completion. A standardized data collection form will be developed for this monitoring.

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When we took over this country from the native Americans, about 220 million acres of fully functioning wetlands were an integral part of the national ecosystem. To build and support a growing country we converted over half our wetland heritage to other uses. We used and enjoyed water purified by wetlands, while filling them to have level places to build our cities and industrial might. We built levees and reservoirs to protect our artifacts from floods while draining the wetlands that used to serve the same purpose. Draining wetlands and harvesting the stored nutrients in the rich organic soils has made American agriculture what it is today.

Study after study is showing the importance of wetland systems for protection of water quality, flood control, groundwater recharge, etc. The National Academy of Sciences' report, *Wetlands: Characteristics and Boundaries*, issued two weeks ago today, did a good job of summarizing the values of wetlands to today's society. The public also recognizes their importance. Restoration of wetlands in many areas is the most efficient way to supply the variety of services provided by a naturally functioning wetland ecosystem. On floodplains, the restoration of wetlands, floodplain forests, and other less intensive uses are important ways to lessen damage from future floods. But just abandoning cropping or planting trees does not a fully functioning floodplain forest make. To realize the full benefits of floodplain restorations, it is generally desirable to restore the original hydrologic regime. Data summarized by Mitsch (1993) show that the rate of timber production on seasonally flooded floodplain forests is about five fold that of a forest remaining on a drained wetland or one that is flooded a higher percentage of the time.

No matter what happens as part of the current debates on the Clean Water Act and Farm Bill, conversion of valuable wetlands will continue and the degradation of remaining wetlands will continue unless more emphasis is put on proactive programs to restore critical wetlands that have been lost and better manage those that remain. Over 75% of our remaining wetlands and nearly all the sites where wetlands can be economically restored are in
private ownership. Significant acres of wetlands and the valuable functions they provide can only be recovered through the voluntary efforts of the owners of private and corporate lands.

Given the information and incentives, private landowners will manage and restore wetlands for their benefit and the public's benefit. Over 14,000 individual landowners have voluntarily restored nearly 250,000 acres of wetlands and associated upland habitats during the last eight years under the Fish and Wildlife Service's Partners for Wildlife program. Only providing technical assistance and part of the construction funds, in several states the program has long waiting lists of landowners wanting assistance. In New York state alone there are over 1,300 landowners waiting for help.

Landowners owning nearly a million acres of wetlands and restorable wetlands in cropland offered to sell permanent easements to government under the U.S. Department of Agriculture's Wetland Reserve Program during the first two pilot signups. Funds were available to purchase only about 125,000 acres. During the last signup, when only 75,000 acres in 20 states could be accepted, landowners offered nearly 600,000 acres. From now on the program will now be available in every state and areas of degraded wetlands in pasture, range, and forest land, as well as in cropland, will be eligible. A real emphasis is being put on working with states on setting priorities for what areas to accept and to use state and local resources multiply the benefits of the program. There is also a plan to give a $400-per-acre bonus in some priority areas.

**Wetlands Conservation Alliances**

I serve as director of the National Wetlands Conservation Alliance (Alliance). Administratively supported by the National Association of Conservation Districts (NACD), the Alliance is a partnership of commodity, environmental, and conservation organizations and government agencies working to build a broad base of support for wetlands restoration and conservation programs.

The objective of the Alliance is to demonstrate to private landowners that wetlands are useful and beneficial natural resource assets that can be successfully integrated into management operations on private lands. We work on developing, and encouraging others to develop, clear and consistent messages to enhance landowner recognition of wetland values and to provide needed technical and financial help to restore, protect, and enhance wetlands on their lands. Our vision is for informed landowners voluntarily deciding to protect and manage existing wetlands and to restore and enhance drained and partially drained wetlands as part of their comprehensive land management plans.

To obtain the necessary coordination to make this happen, state and local wetland conservation alliances are needed. We are working to encourage alliances in every state. The Oregon Wetlands Conservation Alliance is well underway and alliances in Arkansas and Ohio will be holding a series of workshops this summer. I have recently sent information on forming wetlands
alliances to individuals in nearly 30 states. If you are interested in helping in your state, give me a call.

Motivating Landowners to Restore Wetlands

Many private landowners will restore wetlands and other natural habitats if (1) it will increase their net annual income from the land or their business; (2) they can sell the land, or an unneeded portion of the land rights, for a profit; or (3) they believe that as good stewards of land it is the right thing to do and they can afford to do it. Most commonly it is a combination of all three factors. In working to convince your corporation to undertake a wetlands restoration project you need to be sure all facets of these three justifications are considered.

To Increase Net Annual Income

Restored wetlands and woodlands and the wildlife they support make private campgrounds more attractive and profitable. Almost any roadside business, even farm produce stand, can attract more business if it is adjacent to a wetland where the kids can see the frogs and ducks. The Wildlife Habitat Council (Kaplan, 1993) has sponsored several studies that have proven that the development of wildlife habitats and the presence of the wildlife they support on corporate lands significantly increase employee morale and productivity. Wetlands provide a wider variety of wildlife than upland habitats, in addition to the calming effect of water.

There is continual opportunity for income from leasing hunting rights, especially for waterfowl hunting. Near larger cities it is not uncommon for farmers to make more from the duck and goose crop on certain fields than from the corn crop. Obviously wetlands restorations that attract more waterfowl or simply increase the quality of the hunting experience will increase income opportunities. To make direct income from fish and wildlife using natural and restored habitats the landowner is selling a recreational experience. As with any business, there are many factors that must be considered. Most county extension service offices have experts available to help landowners plan recreational enterprises. There are many areas where net farm income can be increased simply by abandoning crop production. Fields or portions of fields that are too wet or flood out frequently may cost a farmer more in fertilizer and seed costs than the crop brings in.

In some areas tax breaks may be available if part of the property is devoted to wetlands. In most areas placing a protective easement on restored habitats will reduce property taxes. Donating an easement to a government agency or a nonprofit organization can often provide significant income tax savings depending on a variety of factors. The Natural Resources Conservation Service (NRCS) has an information sheet being printed that explains some of the options. I am working with a newly formed group of consulting appraisers in Michigan, the Quiet Earth Group, on developing a short publication on these options.
To Sell the Land or a Portion of the Land Rights

Most landowners will sell their land outright or sell easements for restoring wetlands and natural floodplain values if the price is right. The outright purchase of lands by public agencies is probably the simplest way to achieve restorations. It is also the most costly and subject to the most resistance from local governments and farm and business organizations. The purchase of easements for specific purposes is gaining popularity among government agencies and private organizations. The objective is to provide for meeting defined resource goals while keeping the land in private ownership. With landowner stewardship and management of the land, the long-term expense to care for the lands will be much lower.

To Demonstrate Good Environmental Stewardship

If a landowner believes that restoring a wetland is the right thing to do, and it does not cost too much, a wetland will be restored. Landowners will restore wetlands if the perceived value of restoring them exceeds the perceived short- and long-term costs.

Perceived value—Restoration of wetland ecosystems provides a variety of values to the individual landowner and to society. Farmers and other landowners do appreciate the natural environmental amenities provided by wetlands. They do realize the importance of wetlands in preventing runoff from their lands polluting their neighbors’ land or the creek that runs through the town. Information and education activities do need continual emphasis to be sure all landowners recognize the values. And, we need better target information and education activities to adult landowners. We need to put more emphasis on producing informational leaflets that relate to the normal wetlands we want landowners to restore and conserve. We especially need to put more emphasis on educating and informing the state and federal agency and private organization staff that work with landowners on other resource issues.

Short-term costs—Costs of installing restoration structures, blocking drainage ditches, or breaking old drainage tiles to restore the original hydrology are generally quite low. For the over 200,000 acres the Fish and Wildlife Service has helped private landowners restore, construction costs have averaged less than $500 per acre of wetland restored. In almost all cases wetland vegetation suitable to a site will naturally return. Occasionally it may be worthwhile to plant oaks or other hardwood trees to speed succession or to plant particularly attractive wetland plants that might be slow to become established. After restoring the hydrology, unless you intend to manage the restored wetlands intensively for some particular purpose, usually it is best to let nature take its course.

Long-term costs—Both operation and maintenance of the restoration and land costs, including options potentially foregone for future use of the land must be considered. Generally, the operation and maintenance costs for a restored wetland are small. However, land costs, including the option to make other uses of the area in the future, are always a factor. There never
will be enough government funds to pay everyone for easements. Many may not want to sell an easement or do not need a land payment to restore wetlands. Others are concerned that if they improve or restore a wetland they will not be able to make another use of the land in the future or sell the land for another use. Even when they really want a wetland and have no intention of ever draining it, they are hesitant to give up a portion of their land rights.

Several years ago the Corps of Engineers recognized that substantial benefits would be obtained from a restored wetland even if the restoration was temporary. To make it easier to get approval to restore a wetland and to allow undoing of the restoration if the landowner decides to make another use of the land in the future "Nationwide Section 404 permit No. 27" was issued. It allows true restorations and creations to proceed without an individual permit and for the restorations or creations to be undone in the future without the need for a Section 404 permit. To take advantage of this permit, the NRCS must approve the plans to be assured that wetland values are being restored and that preconstruction wetland conditions are documented.

Now we need to work to get state wetlands laws to include the same provisions. I talked a couple of weeks ago with a representative of a Ford Motor Company plant in Michigan. Their employee group is working to restore a wetland on company land. The company is requiring that it be kept under one acre so it will not fall under state regulation and eliminate future options for use of the land, even though it already is in a floodplain.

Conclusion

There is growing public recognition of the value of wetlands and the need to restore some of those converted to other uses, rehabilitate degraded wetlands, and better conserve wetlands for their public values. Private landowners not only own over 75% of the remaining wetlands in the lower 48 states, many of which could benefit from improved management, they also own most of the sites where wetlands can be efficiently restored. Federal and state agencies and private groups run a large variety of programs to help private landowners be better stewards of wetlands resources. Although all of them could accomplish more with adequate funds, closer cooperation and personnel training would make them all more effective in working with landowners.

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CREATING A COMPREHENSIVE WETLAND INVENTORY FOR USE AS A FLOODPLAIN MANAGEMENT TOOL

Jeffrey R. Wood
Greenhorne & O'Mara, Inc.

In 1986 the state of New Jersey enacted the Freshwater Wetlands Protection Act (FWPA). One requirement of this law charged the New Jersey Department of Environmental Protection (DEP) with developing an inventory of freshwater wetlands in the state. MARKHURD Corp. and Greenhorne & O'Mara, Inc. (G&O) were selected to conduct the inventory. MARKHURD Corp. was responsible for quarter quad base map production and digitization. G&O was responsible for conducting the inventory and compiling final manuscripts for digitization. Wetland delineations were performed using stereoscopic interpretation of aerial photography combined with limited field verification. The final digital and hard copy format maps were delivered in May 1995. This comprehensive wetland inventory has proven to be a powerful resource management tool. This paper outlines the tools and methodologies used in the successful completion of this project and discusses some of the many uses of the inventory.¹

Technical Standards

DEP had several technical requirements for the inventory phase of this project. The wetland determination methodology used was that described in the 1989 Combined Federal Manual for the Delineation of Jurisdictional Wetlands. Line placement was required to be within 33 feet of true position on the ground although, using GPS technology, placement accuracy has often proven to be within 10 feet. A minimum mapping unit of one acre was

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employed for all polygonal features. Linear features such as river and streams over 10 feet wide were mapped.

The U.S. Fish and Wildlife Service’s Cowardin Classification System (Cowardin et al., 1979) was used to classify all wetlands including water regimes. A few modifications were made to the system. In the palustrine forested and scrub shrub classes, subclass number eight was added. This subclass represents Atlantic White Cedar (*Chamaecyparis thyoides*), which is an obligate wetland species. An inventory of Atlantic White Cedar habitat was important to DEP because of its high commercial value in the timber industry. Atlantic White Cedar’s distinct signature lends itself to easy identification on color infrared imagery. Use of the forested and scrub shrub eight subclasses allowed a cedar habitat inventory to be embedded in the database. The other change to the Cowardin system was the addition of a modified class. Modified wetlands are wetlands disturbed through human activity, which would revert to jurisdictional wetlands if disturbance or maintenance ended. The modified class included agricultural, disturbed, lawns, and rights-of-way. Because wetlands falling into the modified class are regulated differently than undisturbed wetlands, it was important to include the modified wetlands in the database. The modified classes can be inferred from the Cowardin Classification System.

DEP acquired 1:58,000 color infrared aerial photography (CIR) for use in the interpretation phase of this project. The imagery was quad centered and controlled to meet National High Altitude Photography specifications. CIR imagery was chosen because of its sensitivity to moisture, and thereby surface saturation. Ability to discriminate various levels of soil saturation is particularly important for accurate wetland identification and classification. The photography was flown in late March and early April. Leaf-off spring photography captures the ground surface in its wettest condition, unobscured by deciduous canopy. This imagery was used to generate the 1:12,000 quarter quad format, half-tone mylar photo base maps.

The geographic diversity of New Jersey, and resulting photo signature diversity, demanded that work be carefully organized. The state was divided into five priority areas that reflected its five physiographic regions. Development pressure also influenced the design and ranking of the priority areas. Photo-interpreters maintained high levels of consistency, working in large blocks of similar signatures to completion of the signature group. Before production of a physiographic region began, a photointerpretation key was developed. All imagery for the region was reviewed for consistent signatures corresponding to a variety of wetland types. The signatures were chosen in consultation with local experts and DEP personnel. Agreed upon signatures were then field verified. The key was continuously updated throughout the course of the project to keep it as thorough and accurate as possible. Stereo pairs of the aerial photography with key signatures were compiled with delineation overlays and detailed descriptions of soils, hydrology, and vegetative communities at each site. These signatures were cross referenced to wetlands of the same type across physiographic regions.
The key became a catalog of common wetland signatures throughout the state.

**The Production Process**

The photo-interpreter began the delineation by reviewing all available collateral material. Established key sites were reviewed and referenced to signatures present in the map imagery. Soil Conservation Service maps were photographically enlarged to the 1:12,000 scale of the base maps. Hydric soils and soils with hydric inclusions were color coded for easy reference by the photo-interpreter. U.S. Geological Survey topographic and National Wetland Inventory maps (NWI) were reviewed for general information about the area. Due to the scale of these maps, little detailed information suitable to the production process was available from these sources. The specific photography for the map was then carefully reviewed as the final step before delineation began. At this point the photo analyst was thoroughly familiar with the physical geography and correlating photo signatures.

Delineations were performed using Bausch and Lomb Stereo Zoom Transfer Scopes (ZTS). These instruments were chosen because of several features that make them ideally suited to this task. The ZTS allows the interpreter to match the dissimilar scales of the imagery and the base map. Additionally, the ZTS has an anamorphic correction system, which allows the imagery to be "rubber sheeted" as necessary for an exact match to the base map. The high quality optics of the ZTS allow maximum exploitation of the clear base imagery. Photo-interpreters used stereoscopic analysis to review several terrain variables. These included topographic variations, landform relationships, sizes, and textures. Textural characteristics were particularly important in the differentiation and delineation of vegetation classes. CIR imagery’s responsiveness to differences in infrared reflectance made it particularly well suited to discriminating vegetation types and surface saturation or inundation. Thorough analysis of these variables allowed an accurate draft wetland delineation to be generated.

As the draft delineation was being compiled, the photo-interpreter selected sites to be field verified. Typically six to eight sites were field verified on each quarter quad. Site selection was primarily at the discretion of the photo-interpreter, who considered several factors. The most common sample plots were located in marginal or difficult to classify photo signatures. This was especially true in large, well-established floodplains, where evidence of occasional flooding was present. This flooding was frequently of insufficient duration to support wetland vegetation and therefore, mapped as upland. Anomalous signatures were field verified more than once where possible to ensure consistency of classification.

Field verification teams consisted of the photo-interpreter who compiled the map and a U.S. Army Corps of Engineers certified wetland biologist. Signatures were field verified using the standard Environmental Protection Agency three-parameter approach. Special emphasis was placed on placing data collection points in locations that best exemplified the soils, vegetation,
and hydrology of the photo signature in question. A 75-foot-diameter circle was established. Vegetation was identified and ranked by relative abundance in the herbaceous, shrub, woody vine, sapling, and tree classes. A soil profile at least 18 inches deep was obtained. Characteristics of each soil layer were standard soil texture classifications and Munsell Soil Color Charts. Hydrologic characteristics were visually assessed and identified. Once the data was gathered and analyzed, a Cowardin classification was assigned to the plot. The photo-interpreter then combined on-site analysis of the imagery with known ground conditions to make field annotations to the draft delineation of the site. In addition, the photo-interpreter noted site characteristics not related to wetlands that affect the photo signature, such as fill materials, fire history, and the presence of upland species that give a wetland signature in the aerial photography. Site locations were recorded using a hand-held global positioning system (GPS). The GPS data was post-processed using DEP’s Trenton base station to ensure 5-meter accuracy. This process was particularly important when field verifying areas with few photo-identifiable points. All field data was maintained in a proprietary database developed by G&O.

Following the field verification of a map, the photo-interpreter reviewed the imagery for each site on the ZTS. The draft delineations at each site were revised to reflect the field verification results. The entire delineation was then reviewed and revised as necessary in the context of the data and notations collected in the field. It should be stressed that the field verification was not a postmortem accuracy check but an integral part of the production process. Application of the information gathered during the field verification was critically important to establishing and maintaining map accuracy. All revisions to the maps were made in the context of data gathered in the field. Special attention was given to ensuring consistency in the delineation, and classification of photo signatures throughout the map and the physiographic region. A senior photo analyst then reviewed all delineations as a final quality control measure before submittal to DEP.

Results and Conclusions

The primary, tangible result of this project is a comprehensive inventory of the freshwater wetland resources in the state of New Jersey. The maps have gained wide acceptance and the confidence of public and private users throughout the state. The mapping conventions and final product are tailored to New Jersey’s statutory requirements for regulating and managing wetlands, and the diversity of natural conditions found in the state. The maps have become an important regulatory tool for DEP personnel.

Wetlands are of particular importance to floodplain managers. The role of wetlands in flood prevention is well known. Their ability to absorb and temporarily store large volumes of water can help prevent flooding downstream. Floodplain managers in New Jersey have these maps available in digital and hard copy format. The floodplain manager can combine a
wetland coverage with a digital floodplain coverage to determine which wetlands on which to focus protection efforts.

Long-term research can be done to quantify the correlation between wetland loss and increased flood volumes. Combining these wetland and floodplain coverages with other coverages available in New Jersey could provide additional insight, allowing more targeted and effective land use regulations to be enforced. A combination of the wetland database with succeeding years’ digital ortho quarter quads could be used to efficiently track wetland loss and floodplain development in wetlands. Additionally, the use of the statewide wetland database will allow land use decisions to be made on a watershed wide basis instead of site by site.

Before this project was done, the only wetland maps available to users in New Jersey were the NWI maps. A comparison of NWI maps and New Jersey Freshwater Wetland maps (FWW) reveals a general increase in wetland acreage mapped. Some difference can be accounted for by the use of different wetland definitions and different source materials. The NWI used 1:24,000 base maps and 1:80,000 black-and-white imagery for its mapping effort. Those source materials are not as well suited for mapping wetlands as the 1:58,000 CIR imagery and 1:12,000 base maps used for this project. New Jersey placed much greater emphasis on field verification, especially in marginal areas, than NWI. NWI typically field verified two or three sites per 1:24,000 quad. By comparison, 25 to 30 sites were typically field verified in the same area during the New Jersey production process. This project made extensive use of local experts to tailor mapping conventions to the anomalies of a given region. NWI typically does not recognize or map the MOD classes of wetlands that this project mapped. All these factors account for differences between NWI and FWW.

The use of photo-interpretation combined with limited field verification proved to be an effective method to identify and classify wetlands on a large scale. While maps of this scale do not provide the level of detail necessary to obtain jurisdictional determinations, they do provide the information necessary to make sound land use planning decisions and regulations on a statewide basis. The availability of the database to researchers will allow new investigations into the relationship between wetlands and other variables. The statewide wetlands database has almost unlimited public and private applications. The maps can be obtained in hard or soft copy formats from the New Jersey Department of Environmental Protection Maps and Publications, Bureau of Revenue, in Trenton.

References

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe
Environmental Laboratory  
1987 *Corps of Engineers Wetlands Delineation Manual.* Technical Report Y-87-1, Vicksburg, Miss.: U.S. Army Engineer Waterways Experiment Station.

Federal Interagency Committee for Wetland Delineation  

New Jersey Department of Environmental Protection  

Reed, P.B., Jr.  

Tiner, R.W., Jr.  
Introduction

Land use decisions are made at the local level by lay boards and commissions in the 169 Connecticut cities and towns. Board members need information that is easy to understand and is technically defensible as a planning tool. The Connecticut Department of Environmental Protection (DEP) recognized that need and partnered with the U.S. Department of Agriculture’s Natural Resources Conservation Service (NRCS) to develop a method to evaluate the functions and values of wetlands (Ammann, 1986) for use by people with limited scientific knowledge of wetlands.

This comparative method was devised to (1) evaluate the functions found in each wetland unit, (2) allow for prioritization of wetlands which may have high values and for which more protection may be needed, (3) be the technical basis for protection in conjunction with established regulatory procedures already in place by decisionmaking officials and commission members, and (4) highlight specific wetlands and/or functions of wetlands that may require additional investigation when land use changes are proposed. Since 1988, NRCS has provided five towns and one tribe with an inland wetland database as part of a floodplain management study.

Method

The wetland evaluation procedure is divided into two portions: field investigation and office tasks. The field investigation portion consists of visiting each wetland and recording observable properties, i.e. vegetation, fish and wildlife habitats, ponded water, surface drainage, filled areas, land use, and water quality. The data gathered during the field visit is used to answer questions on the functional value evaluation sheets.

The office tasks portion consists of existing map and aerial photograph analysis, interpretation of soil survey maps, preparation of detailed maps, (i.e., wetland base map, wetland types and land use within a buffer map, and
wetland soils/forestry-agriculture values map), setting the wetland unit boundaries, and completing the functional value evaluation sheets.

The wetland evaluation procedure utilizes simple mathematical and word models to determine the wetland's functional value index (FVI) for each wetland function. This method requires the investigator to compare the existing field condition to the criteria of the model. The FVI for a particular wetland function multiplied by the wetland acreage applicable to that function is the wetland value unit (WVU).

Wetlands are evaluated for 14 functions:

(1) **Ecological Integrity**—evaluates the overall health and function of the wetland ecosystem.

(2) **Wildlife Habitat**—evaluates the suitability of the wetland as habitat for those animals typically associated with wetlands and wetland edge. No single species or group of species is emphasized.

(3) **Finfish Habitat**—evaluates the suitability of watercourses and lakes and ponds associated with the wetland for either warm water or cold water fish. No single species or group of species is emphasized.

(4) **Educational Potential**—evaluates the suitability of the wetland as a site for an "outdoor classroom."

(5) **Visual/Esthetic Quality**—evaluates the visual and esthetic quality of the wetland.

(6) **Water Based Recreation**—evaluates the suitability of the wetland and associated watercourses for non-powered boating, fishing, and other similar recreational activities.

(7) **Flood Control**—evaluates the effectiveness of the wetland in reducing flood damage.

(8) **Groundwater Use Potential**—evaluates the potential use of the underlying aquifer as a drinking water supply.

(9) **Nutrient Retention and Sediment Trapping**—evaluates the effectiveness of the wetland as a trap for sediment and nutrients in runoff water from surrounding uplands.

(10) **Shoreline Anchoring and Dissipation of Erosive Forces**—evaluates the effectiveness of the wetland in preventing shoreline erosion.

(11) **Forestry Potential**—evaluates the potential of the wetland for the production of forest products.

(12) **Archaeological Potential**—evaluates for certain distinguishing signs of previous habitation or use by Native Americans and/or early history.

(13) **Urban Wetland Quality**—evaluates the potential of urban wetlands to enhance their urban surroundings by providing wildlife habitat and other natural values in these (sometimes rare) remaining urban natural areas.
(14) **Noteworthiness**—evaluates the wetland for certain special values such as critical habitat for endangered species, uniqueness, etc..

Each functional value analysis required completion of 8–12 questions about the wetland unit with a comparative ranking system of 0 to 1. Table 1 shows an example of the evaluation results for all wetlands in the study area in terms of FVIs and WVUs.

**Results**

The results of this method provide the city/town with resource information of all wetlands in the project area, a comparative rating system for 14 values, functions and uses of the wetlands, maps ready for digitizing into a geographic information system (GIS), and graphs and tables. This method does not determine which wetland value, function, or use is most important to the community. The community determines importance values. Figure 1 shows an example of a graph that compares the evaluation results of the nutrient retention function for all wetlands in the study area.

**Conclusion**

The wetland database allows the towns to view wetlands as a system rather than looking at each wetland as an isolated unit. Local officials can use the information to set wetland function protection priorities town-wide or within a watershed unit. With a heightened understanding of the resources that exist, the lay members of the land use boards can make enlightened decisions.

**References**

Ammann, Alan P., Robert W. Franzen, and Judith L. Johnson

Table 1. An example of evaluation results of wetlands in the study area.

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<thead>
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| Noteworthiness | 22.30 |
Wetlands Evaluation Study - Abbey Brook Watershed

Nutrient Retention And Sediment Trapping

Figure 1. Sample graph comparing nutrient retention function among wetlands in the study area.
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Section 8

Mapping
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WADING THROUGH THE FACTORS THAT DETERMINE HOW YOUR MAP REVISION REQUEST IS PROCESSED

Maggie Mathis
Dewberry & Davis

Introduction

National Flood Insurance Program (NFIP) maps require changes from time to time as a result of floodplain and watershed changes, flood control and mitigation efforts, or improvements in the techniques used to assess flood hazards. Citizens and local governments play an important role in keeping NFIP maps technically sound and up-to-date as conditions change in their communities.

Map Change Procedures

The Federal Emergency Management Agency (FEMA) responds to revision requests by Physical Map Revision (PMR), Letter of Map Revision (LOMR), Conditional Letter of Map Revision (CLOMR), Letter of Map Amendment (LOMA), LOMRs based on fill (LOMR-F), or informational letter (e.g. deferral letter and best available data letter). Requests for LOMAs and LOMR-Fs will not be covered by this paper.

FEMA now requires that application/certification forms be submitted for all types of revision requests. The application/certification forms have been designed to provide the community and the requestor with guidance in the following areas: the types of revisions that can be obtained from FEMA, the data that must be submitted to FEMA when a revision is requested, and checklists of potential problems that are intended to alert the requestor to commonly made errors and inconsistencies.

The intent of the forms is to ensure that all pertinent data relating to the revision is included in the submittal and to facilitate review of the submittal by FEMA’s Technical Evaluation Contractors (TECs). These forms provide FEMA with the assurance that the data and methodology are based on current conditions, qualified professionals have assembled the data and performed all necessary computations, and all individuals and organizations impacted by the proposed changes are aware of the changes and will have the opportunity to comment on them.
There are three different packages of application/certification forms. The MT-2 form should be submitted with all revision determination types addressed in this paper. These forms must be received before FEMA will issue a determination on a given revision request. FEMA now charges fees to allow for recovery of costs associated with the processing of most types of revision requests under Part 72 of the NFIP regulations. The initial, minimum fees for FEMA’s review and processing of CLOMRs, LOMRs, and PMRs requests can be found in the application/certifications forms. For requests involving a combination of the above, the highest fee will apply. Before a determination will be issued, the requestor will be billed for any actual costs incurred during the review that exceed the initial fee. If the request results in either a LOMR or PMR, the requestor will be charged a fee of $410 per revised panel to cover the costs of cartographic preparation.

Aside from receiving the necessary forms and applicable fees, agreements have been made between FEMA and several state coordinating agencies that state approval must be received before processing of requests in certain states can begin. If in doubt, contact your FEMA Regional Office.

What Kind of Response Can you Expect?

The first question a requestor should ask him/herself is "is the request based on proposed or as-built floodplain modifications?" If the project is proposed, FEMA will issue a CLOMR.

CLOMRs

Revisions to NFIP maps are based solely on existing conditions. In general the effects of proposed projects and future floodplain conditions can not be shown on NFIP maps. However, when requested to do so, FEMA will review a proposed project, such as stream channel modifications, levee construction, or other flood-control projects, to determine the potential effects of the project on flood hazard data presented on NFIP maps. FEMA will issue a letter commenting on those effects and whether a project, if built as proposed, would justify a map revision (LOMR or PMR). Typically, a determination will be issued within 90 days of receipt of all data.

If the request is based on as-built or new/better data than used to develop the effective NFIP map, FEMA will issue a LOMR, PMR, or informational letter. Which of these processing types is chosen is based on the magnitude/nature of the changes.
Physical Map Revisions

Because of the time and cost involved to change, reprint, and redistribute an NFIP map, a PMR is usually processed only when it is necessary to show changes involving a large area of land or increased flood risks. Changes that may warrant a physical map revision include increasing BFEs, adding new Special Flood Hazard Areas (SFHAs) and/or floodways, and enlarging existing SFHAs.

Once review of the submitted technical data has been completed and all applicable changes have been incorporated into the NFIP maps, the maps are issued to the community for review. When PMRs involve new or changed BFEs, the review period is followed by a formal 90-day appeal period, during which the BFEs may be appealed and a six-month period during which the map panels are printed and community ordinances are updated. Typically, requestors can expect it to take approximately 15 months for a PMR with BFE changes to become effective. PMRs without BFE changes are typically processed within one year of the date all data is received.

Due to the costs involved and time frames to make a PMR effective, many map revision requests are now being processed by LOMR or as informational letters.

Letters of Map Revision

LOMRs are particularly well suited to changes that involve only small areas within a community. Typically, LOMRs are used for map revisions that decrease the size of the SFHAs/floodways. However, FEMA will occasionally use the LOMR process to process revision requests involving minor increases in SFHAs/floodways and/or BFEs.

There are four types of LOMRs currently in use:

- **102-D:** This letter is used for cases involving SFHA or floodway decreases but not changes in BFEs. It is also used for graphical changes that do not involve flood hazard information (such as changes to road locations). 102-D LOMRs are effective the day they are issued.

- **102-D-A:** This letter is used for cases involving SFHA or floodway decreases and decreases in BFEs. The LOMR is effective the day it is issued, and a 90-day appeal period is initiated after the effective date.

- **102-I:** This letter is used for cases involving SFHA or floodway increases or shifts but not changes in BFEs. It is not effective until six months after the date it is issued. The community must adopt the revised flood hazard data into its floodplain management ordinances during this six-month period.
• 102-I-A: This letter is used for cases involving SFHA or floodway increases or shifts, and increases or decreases in BFEs. As with the 102-I LOMR, the 102-I-A LOMR is not effective until six months after it is issued. The 90-day appeal period occurs within this six-month period. 102-I-A LOMRs are also occasionally used to add BFEs in areas where BFEs are not currently shown on the maps.

When making decisions regarding the use of these products, the effects of the actions on property owners, and their involvement in the revision process, is taken into consideration. For cases involving increases or shifts in SFHAs, floodways, or BFEs, evidence of property owner notification must be submitted by the requestor or the community before a 102-I or 102-I-A LOMR is processed. For cases in which the number of property owners is too large for such procedures, a map revision or informational letter will be processed.

In some instances, FEMA will allow the processing of 102-D or 102-D-A LOMRs for cases involving shifts or increases; in such cases, the written approval of all affected property owners must be submitted and the appropriate FEMA Regional Office must ensure that the community will remain in compliance with new more stringent requirements necessitated by the LOMR.

Although changes may be made to any of the information shown on the effective NFIP map, FEMA generally will not revise an effective map unless the changes involve modifications to the 100-year floodplain information.

**Informational Letters**

Requests for changes that involve other information, such as corrections to roads, road names, and corporate limits, will usually be filed for future use. If a physical revision becomes warranted at a later date, all requests on file will be addressed at that time.

The three types of informational letters processed by FEMA are:

• Deferral Letter—Letter sent to the chief executive officer (CEO) stating that although the data submitted in support of a revision request are sufficient, FEMA has determined that a revision to the effective FIRM is not warranted at this time and is being deferred to a later date.

• Best Available Data Letter (BADL)—Letter sent to the CEO stating that more up-to-date or more detailed data are available but do not warrant a revision. The letter encourages the community to use the data for floodplain management until a revision is made.

• Informational Letter—Letter sent to the CEO to respond to an inquiry. Such a letter could provide an estimated BFE, explain the
processing of revisions, or correct a typographical error in a study/restudy flood insurance study report or on the NFIP maps.

Deferrals, BADLs, and informational letters are considered letter actions, and the processing of these actions is consistent with that of CLOMRs, LOMRs, and PMRs up to the point of preparation of determination letters. Application/certification forms must be submitted (except for some inquiry cases in which an informational letter may be prepared), and fees may apply. If a request will eventually result in a change to a map, the cartographic fee is applicable, even if a deferral letter or BADL is issued and the map revision will not occur in the near future. Typically, informational letters are issued within 90 days of receipt of all data.
CLOMRS, LOMRS AND HOMRS: AN APPLICANT’S VIEWPOINT

Walter E. Skipwith
Halff Associates, Inc.

C. Jean Hansen
City of Mesquite

Introduction

Flood insurance map revisions frequently are initiated to reflect fill or channel improvements by private developers to create additional buildable land. Increasingly, many communities are faced with a need to amend maps to reflect flood control projects, park and athletic fields in the floodplain, or new bridges involving floodplain, and floodway alterations. This paper addresses several case histories in terms of problems, procedures, schedules, and costs in obtaining Conditional and Final Letters of Map Revision (CLOMRs and LOMRs, respectively) for a variety of public and private projects in North Central Texas. The projects range in scope from mass grading associated with a 100-acre city park to land reclamation by fill on a 2.7-acre commercial site. The five projects are:

- Valley View Park Estates—A cooperative erosion control and reclamation project on Farmers Branch Creek for a private developer and the City of Farmers Branch.
- Andrew Brown Park—A park development project within the floodway of Denton Creek in the City of Coppell.
- Legacy Run—A 16-acre residential subdivision (private) in Plano, Texas.
- Perkins Tract—A private reclamation project in Richardson, Texas.
- Grapevine Creek Drop Structure—A cooperative city and developer project on a previously channelized portion of Grapevine Creek in Coppell, Texas.

Each of these projects dealt with unique problems such as pre-project improvements which had never been submitted or approved by the Federal Emergency Management Agency (FEMA), upstream or downstream...
changes/model updates and corrections which had to be coordinated through [FEMA](https://www.fema.gov) and their review consultant, and [local entity](https://localgovernment.org) and public participation. Several of the projects were in small communities where municipal staff were unfamiliar with [FEMA](https://www.fema.gov) requirements and the final approval process.

**Valley View Park Estates**

This project consisted of design and permitting of erosion control and floodplain reclamation on the east bank of Farmers Branch Creek in an existing residential subdivision. This project was constructed in the early 1980s and some floodplain areas were filled at that time. The development became a victim of the real estate bust and most lots were unsold. Subsequently, a Flood Insurance Study update published in August 1990 (1986 topography) showed a large portion of 10 undeveloped creek lots still in the regulatory 100-year floodplain. In addition, Farmers Branch Creek, a narrow meandering channel, was characterized by eroding channel banks due to high flow velocities. Residents on the opposite (west) bank of the channel had installed erosion control in a piecemeal fashion over the years. The City of Farmers Branch requested that a coordinated erosion control plan be formulated on the east bank as a part of the reclamation project. The "as-built" project consists of stabilization of the left bank by a variety of measures including rock riprap, grass slopes, and vertical retaining walls.

The proposed project was reviewed by the City of Farmers Branch and submitted for a [CLOMR](https://www.fema.gov) in October 1992. This was the first month that the new forms were required by [FEMA](https://www.fema.gov). [FEMA](https://www.fema.gov) requested use of the forms on October 19th and they were submitted within one week of this request. The [FEMA](https://www.fema.gov) review took slightly less than two months and there were no reviewer comments or changes.

The project was constructed through the summer of 1993 and submittal for a final [LOMR](https://www.fema.gov) was made on March 17, 1994. There had been no changes to the original (CLOMR) plan, therefore only Forms 1 and 2 were resubmitted along with geotechnical field density reports and record construction drawings. [FEMA](https://www.fema.gov) also requested a hard copy of the hydraulic model (HEC-2) labelled "as-built." The actual review took approximately two months from the initial submittal. However, there was a delay in paying the additional fees requested by [FEMA](https://www.fema.gov). The review fees for this final LOMR were approximately 40% higher than for the CLOMR. The additional fees were eventually paid in June 1994.

**Andrew Brown Park**

The City of Coppell owns approximately 166 acres of land along Denton Creek near Denton Tap Road and Parkway Boulevard. The park area west of Denton Tap Road is developed into both active and passive recreational uses including softball diamonds and a hiking trail. The 115 acres east of Denton Tap are currently utilized as open space. Both park areas are frequently flooded (by floods less than the 5-year frequency). The purpose of this
reclamation project is to reduce the frequency of flooding in selected high-use areas of the park. The project includes raising three areas out of the 5-year floodplain with a compensating increase in the size of two existing lakes. The natural levee along the Denton Creek channel and the channel itself will be preserved.

Also as a part of this project, inflows into the Denton Creek channel were analyzed. The south bank of Denton Creek bordering the park forms a natural levee that is above the 100-year flood elevation. Overflow pipes with flap gates drain through the levee into Denton Creek. Since the main purpose of this project was to make the park more usable, a low flow analysis was performed. Halff Associates computed water surface elevations for the 2-year flow and for the typical flood control release from Lake Grapevine upstream of the park. The final recommended plan includes building up the one low area along the natural levee and utilizing pumps, when necessary, to facilitate drainage.

This project was originally submitted to FEMA in January 1993. In February 1993, the review of all CLOMRs for the City of Coppell was suspended until the city's Flood Insurance Study (FIS) update was completed. The city had appealed the FIS update on at least three separate occasions. Halff Associates was notified that FEMA had begun the review of this project on March 20, 1993 and the CLOMR was received on May 18, 1993. There were no FEMA review comments or changes to the original submittal. Since this project is to relieve an existing flooding problem for the benefit of the public, there were also no review fees required. Construction of the project is substantially complete.

**Legacy Run 16 Acre Residential Subdivision**

This project involved the channelization of approximately 1000 feet of Stream 5B35 for the reclamation of approximately 1.5 acres of floodplain. Much of this reach had been previously altered when an adjoining street was constructed. The proposed channel will consist of a 20-foot-wide pilot channel with 4-to-1 grassed sideslopes. Upstream and downstream transition areas will be protected by loose rock riprap.

After review and approval by the City of Plano, the project was submitted to FEMA for a CLOMR. The review took just over four months. The only significant FEMA comment was a request for backup calculations regarding the proposed rock riprap sizes. This project also required evaluation using both FEMA (existing conditions) and fully developed watershed discharges because of Plano's more stringent floodplain ordinance. The project is currently under construction.

**Perkins Tract**

This project involved reclamation of a 2.7-acre tract of land on Stream 2C7, a tributary of Duck Creek in Richardson, Texas. The 1.7 acres of floodplain reclamation are compensated for by a proposed swale. Erosion control
measures were also included. Chronologically, the following activities occurred:

12/18/90 Notified FEMA that discharges in effective HEC-2 model did not match discharges in FIS report.
1/11/91 FEMA acknowledges
9/17/91 Richardson approves proposed project
11/21/91 Submittal to FEMA for CLOMR
11/26/91 FEMA acknowledges
12/19/91 FEMA requests additional information
4/28/92 FEMA requests additional review time
5/5/92 FEMA requests additional data, primarily related to an offsite wall, which appeared to confine flood flows to the Stream 2C7 channel upstream of the proposed project. The requested information included:
- structural stability analysis of the wall including seepage and settlement
- certification of freeboard (three ft required)
- as-built construction plans for the wall
FEMA indicated that if the above information could not be provided, the analysis should be revised to omit the wall.
7/16/92 Revised submittal to FEMA, omitting the wall effects.
8/3/92 FEMA acknowledges
8/26/92 FEMA requests additional review time
9/23/92 FEMA requests additional data/analysis
12/31/92 Additional analysis submitted
1/14/93 FEMA acknowledges
2/1/93 FEMA requests additional review fee
2/11/93 FEMA issues CLOMR

This project shows how resolving pre-project problems can significantly delay the CLOMR process. Issues concerning the existence of a wall on an adjoining property probably caused the review to extend an additional nine months. To date, this project has not been constructed.

**Grapevine Creek Drop Structure**

Grapevine Creek is a tributary of the Elm Fork of the Trinity River. The creek enters the City of Coppell from the south at IH 635 (LBJ Freeway) and flows in an easterly direction for six miles to its confluence with the Elm Fork on the Coppell/Irving corporate boundary. This project consisted of obtaining a final LOMR for channelization, a new bridge structure, and a drop structure immediately downstream of IH 635 to Southwestern Boulevard (approximately a 1.0-mile reach of Grapevine Creek).

The channelization and bridge (Freeport Parkway) were constructed in the early 1980s by a previous owner for industrial development. A "belief letter" (CLOMR) or LOMR was not obtained prior to or immediately after this construction. A subsequent property owner’s application for a Final
LOMR was refused by FEMA due to unstable channel conditions (excessive velocities) upstream of the Freeport Parkway bridge in the transition to the natural channel. Since a LOMR could not be issued for the existing channelization, the City of Coppell would not issue building permits for the tracts along the channel.

In March 1987, additional data was submitted to FEMA that included a proposed drop structure to control erosive velocities in the upstream reach of the previously channelized portion of Grapevine Creek. The entire project received a CLOMR in August 1987, stating that the proposed drop structure would create stable channel conditions during flood events. The drop structure was constructed in 1991 and a final LOMR was received in December 1991. Industrial development is underway at this site.

Conclusions

Several lessons can be learned from the events and consequences surrounding these five LOMR projects.

- Time frames for approvals of CLOMRs can be shortened by making complete submittals for well-designed projects.
- Time frames for approvals of CLOMRs can be lengthened for incomplete projects or those projects with pre-project improvements which have significant unknowns and have not been a part of a previous LOMR.
- Public entities in general are not exempt from FEMA's LOMR requirements and should program time and money for these efforts into projects that may impact the floodplain.
- Fees are now required for both CLOMRs and LOMRs. These fees are subject to increase and waivers are harder and harder to come by.
- Applicants should budget adequate time and money for LOMR and CLOMR submittals.

A Word About HOMRs

A HOMR (Headache of a Map Revision) is any application that either the applicant, FEMA, or its reviewing consultant regret ever becoming involved with. One example is the Richardson project mentioned here, which took 14 months to secure the CLOMR. Another might be the $400,000 floodplain study submitted by a municipality for a LOMR but rejected by FEMA for failure to meet various National Flood Insurance Program criteria, such as existing land use hydrology. The recommendations contained in this paper are intended to help minimize the occurrence of HOMRs.
AUTOMATED FLOODPLAIN MODELING AND DELINEATION USING CAD

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Introduction
By integrating the HEC-2 water surface profile program with computer-aided drafting (CAD) software, BOSS International has developed an integrated system to automate water surface profile modeling and floodplain delineation. Using AutoCAD, HEC-2, our digital terrain modeler, and ADS (AutoCAD Development System) programming, we developed a computer software program that allows an engineer to quickly develop a water surface profile model. The software will analyze the HEC-2 model and display the computed profile on a topographic map, with a precise delineation of the flooded area.

Development of this application started in 1989, after recognizing a market need to marry CAD technology with our existing hydraulic and hydrologic engineering software. Initial release of BOSS HEC-2 for AutoCAD as a commercial product was in January 1992. Continued improvements, enhancements, and updates have been added since then.

HEC-2 Modeling Capabilities
Complete support is provided for all of HEC-2’s modeling capabilities, including special bridge, special culvert, floodplain encroachments, subcritical and supercritical flow, normal bridge, split flows, channel improvements, and imperial and metric units. Support of importation and exportation of HEC-2 models is also provided. If desired, the user can link pre-existing HEC-2 data sets to topographic maps, thereby allowing a pre-existing HEC-2 model and its water surface profile analysis results to be shown on the topographic map.

Modeling Data Input
All data entry is performed through easy-to-use menus and straightforward data entry dialog boxes. This allows an engineer to quickly become proficient at using the application. Very little knowledge of AutoCAD is required, and limited knowledge of HEC-2 is necessary. An example dialog box used to define the cross-section overbanks is shown below.
Data input for defining the HEC-2 model is very flexible. For example:

(1) Cut cross-sections by simply drawing a line across a 3-D digital topographic map, with elevations automatically determined by the software where the cross-section cut crosses the contour lines.
(2) Cut cross-sections from either a paper topographic map, 2-D digital topographic map, 3-D digital topographic map, or 3-D TIN (triangulated irregular network).

(3) A topographic map is not required, but can be added at any time to the model, if desired. Cross-sections can be provided by importing HEC-2 files, XYZ point files, station elevation files, Northing-Easting files, or downloading data from a surveying total station or data collector.

(4) Complete and partial HEC-2 data files can be imported. Up to 100 HEC-2 models can reside within a single AutoCAD drawing.

(5) The user can construct a cross-section by stitching together sectional data from multiple and differing sources. For example, the overbank sectional information may be determined by digitizing the topographic map, whereas the channel sectional information may come from field measurements from a survey of the channel.

(6) Up to 400 station-elevation ground points are allowed per cross-section.

(7) A cross-section geometry ground point reduction feature is provided. It uses published Federal Emergency Management Agency (FEMA) methodology (1993, p. A4-12), allowing the user to specify the maximum number of ground points allowed at a cross-section. The program will intelligently remove ground points in accord with FEMA guidelines, eliminating those that add the least resolution. A graphical preview of the original and revised geometry is provided, allowing the reduction rules to be altered if needed.
(8) A built-in hydraulic calculator is provided, allowing the user to instantly compute normal depth, normal discharge, critical depth, critical discharge, critical slope, flow area, average velocity, hydraulic radius, wetted perimeter, and other hydraulic properties for any defined cross-section. Once these properties have been computed, they can be placed into the drawing adjacent to the cross-section or printed out.

![FlowCalc Normal Discharge Results](image)

### Analysis Output Capabilities

Once a HEC-2 analysis has been performed, output results are easily displayed on the cross-section plots. Single or multiple profiles can be displayed on the same cross-section plot, with complete control over plot scale, grid size, axis graduation, line styles, and line colors.

In addition to cross-section plots, the program can automatically create profile plots. Single or multiple profiles can be displayed on the same plot. Plotting multiple profile results on the same profile plot helps the engineer compare results from different flow discharges. As with cross-section plots,
complete control over profile plot scale, grid size, axis graduation, line style, line colors, and line symbols is provided. In addition, all bridge, culvert, and roadway structures can be displayed on the profile plots. This helps the engineer determine for which discharge a particular bridge structure begins to experience pressure flow. Channel improvement inverts are also displayed.

The software can automatically "slice up" the length of river being modeled into standard-sized profile grids, if desired. This allows the user to quickly create usable profile plots for any length of river.

Digital Terrain Floodplain Mapping

Inundation maps can be quickly created, displaying a precise edge of water intersection with the topographic map. The edge is computed using our digital terrain surface modeler, by computing a digital terrain model (DTM) from the topographic map information and the computed water surface profile.

The program automatically develops the floodplain mapping in a fashion to comply with the digital mapping standards of the National Flood Insurance Program (NFIP) (Federal Emergency Management Agency, 1993, p. 9-9).

A 3-D TIN is created from the provided 3-D contour map using the Delauney triangulation method. Existing TINS can be directly processed, as well as 2-D contour maps, although some user interaction is then required. The digital terrain modeler is fast and accurate, processing over 100,000 points per minute on a Pentium 90 mHz PC, with a numerical accuracy of 16 decimal places. The number of points in the surface model is unlimited; users have created models with several million control points on the PC platform.

Benefits of Automated Mapping

• Identification of shallow flooding areas. These help the user to quickly identify ineffective flow areas that could be used for future development.
• Identification of "land bridges," which may require additional cross-section cuts to be performed to properly define these ineffective flow areas. This prevents the engineer from being "under-conservative" (computed water surface elevation lower than the actual), since these areas can be removed from the conveyance calculations.

• Interactive, real-time tracking of the computed water surface elevation and flow depth.

• Contouring of the computed water surface elevation and flow depth.
• More accurate HEC-2 modeling is obtainable, since the computer can instantly update the floodplain map.

• It is much easier to calibrate a HEC-2 model, since the user can quickly compare the computed water surface elevation with any observed flood high water marks, anywhere on the terrain model.

• Better quality of the submitted engineering work. Modeling submission is automatically made consistent with FEMA standards by the software.

• The flow depth contours can be used to estimate the dollar amount of damage due to flooding of cropland and structures.

• The effect of levees and floodwalls is recognized by the software in computing the extent of the flooding.

Significant economic savings are possible, due to (1) reduced human error in modeling and floodplain delineation, (2) decreased time required to complete a floodplain study, and (3) significantly reduced engineering labor costs. Further savings can be realized by using remote sensing and GIS coverages, which lowers the cost of acquiring up-to-date field data.

Future Capabilities
Linkage with ESRI’s ARC/INFO and ArcCAD GIS is being developed. ARC/INFO and ArcCAD will act as the underlying data source to this application, vastly speeding up and simplifying the data retrieval for creating, updating, and maintaining floodplain maps. A pilot study of this capability was performed by the State of Wisconsin for automating HEC-2 model retrieval and mapping for the southern one-third of Wisconsin (Luloff, n.d.).

Work is in progress to couple this interface to HEC-2’s river analysis system (RAS) with forward and backward links to HEC-2. This will allow users to import, model, and export HEC-2 or RAS models. Support for other models, such as the U.S. Geological Survey’s WSPRO water surface profile model, is also being considered.

Conclusion
Integrating HEC-2, AutoCAD, and our digital terrain modeler has provided an easy-to-use yet powerful user interface for automated floodplain mapping. This application saves a great deal of time and expense in performing, submitting, and reviewing HEC-2 water surface profile models.

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INNOVATIVE USES OF DIGITAL TECHNOLOGY IN FLOOD INSURANCE STUDIES
TEST CASE: THE SCHUYLKILL RIVER

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Introduction

As of fiscal year 1995, the Federal Emergency Management Agency (FEMA) requires that all study contractors submit Flood Insurance Study (FIS) results in digital format; this includes Digital Flood Insurance Rate Map (DFIRM) files. Initially, there were concerns that this new digital requirement would cause contractors to incur additional costs, which would inevitably be passed on to FEMA. However, a review of existing digital technologies, including geographic information systems (GIS), by the Flood Plain Management Branch of the Philadelphia District, U.S. Army Corps of Engineers (COE) found that the cost of producing digital floodplain information could be maintained and potentially decreased.

Background

Traditional Digital FIS Methodology

In general, contractors' initial response to FEMA's requirement for digital submissions was reactionary. Initially, very little change occurred in the process of producing DFIRMs. The floodplain boundaries were hand-drawn on hard copy base mapping. The maps were then scanned, vectorized, and coded to meet FEMA specifications. The sole purpose of the last three steps is to convert the data into digital format, which introduce additional time and money to conduct a FIS under the new requirements. Despite these added costs, the majority of studies are still prepared by most contractors using these traditional methods.

Schuylkill River Project

The Philadelphia District chose the Schuylkill River Type 19 FIS as a pilot project for a new proactive response to the digital requirement. The
The Schuylkill project was approached digitally from start to finish, thus eliminating the need for the digitization steps mentioned above.

The study area covers 120 miles of the Schuylkill River, affecting 55 communities in five Pennsylvania counties. At its mouth, the Schuylkill River supports a drainage area of approximately 1900 square miles.

Preliminary Project Preparation

Initial efforts were geared towards acquiring the necessary hardware, software, and knowledge to effectively work in a GIS environment. Arc/Info was selected as the GIS software of choice and was loaded onto Sun workstations. Two full-time positions were established to focus on GIS-related work, including the production of DFIRMs.

Methodology

Data Collection

Whenever possible, data for this project was collected in digital format using photogrammetric processes. Specifically, the following digital data was collected for the entire study reach: a triangulated irregular network (TIN), digital orthophotographs, and digital base mapping (transportation network, hydrography, and political boundaries). This information was collected for a corridor along the river that was specified to assure complete coverage of the anticipated 500-year floodplain. The TIN (also commonly referred to as a digital terrain model (DTM)) is an irregularly placed set of points with x, y, and z (elevation) coordinates are compiled in such a way as to provide a 3-D representation of the ground surface. The TIN was specified to assure 4-foot contour accuracy according to National Map Accuracy Standards.

Not all data could be collected in digital format due to technical limitations of photogrammetry. Certain information, such as bridge geometries and river channel sections (bathymetry), is not attainable from aerial photography. Bridge measurements were acquired either from existing hydraulic models and plans or were field surveyed. Bathymetry presented a more complex problem requiring a more sophisticated solution.

Data Pre-processing

Acquisition of channel sections posed a significant dilemma. Existing channel sections were available for only a limited number of distinct locations throughout the study reach. The hydraulic model would be limited to cross section locations where the channel geometry was known, unless significant efforts were made to manually interpolate these existing channel sections into the selected valley cross sections. Obtaining large numbers of field surveyed channel sections was cost prohibitive for this project. To address this problem, an Arc/Info application, called CHANNEL, was developed jointly by the COE and Greenhome & O'Mara, Inc (G&O). CHANNEL requires the following input: a TIN (without river channel information), digital files...
depicting known river channel locations, and the corresponding river channel geometries compiled in an HEC-2 input file format. CHANNEL uses this information to develop a continuous composite TIN with surface representation both above and below the water surface.

**Hydraulic Modeling**

The compilation of the hydraulic model (HEC-2) was largely automated by CROSS, an Arc/Info application developed by the Philadelphia District. CROSS allows the user to directly access the TIN for selection of river cross sections. CROSS displays contour information, overlaying an orthophoto backdrop, for the user. Using this information, the user selects the layout of the cross sections to be used in the HEC-2 model. CROSS allows cross sections to be sampled along any chosen line, whether it be straight or "dog-legged." CROSS samples points (i.e., station/elevation pairs) from the TIN at a user-specified distance interval. CROSS is also equipped with a filter, based on a user-specified break in grade, which helps to eliminate points that are not critical to the section's geometry (e.g., redundant points in modeling a single slope).

CROSS creates an ASCII output file which contains the river cross section data in HEC-2 input file format (i.e., X1 and GR cards). CROSS also provides X1 card variables including a section identification number (SECNO), the number of stations on the following GR card(s) (NUMST), the left and right bank stations (STCHL, STCHR), and the overbank reach lengths (XLOBL, XLOBR, XLCH). SECNO is set equal to the centerline stream stationing of that cross section from a user-specified base marker (usually station 0 at the river mouth). The channel markers are estimated as the station at which the cross section intersects the digital streams banks, which are part of the digital hydrography coverage. The reach lengths values are all set equal to the centerline stream distance from the closest downstream cross section.

Using the CROSS output file as a framework, a continuous HEC-2 hydraulic model was compiled for the entire study reach. Data not supplied by CROSS was added to the preliminary HEC-2 model including title cards (T1-9), control cards (J1-6), river discharges (QT cards), bridge data (X2, SB, SC, and/or BT cards), and Manning's coefficients (NC cards). The HEC-2 model was then refined using standard modeling and calibration methods. Likewise, a floodway was established using the HEC-2 program.

**Digital FIRM Compilation**

The floodplain mapping was automated using DFMAP (formerly named DFIRM), an Arc/Info application developed jointly by the Philadelphia District and G&O. DFMAP requires the following input: a surface model (i.e., TIN) of the river valley, a digital coverage of the modeled cross sections' orientations and locations (i.e., the coverage generated using CROSS), and the computed 100- and 500-year water surface elevations at
each cross section (in the format of a HEC-2 TAPE96 output file). Using this information, DFMAP generates a digital "terrain" model of the 100- and 500-
year flood water surfaces. These surfaces are based on the HEC-2 computed water surface *elevations*, rather than ground intersection stations (i.e., the SSTA and ENDST variables). These water surfaces are then intersected with the original DTM of the ground surface. Any point within the model limits at which the water surface elevation is greater than the ground elevation is considered to be inundated by the computed flood. DFMAP then delineates the maximum extent of the inundated areas to establish the floodplain boundaries.

DFMAP also uses the HEC-2 generated water surface elevation information to generate the base flood elevation (BFE) lines. DFMAP generates "contours" of constant water elevations at a user-specified interval for the program-generated 100-year flood water surface "terrain" model. These water surface elevation "contours" are added to the DFIRM as BFE lines.

DFMAP produces two output files: the "HYDRO" and "FLOOD" coverages which are generated to meet FEMA’s *Guidelines and Specifications for Study Contractors and Standards for Digital Flood Insurance Rate Maps*. These output coverages are coded with attributes according to Option 3, listed in these guidelines.

In its present state, DFMAP does not map regulatory floodway boundaries. Instead, floodway encroachment stations (i.e., STENCR and STENCL) are marked at each cross section.

**Post-Processing and Delivery**

The floodplain coverages generated by DFMAP were overlayed on the base map and contours, and printed in hard copy, using WORKMAP, an Arc/Info application developed jointly by the Philadelphia District and G&O. These maps were visually inspected for necessary revisions, often based on engineering judgment. The floodway was hand-drawn on the WORKMAP output using the DFMAP-generated markers at each section as a guide.

The hand-drawn floodway was added and revisions were made to the digital floodplain coverages using EDITFIRM, an on-screen editing tool developed by the Philadelphia District. EDITFIRM is a menu-driven application which allows the user to add, modify, and delete lines (e.g., the floodway), points (e.g., elevation reference marks), and polygons in the DFIRM files.

The revised maps were forwarded to FEMA’s technical evaluation contractor (TEC) in both digital and hard copy formats. The Pennsylvania Department of Transportation’s (PenDOT) digitized U.S. Geological Survey quads were provided as the countywide base mapping, since the base mapping generated for this restudy was confined to a relatively narrow corridor along the Schuylkill River.
Results

Benefits Realized

Significant time and cost savings were not fully realized in this "pilot" project. Any savings associated with reduced mapping and digitization efforts were mostly offset by the significant learning process associated with developing and using Arc/Info software and applications. However, despite the training and testing associated with this particular study, the work was completed on schedule within the allotted budget.

The experience and knowledge gained from the Schuylkill River project has already been put to use in subsequent FIS work, leading to reduced costs and increased output reliability. The susceptibility of certain processes to human error, including data collection and mapping, have been greatly reduced. Procedures that were formerly subject to considerable judgment and interpretation, such as floodplain mapping, have been standardized, leading to more consistent, and therefore more "reproducible," results. The software applications have been sufficiently "debugged" to allow more consistent and efficient computer run time. From start to finish, the established workflow provides an efficient process for the production of all future DFIRMs.

The ability to work with digital data has also led to better data management. Digital data is more easily stored and reproduced than the hard copy counterparts. Digital data, including floodplain mapping, can also be more easily incorporated into other GIS applications and databases.

Lessons Learned

At this time, the Arc/Info applications developed under this project have few preliminary error checks. Minor errors in the input data can lead to major program malfunctions. This often leads to time-consuming error checking and debugging efforts. For this reason, it is important that tighter specifications be developed for data collection, including the TIN and other digital layers.

It was found to be very beneficial to document errors encountered while using the applications. Every error was recorded with a history of efforts that were made to correct the malfunction. Notes were made to document the outcome of each "fix," recording whether it was successful or not. This recordkeeping helped to eliminate repeated efforts and to reduce the "down time" associated with program and/or data de-bugging.

Future Work

Application Refinement/Modifications

As a result of user comments and suggestions, many programming refinements and modifications have already been made to the various Arc/Info applications developed under this project. These changes have increased the programs' efficiencies, including pre-process error checking to
determine input data compatibility. Other changes include improved user
interfaces and increased functionality.

Other modifications and additions have been proposed but have not yet
been incorporated. One proposed expansion includes the development of
Manning's roughness coefficient mapping for the study reach, which would
furnish CROSS with the information necessary to provide NC cards to the
preliminary HEC-2 input file. Likewise, river discharge mapping could be
developed by encoding the stream centerline (already required by the
software) with discharge values which could be used by CROSS to provide
QT card information.

Future Work
As stated above, the Philadelphia District now uses this technology in almost
all of its Type 19 and Limited Map Maintenance Program FIS work. The
Philadelphia District has plans to incorporate this technology into other areas
including flood damage identification and analysis, and the development of
real-time flood forecasting/warning systems.

Conclusion
A "start to finish" workflow has been developed by the Philadelphia District
for the production of digital floodplain information, specifically those
intended for incorporation into FEMA DFIRMs. The Philadelphia District's
strategy differs from traditional methods in that the study is approached
digitally from the start. Data for the FIS is collected in digital format,
including a DTM and digital base mapping. Applications were developed for
use in the Arc/Info GIS to automate many procedures, including the
compilation of the HEC-2 hydraulic model, floodplain mapping, and editing
the resulting digital maps. The procedures and applications developed for this
study have led to considerable cost and time savings on all subsequent FIS
work.

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DFIRMS WITH DIGITAL ORTHOPHOTO BASE MAPS

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Dewberry & Davis

Introduction

Digital orthophotos are aerial photographs that have been digitally processed and corrected, pixel by pixel, to remove all distortions so they have the metric properties of a map. They have no contour lines. Until displayed on a geographic information system, or a hardcopy print is made, they have no scale. This variable scale opens the door for cost-sharing among government agencies for the development and maintenance of a common photobase which is standardized and interoperable. Cost-sharing reduces the costs for all involved and accelerates the availability of digital orthophotos for everyone.

Standard softcopy Digital Orthophoto Quarter-Quads (DOQs), produced by the U.S. Geological Survey (USGS), have 1-meter ground resolution and meet National Map Accuracy Standards (NMAS) for 1:12,000-scale (1" = 1,000') maps. The USGS is producing 15,000 DOQs per year and, as they become available, sells countywide DOQ coverage on CD-ROMs for $32 per county. When available nationwide, DOQs will be the most accurate and up-to-date planimetric base maps of the United States. DOQs are already widely used by federal, state, and county governments, industry, and academia; DOQs can be exploited by modern personal computers and popular software, e.g., AutoCAD (v13), ArcView2, and MapInfo.

Where DOQs are available (on CD-ROM from USGS), new digital Flood Insurance Rate Maps (DFIRM-DLGs) (on CD-ROM from the Federal Emergency Management Agency (FEMA)) could be accurately overlaid on the DOQs, reducing concerns about the (in)accuracy and credibility of National Flood Insurance Program (NFIP) products. However, if FEMA does not use DOQs as the horizontal base for DFIRMs, clients will probably overlay the two data sets anyhow; if they do not register correctly, users would question the accuracy of the DFIRM-DLGs, and FEMA's credibility could suffer.

This paper discusses advantages, disadvantages, and options for using DOQs as base maps for DFIRMs so as to improve the horizontal accuracy of DFIRMs and enable simple and direct horizontal determination of individual buildings as either in or out of flood hazard zones.
Advantages of DOQs as Base Maps for DFIRMs

DOQs would provide an accurate image base for key DFIRM roads, streams, bridges, etc. New DFIRMs or DFIRM-DLGs would satisfy NMAS for maps at 1" = 1,000' and possibly even at 1" = 500'. Special Flood Hazard Area boundaries and houses are clearly seen; this should facilitate the assessment of flood insurance rates and promote the sales of flood insurance. DOQs are ideal for accurate placement of Coastal Barrier Resources System (CBRS) boundaries, often delineated by the U.S. Fish and Wildlife Service, to coincide with roads and circumvent the perimeter of developed properties. (Because of federal assistance prohibitions associated with CBRS boundaries, the importance of accurate CBRS boundary placement on any interpretive determination tool provided to the public cannot be overstated.) DOQ base maps should force the resolution of ambiguities or discrepancies which otherwise may not be visible on standard FIRMs or DFIRMs. DOQ-DFIRMs could either include (Figure 1) or exclude (Figure 2) the overprinting of vector road files because road centerlines can be interpreted on DOQ images with relative ease.

Disadvantages of DOQs as Base Maps for DFIRMs

Like all raster images, DOQs can be "unforgiving" and "uncompromising." Raster/vector discrepancies are easily seen, calling for correction of vector deficiencies that may otherwise remain unnoticed and which may in fact be insignificant. DOQs are computer "data hogs." Each DOQ file size is about 55 megabytes, requiring faster computers with large data storage capabilities by Study Contractors (SCs) and Technical Evaluation Contractors (TECs) that simultaneously use numerous DOQs of broad areas in digital form. (Note that this may not be critical to SCs who could use hardcopy printouts of DOQs, but TECs would process softcopy DOQs). Hardcopy DOQ-DFIRMs require different graphic specifications from traditional DFIRMs; dot screens now used for shaded flood zones and floodways would need to be replaced with line patterns to avoid obscuring DOQ image features. DOQ-DFIRM images, overprinted with vector data, appear more cluttered than traditional DFIRMs.

DOQ Utilization Options

Option 1: Printed Image Base

Where standard DOQs are available from USGS, FEMA may choose to utilize DOQs in all DFIRM production and/or revision phases, to include hardcopy DOQ-DFIRM printing by the U.S. Government Printing Office. This option has three sub-options:

- Sub-option 1a: When accurate vector files are available, the DOQ-DFIRM could be modeled after Figure 1, i.e., with road vectors shown and road names annotated. The DOQs would be used to verify that the road vectors are accurate and complete, to make
Figure 1. Hardcopy DOQ-DFIRM segment with road vectors.
Figure 2. Hardcopy DOQ-DFIRM segment without road vectors.
minor corrections to road alignments when necessary, and to correct
the alignment of drainage/flood features to fit the DOQs. The printed
DFIRM would include the DOQ image, and all DFIRM vectors
would be compiled so as to register to DOQ 1:12,000-scale base
maps that meet NMAS.

- Sub-option 1b: When vector files are available but are somewhat less
  accurate than the DOQs, the DOQ-DFIRM could still be modeled
  after Figure 1, but with road, drainage, and flood vectors compiled
to fit the DOQs in or near floodplains only, per current FEMA
policy. The printed DFIRM would include the DOQ image so that
the most important features in or near the floodplains would
correctly register to DOQ base maps.

- Sub-option 1c: When vector files are unavailable or known to be
  very inaccurate (data generated from 1:100,000-scale maps, for
example), the DOQ-DFIRM could be modeled after Figure 2, i.e.,
with road names annotated but without road vectors. The user
would interpret the DOQ image to determine street centerlines.

**Option 2: Unprinted Image Base**

FEMA may choose to utilize DOQs during vector compilation only by
registering DFIRM and DLG vectors to fit the DOQs but not actually
printing the DOQ images on hardcopy DFIRMs. This would solve the
"credibility issue," retain current graphic specifications, and eliminate
concerns that the DOQ-DFIRM may be cluttered and looks different from
current DFIRMs. A DFIRM’s legitimacy would be obvious when the
DFIRM-DLG is computer-overlaid on the appropriate DOQs. Option 2 has
two sub-options, depending on the availability and accuracy of vector base
map files:

- Sub-option 2a: The DOQs might be used at intermediate stages to
  ensure that the road vectors are accurate and/or complete, to make
minor corrections to road alignments when necessary, and to correct
the alignment of drainage and flood features to fit the DOQs. The
printed DFIRM would not include the DOQ image, but all DFIRM
vectors would be compiled so as to accurately register to DOQs
when computer-overlaid by users.

- Sub-option 2b: The DOQs might be used at intermediate stages to
correct the alignment of roads and drainage/flood features in or near
floodplains only. The printed DFIRM would not include the DOQ
image, but DFIRM vectors in or near floodplains would be corrected
so that the most important features would register to DOQs when
computer-overlaid by users.
Option 3: No Use of DOQs

FEMA may choose to avoid the use of DOQs altogether if their use causes a significant increase in production and/or revision costs for DFIRMs.

Conclusions

In prototype tests, Dewberry & Davis has concluded that DOQs can be accurate base maps for either hardcopy or softcopy DFIRMs. DOQs are effective at all scales between 1" = 500' and 1" = 1,000'. Black/white DOQ-DFIRMs can be printed cost-effectively, but the added cost for multicolor printing cannot be justified. SCs could work exclusively with hardcopy DOQs to generate FIRM workmaps, but it would be better if SCs and TECs both exploited softcopy DOQs during DFIRM compilation. However, two key questions (cost of DOQ-DFIRM production, and user preferences) cannot be answered at this time.

Recommendations

A pilot FIS project should be conducted of a county where standard DOQs are available from USGS, to compare Options 1 and 2; evaluate SC and TEC procedures and costs; resolve potential issues; and obtain user feedback on the relative advantages and disadvantages of hardcopy vs. softcopy. Comments and suggestions should be solicited from Association of State Floodplain Managers conference attendees.
GIS-BASED FLOODPLAIN MAPPING 
AND MAP REVISION 
IN LOUISVILLE, KENTUCKY

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Introduction

In 1987, the Louisville and Jefferson County Metropolitan Sewer District (MSD) prepared master plans for the 11 watersheds in Jefferson County, Kentucky. The purpose of the master planning effort was to establish the present and expected future hydrologic and hydraulic characteristics of the creeks and major tributaries utilizing a consistent methodology (HEC-1 for hydrology and HEC-2 for hydraulics). Model input data was developed from the best data available at the time for topography, soils, and land use, consisting of information published on U.S. Geological Survey (USGS) quadrangle maps, soil surveys, and zoning and comprehensive plan mapping. Since the completion of the 1987 master plans, an ARC/INFO geographic information system (GIS) network and the Louisville and Jefferson County Information Consortium (LOJIC) data library have been developed for Jefferson County. LOJIC contains digital data on soils, land use, topography, roads, buildings, streams, conveyance structure locations, and Flood Insurance Rate Maps, which greatly enhances the ability to analyze the hydrologic and hydraulic characteristics of watersheds and to make detailed evaluations of the impacts of development on the floodplains. In 1993, MSD engaged Ogden Environmental and Energy Services to develop a revised, GIS-based process for master planning. The process development and its testing were conducted for a pilot basin, the Cedar Creek Watershed, located in southeast Jefferson County.
Master Plan Objectives

The objectives for the Pilot Basin Study (PBS) were derived from the need to utilize the GIS system to develop solutions for identified flooding problems. The primary objective was to develop a process which:

- Involved the public in the master planning process.
- Identified and assessed both present and future flooding related problems.
- Developed and evaluated solution alternatives based on cost and public expectations.
- Utilized the information available in the LOJIC system and the computational powers of ARC/INFO.
- Was consistent with MSD programs concerning maintenance, greenways, and KPDES permit compliance.

Specific objectives concerning the use of GIS in the master planning process included:

- Computation of sub-basin area, curve number, and lag time for use in the HEC-1 model.
- Computation of input data for the HEC-2 model including stream centerline distance between cross-sections and cross-section x-y coordinates.
- Generation and comparison of floodplains for multiple storms and development/solution scenarios.
- Development and mapping of stream corridors.

There is a myriad of additional potential GIS applications associated with master planning activities which could aid in streamlining and improving the process and products. The emphasis in the PBS was to produce applications which aided in pre-processing data for model development and post-processing model output for graphical and numerical comparisons.

Changes in Hydrologic Computations

The computation of peak runoff rates has been impacted due to changes in the available information. The LOJIC system contains data layers with the basic information required for a Soil Conservation Service method hydrograph calculation: soils, land use, and digital contours. The land use data has been updated since the early master plans were prepared. Land use is defined using seven categories instead of four as before. The increase in land use definition employed in the PBS actually lowered the curve numbers slightly in most cases. This is primarily due to the precise definition of the highly urbanized tracts based on property lines, as opposed to previous rough-drawn land use boundaries based on aerial photography. In addition to more accurate curve number computations, the use of GIS standardizes
methodologies and simplifies the process of testing various development scenarios.

Changes in Hydraulic Computations

Defining the channel cross-sectional geometry is a time consuming task when developing a HEC-2 model. Prior studies within the county utilized USGS quad maps, and more recently LOJIC maps for this purpose. Cross-sections were developed by hand drawing lines on the map and picking off the horizontal and vertical coordinates for each section. During the PBS a GIS application was developed to automate this process. Cross-sections can be developed in two ways.

- User-defined locations, which are digitized into the system.
- Sections generated by the system at a user-defined distance apart.

The cross-sections are generated from digital contour information. Additional survey data is still required for the area covered by water (top-of-bank to top-of-bank) and at bridges and culverts.

Floodplain Generation

Of the GIS applications used during the PBS, the most powerful is the floodplain generation application. This application utilizes the HEC-2 output, stream network and cross-section coverages, and ground surface information to generate the floodplain resulting from any given condition or storm event.

The application uses HEC-2 summary results to create a three-dimensional water surface based on cross-section location and limits, and water surface elevation. The water and ground surfaces are then intersected to produce the floodplain boundary (see Figure 1). The user must take care in defining the limits of the cross-section since the floodplain will be generated in any low point, whether connected or disconnected with the stream, and no floodplain will be generated outside the limits of the cross-sections.

The use of GIS generated floodplains saves time and provides an accurate, consistent floodplain. The real power of the GIS is seen after the floodplain is produced. The floodplain boundary can be overlaid and combined with information contained within LOJIC such as parcel boundary, building location, address, and tax/block/lot information to locate flooded parcels and buildings and identify the associated owner and address. This type of analysis can be used for multiple purposes:

- Evaluate flood damage.
- Provide information for flood insurance and Community Rating System programs.
- Evaluate potential solutions to flooding problems.
- Review and regulate proposed development.
Floodplain Generation in Cedar Creek

For the PBS, floodplains were generated for three conditions (existing, future, and proposed) for three storm events (2-, 10-, and 100-year, 6-hour) in the Cedar Creek watershed. No detailed HEC-2 modeling was conducted in the 1987 master planning effort in Cedar Creek. Models were developed during the PBS to cover the main channel, two main tributaries and two neighborhood areas identified as particular problem areas during field reconnaissance and review of drainage service request records. A future conditions model was created based on zoning information, planned utility installations, and development trends. Future conditions were defined based on expected development in the year 2020, which corresponds with the county's comprehensive plan update being carried out concurrently with the PBS project. Using the future conditions model results and floodplain mapping, flooding problem areas were identified and alternative solutions
developed for consideration. Alternatives for evaluation were selected based on economic justification and public expectations.

The recommended solution alternative was modeled and the resultant floodplain mapped using the GIS application. Costs and benefits of the proposed solution were evaluated based on the number of flooded structures and parcels removed from the floodplain.

GIS-generated Floodplain Products

The floodplain maps produced for the PBS differ from the existing Federal Emergency Management Agency floodplain maps both in content and format. As seen in Figure 2, the floodplain produced from the detailed modeling done during the PBS (darker shade of gray) is significantly smaller than the currently regulated FEMA floodplain (lighter shade) for this particular location. The parcels impacted by the respective floodplains have also been highlighted. In the portion of the study area represented in Figure 2, the PBS floodplain contains two homes, compared to 17 in the FEMA floodplain.

Figure 2. Comparison of FEMA and PBS floodplains.
The information from which the PBS floodplain was produced (i.e., the water surface elevation at each HEC-2 cross-section) resides within the LOIC system. The floodplain elevation at any location can be derived by selecting a cross-section on the screen and querying the database. In effect a "smart" floodplain map has been created instead of the previous paper map. Tasks such as floodplain determinations for insurance purposes can be done on screen. With the GIS models as a base, revised hydraulic modeling can be used to examine the effects of actual or proposed changes to the watershed or stream, and to update the floodplains when physical changes do occur more frequently for a lower cost.

GIS-based Floodplain Mapping and Revision

The next logical step for the use of the floodplains produced during the PBS is to prepare and submit an application for FEMA map revision. FEMA has seen the PBS results and has expressed enthusiasm about receiving a physical map revision request to review. To meet current floodplain mapping formats, the maps produced for Cedar Creek require the addition of a floodway, water surface isolines, and flood zones. These features can be built into the existing application.

GIS-based Floodplain Management

As local floodplain managers, we have a goal of providing the most up-to-date, accurate floodplain information possible to the public for the lowest cost possible. One way to achieve this goal is to generate floodplains from GIS information and to use the GIS to store and manage the floodplain information, updating it when the need arises. As MSD proceeds with the physical map revision request based on the PBS results, the revision process will undergo a new step in its evolution. Continued coordination between FEMA and local GIS-using agencies such as MSD will lead to this process being improved and implemented.
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Section 9

Modeling, New Technology, Software, and Techniques for Their Application
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FLOODWAYS AND ONE-DIMENSIONAL UNSTEADY-STATE FLOW MODELS

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Background
Under the National Flood Insurance Program (NFIP), floodways are often provided to communities as a floodplain management tool. The floodway includes the channel of a river or other watercourse and the adjacent land areas that must remain unobstructed to discharge the base (1% annual chance) flood without cumulatively increasing the water-surface elevation by more than the allowable surcharge (minimum federal standard is 1.0 foot). The remaining portion of the Special Flood Hazard Area (SFHA), or base floodplain, outside of the floodway is the floodway fringe.

The limits of the floodway are determined by using as a starting point the same hydraulic analysis used to establish the 1% annual chance flood elevations and floodplains shown on the NFIP map. The floodway boundary is then determined by artificially "squeezing" the SFHA boundary on both sides of the watercourse toward the center. This is done by simulating vertical walls that remove the edges of the floodplain from the available flow areas in the hydraulic computations. These walls represent fill, structures, a levee, or any other physical obstruction to flow that could be built in an SFHA. Normally, floodway boundaries are computed using the equal conveyance reduction method. This method involves reducing the conveyance of floodwaters on both sides of the watercourse by an equal amount. If 10% of the flow conveyance is blocked on one side of the river, 10% is blocked on the other side. Conveyance reflects the quantity and velocity of flow. Therefore, while the amount of conveyance removed from each side would be equal, unequal surface areas may be blocked on opposite sides of the watercourse depending on factors such as surface roughness and topography in each overbank.

The equal conveyance reduction method is based on the legal need to treat similarly situated property owners in a similar manner. However, the equal conveyance reduction method is not always used because of a variety of
factors including topography, existing development patterns, and a community's comprehensive land use plan.

The floodway limits future increases in 1% annual chance flood levels by preserving an area able to discharge the 1% annual chance discharge. Communities should discourage development and encroachment in the floodway wherever possible. While federal guidelines do not prohibit development in a floodway, the requirements outlined in 44 CFR 60.3(d) of the NFIP regulations must be met. These regulations state that the community shall "prohibit encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge."

**Evolution**

Historically, flood profiles have been determined for the vast majority of the NFIP's mapped floodplains using steady-state step-backwater models. These models utilize a calculated peak discharge to determine the base flood elevations (BFEs). An option within the model is then used, which utilizes the same peak discharge to determine a floodway by encroaching on the base flood profile model to achieve the desired surcharge. However, in recent years, a new generation of models has appeared that considers the entire flood wave rather than solely the peak flood discharge. The use of these unsteady-state models is driven by technical advances that allow for enhanced computational abilities, the availability of flood data, increased sophistication and modeling expertise in the hydraulic community, and the perceived need to address flood timing and storage. Unsteady-state models consider the timing of flood routing and storage effects. Thus, discharges vary along the watercourse, depending upon the amount of storage available. Examples of situations where unsteady-state modeling may produce better results than steady-state models include split flows, reverse flows, and watersheds with large amounts of valley storage.

Several unsteady-state models are currently accepted by the Federal Emergency Management Agency (FEMA), with certain limitations for their use. They include DAMBRK, SWMM 4.30 (EPA version), DWOPER, and UNET. FEMA is currently reviewing other privately developed unsteady-state models for possible acceptance under the NFIP. Limitations associated with already-accepted models usually involve the computation of losses through structures, and the extensive calibration usually required to determine the appropriate roughness coefficients for use in these models. None of the accepted models includes an option for calculating a floodway. When these models are used for NFIP floodplain mapping purposes, early coordination is required with FEMA regional and headquarters staff to resolve issues surrounding model limitations.
Floodways and Unsteady-State Flow Models

Are the floodway concept and unsteady-state models compatible? With a floodway, communities have pre-established "lines" dividing areas that can be developed without significantly increasing base flood levels from areas where further analysis is required to determine the impacts of development in an area subject to natural hazards. These lines simplify floodplain management. Furthermore, steady-state floodways usually encompass areas conveying higher velocities and flood volumes, which are recognized as higher-hazard areas. Carefully analyzing the impacts of development in these areas is intuitively appropriate.

Unsteady-state models are typically used where much overbank storage exists, in very flat floodplains. While the high-hazard, high-velocity aspects of a floodway may not be as intuitively obvious in these areas, it is still necessary to appropriately limit increases in future flood levels and preserve an area for floodwaters. Thus, the floodway concept, in its broadest sense, still applies. The impacts of reducing flood storage often play a greater role than the impacts of reducing conveyance. Therefore, perhaps one criterion for establishing a floodway when using an unsteady-state model would be to develop an "equal volume of storage reduction" approach, instead of the equal conveyance reduction approach used with steady-state step-backwater models.

Even maintaining the "squeezing in" approach, a storage reduction floodway could have an irregular shape that may be difficult for a community to administer. Eliminating the "squeezing in" approach and simply identifying storage areas at any location in the floodplain would likely result in a patchwork-quilt floodway that would be more problematic to calculate, ensure connectedness of storage areas, map, and administer. With either approach, storage floodways would tend to include overbank areas at lower elevations, while excluding higher ground. This distinction is consistent with intuitive understanding of high hazard areas and thus may be palatable to the public.

Calculating floodways by a standard method (such as equal conveyance reduction) is primarily intended to treat property owners fairly. Steady-state floodways ignore potential increases in discharges due to encroachment. However, because unsteady-state models consider reduction in both storage and conveyance, rather than conveyance only (as with steady-state models), an unsteady-state floodway may encompass more area than a steady-state floodway. Given that thousands of streams nationwide have been mapped without considering storage impacts, would property owners affected by an unsteady-state floodway be fairly treated? To answer "no" and require a steady-state floodway ignores new technology that can determine the effects of storage reduction on flood elevations. Failing to calculate flood increases due to storage reduction does not make them any less real. If the intent is to reasonably and accurately assess flood hazards, appropriately calculated unsteady-state floodways make sense.

Calculating unsteady-state floodways poses a challenge for the hydraulic engineer, particularly since none of the unsteady-state models currently
accepted by FEMA includes an automatic floodway determination option. One approach is to continue determining all floodways using steady-state options already available. However, this approach poses several problems. First, a steady-state model must be created for unencroached conditions in order to use available options to compute a floodway automatically. Second, floodways are determined by limiting the surcharge, which can only be determined by comparing unencroached to encroached results. But which unencroached results should be used: steady-state or unsteady-state? If the unsteady-state results are used, the surcharges will have to be calculated independently, and discharges may not be consistent at all locations. Thus, for ease of calculation, it makes sense to use the steady-state results because the floodway surcharges can be calculated automatically. However, using steady-state results highlights any differences between unencroached steady-state and unsteady-state elevations. If these differences are small, then questions arise about why an unsteady-state model, with its increased data and calibration requirements and heightened complexity, was needed to accurately calculate unencroached flood elevations. If the differences are large, not only are the resulting surcharges questionable, but the door is opened to "elevation shopping": those affected by higher flood elevations calculated by an unsteady-state model might challenge the appropriateness of the results, offering instead the lower elevations calculated by a steady-state model (in fact, the very steady-state model used to determine the floodway). Particularly when used in a regulatory context, using two models invites contention. Nevertheless, the complexity of calculating a floodway using an unsteady-state model is recognized, particularly since the lack of any standard floodway options necessitates a trial-and-error approach. This complexity increases when an unsteady-state model is coupled with a continuous simulation hydrologic model to compute rainfall excess, rather than the more conventional design storm approach.

Unsteady-state models have been used to calculate floodways, proving that such an approach is possible. Unsteady-state floodways have been calculated in Puerto Rico and Florida. The same approach was used in both instances and is recommended to those considering other unsteady-state floodways. First, calculate unencroached flood elevations using an unsteady-state model. If a regulatory floodway already exists, modify the cross sections in the unsteady-state model to block the floodway fringe and rerun the model. Compare encroached and unencroached flood elevations to determine the surcharges. If all surcharges are acceptable, maintain the current floodway; otherwise, the floodway will likely need to be widened. Acceptable surcharges are those greater than zero and less than the maximum allowable. If no regulatory floodway exists, or if unacceptable surcharges result, choose a steady-state model with a floodway option. Using the data from the unsteady-state model, create a steady-state model and determine an equal-conveyance floodway. Insert this floodway into the unsteady-state model and run. Check resulting surcharges between encroached and unencroached unsteady-state models. If any unacceptable surcharges result, widen the floodway slightly and rerun. Using the steady-state model as a
starting point serves both to consider equal conveyance reduction and to limit the number of iterations required to develop an unsteady-state floodway. The resulting floodway will be based on equal conveyance reduction principles, but will consider both conveyance and storage effects.

Policy

Currently, if an analysis performed using a step-backwater model takes into account the effects of storage upstream of a constrictive culvert and reduces the discharges downstream of the culvert, FEMA will typically designate the entire floodplain upstream of the culvert as a floodway, in order to preserve available storage. An iterative analysis can be performed to better define the floodway. If the NFIP map reflects flood elevations determined by a steady-state model, an unsteady-state approach must be demonstrated to be clearly superior to the steady-state approach for the situation at hand before FEMA will accept the new approach. If an unsteady flow model is used to define a floodplain, the storage must be maintained unless an analysis demonstrates that the loss of the storage would not increase flood levels more than the allowable surcharge. Current unsteady flow models do not have an option for determining floodways automatically; therefore, either the modeler must manually establish the floodway using an unsteady flow model, perhaps using the approach described above, or a mechanism must exist for the community to ensure that the impact of encroachment into the floodplain will not inappropriately increase future flood levels. Without a mapped floodway, the requirements at 60.3(c)(10) of the NFIP regulations would apply, which state that no new construction, substantial improvements, or other development (including fill) shall be permitted within the SFHA unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and planned development, will not increase the elevation of the base flood more than the allowable surcharge at any point in the community. Without a mapped floodway, an analysis using the unsteady flow model would be required for every proposed encroachment.

Conclusion

Unsteady-state flow models are gaining ever-increasing popularity, particularly for areas where flood storage effects should be considered. Although originally defined for steady-state models, floodways are an appropriate tool for unsteady-state models because they can provide an easily-implementable tool for communities to use for ensuring that development in floodplains does not cause unacceptable increases in flood levels. It is possible to calculate a floodway using unsteady-state models. When used in conjunction with steady-state models, an unsteady-state floodway can be grounded in a principle of fairness, such as equal conveyance reduction, while still determining the effects of development on both storage and conveyance. However, such calculations can be iterative and potentially time-consuming. Those developing unsteady-state flow models could provide an
invaluable service to the hydraulic and floodplain management communities, and perhaps a market incentive for the use of their unsteady-state flow model, by incorporating an automatic floodway determination option into the model. Such an option, which should be based on an appropriate principle of fairness, would advance the state-of-the-art and would provide a more encompassing tool for reducing potential future flood losses.
THE THEORETICAL UNDERPINNING OF THE RATIONAL METHOD

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Introduction

The Rational Method equation for estimating peak flow rates for stormwater runoff is derived from the balanced design storm unit hydrograph approach presented in the U.S. Army Corps of Engineers HEC Training Document 15. The new form of the Rational Method equation is \( Q_p = (\alpha I - \phi)A \), instead of the well-known \( Q_p = (I - \phi)A \); or \( Q_p = \alpha CIA \), instead of the well-known \( Q_p = CIA \), depending upon the respective loss function used in the unit hydrograph effective rainfall model. The above fixed constant is found to depend upon the type of unit hydrograph used (i.e., S-Graph) and the log-log slope of the rainfall depth-duration curve, and is easily determined by equating to a known unit hydrograph design storm model peak flow rate result. This new development provides a significant foundation for use of the well-known Rational Method equation in small catchments where depth-area effects are negligible.

1. Unit Hydrographs

Unit hydrographs (UH) for a catchment may be developed from normalized S-graphs. The S-graph, which is developed from regional rainfall-runoff data, is typically expressed by

\[
S(\ell) = \frac{100}{\gamma T_c}
\]

where now UH is a function of \( T_c \) and is obtained from the derivative of \( S(t) \) with respect to time \( t \).

For \( T_c = 1 \) and catchment area \( A = 1 \), a normalized UH results, \( U(t) \). For \( T_c \neq 1 \) or \( A \neq 1 \), the catchment UH, \( u(t, T_c, A) \), is related to \( U(t) \) by
2. Rainfall Depth-Duration Description

Precipitation depth-duration relationships, for a given return frequency, is generally given by the power law analog,

\[ D(t) = at^b \]  

(4)

where \( a > 0 \) is a function of return frequency, and is held constant for a selected design storm return frequency; \( "b" \) is typically a constant for large regions (e.g., entire counties); \( D(t) \) is the rainfall depth; and \( t \) is the selected duration of time.

Mean rainfall intensity, \( I(t) \), is

\[ I(t) = \frac{1}{t} D(t) = at^{b-1} \]  

(5)

and instantaneous rainfall intensity, \( i(t) \), is

\[ i(t) = \frac{d}{dt} D(t) = abt^{b-1} = bI(t). \]  

(6)

With respect to HEC TD-15 (1984), a balanced design storm pattern (of nested uniform return frequency rainfall depths) can be described by the time coordinates \( t^\pm \) shown in Figure 1. For a proportioning of rainfall quantities by allocation of a \( \theta \) proportion prior to time \( t^\pm = 0 \) (see Figure 1), instantaneous rainfall intensities are given by

\[ i'(t) = i'(\theta t) = i(t) \]  

(7)

or

\[ i^\prime(t^-) = i\left[\frac{t^-}{\theta}\right] = \left(\frac{1}{\theta}\right)^{b-1} i(t^-) \]  

(8)
Similarly,
\[ i^+ (t^+) = \left( \frac{1}{10} \right)^{b-1} i(t^+) \]  

(9)

3. Peak Flow Rate Estimates from the Balanced Design Storm Unit Hydrograph Procedure

Let \( v(t) = v(\eta T_e - t) \); that is, \( v(t) \) is a time-reversed plot of the UH, \( u(t) \).

From Figure 1, and aligning the UH peak to occur at time \( t^+ = 0 \),

\[ v^+ (t^+) = u(T_p - t^+) \]  

(10a)
\[ v^-(t^-) = u(T_p + t^-) \]  

(10b)

Then the balanced design storm UH procedure estimates the peak flow rate, \( Q_p \), by

\[
Q_p = \int_{t^+ = 0}^{T_p} e^+ (t^+) v^+ (t^+) \, dt^+ + \int_{t^- = 0}^{\eta T_e - T_p} e^- (t^-) v^- (t^-) \, dt^-
\]

(11a)

\[
= \int_0^{T_p} i^+ (t^+) v^+ (t^+) \, dt^+ + \int_0^{\eta T_e - T_p} i^- (t^-) v^- (t^-) \, dt^-
\]

\[- \phi \left[ \int_0^{T_p} v^+ (t^+) \, dt^+ + \int_0^{\eta T_e - T_p} v^- (t^-) \, dt^- \right]
\]

(11b)
where $\eta T_c$ is the total duration of the UH, and $T_p$ is the time to peak of the UH. In (11b) a "phi index" (or constant) loss function is used to compute rainfall excess; also, a necessary constraint imposed is that $i(\eta T_c) \geq \phi$.

The last term of Equation (11b) is solved by

$$\phi = \left[ \int_0^{T_p} v^+(t^+) dt^+ + \int_0^{\eta T_c-T_p} v^-(t^-) dt^- \right] = \phi \int_0^\infty u(t) dt = \phi AU_0$$  (12)

The first two integrals of (11b) are rewritten by including Equations (8) and (9),

$$\int_0^{T_p} i^+(t^+) v^+(t^+) dt^+ = \left[ \frac{1}{1-\theta} \right] \int_0^{T_p} i(t^+) v^+(t^+) dt^+$$  (13a)

$$\int_{t=0}^{\eta T_c-T_p} i^-(t^-) v^-(t^-) dt^- = \left[ \frac{1}{1-\theta} \right] \int_{t=0}^{\eta T_c-T_p} i(t^-) v^-(t^-) dt^-$$  (13b)

The next step in the mathematical development is to introduce a $T_c$-based coordinate system defined by

$$s = \frac{t}{T_c}$$  (14)

Then $t = sT_c$, $dt = T_c ds$.

The balanced design storm instantaneous rainfall intensities, $i^\pm(t^\pm)$, can now be rewritten in terms of $s^\pm$ (analogous to $t^\pm$) by

$$i^+(t^+) = \left( \frac{1}{1-\theta} \right) b^{-1} ab(s+T_2)b^{-1} = \left( \frac{T_c}{1-\theta} \right) b^{-1} i(s^+)$$  (15a)

and

$$i^-(t^-) = \left( \frac{T_c}{\theta} \right) b^{-1} i(s^-)$$  (15b)

Similarly, the $v^\pm(t^\pm)$ functions can be rewritten in terms of coordinates $s^\pm$ by

$$v^+(t^+) = u(T_p-t^+) = \frac{A}{T_c} U \left( \frac{T_p-t^+}{T_c} \right) = \frac{A}{T_c} U (t_p-s^+)$$  (16a)

$$v^-(t^-) = u(T_p-t^-) = \frac{A}{T_c} U \left( \frac{T_p+t^-}{T_c} \right) = \frac{A}{T_c} U (t_p+s^-)$$  (16b)

where $t_p = T_p/T_c$ is a constant for a given $S$-graph type.
Combining Equations 11 through 16 gives

\[ Q_p = \left( \frac{1}{1-\theta} \right)^{b-1} A \int_0^{T_p} \frac{T_p}{T_c} a(s^+) b-1 \left( \frac{1}{T_c} \right) U((t_p-s^+) T_c \, ds^+ + \left( \frac{T_p}{T_c} \right)^{b-1} \right) \]

\[ \int_0^{T_p} \frac{T_p}{T_c} a(s^+) b-1 \left( \frac{1}{T_c} \right) U((t_p-s^+) T_c \, ds^+ - \phi U_0 \]

where it is recalled that it is assumed \( i(\eta T_c) \geq \phi \).

Equation (17) is rearranged to give

\[ Q_p = A \cdot a(T_c)^{b-1} \left( \frac{1}{1-\theta} \right)^{b-1} \int_0^{T_p} b(s^+) b-1 U((t_p-s^+) \, ds^+ \]

\[ + \left( \frac{1}{\theta} \right)^{b-1} \int_0^{T_p} b(s^+) b-1 U((t_p-s^+) \, ds^- - \phi U_0 \]

\[ = A \left[ a(t_p)^{b-1} \alpha - \phi U_0 \right] \]

(18a)

(18b)

where \( \alpha \) is constant. For a given S-graph, and a given precipitation region where exponent "b" is a constant, then \( t_p \) and \( \eta \) are constants, and Equation (18) can be simplified by including (5) as

\[ Q_p = [\alpha I(T_c) - \phi U_0] A \]

(19)

where \( \alpha \) is a constant for the given S-graph and precipitation region.

For English units, \( U_o = 1.008 \), which is simplified to be simply \( U_o = 1 \).

Then,

\[ Q_p = [\alpha I(T_c) - \phi] A \]

(20)

In comparison, a Rational Method peak flow rate estimator, for an equivalent mathematical structure for estimating rainfall excess by a phi-index (constant loss function), is

\[ Q_R = [I(T_c) - \phi] A \]

(21)

Application

In (20), the single "calibration" constant, \( \alpha \), can be determined by equating (20) to (11a) for a single peak flow rate estimate (again, observing \( i(\eta T_c) \geq \phi \)). Several California Hydrology Manuals use two S-graphs, one
for "urbanized" and another for "undeveloped" regions. By equating (20) to (11a), \( \alpha = 0.99 \) for the "urbanized" S-graph and \( \alpha = 0.86 \) for the "undeveloped" S-graph. In these determinations, the rainfall exponent (b) of Equations (4) to (6) was \( b = 0.55 \). Additionally, the constraint of \( \eta T_c \geq \phi \) resulted in \( T_c \) limitations of 45 minutes to 180 minutes for 10-year to 100-year storms (and typical loss rates of 0.4 inch/hour), respectively.

### Constant Fraction Loss Rate

Another popular loss function is to use a constant proportion loss rate function, to estimate rainfall excess, given by

\[
e(t) = k_i(t)
\]  

Using (22) in the above development results in the balanced design storm UH procedure peak flow rate estimator, \( Q_p \), given by

\[
Q_p = k \alpha I(T_c) A
\]  

where in (23), \( \alpha \) is the same constant (and same values) used in (20), and the constraint of \( i(\eta T_c) \geq \phi \) is eliminated. The corresponding well-known Rational Method peak flow rate estimator, \( Q_R \), is

\[
Q_R = k I(T_c) A
\]  

From the above example, Equation (23) results in

\[
\begin{align*}
Q_p &= k I(T_c), \text{ for urbanized areas} \\
Q_p &= 0.86 k I(T_c), \text{ for undeveloped areas}
\end{align*}
\]  

(25)

where again in (25), the rainfall exponent is \( b = 0.55 \).
IMPROVEMENTS TO
THE MODIFIED RATIONAL METHOD
OF DETENTION BASIN DESIGN

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Introduction
Numerous municipalities use the Modified Rational Method for designing detention basins to control runoff from small developing sites. However, past experience has shown that this method may undersize the required storage volume for the detention basin due to several shortcomings. The shortcomings have been shown to be based on the problems associated with the assumed inflow hydrograph shape, assumed constant outflow of the detention basin, and the inherent limitations of the Rational Formula. Many studies have been performed that document the perceived shortcomings of the Rational Formula as being due to the fact that the method does not account for the variation of runoff due to rainfall intensity, watershed slope, hydrologic soil type, percent imperviousness, etc. (Rossmiller, 1980; Debo and Reese, 1995; Malcom et al., 1974). This paper presents a refinement to the Modified Rational Formula method of detention basin design and the Rational Formula for peak flow estimation to account for these shortcomings and provides a method to develop more accurate solutions of storage volume and outlet structure size when compared to full storage-indication routing procedures.

Hydrograph Shape
The majority of Modified Rational Formula method applications assume a constant inflow hydrograph flow and a constant release rate. The inflow hydrograph is shaped as a rectangle with the base equal to the storm duration and the height equal to a maximum discharge computed using the Rational Formula. A range of reasonable small watershed storm durations is analyzed to provide a maximum storage volume as a result. The permissible outflow rate is typically based on a pre-developed land use runoff rate. The shape of the inflow and outflow hydrographs is presented in Figure 1. This approach does not accurately represent the actual inflow hydrograph shape and variable
Figure 1. Modified Rational Formula Method hydrograph shape.

outflow and therefore can result in un-conservative detention basin storage volume.

To more accurately represent the hydrograph shapes, several municipalities are using a revised Modified Rational Formula method which is illustrated in the bottom half of Figure 1. The inflow hydrograph from the watershed accumulates until the time-of-concentration is reached. Then it levels out until the storm duration is reached. The recession limb is assumed to be similar to the rising limb. The total inflow volume under each of the inflow hydrographs or any duration is equal, though the volume is accumulated at different overall rates. The equation for the storage volume for this method is:
Vol = 60\left(C i A t - R(t + t_c) / 2\right)

(Equation 1)

where:

\[ \text{Vol} = \text{required volume of the pond (cubic feet)} \]
\[ C = \text{post development C factor} \]
\[ i = \text{rainfall intensity from the IDF curve (in/hr)} \]
\[ R = \text{allowable release rate} \]
\[ t = \text{storm duration to maximize the storage volume (minutes)} \]
\[ t_c = \text{post-developed time of concentration} \]

The normal method of solution is to set up a table of calculations of volume over a range of durations. The duration which maximizes the required storage volume is chosen. It is normally a trial and error procedure, however, a closed-form solution can be found which gives the required durations and volumes without trial and error by substituting the following formula into Equation 1.

\[ i = \frac{a}{(t + b)^n} \]

(Equation 2)

where:

\[ i = \text{rainfall intensity (in/hr)} \]
\[ t = \text{time (minutes)} \]
\[ a, b, \text{and } n \text{ are fitting values} \]

The resulting equation is differentiated with respect to time and then the result is set equal to zero to solve for the critical duration. The resulting critical duration, the time at which the storage volume is maximized, can be found solving the following equation.

\[ t = \sqrt{\frac{2ACab}{R} - b} \]

(Equation 3)

where:

\[ t = \text{critical storm duration (minutes)} \]
\[ a = \text{location-specific constant in the rainfall equation} \]
\[ b = \text{location-specific constant in the rainfall equation} \]
C = post development C factor
R = allowable release rate (cfs)
A = area (acres)

The maximum required volume can be found using Equation 4.

\[ V_{\text{max}} = 60A[Ca-(2Cabr)^{1/2}+r/2(b-t_c)] \]  
(Equation 4)

where:

\[ V_{\text{max}} \] = required storage volume (cubic feet)
\[ t_c \] = fully developed time of concentration (minutes)

Impervious Cover, Hydrologic Soil Type

The previous section addressed the perceived shortcoming of the Modified Rational Formula method due to the shape of the inflow and outflow hydrographs. However, more accurate and widely accepted methods of estimating the volume of runoff from a small watershed are commonly used that account for the volume of rainfall that is lost during a storm event. The Soil Conservation Service's (SCS) methods of generating hydrograph shapes and volumes are an example of one of these methods. In addition, the SCS methods account for the effects of the underlying soil type on the resulting runoff potential of the watershed.

The authors note that in small urbanized watersheds the effects of the initial losses and the underlying soil types are typically minor for the post-developed conditions. However, these effects for the pre-developed conditions analysis are significant using the SCS procedures. For example, the SCS methodology typically predicts that a 3-acre meadow underlaid with a hydrologic soil type B will discharge in the range of 2 to 3 cfs during a 10-year storm event. The Rational Formula typically predicts a pre-developed condition discharge of 15 cfs. The result of this over-prediction by the Rational Formula is significant during the design of detention basins should the site develop to an urban land use.

To account for these differences, the authors performed numerous computer modeling exercises for a wide range of land use coverages, basin sizes (ranging from 1 to 5 acres), watershed slopes, etc. using the SCS methodologies for computing runoff. Average Rational Formula C-values were assigned for each of the tested land uses that mimic the runoff predicted by the SCS methodologies. Table 1 lists some of these results.
Table 1. Some results of the computer modeling for differing land uses, basin sizes, and watershed slopes.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Storm Event</th>
<th>Hydrologic Soil Type A</th>
<th>Hydrologic Soil Type B</th>
<th>Hydrologic Soil Type C</th>
<th>Hydrologic Soil Type D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slope</td>
<td>0.2 2.7 7+</td>
<td>0.2 2.7 7+</td>
<td>0.2 2.7 7+</td>
<td>0.2 2.7 7+</td>
</tr>
<tr>
<td>1/8 acre lots</td>
<td>2 yr</td>
<td>0.27 0.28 0.28</td>
<td>0.42 0.43 0.44</td>
<td>0.62 0.63 0.64</td>
<td>0.65 0.66 0.68</td>
</tr>
<tr>
<td></td>
<td>10 yr</td>
<td>0.40 0.41 0.43</td>
<td>0.56 0.58 0.60</td>
<td>0.71 0.73 0.75</td>
<td>0.78 0.79 0.82</td>
</tr>
<tr>
<td></td>
<td>25 yr</td>
<td>0.42 0.44 0.46</td>
<td>0.65 0.66 0.69</td>
<td>0.77 0.78 0.81</td>
<td>0.79 0.81 0.84</td>
</tr>
<tr>
<td></td>
<td>100 yr</td>
<td>0.53 0.55 0.57</td>
<td>0.70 0.72 0.75</td>
<td>0.79 0.81 0.84</td>
<td>0.85 0.87 0.91</td>
</tr>
<tr>
<td>1/4 acre lots</td>
<td>2 yr</td>
<td>0.05 0.05 0.06</td>
<td>0.19 0.19 0.20</td>
<td>0.36 0.36 0.38</td>
<td>0.46 0.46 0.48</td>
</tr>
<tr>
<td></td>
<td>10 yr</td>
<td>0.05 0.08 0.11</td>
<td>0.22 0.25 0.28</td>
<td>0.32 0.36 0.38</td>
<td>0.46 0.48 0.50</td>
</tr>
<tr>
<td></td>
<td>25 yr</td>
<td>0.13 0.16 0.20</td>
<td>0.39 0.42 0.46</td>
<td>0.57 0.60 0.65</td>
<td>0.67 0.69 0.75</td>
</tr>
<tr>
<td></td>
<td>100 yr</td>
<td>0.21 0.24 0.28</td>
<td>0.46 0.50 0.54</td>
<td>0.64 0.67 0.73</td>
<td>0.72 0.76 0.81</td>
</tr>
<tr>
<td>1/2 acre lots</td>
<td>2 yr</td>
<td>0.05 0.06 0.08</td>
<td>0.06 0.06 0.06</td>
<td>0.30 0.30 0.32</td>
<td>0.42 0.43 0.45</td>
</tr>
<tr>
<td></td>
<td>10 yr</td>
<td>0.06 0.09 0.11</td>
<td>0.21 0.24 0.28</td>
<td>0.45 0.49 0.54</td>
<td>0.56 0.58 0.64</td>
</tr>
<tr>
<td></td>
<td>25 yr</td>
<td>0.05 0.08 0.13</td>
<td>0.26 0.30 0.35</td>
<td>0.48 0.51 0.57</td>
<td>0.63 0.66 0.73</td>
</tr>
<tr>
<td></td>
<td>100 yr</td>
<td>0.10 0.14 0.18</td>
<td>0.35 0.40 0.45</td>
<td>0.58 0.62 0.69</td>
<td>0.68 0.72 0.80</td>
</tr>
<tr>
<td>Apartments</td>
<td>2 yr</td>
<td>0.27 0.28 0.28</td>
<td>0.42 0.43 0.44</td>
<td>0.62 0.63 0.64</td>
<td>0.66 0.66 0.68</td>
</tr>
<tr>
<td></td>
<td>10 yr</td>
<td>0.40 0.41 0.43</td>
<td>0.56 0.58 0.60</td>
<td>0.71 0.73 0.75</td>
<td>0.78 0.79 0.82</td>
</tr>
<tr>
<td></td>
<td>25 yr</td>
<td>0.42 0.44 0.46</td>
<td>0.65 0.66 0.69</td>
<td>0.77 0.78 0.81</td>
<td>0.79 0.81 0.84</td>
</tr>
<tr>
<td></td>
<td>100 yr</td>
<td>0.53 0.55 0.57</td>
<td>0.70 0.72 0.75</td>
<td>0.79 0.81 0.84</td>
<td>0.85 0.87 0.91</td>
</tr>
<tr>
<td>Commercial, Business</td>
<td>2 yr</td>
<td>0.54 0.55 0.56</td>
<td>0.65 0.66 0.68</td>
<td>0.76 0.76 0.76</td>
<td>0.77 0.78 0.79</td>
</tr>
<tr>
<td></td>
<td>10 yr</td>
<td>0.70 0.71 0.72</td>
<td>0.78 0.79 0.79</td>
<td>0.84 0.85 0.86</td>
<td>0.88 0.89 0.90</td>
</tr>
<tr>
<td></td>
<td>25 yr</td>
<td>0.75 0.76 0.77</td>
<td>0.80 0.81 0.82</td>
<td>0.85 0.86 0.87</td>
<td>0.89 0.90 0.91</td>
</tr>
<tr>
<td></td>
<td>100 yr</td>
<td>0.79 0.80 0.81</td>
<td>0.86 0.87 0.88</td>
<td>0.89 0.90 0.92</td>
<td>0.90 0.91 0.92</td>
</tr>
<tr>
<td>Pools, Driveways, Streets, etc.</td>
<td>2 yr</td>
<td>0.98 0.99 0.99</td>
<td>0.98 0.99 0.99</td>
<td>0.89 0.89 0.89</td>
<td>0.89 0.89 0.89</td>
</tr>
<tr>
<td></td>
<td>10 yr</td>
<td>0.92 0.93 0.94</td>
<td>0.92 0.93 0.94</td>
<td>0.92 0.93 0.94</td>
<td>0.92 0.93 0.94</td>
</tr>
<tr>
<td></td>
<td>25 yr</td>
<td>0.93 0.93 0.93</td>
<td>0.93 0.93 0.93</td>
<td>0.93 0.93 0.93</td>
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</tr>
<tr>
<td></td>
<td>100 yr</td>
<td>0.95 0.95 0.95</td>
<td>0.95 0.95 0.95</td>
<td>0.95 0.95 0.95</td>
<td>0.95 0.95 0.95</td>
</tr>
<tr>
<td>Open Spaces</td>
<td>2 yr</td>
<td>0.05 0.05 0.05</td>
<td>0.05 0.05 0.05</td>
<td>0.12 0.13 0.14</td>
<td>0.29 0.30 0.32</td>
</tr>
<tr>
<td></td>
<td>10 yr</td>
<td>0.05 0.05 0.05</td>
<td>0.05 0.05 0.05</td>
<td>0.29 0.30 0.31</td>
<td>0.45 0.46 0.49</td>
</tr>
<tr>
<td></td>
<td>25 yr</td>
<td>0.05 0.05 0.11</td>
<td>0.11 0.16 0.33</td>
<td>0.34 0.38 0.46</td>
<td>0.47 0.51 0.50</td>
</tr>
<tr>
<td></td>
<td>100 yr</td>
<td>0.05 0.05 0.12</td>
<td>0.18 0.24 0.35</td>
<td>0.45 0.49 0.58</td>
<td>0.57 0.62 0.72</td>
</tr>
</tbody>
</table>
Conclusion

These values were derived for a specific rainfall distribution, rainfall intensity, range of watershed sizes, etc. and should therefore not be applied to all conditions. The authors compared the resulting storage volumes and outflow structures for 10 hypothetical sites based on the above described method with detention basin sizes using SCS hydrograph generation methods with storage-indication routing techniques and found the differences to be minimal.

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U.S. Department of Agriculture
TRIALS AND TRIBULATIONS OF TWO-DIMENSIONAL MODELING FOR THE NOOKSACK RIVER, WASHINGTON

Lorna Taylor
Dave Carlton
A.M. (Tony) Melone
KCM, Inc.

Introduction

Computer modeling has been the basis for mapping floodplains for many years. Until now, most detailed floodplain maps have been based on results produced by one-dimensional steady-state computer models. New, faster computers have made it possible to develop two-dimensional models for river floodplains that give much more detailed flooding information.

The purpose of developing a two-dimensional model of the lower Nooksack River was to create a better set of tools for long-term flood hazard management in Whatcom County. In the past, flooding along the river has been extremely costly. Unfortunately, regulations based on the existing floodplain mapping allow development in potentially hazardous areas.

Two-dimensional flow-field models yielding better, more comprehensive results than one-dimensional models are becoming accepted for flood hazard management. While the two-dimensional model has produced excellent results for the Nooksack, they have not come easily. The time to construct and run a two-dimensional model is excessive compared to one-dimensional models.

History

The Nooksack River originates high on the slopes of Mt. Baker in northwestern Washington (Figure 1). It flows approximately 80 miles, and drops 10,000 feet in elevation before discharging into Puget Sound. Along its lower reaches, the river flows through a large, flat, agricultural floodplain that regularly experiences damaging floods. Historically this floodplain was a natural grass prairie. Through the years, levees have been constructed along much of the lower 30 miles for flood protection.
Figure 1. The perennial problem of flooding along the Lower Nooksack River is being addressed through the preparation of a comprehensive flood hazard management plan.
Since records were first kept in the 1930s, damaging floods have occurred about every eight to ten years. Floodwaters follow multiple flow paths through the floodplain, often with more flow overland than in the channel itself. One major flow path is over a low interbasin divide that empties into the Fraser River basin in Canada.

In November 1990, two back-to-back floods of less than a 50-year return frequency produced $22.5 million in damage, flooded hundreds of homes, and closed several major roadways in Whatcom County and Canada. Several water and sewer treatment facilities were threatened. Losses to the agricultural community included drowned livestock, eroded fields, and deposition of river gravel and silt onto farmlands. Some farmers along the river banks lost as much as 40 acres when the river changed its course.

Floodplain Mapping

While Federal Emergency Management Agency (FEMA) floodplain maps exist for the Nooksack River basin, flood levels measured during the 1990 floods showed the maps to be incorrect. High water marks from the 1990 storms were measured at many locations along the lower 30 miles of the river as well as along the overflow to Canada. The 1990 streamflow was between that predicted for the 10- and 25-year return frequencies, but in places as much as six feet higher than the 100-year elevations predicted by FEMA.

The FEMA floodplain maps were based on results produced by a one-dimensional steady-state computer model. In many instances, this type of modeling can reasonably represent the extent of flooding, depths, and flow velocities during a flood. However, the Nooksack River is one of several rivers in Washington where the results of a one-dimensional model do not adequately represent the actual risk of flooding or the severity of the hazard.

Action

After the 1990 floods, Whatcom County and several communities formed an advisory committee to review all actions and policies associated with flooding within the County. The committee makes recommendations to the County Council for adoption, and is seeking a cost-effective combination of nonstructural and structural solutions to the flood problems. The challenge in the Nooksack valley is that a solution to one flooding problem may compound another problem elsewhere. Before any significant changes are made, it will be necessary to verify that other flood problems are not aggravated.

A computer model is a good tool to use in determining these potential impacts. However, the existing model did not produce correct results. Obviously, a better tool was required if the County was to ensure that proposed flooding solutions do not create new problems. The tool selected was a two-dimensional model to more accurately represent actual flooding in the valley. This model could be used for making land use decisions, for alternatives analysis, and in explaining regulatory actions to the public.
Two-Dimensional Modeling

The FESWMS-2DH program developed by the U.S. Geological Survey with assistance from the Federal Highway Administration was selected for modeling the Nooksack River. The two-dimensional model uses a finite element grid system composed of quadrilateral and triangular elements to solve for flow depth, direction, and velocity at each node point within the grid. Triangular and quadrilateral elements have six and nine nodes, respectively. The results can be displayed as water surface elevation contours, or velocity vectors showing the direction and magnitude of flow. Total energy head can also be plotted. Figure 2 shows velocity vectors generated by FESWMS-2DH.

**Modeling Approach**

The first step in the modeling process is gathering topographic data for model input. For the Nooksack, this was a significant effort because the

![Figure 2. Velocity vectors generated by FESWMS-2DH.](image)
The second step is creating the finite element grid. For the Nooksack model, selected points from the digital survey mapping were used to create the grid because the total number of points used in generating the survey mapping exceeded FESWMS-2DH limit of 4,000 elements and 13,000 nodes. Selecting these points was an involved process. First, a custom fortran program was used to reduce the density of surveyed points from about 25,000 points per square mile to 2,000 points per square mile. The program filtered out adjacent points with nearly the same elevation. Points to be used in the model were then manually selected from the filtered survey points using Intergraph.

The preprocessor, FASTTABS, developed at Brigham Young University, was used to connect the grid points and create elements. While grid generation can be done in FESWMS-2DH, FASTTABS with its graphic environment makes this task much easier. Land use within the valley and the corresponding roughness coefficient were determined from the survey photos and maps and then input in FASTTABS.

Once the grid was created and checked in FASTTABS, FESWMS-2DH was used to model flows through the floodplain. FESWMS-2DH uses the finite-element method to solve the equations that govern two-dimensional flow in a horizontal plane (Froehlich, 1993). For large river systems, the first step is called the "spin-up." Initial boundary conditions, the downstream water surface elevation and upstream flow, are set and then adjusted incrementally toward the final solution. Each successive run uses the data produced during the previous run to converge on a final solution.

The models were calibrated from known water surface elevations and flows from the November 10, 1990 flood. Several flood events in addition to the 100-year flood will be modeled to allow for the analysis of alternatives.

Challenges
Obstacles to creating and running the model for the Nooksack were:

- The FESWMS-2DH software is limited to 4,000 elements and 13,000 nodes. For current PC uses, this software limitation is not unreasonable. Processing time on any larger grid would be too time-intensive. To stay within software and hardware limitations, the lower 30 miles of the Nooksack River was divided into five separate modeling segments.

- Once the model and grid are built and debugged, it is necessary to spin-up the inflow and tailwater boundary conditions before meaningful results can be generated. This spin-up process can take a long time. For example, the full spin-up for each segment took between 19 and 24 hours on a 90 megahertz Pentium PC.
Whenever the grid is revised, the entire spin-up process must be repeated. This may be necessary for analysis of each alternative, such as a new levee or overflow channel. For alternatives in the upper reaches of the Nooksack, the downstream reaches had to be rerun to assess the downstream impacts of the upstream alternatives.

Grids generated using survey data tend to have a wide assortment of element sizes and shapes. This type of configuration converges on a solution more slowly than an ideal grid based on orthogonal elements.

Conclusions

Once operational, the model calibrated extremely well with known high water marks and overflow pathways. The velocity vectors and water surface elevation contours generated by FESWMS-2DH add a whole new dimension to flood hazard management. The velocity vectors clearly indicate where floodwaters are flowing fast (more likely to be destructive) and where they are stagnant (providing storage and protecting downstream areas from further flooding). Isolated high areas are also identified.

Two-dimensional models are being used by local officials in conjunction with other environmental, engineering, and economic studies to predict the impact of potential projects and to develop a Comprehensive Management Plan for the Lower Nooksack River which will minimize flood hazards in a manner acceptable to County residents. New management policies will prohibit new structures in areas shown by the model to be hazardous. Using this model to decide where development is desirable and permitted will allow preservation of the areas required for flood conveyance and storage, thus preventing worse floods from occurring in the future.

References

Whatcom County, Washington

Whatcom County, Washington

Froehlich, David C.
Introduction

Hydrologic modeling of urban areas poses many challenges for the engineer. Many analysis tools exist for urban areas, all requiring various quantities of input data and different levels of modeling expertise. This paper describes the efforts of the U.S. Army Corps of Engineers (COE), Charleston District, for an urban flood damage reduction study for the City of Charleston, South Carolina. This paper summarizes the analysis methods used for this study and presents insight regarding how these tools can be utilized for other areas.

Study Area

Urban storm water runoff is a major problem within the City of Charleston. Frequent surface flooding occurs throughout the city as a result of moderate to heavy rainfall events. Damage and consequences resulting from the flooding include the disruption of vital services, loss of mobility and income, property damage and loss, and a threat to the health and safety of the population. Causes of the flooding can be traced to a number of factors, including the capacity of the existing storm sewer system, tidal backwater effects, and the natural terrain of the area. The downtown area of the City of Charleston lies upon a peninsula bounded by the Ashley and Cooper rivers, which combine to form Charleston Harbor, a tidal estuary (Figure 1). The area can be characterized as low-lying with slight undulations and gentle slopes. Development within the peninsula area is heavy, with approximately 90% of the land area presently developed. The existing storm sewer system consists mainly of vitrified clay pipe and brick arches, the main component of which is a brick arch tidal drain system which was constructed in the 1850s as a combined sanitary and storm sewer. These arches, which are approximately three to four feet wide and seven feet high, are interconnected with outfalls to the Ashley and Cooper rivers. Originally this system of archways was manually controlled by gate valves at each discharge point. Over the years the archway network was converted to strictly a storm sewer system and the gate valves were removed, leaving the discharge points
uncontrolled and subject to siltation and water level fluctuations from tidal exchange. The carrying capacity of these arches is severely impacted if rainfall occurs in conjunction with periods of high tides.

As this was a reconnaissance level study, existing available data was utilized wherever applicable. Drainage basin delineations and an inventory of the existing storm sewer system were available from a master drainage plan.
of the City of Charleston completed by the A/E consulting firm of Davis & Floyd (Davis & Floyd, 1984). To keep the reconnaissance study to a manageable scope, it was decided that one "representative" basin in the downtown area would be analyzed to determine whether federal interest exists in a storm damage reduction project for the City of Charleston. The basin selected, designated as the Calhoun West basin, encompasses more than 200 acres within the central and west central regions of the peninsula, as shown in Figure 1. This basin was selected primarily because of existing flood problems, flood damage potential, and the city’s priorities. Included in this basin are three major hospitals, a university, an elementary school, numerous commercial and residential structures, and a large portion of one of the main east-west thoroughfares of the city, Calhoun Street.

Selection of Hydraulic Model

Due to the complex and unique nature of the study area, an extensive search was made of available urban hydraulic modeling techniques. In developing a numerical model of an urban area, some important mechanisms which must be accounted for include the rainfall-runoff process, overland flow routing, and pipe network routing. For this particular study area, other factors complicate the modeling process, including backwater from estuary tide levels, flooding of the system due to surcharging of inlets that exceeds the ground elevation, and the routing and storage of these surcharge flood flows. Physical features to be modeled for this study include flow through arch, box, and circular conduits, flow through open channels, pump stations, and depression storage areas. Many simplified hydraulic tools exist that provide the user with the capability to analyze and design storm sewer systems; however, many of these models lack the ability to adequately simulate surcharging of pipe network systems and flooding of the ground surface. For the purposes of economic evaluation, the main product of the hydraulic analysis is a series of flood elevation/duration/exceedance probability relationships for existing and improved conditions throughout the study area.

Due to these requirements and the complexity of the study area, the Storm Water Management Model (SWMM) of the Environmental Protection Agency was selected as the primary analysis tool for the simulation. SWMM is a comprehensive water quantity and quality simulation model developed primarily for urban areas. To allow for user access to the many different facets of urban storm water runoff problems, the model is organized to run as a series of separate routines, referred to as "blocks." The SWMM blocks include the Runoff Block for generating runoff hydrographs, the Transport and Extended Transport (EXTRAN) Blocks for routing hydrographs and pollutographs through a drainage system, and the Storage/Treatment Block for simulating the effects of control devices upon flow and quality. For this study, only the EXTRAN block of SWMM was utilized. EXTRAN solves the full dynamic equations for gradually varied flow (St. Venant equations) to allow for accurate simulation of backwater conditions, looped connections, surcharging, and pressure flow (Huber and Dickinson, 1992).
Existing Condition

Hydrology
The Calhoun West drainage basin encompasses 212.6 acres within peninsular Charleston. The basin is almost fully developed, with the primary land uses being residential, institutional, and commercial. For simulation purposes the basin was divided into 30 subbasins, which were selected primarily based upon existing and anticipated future drainage features. While SWMM’s RUNOFF block has the capability to compute inflow hydrographs, it was decided instead to use the COE HEC-1 model for this task. The kinematic wave catchment analysis option of HEC-1 was utilized to model the runoff process, while the loss rates were estimated using the Soil Conservation Service (SCS) curve number methodology (U.S. Department of Agriculture, 1986). All physical parameters including slopes, overland flow paths and lengths, and land use were taken from topographic/planimetric maps and site investigations of the area. Synthetic rainfall data for Charleston was taken from National Oceanic and Atmospheric Administration (NOAA) reports (U.S. Department of Commerce, 1961; Frederick et al., 1977). The HEC-1 output hydrographs were reformatted to be used as input to the SWMM EXTRAN block for subsequent routing.

Hydraulics
The SWMM EXTRAN block is a link-node model, with links (such as conduits or open channels) that connect nodes (such as manholes, inlets, and outfalls). Input hydrographs from the HEC-1 output were read into SWMM and assigned to the proper nodes. Model parameters describing the physical properties of the existing storm drainage system were determined from the previously completed master drainage plan of Charleston (Davis & Floyd, 1984). Equivalent pipes were used wherever possible to reduce computational requirements, provide fairly consistent pipe lengths, and promote numerical stability in the model. Detailed maps of the area showing all topographic and planimetric features were digitized into three-dimensional CADD drawing files. The topographic information was used to create a digital terrain model of the Calhoun West basin using a surface modeling software package. To model surface flows resulting from the flooding of nodes, surface flow paths also had to be defined in the model. It has been observed in the field that when flooding of manholes and inlets occurs, the excess water either ponds in the immediate area if surface depression storage exists, or flows overland until it reaches either another inlet at which it can reenter the drainage system or until it reaches a depression storage area. Typically, most of this overland flow from surcharging takes a flow path along the street and curb, which tends to form a sort of asphalt/concrete-lined, shallow, rectangular channel. These "channels" offer minimum frictional resistance to flow. For this model, the overland flow paths were defined as open channel link elements. Manholes were represented as equivalent pipes in the model to connect the
underground conduit portions of the storm sewer network with the open channels occurring at the ground surface elevations of the junctions. The open channel surface flows were interconnected to adjacent manholes and eventually to depression storage areas in the model. The depression storage areas were defined in the model as variable-area storage nodes and were assigned area-capacity curves. Excess flow can enter the storage nodes through the surficial open channels when flooding of junctions occurs and can subsequently exit the storage nodes and return to the underground portion of the storm sewer network as flood flows recede and the hydraulic grade line drops throughout the system.

Output from the existing condition SWMM models yielded flood elevation-duration relationships for each surface storage area for each storm event modeled. The flood elevations were merged with the digitized topographic mapping of the area to produce flood inundation maps for the various storms.

Improved Condition

The existing condition SWMM model was modified to simulate improvements to the existing stormwater drainage system. The original concept design consisted of the addition of a storm water pump station to minimize backwater effects during periods of high tides, the addition of large conduits to convey flow from the existing system to the pump station, and the addition of extra conveyance in feeder lines where the capacity of the existing lines was exceeded. This concept design was then altered to reflect the usage of a deep tunnel collection system, and associated changes in the wet well, pumping configuration, and pipe network due to the use of the tunnel. A similar deep tunnel project is currently under construction by the City of Charleston in an adjacent drainage basin.

Output from the improved condition SWMM models yielded flood elevation-duration relationships for each of the surface storage nodes for each recurrence interval storm modeled. The improved condition results indicate that no significant surface flooding would occur for events up to and including the 4% chance exceedance flood event.

Conclusions and Recommendations

SWMM has been a valuable analysis tool in the Charleston District’s Storm Damage Reduction Study of the City of Charleston. Unlike many other urban hydrologic models, SWMM has the ability to analyze system performance not only under the design conditions, but also when the design conditions are exceeded. Urban flood minimization projects are typically justified based upon surface flooding damage; therefore, it is very important to accurately quantify system surcharges and track total volumes. SWMM has the capability to compute and route entire hydrographs through a system undergoing surcharging and flooding. This feature, along with the model’s capability to also perform water quality simulations, make SWMM a viable
tool that should be considered for use when faced with a complex urban storm water situation.

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STORMWATER MODELING
ENHANCED THROUGH GIS

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Casco Bay Estuary Project

Introduction
Responsible watershed management has become the subject of increasing public attention due to a combination of natural events and government legislation. Efficient and accurate stormwater modeling capabilities are necessary to support demands for development while minimizing impacts downstream. Current "semi-automated" procedures for modeling stormwater behavior require tedious and time-consuming data collection, manipulation, and data input preparation activities. Computer-based models present primitive punchcard-like interfaces for entering data and commands and produce volumes of output in non-graphical, tabular report format. Calculating parameters such as drainage area, curve number, and time of concentration can take weeks for a single watershed. This paper describes the application of new computer technology that reduces and refines stormwater analysis activities.

This application is a suite of stormwater modeling tools that can help engineers conduct stormwater analysis in a fraction of the time required using conventional methods. These tools are based upon Geographic Information System (GIS) software and databases. This paper includes a brief overview of the widely-used models that form the basis of the software suite: TR-55, TR-20 and HEC-2. It includes an examination of the functionality of the models and their enhancement through GIS.

Background
Innovative System Developers, Inc., under the sponsorship of Prince George's County, Maryland, embarked on a project to modernize the process of watershed modeling in 1992. This program called for the integration of several independent stormwater models into a state-of-the-art computer system, based on geographic information system (GIS) technology. The
project objectives included faster review of plans submitted by developers, improved staff productivity, and more accurate prediction of the effects of development on county watersheds. The result is a system that features modeling capabilities from headwater to outfall, estimating storm runoff volume, time to peak, and surface flood elevation levels. All functionality is accessible from a point-and-click graphic computer environment. Model input comes from the county-wide GIS database. Output includes map compositions as well as tabular reports.

System Overview

The stormwater system, called Geo-STORM™, was developed in three phases, one for each model component. This approach was natural, since each model addressed a different aspect of the overall solution. The models employed are U.S. Department of Agriculture, Soil Conservation Service’s Technical Release 55 (TR-55) and Technical Release 20 (TR-20), and the U.S. Army Corps of Engineers’ HEC-2 model.

The TR-55 component addresses stormwater behavior during initial overland flow. Specifically, it calculates drainage area, curve number, and time of concentration for small watersheds. Output produced by TR-55 provides input to the second component, TR-20. TR-20 models stormwater behavior through drainage network channels and reservoirs, computing peak discharge and times of occurrence. These discharge values in turn provide input to the third component, HEC-2. This model considers the effect that culverts, bridges, weirs and other obstructions have on stormwater flow. Output from HEC-2 refines rating table information in the TR-20 model, yielding an iterative process that improves model results. HEC-2 also calculates water surface elevation, which can be used to delineate floodplain extents.

All three of these models were integrated into the ARC/INFO® GIS, produced by Environmental Systems Research Institute, Inc. in Redlands, California. ISD’s Geo-GUIDE™ product, a graphic user interface to ARC/INFO, provides a friendly environment for interacting with the GIS and stormwater models. The stormwater model applications were built using a combination of programming languages, including ARC/INFO’s Arc Macro Language (AML), FORTRAN, C, AWK, and csh. The software is supported on Sun, HP, DEC Alpha, IBM, and Data General workstations.

Enhancement through GIS

The ARC/INFO GIS provides many powerful functions that aid in stormwater modeling. It is able to perform huge overlay processes that take weeks to do by hand, in a matter of minutes. It supports easy change of variables within the models, and quick re-execution of the models. Using the GIS, graphic capabilities are greatly enhanced. The software provides the ability for users to view a 3-D perspective of a subarea. Hydrographs created in the TR-20 model can be displayed in graph form to compare upstream and
downstream values. The floodplain can be created and viewed using the elevation data and the topographic surface. Other layers, such as roads and buildings, can be overlaid on the floodplain to see the effect of the rising water. The cross section profiles can also be drawn on the screen, and the right and left bank stations can be graphically selected. Using ARC/INFO coverages or grids as data sets allows for many different sources of data to be employed, and allows the performance of creative functions using the attributes associated with the coverages. The many benefits of incorporating stormwater models into a GIS have significantly reduced the amount of time required to perform the analysis with no loss of accuracy of computations. The powerful functionality, great graphics, database link, and readily available data sets all enhance the stormwater modeling process.

**Functional Analysis**

**Organization**

The Geo-STORM software is organized into projects. This is a data storage scheme that holds all GIS coverages, grids, and attribute tables in an ARC/INFO workspace. Using the project to contain all the information allows you to operate on many projects within a single Geo-STORM session. A project is created when a new Geo-STORM job is run.

**Necessary Data Sets**

A minimum of three data sets or themes must be present to run the Geo-STORM software: landcover, soils, and topography. A fourth data set, the stream network, also is required, but it can be produced from the topography set by selecting the ARC/INFO coverages that define the network, then mapping attribute values from those coverages to known software values.

**Running the TR-20 Model**

The first stage of running TR-20 is specifying the input data. This data is used to create the input file. Using the GIS, this process is virtually automatic because the data resides in the GIS as an attribute. The database element also insures that the data is always in the proper format for the input file.

In the GIS any data set can be graphically displayed, including the stream network, topography, soils, and landcover. The ability to view these layers can help you to decide where to place cross sections and the upstream and downstream ends of structures. The location of these positions can be graphically selected by pointing and clicking on them. Once specified, the rating tables for the cross sections can be entered or retrieved from the database. Geo-STORM can retrieve the rating table from the GIS if it is stored as an attribute, otherwise, the data can be entered through the graphical user interface. After the cross section positions have been determined the software can determine the curve number, drainage area, and time of concentration values for all the subareas. Once the model calculations
are complete, the hydrograph elevation and discharge values for all subareas are extracted from the output and placed in the database.

**Running the TR-55 Model**

The TR-55 functionality is embedded in the TR-20 software. The TR-55 model computes the weighted curve number (CN), drainage area (DA), and time of concentration (Tc) values for a subarea. Default parameters can be set for use in calculating the CN and Tc. These values are stored in the GIS and can be updated at any time. Other values that can be changed are the rainfall amount for each storm year, Manning's coefficient for each landcover type, the CN value for each hydrologic soil group within each landcover type, the wetted perimeter, and the hydraulic radius of the stream. The CN and DA are computed using the landcover, soils, and topographic database layers from a user-specified point of interest. This point can be anywhere on the stream network, and is selected by pointing and clicking. Once selected, a coverage is produced showing the boundary of the subarea. This is graphically depicted in the GIS by a polygon coverage. The area of the polygon is already stored in the GIS as a default attribute, and the CN is easily computed by spatial overlay functions in a matter of minutes.

The Tc for each subarea is computed using a GIS function that finds the path from a graphically selected point on the ridgeline to the design point, taking into consideration slope and landcover type. The Tc is computed from the three basic flow types: sheet, shallow concentrated, and channel. A coverage is then created depicting the path that was determined. The landcover and elevation attributes are extracted from the GIS, and a report is created showing the distance and the Tc. This is easily recalculated by selecting a different point on the ridgeline. In the GIS the path is created as a line coverage which can be viewed showing each flow type in a different color.

**What-if Analysis within TR-20**

The Geo-STORM TR-20 software supports “what if analysis” type operations. You can change the landcover element of the database and recalculate the model values. Landcover areas can be selected using tools such as a box, polygon, or radius, or by overlaying another GIS database layer, such as property lines. The CN and Tc can then be determined based on the modified landcover type.

**The TR-20 Routing Process**

Within the GIS, the stream network is associated with the subarea data. This assigns the CN, DA, and Tc values to the proper stream segments. Using the GIS data sets, the stream network is traversed from the top of the watershed to the last design point. The software is able to determine when a specific type of routing, reservoir or reach, is needed based on the GIS database information. The software is able to internally control the input and output
hydrograph values and determine the order in which the subareas should appear in the standard control.

**Viewing TR-20 Output Hydrographs**

Hydrographs are developed for runoff and local drainage along the stream channel, combined, and routed through the watershed. The software supports viewing of flood hydrographs for all subareas. This allows you to compare the hydrographs of the watershed's subareas.

**Creating the HEC-2 Input File**

All HEC-2 input records are accessed from within the software through an easy to understand graphic user interface. The records are presented using the card name and common terminology. This allows experienced as well as inexperienced HEC-2 users access to the model. Users are given the opportunity to enter as much or as little data as they want, and the software will use the default value for any data that was not entered. For example, if a cross section does not have a GR record, the elevation and station data will be derived automatically from the topography, and a GR record will be created. Another way to enter data into the GIS database is by reading in an existing HEC-2 input file. The software reads all the input records and puts them into the database. When data is entered this way, the position of all HEC-2 cross sections must graphically specified, the attribute data will be attached to the graphic data automatically.

**Running the HEC-2 Model**

The HEC-2 model calculates water surface profiles using TR-20 cross section discharge values as input. Once the input data has been entered, the model is executed using the specified input and output files. After the model execution, the water surface elevation data is extracted from the output file and put into the database. The output file that is created can be viewed on the screen or printed.

**Viewing the Floodplain**

The water surface elevation data extracted from the output file is associated with each graphic cross section position. The elevation data is used in association with the topography to produce a graphic depiction of the floodplain. The floodplain is interpolated between cross section positions to depict it throughout the entire HEC-2 run.

**Conclusion**

Geo-STORM is a complete GIS-based stormwater modeling solution. The solution contains the TR-55, TR-20, and the HEC-2 models. The enhancements through GIS allow hydrological engineers and hydraulics engineers to model stormwater from ridgeline to outfall in an accurate,
efficient manner. Using a GIS, especially one like ARC/INFO, to help in
stormwater modeling brings about many benefits. The benefits include
graphic output capabilities and incredible time savings during computation
and “what if analysis.” The combination allows you to visualize the result of
proposed changes in a watershed, and allows engineers the flexibility to work
through many scenarios to make better informed stormwater decisions.

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Environmental System Research Institute, Inc.
CONSISTENCY IN COMPUTATIONAL METHODS
FOR FLOOD INSURANCE STUDIES

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Federal Emergency Management Agency

Introduction
The Association of State Floodplain Managers’ Mapping and Engineering Standards Committee is pursuing a policy to be adopted with regard to Technical Methods and Models for submittals to the Federal Emergency Management Agency (FEMA). Historically, steady one-dimensional models have been used to determine water-surface elevations. Recently, unsteady flow one-dimensional models are being used to determine water-surface elevations. Usually, single event hydrologic models are used to determine discharges. Continuous events models are now being used to determine discharges. Although unsteady flow and continuous events models use more complex computational algorithms, the basic equations for friction loss, loss through culverts and bridges, and infiltration methods are the same as in steady flow and single event models. Therefore, the basic issue is not which models should be used for FEMA submittals, but whether the methods used in these models will give consistent results. This paper presents the computational methods used in the unsteady flow models UNET, FEQ, and adICPR. The different results from analyzing infiltration losses for hydrologic models, friction loss methods in water-surface profiles computations, losses at the bridges and culverts, and the use of hydraulic grade line and energy grade line computations in storm sewer analysis are discussed. Consistent computational methods should be established so that the results will be the same no matter which computer program is used for a particular type of flow.

Unsteady Flow Models
Unsteady flow analysis combines the hydrologic and hydraulic computations within one model. Discharge hydrographs or rainfall excess are specified at
the upstream boundaries or at any location of the stream system. The stage-
time relationship, normal depth, or critical depth options are specified as the
downstream boundary condition. The discharge hydrographs are combined
and then hydraulically routed through the stream system. In some programs
steady flow files can be converted into unsteady flow files with some minor
modifications. Table 1 shows a comparison between the U.S. Army Corps of
Engineers (USACE) UNET program, Linsley and Kraeger’s FEQ program,
and Streamline Technologies’ adICPR program.

From Table 1 it can be seen that unsteady flow programs use the same
hydrologic methods as traditional single event hydrologic programs, and the
same hydraulic analysis as steady flow programs. A brief review of the
results obtained by different hydrologic methods and hydraulic computations
are presented below.

Hydrologic Methods
For hydrologic methods, four areas of concern are total rainfall and rainfall
distribution, infiltration methods to determine the excess rainfall,
transformation methods to transform rainfall excess into discharge
hydrographs, and channel routing methods where unsteady flow models are
not used.

At this time there are several methods to establish rainfall distribution of
total rainfall amounts, infiltration rates, transformation methods (unit
hydrograph methods) and routing methods. However, there is not enough
information published to select the best methods to develop discharge
hydrographs.

Infiltration Methods
Different infiltration methods were tested for a small watershed in the City of
Albuquerque, New Mexico (Khine, 1992) following accepted procedures to
reproduce a storm. The infiltration methods used were initial and uniform
loss rate, curve number, Green-Ampt, and Holtan. The kinematic wave
routing method was used as a transformation method. The popular curve
number method cannot reproduce the flood hydrograph. Of all the loss rate
methods tested, the Holtan loss rate method appears to reproduce the flood
hydrograph quite well.

Transformation Method
The kinematic wave method appears to be better than the unit hydrograph
method for transforming the excess rainfall into a discharge hydrograph
because the kinematic wave method is based on the topographic condition and
roughness of the surface for a particular site and the information is readily
available. However, some analysts indicate limitations on its use for large
drainage areas.
Table 1. Comparison of unsteady flow programs.

<table>
<thead>
<tr>
<th>UNET (June 1994)</th>
<th>FEQ (February 1994)</th>
<th>adICPR (December 1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Hydrographs from HEC-1</td>
<td>1. Excess rainfall</td>
<td>1. Transformation method</td>
</tr>
<tr>
<td>2. Known hydrographs</td>
<td>2. Known hydrographs</td>
<td>a. SCS unit hydrograph</td>
</tr>
<tr>
<td><strong>Hydraulics</strong></td>
<td></td>
<td></td>
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<tr>
<td>a. Friction loss equation</td>
<td>a. Friction loss equation</td>
<td>a. Friction loss equation</td>
</tr>
<tr>
<td>i) geometric mean</td>
<td>i) geometric mean</td>
<td>i) average conveyance</td>
</tr>
<tr>
<td>ii) arithmetic mean</td>
<td>ii) arithmetic mean</td>
<td>ii) geometric mean</td>
</tr>
<tr>
<td>iii) harmonic mean</td>
<td>iii) harmonic mean</td>
<td>iv) harmonic mean</td>
</tr>
<tr>
<td>2. Left overbank, channel, and right overbank distances</td>
<td>2. Left overbank, channel, and right overbank distances</td>
<td>2. Channel distance</td>
</tr>
<tr>
<td>4. FHWA culvert analysis</td>
<td>4. USGS culvert analysis</td>
<td>4. Own culvert analysis, siltation, crushed pipes</td>
</tr>
<tr>
<td>5. HEC-2 normal bridge / special bridge</td>
<td>5. WSPRO bridge</td>
<td>5. Nagler and d'Aubuisson formulas</td>
</tr>
<tr>
<td>7. Not applicable</td>
<td>7. Storm sewer analysis</td>
<td>7. Storm sewer analysis</td>
</tr>
<tr>
<td>10. Ice cover</td>
<td>10. Not applicable</td>
<td>10. Not applicable</td>
</tr>
<tr>
<td>11. Floodway option not included</td>
<td>11. Floodway option under testing</td>
<td>11. Floodway option not included</td>
</tr>
</tbody>
</table>

Routing Method

The Muskingum-Cunge channel routing method and the modified Puls method for level pool routing are the two routing methods that can use available topographic maps and roughness conditions.

Although theory and practice provide information on the most suitable loss rate, transformation, and routing methods, there is little consensus in the hydrologic community on which method should be used. The Association and FEMA should join forces to identify areas which need further research to establish consistent methods in hydrologic analysis.

Hydraulic Methods

In the unsteady flow models, the hydrographs are routed down the stream system using conservation of mass and conservation of energy equations. In the energy equation, friction losses and transition losses are considered.

Friction Loss Method

The USACE has investigated the accuracy of water-surface profiles (U.S. Army Corps of Engineers, 1986) using three different friction loss equations: arithmetic mean, geometric mean, and harmonic mean friction slopes. USACE did not investigate its default friction slope method, average conveyance, used in the HEC-2 program. Instead of investigating which
friction slope method should be used, USACE recommended placing the cross sections not more than 500 feet apart. Further research is needed to select the proper friction slope method.

Transition Loss Coefficients

The other loss in the energy equation is the transition loss. Although general guidance is given in the HEC-2 user's manual, there is no specific guidance on what factors should be considered in selecting the transition loss coefficients. Further research is needed to select the proper transition loss coefficients.

Bridges

Losses through bridges (Federal Highway Administration, 1986) are computed by the momentum principle, energy principle, Federal Highway Administration (FHWA) method, and U.S. Geological Survey (USGS) method. Based on the analyses made by Schneider, et al. (1977) of USGS, the bridge routine in the WSPRO program should be used in all computer programs when analyzing losses through bridges.

Culverts

Losses through culverts can be computed by the momentum principle, energy principle, FHWA method and USGS method. Different results were obtained by these methods (Khine, 1991) for a twin 10-feet-wide by 5-feet-high reinforced concrete box culvert. The difference in results is due to the differences in classification of free flow or full flow for high head condition, hydraulic grade line at the outlet, and the submergence of the outlet. Further research is needed to obtain information on all three areas.

Storm Sewer Analysis

Traditional storm sewer analysis is based on the concept that the pipe will be just flowing full for a design discharge. In that case, the hydraulic grade line along the storm sewer system can be determined without considering the velocity head in the outflow pipe. The design discharge is normally less than the 1% annual chance flood. When the 1% annual chance flood is forced to pass through the storm sewer system, then pressure flow will exist and the velocity head in the outflow pipe must be considered as additional head required in the upstream manhole. The results from the two concepts (Khine, 1994) are shown in Figure 1 for three segments of the storm sewer pipe, which has a diameter of 66 inches. The losses at the manhole are computed based on Virginia Department of Transportation (VDOT) equations.

Review of the adICPR Program

Although FEMA is aware that different results can be obtained from different programs, in most cases there is not enough evidence to make a clear cut
decision on methods, programs, and results. FEMA's review of adICPR has necessitated the adoption of some guidelines on the model's use. The following issues have been agreed to between FEMA and the author of adICPR, to allow for the use of the program for FISs.

**Hydrology**

The SCS unit hydrograph method, kinematic wave method, and curve number method in the adICPR program yield results similar to the results from the HEC-1 and TR20 programs.

**Bridges**

WSPRO bridge analysis should be included. Before implementing this option, the adICPR manual will include a statement to the user that rating curves must be developed based on the WSPRO bridge analysis.

**Culverts**

The USGS six basic types of flow through the culvert will be implemented. FHWA culvert equations and coefficients will be used. Classification of full flow or free flow for the high head situation will be based upon the depth at the vena contracta.

![Figure 1. Comparison of hydraulic grade lines (Khine, 1994).](image-url)
The submergence of the culvert will be based on the downstream tailwater without considering momentum balance in the downstream reach. This criteria will be modified if more information is available on the submergence of the culvert based on the momentum principle.

The hydraulic grade line at the outlet of the culvert for full flow with free outlet will be based upon FHWA criteria of \((D + Dc)/2\). This criteria will be modified if more information is available on the hydraulic grade line at the outlet for different shapes of culverts.

**Weirs**

The rectangular weir equation will be used for all shapes of weirs. USGS submergence coefficients for weir flow for gravel and paved surface will be included as an option.

**Storm Sewers**

Additional losses at the manholes based on the VDOT equations and the velocity head in the outflow pipe will be considered for pressure flow conditions.

**Drop Inlet Structure**

Portland Cement Association criteria may be used as an option.

**Manning's "n"**

Variation of Manning's "n" in the vertical direction will not be included at this time.

**Distances**

Channel distance only can be selected at this time. Left and right overbank distances will not be included at this time.

**Revision Process**

The adICPR program should not have stability problems when inserting additional cross sections or locating bridge and culvert sections based on traditional concepts.

Other options such as output tables and error messages will be included such that it will be helpful to prepare FiSs and to run the program more efficiently.

**Conclusion**

FEMA is responsible for publishing flood insurance rate maps for the entire nation. The maps and profiles are based on the results obtained from computer models, and it is important that consistent methods are used in the computer programs to produce consistent results. A unified computer
program agreed upon by the hydraulic community may be the best solution to the consistency problem, but is unrealistic. Another solution to the consistency problem is to set specific guidelines for flood insurance mapping and require that the computer programs comply with these guidelines. FEMA may need to work with other organizations to conduct experiments, verify the methods, and pass on the information to the different programmers so that the programs will give consistent results no matter which program is used. Model result consistency would be an appropriate issue to be investigated by the Technical Mapping Advisory Council established by the National Flood Insurance Reform Act of 1994.

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A KNOWLEDGE-BASED SOFTWARE FOR CONSTRUCTION STANDARDS IN FLOODPRONE AREAS

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Floodplain Development and Land Use Regulations

Residential development within floodplains in participating National Flood Insurance Program (NFIP) communities involves a myriad of regulations. Construction standards and retrofitting measures vary with flood depths, flood velocity, source of flooding (riverine, coastal, alluvial, mudflows), structural characteristics (type of foundation, materials used), loads to which the structure is subjected (hydrostatic, hydrodynamic, impact, wind), and the extent of technical data available. Floodplain administrators and private citizens alike are finding it increasingly difficult to identify and locate those standards and regulations that apply to a particular situation. It is not surprising that a large number of NFIP violations result from lack of information about applicable NFIP requirements.

Floodplain managers and building officials need specific rather than generic information to protect structures they work with on a daily basis from the hazards associated with floods. They need to recognize incorrect procedures and how to effect immediate relief and alternatives. Engineers and planners need up-to-date knowledge of legislation in the field of flood hazard management, and how the legal requirements affect the practice of their profession. This is compounded by the fact that several NFIP standards are vague and ambiguous, and inconsistently categorized. Some mandatory requirements are difficult to understand and state lofty goals without providing a hint of the means and methods that must be taken to achieve them. Several are out-of-date and unrelated to the technological changes that have occurred.

Software Development

Identifying flood hazards at the proposed building sites and recommending appropriate solutions requires manipulation of a database of NFIP regulations and other practical considerations. A knowledge-based program was found to be appropriate to capture the available information to solve various flooding
problems. An expert system shell called Guru was selected as the development tool for this research. The programming was done in Guru's powerful fourth-generation Knowledgeman Guru Language (KGL) within an integrated information management environment that combined the powers of a sophisticated expert system and relational database with common business tools such as spreadsheet and text processor. KGL is a blend of interpreted procedure codes stored in .IPF files, compiled user defined functions stored in .KGL files, rule set source codes stored in .RSS files, and calls to externally compiled programs written in high level languages such a C or FORTRAN code.

A rule set was developed to capture expert judgment on residential development within floodprone areas. The rule set is called using the main procedure file FLOOD.IPF. The file FLOOD.IPF is designed to facilitate expansion of the program by permitting inclusion of new rules on other aspects of the NFIP, namely, commercial development within the floodplains, flood insurance purchase requirements, flood hazard mapping, and a local government's role in floodplain management. As additional modules are developed, they can be linked to the main framework by adding them to the CASE statement in the program.

Knowledge Acquisition

The complex and divergent nature of residential projects in floodprone areas generates many different types of flood hazards. Knowledge of the law and floodplain management expertise is required to fulfill the numerous legally required administrative duties, and to reduce flood damage. The Code of Federal Regulations (Emergency Management and Assistance) and publications by the Federal Emergency Management Agency (FEMA), Federal Insurance Administration, U.S. Army Corps of Engineers, U.S. Geological Survey, Soil Conservation Service, U.S. Department of Agriculture, Tennessee Valley Authority, Environmental Protection Agency, and other agencies were consulted to identify different sources of flood hazards on a site. Appropriate precautions to reduce/avoid these hazards were arrived at by studying the technical literature and through consultations with professionals in the industry.

Knowledge Representation

Using Guru's rule set manager, the knowledge obtained from NFIP regulations and other sources was written as rules for the inference engine to work on during the consultation. Variables were assigned to the different pieces of information required from the user to analyze the hazardous condition(s) under study. The values of these variables are obtained by using an input-requesting screen form. On-line help was provided wherever it was deemed necessary. The input required by the program is usually a character "Y" or "N" indicating "yes" and "no," respectively, or a numerical value. Once the input values are assigned to the corresponding variables, the
inference engine performs a forward or backward chaining on the rule set to analyze the problem and generate the appropriate flood hazard management suggestions.

Output

The output of the program is a series of suggestions for reducing the hazards in the environment being studied. These suggestions are stored as screen forms and, as a rule is fired, the corresponding form is called by the inference engine for display. The output contains a reference to the NFIP standards to be followed. Definitions of various terms used are stored as screen forms and can be produced as an output at the request of the user.

Conclusions

The advantage of a knowledge-based software over paper standards is comparable to that of electronic over manual computations. The system incorporates an executable form of knowledge and conducts computations needed to assess conformance with standards/regulations. The program explores the different sources of unsafe conditions at a site and analyzes each of these conditions for the project at hand. It provides advice on alternatives for compliance where there is a chance of standards being violated. Users can obtain a printout of the recommendations generated by the system. Computerization of NFIP regulations has made them more user friendly. The system eases the search for regulations applicable to a project or environment and, in turn, increases awareness. Rules, standards, and technical terms are interpreted in everyday language. The system can be easily updated and customized to suit the needs of a variety of clients in the construction and insurance industries.

The software provides floodplain administrators and local officials with a means to identify problems before violations occur. Reduction in non-compliant structures, associated insurance premiums, and disaster relief costs are direct benefits that may accrue. Use of the software in field offices of the Michigan Department of Natural Resources, FEMA regional offices, and local community offices will advance the general public’s understanding of the NFIP regulations and improve the enforcement of those regulations.

References

Federal Emergency Management Agency

Federal Emergency Management Agency
Federal Emergency Management Agency

Federal Emergency Management Agency

Micro Data Base Systems, Inc.

National Archives and Records Administration

U.S. Army Corps of Engineers
FIELD SURVEY TECHNIQUES FOR ASSESSING FLOOD DAMAGE

William G. Fry
David F. Maune
Dewberry & Davis

Introduction

In response to floods in 1994, the Federal Emergency Management Agency (FEMA) asked Dewberry & Davis to utilize global positioning system (GPS) and geographic information system (GIS) technology to rapidly inventory approximately 5,700 flooded buildings in Georgia, Florida, and Alabama, and 2,500 flooded buildings in Texas. D&D subsequently evaluated seven technical approaches, from low-tech to high-tech, as alternatives to best satisfy FEMA's future flood inventory requirements.

This paper discusses FEMA requirements for flood inventory data; lessons learned from the 1994 flood inventories; technical options for future field inventory surveys and geocoding of addresses; time-, accuracy-, and cost-benefit analyses of various options; and rationale for considering any and all of the technical options under differing scenarios.

FEMA Flood Inventory Requirements

FEMA headquarters and disaster field offices (DFOs) required three deliverables, as follows:

1. **GIS database** with geocoded locations (latitude/longitude) of flooded buildings, digital images of each building, and approximately 20 GIS data attributes describing each building and its depth of flooding; as well as special flood hazard area (SFHA) and political boundaries.

2. **Flood damage assessment maps** (scales between 1\" = 500' and 1\" = 1,000') that showed SFHA and political boundaries, and locations of flooded buildings—symbolized to reflect building types, and color-coded to reflect depth of flooding.

3. **Field inventory data sheets** showing values for the 20 GIS attributes describing each building, the image of each building, and its location centered on a small-scale area background map. Each data sheet is a unique form, with image inserts, like the example shown in Figure 1.
Georgia Disaster 1033-DR Observation Data Sheet

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<tbody>
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<tr>
<td>COMMUNITY: ALBANY</td>
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<tr>
<td>ADDRESS: 301 ALICE AVE</td>
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REMARKS:

Figure 1. Field inventory data sheet.
Lessons Learned from 1994 Flood Inventories

D&D personnel and GPS surveyors from GeoResearch Inc. (GRI) deployed within 48 hours of the notice to proceed and survey/inventory procedures were quickly initiated. In Georgia, Florida, and Alabama, GPS quality control was initially a problem, and deliverables were delayed by several weeks. In Texas, several months later, most controllable technical problems had been resolved.

All GPS survey options are limited when areas to be surveyed obstruct satellite signals (e.g., extensive tree canopy cover) or cause multi-path errors (e.g., when satellite signals reflect off marble buildings in cities.)

Horizontal and vertical survey accuracy requirements need to be carefully defined; if relative depth of flooding can be "eyeballed" to the nearest foot from the survey vehicle, and if horizontal coordinates of geocoded addresses accurate to 10 meters are acceptable, there's no need for a local GPS base station. A nationwide wide-area differential GPS network enables geocoding of vehicles with meter-level accuracy, prior to measuring the offset distance/bearing from the vehicle to the building being surveyed.

Requirements and priorities vary, depending on the scenario, preferences, and automation of the local DFO. In the Southeast in July 1994, the local DFOs had no GIS; the field inventory data sheets were highest priority and the GIS databases were lowest. In the automated Houston DFO in November 1994, priorities were exactly the opposite.

In Georgia, Florida, and Alabama, field surveys of all flooded buildings (within selected communities) were executed "ASAP" and included "windshield" damage estimates by certified flood adjusters; the intent was to estimate damage before owners or tenants made significant progress in cleanup and repair. These hasty estimates were controversial and possibly counterproductive, especially when they were subsequently compared with detailed estimates from adjusters inside the buildings. In Texas, surveys were initiated much later; only the 2,500 most-severely damaged buildings in the area were selected, after claim data had already been submitted; and no expedient damage estimates were made.

Digital images were integrated efficiently within the GIS databases.

Although several techniques were used to measure peak flooding, horizontally and vertically, most measurements were approximations only.

Homeowners and tenants are suspicious of "intruders" after a disaster. One GPS survey team was shot at, even when remaining in their vehicle on the street and conducting a "windshield survey." No attempts were made to conduct detailed surveys that would intrude on private property.

Options for Field Inventories and Address Geocoding

The following options, from low-tech to high-tech, were evaluated by D&D for satisfaction of FEMA's future flood inventory requirements.
Option 1: Nonautomated Field Surveys

Personnel in survey vehicles would be equipped with community street maps, database forms/checklists, and Polaroid or 35mm cameras. Estimated 2-D locations of damaged buildings would be annotated on the maps and database entries would be completed on the forms and provided to GIS specialists located in the local DFO, hotel room, etc. Photos would be scan digitized; GIS specialists would use GIS software to geocode addresses and generate GIS files and field inventory data sheets. SFHAs and flood extent estimates would be digitized; flood damage assessment maps would be produced after return to the home office (same with all options).

Option 2: Semiautomated Field Surveys

Survey teams would be equipped with digital cameras and laptop computers with dBase IV for collection of data for the GIS database. The digital imagery and dBase data would be subsequently downloaded into the selected GIS. Estimated 2-D address geocoding would be performed manually in the field, using community street maps, and converted to digital geopositioning in the hotel room each evening by GIS specialists.

Option 3: Raster Map Geocoding

Survey teams would be provided with digital raster graphics (DRGs) from the U.S. Geological Survey or scanned community street maps. Teams would be equipped with digital cameras and laptop computers with ArcView2, MapInfo or PC ARC/INFO GIS. Estimated 2-D address geocodes, digital images, and database values would be entered directly into the GIS in the field.

Option 4: Vector Road File Geocoding

Survey teams would be provided with vector road files (e.g., TIGER data), digital cameras, and laptop computers with PC GIS software. Estimated 2-D address geocodes, digital images, and database values would be entered directly into the GIS in the field.

Option 5: Digital Orthophoto Geocoding

Survey teams would be provided with digital orthophoto quarter-quads (DOQs), digital cameras, and laptop computers with PC GIS software. Accurate 2-D address geocodes, digital images, and database values would be entered directly into the GIS in the field. Option 5a assumes DOQs are available; option 5b requires that DOQs first be produced.

Option 6: GPS Geocoding

Survey teams would be provided with differential GPS receivers, digital cameras, and laptop computers with GPS-GIS conversion software, e.g., GeoLink. Approximate 2-D address geocodes, digital images, and database
values would be entered, using GeoLink or equivalent software. Following GPS post-processing, final GIS data would be generated.

**Option 7: GPS TruckMAP Geocoding**

Each survey team would operate from a GPS TruckMAP vehicle equipped with dual GPS receivers, gyroscopes, computers with GPS-GIS conversion software, and a bore-sighted digital camera that photographs each point being accurately surveyed in 3-D by an eyesafe laser rangefinder and displays the target point location on a background map of the area, e.g., DRG, TIGER, or DOQ. Accurate 3-D address geocodes (latitude, longitude, NGVD or NAVD elevation), digital images, and database values would be entered. GIS databases and field inventory data sheets could be produced in near real-time.

**Comparison of Technical Options**

Table 1 compares the speed, accuracy, cost, and other performance factors for the technical alternatives and thus is useful in selecting appropriate options for a specific post-flood inventory. For example, if speed in acquiring GIS data is critical, choose Option 7. If accuracy of horizontal geocoding is critical, choose Option 5a, but beware of time delays if DOQs do not already exist (Option 5b). If vertical accuracy is needed, e.g., to survey high-water marks on buildings, Option 7 is the only viable alternative. If cost is critical, Options 1 through 5a are cost-competitive. The "weighted" values in the third row of Table 1 provide a possible 50 points for speed, 20 points for accuracy, 20 points for cost, and 10 points for other factors, i.e., ability to expand for major disasters, speed in commencing surveys, and use of locally hired personnel. These numbers can be changed if the user desires different weighted values.

Readers are invited to contact D&D’s Geodigital Services Department for technical assistance.
Table 1: Cost-effectiveness of options.

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UTILIZATION OF GPS AND GIS TECHNOLOGY TO CONDUCT A RIVER BASIN STUDY IN THE NEW YORK CITY WATERSHED

Gary L. Lamont
U.S. Department of Agriculture
Natural Resources Conservation Service

Introduction

New York City's water supply is the largest unfiltered surface storage and supply system in the world, covering over 1.2 million acres in upstate New York. Approximately eight million residents of New York City and an additional one million residents of upstate counties utilize it as their primary drinking water source. Three reservoir systems: the Croton, Delaware, and Catskill, collect and transport water to New York City with the Catskill and Delaware systems providing 90% of its need.

In the late 1980s, Surface Water Treatment Rules of the Safe Drinking Water Act stipulated that unfiltered water supplies coming from surface water sources must meet new federal and state clean raw water standards or must be filtered. Pollutants Cryptosporidium parvum and Giardia are the primary concerns being addressed by these regulations. Presence of these pathogens in drinking water can cause severe intestinal disorders and even death in individuals with weakened immune systems as evidenced by Milwaukee, Wisconsin's public health catastrophe two years ago as a result of these protozoa.

Five to eight billion dollars is the estimated cost to build a system large enough to filter over 1.2 billion gallons of water daily. Annual operating costs alone have been calculated between $200 and $500 million. Standing on the provision of state health laws, which give purveyors of water coming from surface sources the right to initiate rules and regulations in the watershed supplying their needs, New York City decided to update and toughen its 1953 rules in hopes of avoiding these filtration costs.

New York City's Department of Environmental Protection issued a draft of the new regulations in 1990. Agriculture would be heavily impacted by these new rules since it represents a high percentage of the land use and its livestock are believed to be a significant source of the two pathogens. For example, farms in the watershed would be required to eliminate surface runoff from grazing areas, barnyards, and feedlots: an impractical if not
impossible expectation on most farms. Understandably, these new rules evoked disbelief and outrage. Painstaking negotiations of an ad hoc task force persuaded the city to recognize agriculture as the preferred land use and to agree to pay for 100% of the costs to implement the practices recommended in the "whole farm plans" currently being prepared for farms located in the watershed.

The Watershed Agricultural Council (which now has oversight for the program) is a non-profit organization of farmers, agribusiness, and New York City’s Department of Environmental Protection that formed as a result of the ad hoc task force’s efforts. Presently the council is experiencing a positive response to the program from a significant percentage of the farming community, who are signing on to work with planning teams developing the whole farm plans. New York City is financing this five-year phase with $35 million to cover administration and implementation of recommended practices on farms.

**River Basin Study**

The Natural Resources Conservation Service’s (NRCS’s) efforts toward a cooperative river basin study began by opening our Walton office in 1992. Historically, NRCS has been an integral participant in many such studies. The primary purpose of a study is to assess the natural and economic resource conditions in a watershed. These analyses indicate whether or not there is justification in applying for money through P.L. 566 legislation to correct a problem. Flooding would typically initiate such a study, but in recent years money to accelerate implementation of conservation practices has become a priority as well.

The magnitude of the New York City watershed's impact on such a great number of people was NRCS's impetus in initiating a river basin study. The Watershed Agricultural Council and the U.S. Forest Service subsequently joined NRCS in signing an agreement to conduct the study and together established several goals. One goal was to provide a method of prioritizing the many sub-basins within the watershed. Rather than a "shotgun" approach to farm planning, prioritizing would equip the Watershed Agricultural Council and the planning teams with a systematic method as well as with the ability to provide accountability for the allocation of funds. Second, this data would then be available for use by local planning teams working with farmers. Third, it would be an effective opportunity to utilize new technology: geographic information systems (GIS) and global positioning systems (GPS).

Our first task was to design a general inventory to be conducted on all farms in the watershed. The inventory consists of 45 questions dealing with such factors as type of operation, number of animals, cropping information, manure, fertilizer and pesticide management, distance of facilities to water, etc. Inventories are normally accomplished through farm visits where we obtain this information, estimate the location of the farm on a map or aerial photograph, and then enter the data into either a spreadsheet or database. The
decision was made to purchase GPS equipment that could be used to gather information in the inventory. This has proven to be an excellent tool. Information can be gathered about each farm while simultaneously determining the farm's geographic coordinates. Receivers with dataloggers and a base station allow us to obtain horizontal accuracy of between 2 and 5 meters after differentially correcting the field data. In approximately 5 minutes while standing near the main barn, the information about a farm can be entered in the datalogger. Field data is corrected against the base station at the end of each day and is then exported into a format acceptable to our GIS.

A geographic information system was the other logical technological choice for the project. With the ability to store and analyze data and create maps, GIS was seen to be a powerful addition to our toolbox. We purchased a workstation with 3.5 gigabytes of storage on hard drives, 1/4 inch tape drive, 8mm tape drive, CD-ROM, color inkjet printer, black and white laser printer, digitizing board, and a large format plotter. The GIS utilized has been Geographic Resources Analysis Support System (GRASS), a public domain package developed by the U.S. Army Corps of Engineers Research Lab (CERL), partially supported by NRCS. This software has been an excellent GIS for us in that it is relatively easy to use and works well with both vector and raster analyses.

Data tends to be one of the more expensive and/or time consuming components of a GIS. This liability has been minimized by our accessibility to other sources providing pertinent information on resources such as hydrography, land use, elevation, hydrologic boundaries, and many others. All of the soils maps for the watershed have been digitized, providing an extremely valuable data layer. Our office has digitized roads from all of the U.S. Geological Survey topographic quadrangles covering the area as well as some farm field boundaries.

Once GPS data has been differentially corrected, it is placed in our GIS where information about each farm is placed in a relational database, thus linking each farm's spatial and tabular data. Various queries can then be created for use with the database: we can do a "point and click" operation with maps on the screen to query the database or create a map of farms that meet specific criteria. This capability enables the farm selection process to be a systematic one during the early stages when basin ranking is not yet available.

The second phase of our study involves a detailed inventory conducted on approximately 800 statistically selected points. Types and rates of application of fertilizers, pesticides, and manure; crop rotations used; year in rotation, and many other pieces of information are examples of the specific data utilized by our water quality model, SWRRB, Simulator for Water Resources in Rural Basins. Sub-basins will be ranked against one another (rather than absolute values of pollutants leaving a sub-basin determined) by this continuous simulation, basin-level model. Comparative analyses on the effect of various levels of land treatment can also be ascertained.

Like most models, SWRRB is extremely data intensive; this causes data entry, rather than actual running of the model, to be the most time
Lamont

Our office in Ft. Collins, Colorado, has been developing a user-friendly interface between GRASS and Informix (a relational database which links tabular data from the database to the spatial data such as soils, hydrography, and topography) to alleviate this problem.

Technological usage through the course of this study has not been limited to data gathering on farms and analyses of the data through models. Other benefits have been realized and utilized. GPS has been used to delineate small watersheds which have been difficult to determine from USGS topographic maps, identify the coordinates of moisture readings on a farm for a research project being conducted by Cornell University, and obtaining the coordinates of transects to be studied by one of the NASA shuttle missions.

GIS has enabled us to create various interpretative maps based on the digitization of soils data. Drainage classifications used to help identify areas of hydrologic sensitivity and hydric soils maps for use in wetland determinations are examples of this. These maps, in combination with other layers, provide valuable planning tools. Land use maps that have served as one of these supplementary layers (despite their dated information) will soon be updated through the advantage of technology using remotely sensed imagery produced by a satellite belonging to India. Digital orthophotography is another data layer we eagerly await that will enable us to do on-screen digitizing of farm features while being linked with the database.

NRCS activities often impact cultural resources. GIS can insure a positive impact. Once the data layer is created, GIS will enable us not only to determine the location of known archaeological sites but also to predict and pinpoint unknown sites as well, securing the preservation of such resources.

GPS and GIS have both proven themselves nonexpendable in conducting this River Basin Study: GPS providing precise locational information in timely manner and GIS enabling many analyses that would take significantly longer without the technology. Logically, this does not come without cost: the obvious financial outlay needed for hardware, software, and data as well as payroll costs when personnel are needed to create required data. Initially there is also a rather steep learning curve when starting out with these technologies. Despite the inevitable frustration of having no tangible "product" to show in the early stages, I believe the rewards will far outweigh the costs in the long run.
FLOOD DAMAGE REDUCTION AUDIT PROGRAM

U.S. Army Corps of Engineers, Seattle

Introduction

The Seattle District of the U.S. Army Corps of Engineers (USACE) has developed an "automated" computer program in conjunction with a flood audit study for two communities in western Washington. The study and program were done for the Federal Emergency Management Agency (FEMA) and were modeled after an earlier study done by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) for the community of Stamford, Connecticut.

A flood warning and alert system can help reduce flood damage where structural solutions are not appropriate, provided the community and individual property owners take appropriate action. Three components are needed for a flood warning system to successfully reduce damage: an automated warning system, a community emergency action plan, and individual property owner action plans. The flood audit computer program provides components of the individual property owner action plans and elements that will enhance the community's emergency action plan.

Individual Action Plans

The flood audit program provides detailed flood information on flood levels at individual properties, relating flood heights at the gage to depth of flooding at buildings on the property. Individual action plans generated by the program recommend specific actions to take in response to forecasted flood warnings. Permanent flood proofing techniques, such as elevating or relocating the home or building a floodwall or levee, can be evaluated and recommended using a subroutine developed by the Sacramento District of the Corps. Where permanent flood proofing techniques are infeasible, graphs provided by the program can be used with flood warning data, broadcast by radio or television, to determine how high to elevate contents and when to relocate vehicles or evacuate.
Community Emergency Action Plans

The flood audit program also provides information that can enhance the community emergency action plan including graphs showing which homes in a neighborhood will be inundated at various levels of flooding. During a flood the program can be used to display these graphs to show which properties would be below the forecasted flood warning level. The program can also provide a “call-down” list for those properties below the forecasted flood warning level.

Data Required

Initial information required for the flood audit program includes elevations of various floods at individual properties, which can be obtained from flood maps and profiles, if available. Return frequencies for the various floods can be specified by the user but must be the same for all properties. Also required at each property are the levels of the floors in the home, garage, out-buildings, and adjacent ground, which will most likely require a field survey of the target neighborhoods. Recent advances in global positioning system (GPS) surveying techniques are expected to reduce field survey costs.

Optional input includes a detailed inventory of the contents of each home including which floor each item is on and its height above the floor. Following the NRCS’s example, Seattle District interviewed each property owner to obtain other physical data including a detailed inventory of the contents of each home. Subsequently, we found the interviews and inventories of contents were a not a productive use of time and money. In the final analysis, only the floor levels are needed since recommendations for permanently relocating shelves, cabinets, electrical outlets, etc. are tied to the flood depth above the floor. All other pertinent data needed for the flood proofing analysis and other aspects of the audit can be obtained from the county assessor’s files, FEMA’s flood insurance and disaster assistance files, or during the field survey.

Output

The following items are generated by the computer program:

(1) User-modifiable initial letters and mailing labels announcing the audits. Instead of letters we suggest announcing the audits via the media, i.e., television, radio, and newspapers, specifying the time and place of a public meeting to explain the audits.

(2) The individual property owner flood audit packet, which includes:

- User-modifiable cover letters and mailing labels
- Flood warning graphs
- User-modifiable Individual Action Plans specifying actions to take before the next flood, during a flood, and after the flood.
Floodproofing alternatives—benefit/cost analysis for:
- temporary closures
- levees
- floodwalls
- fill for future construction
- raising existing structure on fill
- relocating.

Recommended Additional Material
In addition to the items generated by the computer program, the following should be included in the flood audit packet sent to individual property owners:

(1) Property location map
(2) Flood warning map showing:
   - areas flooded at different stages
   - neighborhoods studied
   - evacuation routes
   - locations of shelters
(3) FEMA Fact Sheets explaining:
   - what to do in preparation for a flood
   - how to clean up after a flood
   - means of preventing future damage.

Future Updates
Currently, the computer program is DOS oriented. If sufficient demand exists it will be updated to a Windows format. Then the FEMA handouts, many of which contain graphic drawings, and the flood warning map could be scanned and included as bitmap files in the program. Advantages of this should be obvious as this would allow "on-screen" display of the flood warning map to be used as a backdrop for displaying the location of a specific property.
USING A COST-TO-BENEFIT INDEX (CBI)
TO SET PRIORITIES FOR A CITY MASTER PLAN
DRAINAGE SYSTEM

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Introduction

In urbanized areas, where development is essentially uniform with respect to drainage to streets, the flood damage potential may be related to the flood depth in the adjacent street section. For a particular street geometric cross-section, a given flood depth may be correlated to different levels of flood damage potential depending upon the development of contiguous land areas. Additionally, the greater the flood depth in the street section, the higher the flood damage potential to the adjacent property. The flood damage potential can be estimated if relationships between the street section flood depth and the various associated land use designations exist. By a "master plan of drainage" study of the flood control system, the cost of reducing the potential flood damage (according to local agency standards) can be estimated. Details regarding development of such master plans, linkage to geographic information systems, and other methods for prioritizing flood control system elements can be found in Hromadka et al. (1993).

Dividing the flood damage potential by the cost of upgrading the appropriate flood control system determines a cost-to-benefit index. A higher cost-to-benefit index value indicates that more benefits can be achieved with the associated investment to upgrade the local flood control system. A prioritization of the master plan of drainage system elements can then be developed based upon a ranking of each master plan system element's cost-to-benefit index. A computer model, called "CBI," was prepared to perform the above described tasks. The CBI approach enables a prioritization of master plan system improvements in order to increase utilization of agency funds to remove system deficiencies. By graphically displaying CBI values, prioritization becomes more visually apparent in that systems demonstrating a more efficient use of agency funds (in removing deficiencies) are graphically identified.

The CBI mapping approach draws upon well-known experience in plotting other phenomenon, such as earthquakes, as geometric symbols (such
as hexagons) whose diameters reflect, for example, the magnitude of the earthquake and the symbol's centroid is located at the earthquake's epicenter. In the CBI graphical display, the geometric symbol's diameter reflects the CBI magnitude and the symbol's centroid is located at the mid-point of a drainage element at which the CBI value applies.

**Coupled Street and Storm Drain System Deficiency Categories**

A typical drainage system element from a master plan of drainage consists of the combined capacity of a particular street section, with an underlying pipe or box flood control system. For evaluation purposes, three deficiency classifications of coupled street and storm drain models are used in the CBI analysis; these categories reflect the varying storm-flow carrying capacity of each street section used in the study. The categories are:

- **Deficiency Category I (roadway sumps)**—For street grades equal to zero, deficiencies typically correlate to the volume of runoff ponded at the particular vicinity, for the selected design storm event.

- **Deficiency Category II (arterial streets)**—For any street with a maximum allowable design flow depth less than or equal to the street top-of-curb. A typical case is when it is required that one or more lanes of traffic be maintained flood-free during a design storm. Generally, such a criterion applies to major or arterial streets.

- **Deficiency Category III (residential streets)**—For any street with a maximum allowable design flow depth greater than or equal to top-of-curb, for the selected design storm event. Generally, residential streets fit into this category.

**Definition of Flood Damage Potential**

A set of flood damage potential curves is needed for each deficiency category. The curves define a street flow depth versus flood damage potential relationship, for various land use designations. Generally, flood damage of habitable structures can be estimated to occur at a specific depth of flow above street top-of-curb (such as a one-foot depth above top-of-curb). At this depth, it is assumed that flood flows are damaging property, and potential damage costs can be computed. For greater depths, higher potential damage values may be assigned. For lesser flow depths, where property damage might not occur, a "penalty" may be assigned that generalizes "damage" due to traffic obstruction, risks to emergency services, among other factors. For example, assuming a 10% damage potential for flow depths 0.5 foot above top-of-curb may be appropriate. A continuous damage potential versus flood depth relationship is defined. Although potential damage costs may be computed, they are not necessary in the CBI approach as a subsequent
normalization of CBI values is used for prioritization purposes. Consequently, the key to the CBI analysis is a relative flood damage potential definition, with respect to both flood depth in the street and land use designation. The ranking of master plan system elements with respect to CBI values is analogous to the more standardized cost-to-benefit ratio approach such as is used by the U.S. Army Corps of Engineers (Sheaffer et al., 1982).

CBI Model Interface with Other Computer Programs

The CBI model was written to interface with the Advanced Engineering Software (AES) RATCAD/GIS hydrology model (Hromadka, 1987, pp. 22-27, 28-43); Hromadka et al., 1987) and the Boyle Facility Management System (BFMS) database application (Boyle, 1994). The RATCAD program provides the peak flow rates for each coupled street/storm drain element (i.e., link) within the catchment master plan. The BFMS utilizes the RATCAD peak flow rates to identify the deficient reaches within the entire drainage system and provide improvement options based upon the agency’s standards (for example, see the County of Los Angeles Hydrology Manual, 1992). Next, a database file is created by the BFMS for use with the CBI analysis. After determining the cost-to-benefit index for each element in the entire master plan of drainage, a graphics database file is created for use in preparing CBI mapping.

Cost-to-Benefit Index Procedure

The CBI analysis procedure is described below.

**Determine Element Deficiency Category**

The element deficiency category under study can be determined by using the master plan system element’s street cross-section information (contained in the database) and the element’s deficiency category definitions as described previously.

**Determine Existing Condition Street Flow Depth**

Manning’s equation for normal depth flow is used to determine the existing condition (i.e., no new drainage improvements) street flow depth, for each system element, by using the peak flow rate, existing storm drain capacity, and street cross-section information. The street flow homographs from the Los Angeles County Flood Control District Design Manual (Hydraulic) can be used to estimate the normal street flow depth. This flow depth corresponds to the condition where storm drain improvements have not yet been made to remove deficiencies, for the selected design storm event.

**Determine Flood Damage Potential**

After determining the existing condition street flow depth, the flood damage potential is determined from the flood damage potential curves, based upon
the proper street deficiency category and the adjacent land use. If the system element under study contains mixed land uses, the flood damage potential for each land use is calculated, and an area-averaged value is used to represent a composite flood damage potential, for the selected design storm event.

**Determine Improvement Costs to Remove Deficiencies**

Improvement costs for each deficient street/storm drain reach are provided by the master plan of drainage results. These costs reflect the cost to remove deficiencies, consistent with agency standards, for the selected design storm event.

**Calculate the Cost-to-Benefit Index Value**

The CBI is calculated as follows:

\[
\text{CBI (cost-to-benefit index)} = \frac{\text{Flood Damage Potential}}{\text{Improvement Costs}}
\]

**Store Cost-to-Benefit Index Values**

The CBI value computed by Equation (1) for each street/storm drain reach is then stored in the computer database with respect to its deficiency category.

**Normalize Cost-to-Benefit Index Values**

After completion of the CBI analysis for the entire master plan of drainage, statistical calculations of mean value and standard deviation, for each of the three different deficiency categories, are prepared. By dividing the entire CBI range of values by the maximum CBI value (based upon the deficiency category), normalized CBI values are computed with a range of zero to one. The normalized values are written to another data file for subsequent graphics display. Note that a CBI value of zero corresponds to a zero deficiency pursuant to agency standards and the selected designed storm. A CBI value of 1. corresponds to the maximum value of the CBI per Equation (1).

**Cost-to-Benefit Index Graphics Display**

A graphical representation of the CBI values can then be prepared by plotting graphics symbols onto the storm drain system maps. The composite CBI map will have three different symbols to represent each deficiency category:

- Deficiency Category I (sumps): triangle
- Deficiency Category II (local streets): hexagon
- Deficiency Category III (arterial streets): circle
The standard unit plot for each symbol represents the mean CBI value for each respective deficiency category. The larger the symbol, the greater the CBI value, proportional to the symbol diameter. In other words, the larger the symbol, the higher the ranking of the prioritization within the associated deficiency class.

**Application**

The City of Santa Ana encompasses approximately 29 square miles and is located in Orange County, California. The CBI analysis was applied to the city’s latest master plan of drainage system to provide prioritization for the recommended improvements. A graphical map that displays the CBI analysis results has been compiled, and the diameter of each symbol represents the mean CBI value for each deficiency category. In this application, the mean CBI values are 0.22, 0.29, and 0.26 for Deficiency Category I (roadway sumps), Deficiency Category II (arterial streets), and Deficiency Category III (residential streets), respectively.

Systems A, B, and C are also depicted on the city’s map illustrating how CBI symbols are used to prioritize clusters of deficiencies. Prioritization for the City of Santa Ana master plan of drainage system (Boyle Engineering Corporation, 1994) can be determined by ranking from the largest to the smallest cluster size of symbols for each deficiency category.

The city identified the need to establish a prioritized list of the top 50 projects for implementation. Based upon the CBI values and engineering evaluation procedure (described below), the top 50 projects were identified.

A descending database sort of the CBI values for all deficient links within the system was prepared. Based upon this listing, the top 50 projects were conceptualized by identifying sites with the highest CBI value, along with all deficient downstream reaches (regardless of index value) which would necessarily require relief/upgrade before the localized improvement would be effective. Immediately contiguous upstream deficient reaches were also evaluated for relative CBI values as well as logical extensions within same streets (to minimize future multiple neighborhood construction impacts) and were often included in the conceptualized projects. The database was continually and systematically updated to identify links to be improved until 50 separate projects were developed.

**Conclusions**

The Cost-to-Benefit Index (CBI) method is a graphical means to communicate important information regarding master planning prioritization of flood control system elements targeted for improvement. Using the CBI approach, decisions can be made regarding which system reach or system elements may be ranked as having the highest priority in scheduling construction. Additionally, a CBI map aids in communicating to the public the relative importance of any particular element with respect to the overall master plan.
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Section 10

Floodproofing
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FLOOD PROOFING: HOW TO EVALUATE YOUR OPTIONS

Larry S. Buss
U.S. Army Corps of Engineers

Introduction
A large amount of information, some in great detail, exists on the subject of flood proofing. Because of this many people are "overwhelmed" by the subject. The U.S. Army Corps of Engineers' National Flood Proofing Committee (NFPC) recognized the need for a report containing "condensed" information on flood proofing that would enable the reader to make decisions related to the use of flood proofing as a flood damage reduction technique. Funding for the effort came from the Corps Flood Plain Management Services Program. The resulting 1993 report is entitled, Flood Proofing: How to Evaluate Your Options.

The report provides the reader with an introduction to flood proofing and explains factors that need to be considered when deciding whether or not to flood proof. It provides information showing how to evaluate a flood proofing project from the viewpoint of economic and engineering feasibility. This paper reviews the purpose and describes the contents of the report.

Report Content
Chapter One introduces the topic of flood proofing and how it can reduce flood damage to buildings and their contents. It also points out the potential for future flooding with and without flood proofing. Effectiveness and safety of flood proofing measures are also addressed, followed by a discussion of the suitability of flood proofing for various building types.

Chapter Two contains information on factors that should be considered when contemplating the question, "Should flood proofing be used?" Factors to consider include:

- Available flood proofing assistance
- Applicable building codes
- Cost of flood proofing
- Benefits of flood proofing
  Reduced flood damage
Reduced personal inconvenience
Increased health and safety
• Architectural aesthetics of flood proofing methods
• Emergency measures
• Flood insurance
• Level of protection.

Chapter Three discusses the methods used to accomplish the three general approaches to flood proofing, which include:

• Raising or moving the building
• Constructing barriers to stop floodwater from entering the building
• Modifying the building and relocating its contents.

The flood proofing methods discussed include elevating or relocating the building, constructing floodwalls and levees, dry flood proofing, and wet flood proofing.

Chapter Four discusses how to assess the characteristics of individual flood situations so the applicability of flood proofing measures can be determined. These characteristics are:

• Flood characteristics
  Flood depth (shallow, moderate, or deep)
  Flood velocity (slow, moderate, or fast)
  Flash flooding potential (yes or no)
  Ice and debris flow potential (yes or no)
• Site characteristics
  Site location (coastal flood plain or riverine flood plain)
  Soil type (permeable or impermeable)
• Building characteristics
  Building foundation (slab on grade, crawl space, or basement)
  Building construction (concrete/masonry or wood)
  Building condition (excellent to good or fair to poor).

The discussion is focused on creating an awareness of all factors relative to flooding that need to be considered when deciding what flood proofing measure, if any, to employ.

Chapter Five describes the process of evaluating the applicability of flood proofing as a flood damage reduction measure. The evaluation process consists basically of three considerations:

• Physical characteristics/engineering feasibility
• Economic feasibility
• Aesthetic appearance and risk.
Decisions to flood proof are made for a variety of reasons. Some individuals will flood proof their buildings only if doing so is economically feasible. Others will do so because flood proofing will eliminate inconvenience and frustration. Still others will do it simply for peace of mind. Whatever the reason, property owners must assess their financial and personal situations and flood risks to determine what flood proofing options are viable. Most people are concerned with how the flood proofed structure will appear aesthetically. All individuals considering successful flood proofing must be concerned with the physical aspects of the flood situation and engineering suitability of flood proofing measures. From this assessment, property owners must make a decision in their best interest.

Chapter Five also contains a flood proofing matrix developed by the Federal Emergency Management Agency that enables the person interested in flood proofing to evaluate the engineering feasibility of nine flood proofing measures to solve a flood damage problem relating to the characteristics of the flood, the site, and the building.

The report contains three appendices. Appendix A, "How to Perform a Detailed Evaluation of Flood Proofing Options," shows in detail the steps needed to evaluate the feasibility of flood proofing from economic and engineering considerations. The appendix assists the reader in making a reconnaissance-level decision regarding whether or not to flood proof and what method to use. Steps in the evaluation are:

- Develop an elevation-discharge curve
- Develop a discharge-exceedance probability curve
- Determine the elevation when floodwater damages the building
- Determine the building's first-floor elevation
- Determine depth-damage data
- Determine probability-damage data
- Determine flood damage prevented
- Determine present value of damage prevented
- Determine the flood proofing measures that are most feasible from an engineering viewpoint
- Compare present value of damage prevented to costs of flood proofing measures.

The appendix contains information on typical depth-damage relationships for various structures and contents as well as costs (based on national averages) of various methods of flood proofing.

Appendix B contains a flood worksheet and three types of graph paper for use in conducting the detailed evaluations of Appendix A.

Appendix C, "Case Studies—Evaluating Flood Proofing Options," contains six examples of how building owners evaluated whether or not to flood proof their buildings. The methods in Appendix C are intended for those individuals who may not require the detailed evaluation process of Appendix A to make a flood proofing decision.
Conclusion

The NFPC has recognized a need for a concise, condensed publication that can be used as a guide in evaluating the options relative to flood proofing individual structures. The report is intended for those wanting to know how to make a planning decision on whether or not to flood proof and what method may best solve their problem.

The information presented, such as depth-damage, cost, etc., is, however, based on national averages and should not be substituted for actual site-specific data. After making a decision to flood proof using the information in the report, an engineer and/or contractor knowledgeable in flood proofing should be consulted prior to actual implementation.
LOCAL FLOOD PROOFING PROGRAMS

Joseph R. Wanielista
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Introduction

Studies have shown that financing is often the greatest impediment to implementing a flood proofing project. While many people want to flood proof, lack of funds was listed as the most important reason why they did not. Some federal agencies have financed flood proofing projects. Statutory authority and limited resources keep the federal programs from reaching many people.

A few local governments have financed or provided financial support for flood proofing projects. Each community's program was developed differently and is administered differently. The experiences of these communities can be very helpful in guiding other flood-prone communities in developing their own approaches to flood proofing.

Purpose

This paper identifies lessons learned that can help communities interested in financing flood proofing projects. It is not a recipe for developing a model program, as each community must design its own approach based on local flood hazards, building conditions, financial needs, and resources. Detailed information is found in a Corps publication, Local Flood Proofing Programs, June 1994, which is also the source for this paper.

General Considerations

Before initiating a flood proofing funding program, certain factors need to be considered by community officials. Six of the most important factors are covered in this paper:

1. Ensure that the projects to be funded are appropriate for the flood hazard.
2. Identify the source of the funds.
3. Get others in the community interested in and supportive of flood proofing.
(4) Involve the property owners in the flood proofing and funding decisions.
(5) Ensure that the community has the legal authority to fund the projects.
(6) Ensure that local staff will be free from liability.

**Appropriate Projects**

The financial benefits of flood proofing can be very attractive to community officials. It is usually cheaper to protect a building in place than to acquire and/or remove it. However, flood proofing techniques that leave a building in the floodplain are not appropriate in areas subject to the high hazards of deep flooding, erosion, flash flooding, high velocity flooding, or heavy debris flows.

Flood proofing is an appropriate flood protection measure only for certain flood hazards and particular types of buildings. A community should develop criteria to decide which properties should be protected by which measures. The Corps publication, *Flood Proofing - How to Evaluate Your Options*, is an example of a document which provides guidelines on determining the most appropriate measure for an individual building.

Communities should generally restrict flood proofing projects to areas subject to low velocity and/or shallow flooding. Some limit their funding to the safest types of projects as seen by these examples:

- Des Plaines, Illinois, restricts its funding to sewer backup protection projects.
- The flood protection plan developed by Homewood, Illinois, recommended funding only elevation projects rather than cheaper dry flood proofing projects.
- The Illinois Department of Transportation, Division of Water Resources, helped establish a low interest loan program for communities in 1988. It gave the communities guidelines to determine which types of projects could be funded based on the flood depths and building types.
- Prince George’s County, Maryland, established guidelines for its funding program based on 100-year flood levels developed by the county, assuming a fully developed watershed.

**Funding Sources**

Wanting to finance flood proofing projects is one thing; having the money to do it is quite another. Communities may encounter one or two problems in devoting funds to flood proofing: having adequate funds to start a new program, and/or having the legal authority to spend the money on flood proofing.

*Property Taxes.* Property taxes are the mainstay of most local governments. There are two kinds of property taxes, general and special
purpose. Most communities have a "general corporate fund" or "general revenue fund" that may be used to finance many kinds of activities, especially staff and administrative expenses. Frankfort, Kentucky; Rosemont, Illinois; and Fairfax County, Virginia, identified this kind of fund as one of their sources for the money.

A special purpose storm drainage property tax finances the program in Prince George’s County, Maryland. Revenue from this separate state-approved tax goes into a special fund. King County, Washington, has a county-wide property tax levy that goes into its River Improvement Fund.

**Sales Tax.** Some states authorize communities to levy sales taxes for special purposes. The Economic Development Council of Kemah, Texas, is supported by a 0.5% sales tax. The Council funds community improvement activities like drainage projects, floodplain acquisition, and flood proofing.

**Bond Issue.** Bonds are usually issued to pay for large public works projects, including flood and drainage improvements. Fairfax County, Virginia, and Homewood, Illinois, identified bonds sold for stormwater or drainage improvement purposes as one of their funding sources.

**Impact Fees.** Some drainage projects in Fairfax County, Virginia, are paid by developers, who are required to contribute to the cost of handling the increased stormwater runoff produced by their developments.

**Creative Financing.** A community is limited only by its imagination. Several have found "creative" ways to find funds for flood proofing. For example, Illinois levies an income tax which it shares with local governments. The City of Des Plaines appropriated $200,000 from this "extra" money to establish a fund for its flood proofing rebate program.

**State Support.** Some states have had special appropriations to support local programs. In 1988, the Illinois Housing Development Authority set aside $500,000 for low interest loans for flood proofing.

**Federal Support.** Several federal agencies, such as the Corps of Engineers and the Tennessee Valley Authority, have directly funded flood proofing projects. The lessons learned from this work are often transferrable to local government programs. One example of this is the Corps’ publication, *A Flood Proofing Success Story*, which provides documents on dealing with property owners and contractors that are applicable to all financing programs. The Department of Housing and Urban Development’s Community Development Block Grant and the Federal Emergency Management Agency’s Public Assistance and Hazard Mitigation Grant Programs provide funds for communities to administer.

**Community Interest**

What motivates a community to fund flood proofing projects? Those that have investigated or implemented funding programs cited these reasons.

**Economics.** The most frequently cited reason for funding flood proofing was cost—it was shown to be less expensive than other flood protection measures. In some cases, as in Fairfax County, Virginia, and King
County, Washington, studies of local flood problem areas reviewed a variety of structural and nonstructural alternatives. Two cautions must be noted. First, communities must remember that flood proofing does not stop street and yard flooding, damage to infrastructure, traffic disruption, and other problems that accompany floods. Second, predicting the actual costs of projects in areas with little flood proofing experience may be difficult.

**Comprehensive Planning.** Some communities have prepared comprehensive floodplain management or flood damage reduction plans. During the planning process, they concluded that flood proofing should be a part of the program. King County, Washington, prepared such a comprehensive plan, which made project recommendations for over 120 flooding and erosion problem sites in the county.

**External Impact.** Sometimes flood proofing is selected because other flood protection measures have adverse impacts on other properties or the environment. Flood proofing can also be less disruptive to a neighborhood than, for example, removing houses or building a large wall.

**Community Rating System.** The Community Rating System (CRS) is a part of the National Flood Insurance Program (NFIP). Once in the CRS, some communities want to improve their insurance rate reduction, so they initiate new programs to receive more credit for more activities. For example, officials in Kemah, Texas, and South Holland, Illinois, have implemented public information programs and have planned funding programs.

**Post-flood Mitigation Programs.** Usually a community becomes interested in flood protection programs after a flood. Not only is there interest in trying new approaches, there may be funds available to support new programs. For example, while processing the applications for grants to repair flooded wastewater treatment plants or other public buildings, FEMA staff identify flood proofing or other mitigation alternatives. The Department of Housing and Urban Development's Community Development Block Grant program also has a post-disaster funding program. The Village of St. Charles, Michigan, took advantage of this program to fund a comprehensive flood damage reduction program after it was flooded in 1986.

**Property Owner Involvement**

Voluntary property owner involvement is vital to the initiation and long-term operation and maintenance of a flood proofing project. Keeping residents informed was the recommendation most frequently voiced by communities experienced in implementing flood protection plans. This requires both the right attitude and sound technical data that can be explained in lay terms.
Statutory Authority

Two legal questions sometimes arise when considering government involvement in flood proofing: the statutory authority to spend public money on improving private property, and liability for protecting private property. In some communities, legal challenges have prevented implementation of well-planned programs. Most states do not have laws that address flood proofing so clearly. A few communities reported either that it was against state law or there was not specific authority to use public money to improve private property.

In Illinois, the strongest authority comes from statutory authorizations for communities to undertake community development activities, to bring buildings up to safe and sanitary conditions, and to protect their residents from the health and safety problems of flooding. In most states, there is authority to spend local funds on activities whose costs are shared with a state or federal agency.

Liability

What if a flood proofed property is later damaged by a flood? What if the owner failed to maintain a protection measure? These questions have been debated nationally for some time. A community has five ways in which it can protect itself from lawsuits:

1. Staff should become technically competent in the field.
2. Staff should limit flood proofing advice and projects to areas where it is appropriate, i.e., areas of lower velocities and flood depths.
3. The community should enter into a contract or agreement with each property owner. The agreement should specifically exempt the local government from liability.
4. Staff should follow nationally recognized flood proofing guidelines.
5. The community may want to purchase liability insurance or establish a self-insurance pool or plan to protect itself.

Funding Arrangements

This section discusses how funds actually have been managed. The local programs reviewed fall into one of the following five categories.

Full Funding of Projects on Public Property

Under this approach, a community selects flood proofing as the best way to protect its public facilities from flooding. This is the easiest approach to implement, as it avoids the problems of coordinating activities with a property owner, legal complications of how money should be spent, and concerns about liability.
Full Funding of Projects on Private Property

Under this approach, the community assumes full responsibility for designing, contracting, funding and managing the flood proofing project. It is similar to full funding on public property except that there needs to be a great deal of coordination with the property owner.

Cost Sharing with State or Federal Funds

Another way to reduce the direct cost to the community is to piggyback with another agency’s program. The two most common programs are the Department of Housing and Urban Development’s Community Development Block Grants and FEMA’s post-disaster Hazard Mitigation Grants. The CDBG has funded 100% of the cost to elevate homes in Terrebonne Parish, Louisiana; Kampsaville, Illinois; and St. Charles, Michigan. Several communities have used "soft matches" such as in-kind services, which are given a dollar value and credited toward the local share.

Cost Sharing with the Property Owner

Having the owner of the protected property contribute to the project’s cost has two advantages; the community’s funds will go further, and it gives the property owner a stake in the project. With an investment in flood proofing, the owner has an incentive to make sure the property is properly maintained.

Low Interest Loans

Low interest loans look attractive to a funding agency. Eventually, the funds will be repaid so they can be loaned to flood proof other properties. Loans also avoid the challenge that the community is "giving" money to improve private property. However, loan programs have yielded mixed results. Michigan and Illinois offered them before floods had occurred, but there were few takers. On the other hand, the Small Business Administration’s 4% disaster assistance loans have been widely used to flood proof properties.

Conclusion

In conclusion, the potential for flood proofing to reduce flood losses is significant. Many people have flood proofed their homes or businesses, often by using common sense or self-taught approaches. In the last 10 years, federal, state and local agencies have been researching techniques, promoting flood proofing as a viable flood protection measure, and assisting property owners in implementing projects.
Section 11

Flood Warnings
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A STATEWIDE FLOOD WARNING SYSTEM FOR THE STATE OF ARIZONA
OR HOW TO SUCCESSFULLY INVOLVE THE CORPS IN LOCAL FLOOD WARNING SYSTEMS

Joseph R. Dixon
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Background

From late December 1992 through February 1993, a series of winter storms produced record-breaking amounts of precipitation and severe weather across Arizona. At that time the state was in its third consecutive year of above-average precipitation, upper watersheds were saturated, and record-breaking snowpack was recorded statewide.

Heavy rains in January, combined with the rapid melting of the snowpack, caused intense runoff and flooding of streams and rivers throughout the entire state. The 15-day period of heavy rain and high flood stages in early January 1993 was the most damaging and extensive winter flood event on record.

On January 19, 1993, a Presidential disaster declaration was issued for 10 of the 15 counties in Arizona. By February 5, three more counties were added.

In February more storms followed, bringing precipitation of 400% above normal for the month. Streams and rivers statewide, still partially full from January runoff, experienced additional high flows for periods of up to 10 days. In some areas of the state, the additional runoff caused flooding in areas not affected by the January storms.

Damage was widespread and significant. Total public and private damage exceeded $400 million. Eight deaths and 112 injuries were reported by the Red Cross. Total federal flood-related expenditures exceeded $220 million.

The agriculture industry alone, which accounts for about one-sixth of the Arizona economy, suffered direct damage of approximately $70 million in lost crops, eroded or destroyed land and buildings, and lost income.

Flooding caused widespread damage to public infrastructure and facilities, impacted people in over 100 communities and on several of the 22 Indian reservations in the state. The economy of Arizona was impacted in
numerous ways. Tourism, an important part of the economy, was below normal in many areas during the peak winter season. The mining industry suffered extensive physical damage, lost production, and increased expenses. Environmental and economic impacts resulted from sewage spills, loss of vegetation and wildlife in floodplains, and sedimentation and debris deposition within Arizona rivers.

**Action**

The severe extent (statewide) and duration (months) of this extended flooding event brought a visibility and action to a problem which, at least in Arizona, is typically highly localized in extent (in a single community or a county) and of short duration (minutes or hours).

The flooding prompted a number of legislative actions at both the state and federal level that ultimately led to a cooperative study effort between the U.S. Army Corps of Engineers (Corps) and the Arizona Department of Water Resources (ADWR).

One of the first actions that took place, actually while the event was still ongoing, was the formation of the Governor’s Task Force on Gila River Flooding. This group, composed of 23 key individuals and agencies, was brought together by Governor Symington and provided a forum for discussion and interaction, ultimately leading to specific legislative actions by the U.S. Congress and the Arizona State Legislature.

The members of the Arizona congressional delegation, receiving input from the Governor’s Task Force on Flooding, were able to provide funding and direction to the Corps. Congress, through a supplemental appropriation bill, further emphasized the criticality to respond quickly and provided new direction. The new direction expanded the Corps’ study authority beyond the typical watershed boundary approach which had limited the Corps efforts in developing a statewide communication and flood warning system. The appropriation legislation contained a key phrase which had not been provided to the Corps in other work performed in Arizona and had limited its efforts to individual watersheds. The language directed the Corps to identify corrective measures to prevent future damage and loss of life throughout Arizona. That phrase, "throughout Arizona," was interpreted to mean a flood control approach that would benefit the entire state. Working with the state of Arizona, it was determined that the only approach to satisfy this legislative direction was a statewide flood warning system.

At the same time that the Corps was receiving guidance (summer of 1993), the state of Arizona legislature was holding special hearings on how best the state could deal with the type of flooding that had taken place during the winter of 1993. The Corps was asked to testify at those hearings and help the legislature to identify the scope of the problems and potential solutions. The results of those hearings was a legislative package that provided the ADWR with personnel and funding to implement a statewide flood warning system.
System Development

The result of the Corps’ study effort was the development of a statewide flood warning system. A flood warning system can be broken down into five components: flood threat recognition, warning dissemination, emergency actions, recovery, and continuous management. Each component is a vital part of flood warning systems, but the first step is flood threat recognition. The study focused on the first component.

A three-level approach was developed by the Corps, ADWR, and the public. The levels were (1) where there are no existing systems, (2) improving existing systems, and (3) develop a statewide flood warning system.

First, many areas in Arizona have no flood warning capability. Precipitation and stream gauging is nonexistent or, if in place, read manually, providing no input to any flood warning network. Many of these areas were in upper watersheds, where provision of even one precipitation gauge and transmitter would facilitate some degree of flood warning in more heavily populated areas downstream. Therefore, the study looked at those areas where gaps in data collection existed, and evaluated the potential for placement of gauges to be linked to the flood warning network.

Second, in some areas of Arizona, notably around the major metropolitan areas of Phoenix and Tucson, and less so in some limited outlying areas, flood warning systems already exist. In some areas the systems work well, but would work better with the addition of gauging stations. In other areas, existing systems work poorly or not at all. Improvements or additions to existing systems, and their potential linkage to the central system, were therefore considered in the study.

Third, no centralized statewide flood warning system exists in Arizona. Local counties or towns are solely responsible for flood warning in their area. Maintenance, expertise, and emergency response are variable throughout the state. No mechanism exists for relaying vital information from adjacent or far-away watersheds to locals of approaching storm events. Consequently, locals must wait until the storm is upon them before any warning of potential flooding is available. In many cases, the warning time provided is insufficient to prevent any significant degree of damage or loss of life. Additionally, there is no statewide institutionalized responsibility for provision of flood warning and adequate maintenance by locals, or for collection and archiving of data which could be used to provide better future flood warning. Storm event data is often lost, and in many cases expertise is not available at the local level to utilize incoming data or to interpret the data after the storm has passed.

Utilization of existing gauging sites was identified as a low cost method of installing flood warning equipment, and typically involves letters of agreement with participating agencies. The ADWR has existing agreements for this specific purpose, and will be responsible for provision of the sites. The environmental impacts associated with using existing gauge sites are minimal.
The major basins were weighted for their contribution to statewide flooding. In identifying damage centers, the study used the public meeting and coordination meetings with the ADWR to provide a list of damage centers. The damage centers that had the potential to provide the largest warning times produced the greatest possible economic benefits. That was the key parameter in determining federal participation.

Seven basins were analyzed as part of a backbone statewide flood warning system. They were Little Colorado River, Upper Gila, Middle Gila as affected by the San Pedro River, Santa Cruz River, Verde River, Sacramento Wash, and Lower Gila River.

The Plan

The plan calls for a "backbone" system with the installation of 120 Automated Local Evaluation in Real Time (ALERT) gauges transmitting to both a local and a central base station located at the Arizona Flood Warning Office, ADWR. The central base station will also receive data from other existing agency gauges (U.S. Geological Survey, National Weather Service, Soil Conservation Service, and the Corps), Phoenix Real-Time Instrumentation for Surface Meteorological Studies (PRISMS), lake levels, snow, lightning, stream, precipitation, and other ALERT systems.

At the central base station, the data will be analyzed and stored on two existing pre-programmed mainframe computers operated by Salt River Project and NWS. This data will be accessible from the Internet and through graphic workstations, electronic bulletin board dial-up, and output to faxes for other agencies.

On the Internet, other agencies, such as the Corps, the Colorado River Basin Forecast Center, and Bureau of Reclamation, would be able to input scheduled releases and planned operations of dams into the mainframe for other interested water resource planning and emergency action agencies.

This system allows for additional gauges, basins, and agencies to participate as the need arises and is justified.

A combination of 72 rain and 48 stream/rain ALERT gauges are proposed for the statewide flood warning system. Gauge locations were selected on major basins and existing sites.

The study pursued a plan of avoidance dealing with significant real estate requirements and environmental impacts. This can be achieved for real estate due to the variable location of gauges. If a cost is required for a gauge it would be placed up- or downstream to avoid the cost. An environmental assessment is being conducted and will be submitted with the final report.

In addition to the gauges, it was assumed, based upon the areas needing coverage, that 10 repeater stations would need to be added to relay transmissions to the Central/Local Receiving and Processing Stations (C/LRPS). Repeaters already exist in many areas and would be utilized to the maximum extent. There is a design redundancy in having both local stations and the central station to ensure maximum warning time to local officials.
Conclusion

The plan appears to be sound, meeting all the current technical and policy criteria for implementation. It is economically justified, environmentally and publicly acceptable, and utilizes the most current state-of-the-art engineering design. The South Pacific Division of the Corps has recommended that the plan go forward. The ADWR has indicated willingness to be the local cost-sharing partner.
PREVENTING FLOOD DAMAGE THROUGH THE USE OF AUTOMATED FLOOD WARNING SYSTEMS AND FLOODPROOFING OF STRUCTURES

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Introduction

The State of Connecticut's Department of Environmental Protection (DEP) owns and operates an automated flood warning and response system. In 1988 the DEP hired a full-time meteorologist and electronics technician to program the computers and maintain the field gauges that make up the flood warning system. In addition, Doppler radar and satellite data are also received by the DEP. The DEP serves as the forecasting and weather monitoring arm of the Office of Emergency Management during severe weather events in Connecticut, and has been activated on over two dozen flooding events since 1988.

The Connecticut Automated Local/Statewide Evaluation in Real Time (ALERT) system is an automated early flood warning system. The ALERT system was installed in Connecticut by the Natural Resources Conservation Service (NRCS) in cooperation with DEP in 1985. The system was installed as a direct result of severe flooding that killed 13 persons in June 1982. The purpose of the flood warning system is to aid the DEP and National Weather Service (NWS) in issuing faster flood watches and warnings, and to assist communities in responding more rapidly to flash flooding.

The system consists of 48 rainfall gauges, 21 river gauges, 6 weather stations, and 3 coastal tide gauges (1995). These gauges monitor rainfall and river levels statewide, and transmit their data via VHF radio signals to a pair of computer base stations in Hartford, Connecticut (Figure 1). Radio repeaters are used to relay data from the field gages to the centrally located computers.

The base stations are located at the City of Hartford Public Works Department, and at the State Office Building within the offices of the DEP/Inland Water Resources Division (IWRD) in Hartford. Once received, the precipitation, river, tidal, and weather data are stored in the base station computers. Special software is used to analyze the data and alert IWRD staff of potential flooding conditions before they occur. The data is also uploaded in near real-time to the NWS Northeast River Forecast Center (NERFC) in
Figure 1. Statewide flood warning system.

Taunton, Massachusetts, and used to monitor rainfall and prepare river flood forecasts.

In addition to the statewide ALERT system there are five local river basin automated flood warning systems. Five towns that suffer from repeated flooding have installed ALERT systems to increase their flood warning and response time. Each town has its own computer base station that can monitor local conditions as well as communicate via phone modem with the central base stations in Hartford. Once connected to either of the Hartford base stations, towns can view heavy rainfall outside their own system before it arrives. Data from these individual systems are also relayed into the central computers in real time via radio repeaters.

Individual towns that join the statewide system by installing a local system receive financial and technical assistance from the DEP and the federal government. Because of this assistance, the cost to each town to install a new system is minimal compared to the dollars saved during a flood. On average, a local automated flood warning system includes three rainfall gauges, one river gauge, and a computer station. The average cost of a system is approximately $50,000. In Connecticut, towns installing new systems can receive grants of up to 67% of the total cost. Currently, the towns of Wallingford and North Haven are installing local ALERT systems, joining the communities of Hartford, Milford, Southington, Norwich, and...
Stamford, and the South Central Connecticut Regional Water Authority already in the ALERT system network.

The Benefits of an Automated Flood Warning System

Communities that suffer from repeated water damage caused by the flash flooding of small rivers and streams can typically increase their warning time by a minimum of 3-4 hours, providing emergency personnel with an invaluable tool for responding to flooding emergencies. The Connecticut ALERT system is designed to provide NWS forecasters with the necessary data to make forecasts within two hours of the start of heavy rainfall. Storm data is stored for retrieval and analysis, which typically includes an estimate of the magnitude or frequency of the flood event. The ALERT system also provides fairly accurate rainfall and meteorological data to the Departments' Forestry Division Fire Monitoring Program, and approximately two dozen engineering and water quality testing firms. Water quality tests often can only be conducted under specific runoff and rainfall conditions.

The No Action Benefit

An added real benefit of Connecticut's ALERT system that is often overlooked is the "no action" benefit. This refers to cases where a community can choose not to act in an otherwise borderline situation because their personnel know that flooding will not occur. The instantaneous collection of data by the automated system allows towns to keep work crews from acting unless it is necessary. For instance, the unnecessary mobilization of a 10-person sandbag crew for one 8-hour shift may cost an average of $5,000 in staff and materials.

In addition, Connecticut's system is designed to operate in a sleep mode requiring no human monitoring unless flooding is occurring. This is made possible by voice synthesizers and auto-dialing phones within the system at two locations, allowing the computers monitoring flooding conditions to automatically call IWRD, NWS, and local staff at home and alert them of potential flooding.

The Flood Audit Program

In Connecticut an essential element of the installation of an automated flood warning system is the survey of critical entry elevations of homes and businesses within the 100-year floodplain of selected rivers. 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 that provides the homeowner or business with detailed emergency actions to take in case of flooding. When flooding is imminent, audit holders may be called by phone and given the latest forecast. As seen on the Day curve (see Figure 2) the greater the warning lead time (the time lag between the start of heavy rainfall and the beginning of flooding) the greater chance that the damage can be reduced (Day et al., 1969). Because objects such as
water heaters, carpets, out buildings, and furnaces cannot be moved quickly, damage reductions reach a maximum value of around 35% of avoidable damage for a warning lead time of 48 hours or greater. Audit holders are also given a customized list of actions that can be taken well in advance of the next flood to reduce damage, such as installing check valves or strapping down oil tanks. Connecticut’s system is designed to operate most effectively for rivers with 4-16 hours of warning lead time.

Pilot Projects

Connecticut has undertaken several pilot projects to enhance its ability to warn residents against flooding. Some of these projects include:

- The installation of 300 advanced technology National Oceanic and Atmospheric Administration weather warning radios in schools, police, fire, and emergency services departments statewide. These radios operate on the WRSAME (Weather Radio Specific Area Message Encoder) system which allows the NWS to direct its warnings to specific locations. Cost: $140,000.

- The installation of automated water level gauges within a Corps of Engineers dike system in Hartford, Connecticut. This system allows the City Public Works Department to monitor the entire stormwater collection and pumping system from a single location. Cost: $62,000.
The City of Milford is installing a coastal flood warning system consisting of a public address system and 57 hurricane evacuation signs that also show the land surface elevation at each location in relation to mean sea level. Cost: $85,000.

The state DEP is installing an automated coastal flood warning system to monitor water levels, wave heights, wind speeds, and temperatures at three coastal locations within Long Island Sound. Hurricane evacuation signs showing evacuation routes and ground surface elevation relative to mean sea level will be installed at over 300 locations. Cost: $82,000.

References

Connecticut Department of Environmental Protection

Day et al.
1969 Untitled paper on flood warning lead time.
To fuel the industrial revolution, the power of flowing water was harnessed through dams. Above and below these dam sites, communities developed as people relocated to work in the water-powered mills. The story was the same any place in New England where there was enough geological chance to form a waterfall that could be dammed. When the tide of industrial growth changed from water to electricity, the dams were upgraded to become hydropower generators. The growth that had begun in the late 1700s continued and homes and businesses intermingled with factories on the banks of Maine rivers. Before development took place, any flooding that occurred on these rivers was contained in uninhabited "intervales," which are in reality terraced floodplains formed over the centuries. Along the Kennebec River, the intervales were used for farming until the demise of agriculture as a strong economic force. Once the floodplains were no longer viable as farmland, they began to look very attractive as building sites. The ground was flat and the soils supported lawns, just as they had crops.

By the spring of 1987, hundreds of years of human interaction with the river had placed the communities along the Kennebec in jeopardy. Very few people were aware of just how powerful the river could be, and words such as "flood of record" or "hundred-year flood" had little meaning except to a handful of river watchers who had noted some disturbing increases in the frequency and severity of flooding. The April Fools Day flood changed the way people throughout Somerset County looked at flooding and flood awareness. The flood did $20 million worth of damage in the Kennebec basin and $60 million statewide.

During the many hours of debriefing that followed the disaster, one fact emerged: there was not adequate warning given to local emergency managers. This is not to say that the information to provide the warning was not available, rather it describes a scenario where the information did not get down to the local level in a means that was readily understandable. While
there was much discussion after the flood, it took five years before a set of events would take place to begin the process of improving flood warning.

The first event was a flood awareness workshop sponsored by the newly appointed County Director of Emergency Management. During the workshop, it was very evident that the people charged with managing emergencies had never seen a map of the flood hazard area. Firefighters, police, and public works departments were all in attendance at the meeting and when presented with the information available to them from a Flood Insurance Rate Map, asked, "Why haven't we seen this before?" The answer was that the maps and the Flood Insurance Study that accompanies them were usually the responsibility of the Planning Board and were used only to locate new structures and to set insurance rates—which was and still is the primary reason for the maps to exist.

Now that the problem had been identified, a solution had to be found. Merely distributing the maps out to the various public agencies was not in itself enough. A warning network had to be established that could be used any place in the river valley by any individual who had received training in monitoring the river's rise. Before this project began there was no unified network of river gauges available to local emergency managers. The U.S. Geological Survey had several gauges in the basin but the data from them was not readily available, and the gauges were used primarily for flood forecasting. At the local level, a method was needed to translate the forecast information into numbers that would help those monitoring the river and who were ultimately responsible for the evacuation of people and property. The solution to this part of the problem took the form of a Hazard Mitigation Assistance Grant from the Federal Emergency Management Agency (FEMA).

Because of the grant, Somerset County was able to site 29 flood warning gauges. The gauges are tied to mean sea level (NGVD) and each site has at least two permanent survey markers to allow replacement of the gauges if they are destroyed. A local surveying company worked with the project managers to develop a network of vertically and horizontally controlled survey points through the use of survey-grade global positioning system satellite receivers. The accuracy that was achieved through this method of surveying exceeded the accuracy that could have been obtained through more conventional means. By using GPS, the surveying phase of the project was accomplished in one week at half the originally projected cost. The survey points have also been added to the map of Somerset County on file at the Maine Office of Geographic Information Systems.

After the surveying had been completed, each municipality in the river valley could position flood warning gauges that would fit their local needs but would still be tied into the overall flood warning network. Training was given to members of fire departments, police departments, and public works departments in reading both the gauges and the FIRMs and in using a uniform reporting form. The County Office of Emergency Management will provide overall coordination during an actual event and through the use of the FIRMs and its computer will be able to use the flood forecasts form the Maine Emergency Management Agency to provide information to the river
monitors, which will allow them more time to carry out evaluations, should they be necessary.

In addition to providing enhanced warning capabilities in the river valley, this project has served to focus people's attention on the need for proper management of the floodplain. The permanent gauges are a constant reminder that there is a potential for disaster. Property owners can also take advantage of the surveyed elevation points in obtaining flood insurance. These points are the best available information of the height of structures above the base flood elevation established by FEMA.
TRANSITION PLANS FOR
THE NORTHEAST RIVER FORECAST CENTER

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Introduction
River forecasts throughout the country are prepared by 13 National Weather Service (NWS) River Forecast Centers. The Northeast River Forecast Center (NERFC) is tasked with providing forecasts of river stages for nearly 100 locations throughout New England and upstate New York. Major drainage basins that receive daily forecasts are the Connecticut, Hudson, and Genesee River basins. In addition to daily stage forecasts, NERFC prepares a monthly water supply paper that provides an outlook of current soil moisture conditions.

NERFC is in the midst of a major overhaul of its operations. These transitions, which are occurring throughout the country at all River Forecast Centers (RFC), involve new staff positions, new technology, and the application of improved science.

Transition in Location
Perhaps the most visible transition to take place at NERFC is the physical location of the office. For many years, the RFC had been located in Bloomfield, Connecticut. In July 1993, the NERFC moved to Taunton, Massachusetts, where it is now co-located with the Weather Forecast Office (WFO) for Southern New England. This move was prompted by two policies of the NWS modernization. The first was a restructuring resulting from the implementation of the WSR-88D radar system. Many forecast offices were moved based on siting considerations for the new Doppler radar system. The second policy decision was that RFCs would be co-located with WFOs to enhance communication and joint hydrometeorological operations.

At Taunton, it has now been over a year since the two offices were co-located. Generally, this transition has been extremely beneficial for both offices. Understanding of each other's functions has greatly improved. Joint daily weather briefings allow the meteorologists to have a better awareness of the hydrologic conditions that they need to monitor, while the RFC
hydrologists are provided an improved understanding of upcoming weather events for which they may need to prepare.

**Transition in Staffing**

As part of the NWS modernization, many staffing positions were restructured and new ones have been defined. Two new positions have been added at the RFCs. The first position is the Development and Operations Hydrologist (DOH). This position has replaced the Deputy Hydrologist-in-Charge. The DOH is slated as the science and technology leader for the office. As such, the DOH is responsible for overseeing many modernization activities, including introduction of new forecast procedures and new computer hardware, overseeing day-to-day operations, as well as outreach, particularly to the university research community.

The second new position is the Hydrometeorological Analysis and Support (HAS) forecaster. Historically, the NWS has had a significant gap in communication and understanding between the meteorologists and hydrologists within the agency. The development of the HAS position is an effort to couple the two sciences. The HAS function will integrate quantitative precipitation forecasts prepared by the various WFOs for input to the hydrologic models; will perform routine quality control of the radar estimated precipitation over the RFC forecast area; and will perform a significant coordination role between the RFC and the WFOs. NERFC will require coordination with WFOs in Gray, Maine; Burlington, Vermont; Taunton, Massachusetts; and Brookhaven, Albany, Binghamton, and Buffalo, New York.

**Transition in Technology**

The NWS is in the midst of a major modernization process. This has included moving offices and redefining many staff positions, but the motivation behind these changes is the revamping of technology which is beginning to take place.

The NWS has used a 1950s-era radar system to support forecast operations for years. This old technology being replaced by a new weather radar network, referred to as WSR-88D. From the standpoint of hydrologic forecasting, the WSR-88D can depict gridded rainfall accumulations over a specified period of time. The radar will provide a much better depiction of rainfall patterns than does a sparse network of rain gages. Incorporation of gage data along with the radar-estimated precipitation should also ensure numerical accuracy of the precipitation estimates. Output from 11 radars will be mosaiced to generate displays of precipitation over the entire northeast.

Another cornerstone of the NWS modernization is the introduction of new computers and communication capabilities at each of the local field offices. The AWIPS system will provide a network of Unix workstations at each office. These workstations will provide a much higher resolution color graphic display than has been previously available. In addition, and most
importantly, they will place in the hands of the local forecaster significant computational ability which until this time has only been available on centralized mainframe computers. NERFC is anticipating receiving a prototype of AWIPS hardware in June 1995. This initial delivery will provide only a limited subset of the full AWIPS functionality.

**Transition in Hydrologic Forecast Procedures**

A final, but perhaps most important, transition that is being made at NERFC is the transition in forecast procedures. For many years, NERFC forecast operations have been based upon an Antecedent Precipitation Index (API) rainfall-runoff technique developed within the office. The API procedures have performed well over the years, but for several reasons discussed below a decision has been made to transition away from the API procedure. As a result, NERFC has begun a transition to the NWS River Forecast System (NWSRFS) using the Sacramento Soil Moisture Accounting operation.

The primary advantage in this change is the adoption of a physically based conceptual model, as opposed to the more statistically based API technique currently used at NERFC. The Sacramento model is a continuous model which directly accounts for surface runoff, direct runoff, interflow, as well as baseflow. Interactive parameter calibration techniques, and a better understanding of the physics of the model, will result in improved forecasts being provided to the public.

Second, over the past several years, a significant development effort has been made to provide an interactive front end to the NWSRFS system. Historically, NWSRFS has existed as a batch process on a mainframe computer. This has made real-time adjustments to the forecast procedure time consuming and difficult. As a result, many RFCs, including NERFC, have resisted fully embracing NWSRFS for their forecast procedures. However, the Interactive Forecast Program (IFP) will be provided as an integral part of the AWIPS software configuration. The IFP places the capability to make run-time modifications to state variables, rainfall, or other time series information at the forecaster’s fingertips.

Forecast procedures should also be enhanced through the use of additional operations within NWSRFS. First is the dynamic wave routing technique. Currently, NERFC is unable to provide forecasts at many downstream points near the coast due to the backwater effects from the tidal influence. For instance, at Hartford, Connecticut, over 50 miles upstream from the mouth of the Connecticut River, tidal fluctuations of as much as two feet may occur during low flow. The use of the dynamic wave procedures may allow NERFC to model these tidal variations in river stage thus allowing more reliable forecasts to be made further downstream.

Another option within NWSRFS is the use of extended streamflow prediction (ESP). ESP will provide a probabilistic forecast of streamflow or volume for several weeks, or even months, into the future. Such a forecast has been invaluable in other parts of the country where ESP has already been set up. Reservoir operators can use ESP to make decisions on whether water
needs to be released or stored based on current snowpack conditions. The introduction of ESP cannot be done until accurate calibrations of the Snow and Sacramento models are performed.

In addition to the adoption of NWSRFS, special emphasis is being placed on the use of quantitative precipitation forecasting (QPF) to enhance the hydrologic forecast product. QPF will provide forecasts of precipitation for the next 24 to 48 hours that can be incorporated into the hydrologic model. Use of QPF should provide the capability for increased lead time on warnings of potential flooding. The ability to enhance the hydrologic forecast obviously requires a reasonable skill level to be achieved in the QPF. While this is improving, errors will continue to occur as QPF is not an exact science. However, the potential benefits of the use of QPF are great.

**NERFC Products**

NERFC generates a number of products that are available to the public. The form of some these products will change, as modernization progresses, and new products will be developed. The RVF, or river forecast product, provides a six-hour time step hydrograph for the next two to three days for each location for which NERFC produces a forecast. This product is issued in SHEF (Standard Hydrometeorological Exchange Format) to make easy ingest of the product possible. Five regional RVF products are issued—one for the Connecticut River basin, one for Maine and New Hampshire, one for southern New England rivers, one for eastern New York and Vermont, and one for the Great Lakes drainage in western New York.

Daily stage forecasts are issued for approximately 100 locations throughout New England and New York. Mainstem rivers included in these forecast products include the Kennebec, Merrimack, Connecticut, Housatonic, Hudson, Mohawk, and Genesee. In addition several smaller rivers are also included. As development of the new modeling procedures advances, additional forecast points may be considered.

The hydrometeorological discussion product is designed to provide the user with a general understanding of hydrometeorological conditions throughout the RFC forecast area. This includes the amount of precipitation that has fallen, the precipitation outlook for the next few days, and potential impact on river conditions. Also included is information on flash flood guidance and current soil conditions.

The flash flood guidance (FFG) is also issued as a separate product. This product provides an estimate of how much precipitation in a specified time frame is required to result in flooding. The FFG is provided for zone areas, which generally correspond to county boundaries. Besides these daily products, a monthly water supply outlook paper is issued from the RFC. It is anticipated that once ESP is set up at NERFC this water supply paper will include ESP information which should be much more useful for many users.

In the future, NERFC will also be generating a precipitation product at both hourly and daily intervals. It will be based on composite information
from radar, precipitation gages, and satellite. The precipitation field will be displayed on roughly a four-km grid over our entire forecast region.

All watches and warnings are issued by the Weather Forecast Offices, generally based on information and products prepared by the RFC. For NERFC, this is also a change. NERFC had warning responsibility for most of southern New England prior to December 1994. The use of the WFO for issuing public products and warnings provides local coordination on the products, and allows a single point of contact for emergency managers when a warning is issued, regardless of whether the warning is for flooding and other severe weather events.

Data Needs

There is an ever-increasing need for improvements in the timeliness and accuracy of all forms of hydrometeorological forecasts, including river stage. While the use of the new technology should provide a means of achieving that goal, the need will always remain for the availability of precipitation and streamflow gages. Verification and calibration of models require the use of ground truth measurements in order that appropriate adjustments be made.

The NWS is dependent on many others for much of this ground truth data. While new hydrometeorological stations (referred to ASOS, Automated Surface Observing Systems) are being fielded at this time at many airport locations, most of these are replacing existing manual observations. A high reliance on cooperative reports, providing daily precipitation amounts, still exists and should always exist. However, these do not always provide the most timely information in rapidly developing events. Some very valuable state or local networks, such as the Connecticut ASERT system, are available; however, these have not been widely set up, and in some cases, have been poorly maintained. Stream gages are typically owned by the U.S. Geological Survey, the Army Corps of Engineers, or various power companies. Unfortunately, in many cases, due to budget concerns, the availability of these data is being reduced. We continue to seek out new sources of real-time, automated precipitation and streamflow data sources so that our hydrologic forecast procedures can be enhanced.

Summary

Northeast River Forecast Center is in the midst of many significant changes. The intent of the changes is for an improvement in forecast services. New radar equipment should provide better definition of the spatial and temporal precipitation patterns that are driving the hydrologic models. The improved computer hardware should allow the forecasters to focus on the hydrologic aspects of their job and less on the computational restrictions with which they are now often faced. The improved procedures should allow the forecasters the flexibility and capability to appropriately model the river basins and generate river forecasts in timely and accurate fashion. The result of this modernization should be improved forecasts and warnings for all users.
USE OF HEC-1 IN FLOOD FORECASTING FOR CYPRESS CREEK, HARRIS COUNTY, TEXAS

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Introduction

Over the years, Harris County, Texas, and the greater metropolitan Houston area have experienced recurring flood problems. In 1937, the Harris County Flood Control District (HCFCD) was established to resolve some of the impacts associated with such flooding. In 1983, after many devastating floods, the HCFCD set up its Flood ALERT Center. The ALERT Center’s original purpose was to provide flood warning capabilities and to disseminate flood warning information to the public.

The ALERT Center consists of an ALERT (Automatic Local Evaluation in Real Time) system that electronically monitors rainfall and stream gage heights for the more than 80 gages that cover the county. Data in this system is continuously monitored and updated.

During a flood the ALERT Center is staffed around the clock to collect and disburse as much information as possible on the actual event. In a major event, the center may function with a staff of two engineers (to monitor the flood gages), two technicians (to troubleshoot problems with the system), and three or four administrative personnel (to answer telephones and conduct media interviews). Numerous gaging crews are also dispatched throughout the county to take field measurements for verification of gage data.

Current Flood Warning Techniques

Current flood warning techniques are varied. They consist of a “seat-of-the-pants” technique, comparisons to historic hydrographs, and “eyewitness” communication.

The seat-of-the-pants approach involves observing the real-time data of a flood hydrograph and attempting predict the peak time and flood level, provided there is no more precipitation. Though this technique works fairly
well, it has its drawbacks. First, the engineer must have knowledge of the various basin anomalies which occur within the watershed of interest. For example, Cypress Creek in Harris County exhibits a double-peaking hydrograph when there is a basin-wide rainfall. This is due to the developed areas in the lower half of the watershed and the relatively undeveloped areas in the upper half as well as the elongated shape of the basin. It may be that not every engineer staffing the ALERT Center will have knowledge of such peculiarities. Second, this technique relies on a "no fail" situation with the gages. Once a stream gage ceases to function properly, any estimate of crest predictions may be erroneous.

Comparison of real-time flood conditions to historic hydrographs also works fairly well; however, it too has its limits. First, there is a limited window of historical events since most of the ALERT gages provide data only back to about 1986. Second, each storm is different. Each rainfall event will vary with areal distribution, amount of precipitation, and the center of the storm. So it may be difficult to find a historical event close enough to the real-time data to provide a reliable projection for crest prediction.

By far the most accurate is eyewitness information from individual property owners who know when problems start in various trouble spots across the county. Unfortunately, access to this information is limited since a data base of these property owners does not currently exist. Further, it is usually determined that an eyewitness is needed when it is too late.

The River Forecast Center

It has been asked whether or not the National Weather Service River Forecast Center (RFC) in Fort Worth, Texas, might be able to adequately predict river cresting in Harris County. It was determined that using the RFC would be insufficient. This insufficiency stems from two factors. The first is that the RFC forecast model for the San Jacinto River Basin is not detailed enough to handle the major tributaries of Buffalo Bayou (i.e., White Oak Bayou, Greens Bayou, Sims Bayou, and Brays Bayou) that meander their way through downtown Houston. The second point is that the RFC model currently has a minimum time step of six hours. Even if this could be narrowed to three hours, the model would in all probability miss the peak of the hydrograph for most of the flooding sources in and around Houston since these streams are urbanized and respond quickly to rainfall events. Therefore, there is a need for a model which could adequately analyze the responses to different rainfall events within any given basin in Harris County.

History of Model

The model discussed in this paper is a HEC-1 hydrologic model that can be easily compared with and quickly calibrated to real-time data from the ALERT system data base. It is based on work previously done by Carl Woodward (Woodward, 1995). Woodward explained in detail the use of a program called Hec1_Data_Pre which is used to interface the HEC-1 model.
with data from the ALERT system data base. The batch files used in our
system incorporate the use of this Hec1_Data_Prep program. The work
identified herein addresses some of the conclusions Woodward's previous
paper, namely, adjustment of initial loss rates and use of a HEC-1 model that
has been calibrated to large historical events (Woodward, 1995). It also
furthers the work already done by developing a user friendly and easy way to
calibrate the model during forecasting.

One may ask, "Hasn't the Corps of Engineers developed a model called
HEC-1F for flood forecasting purposes?" The answer is yes. However, the
HEC-1F model uses only Snyder's unitgraph parameters, while all of Harris
County's HEC-1 models utilize Clark's unitgraph. A change over to HEC-1F
would necessitate a wholesale change in the model configuration for each
subarea in a given model in Harris County. Initial analyses indicated that the
change from Clark's time-of-concentration to Snyder's lag time would be
fairly methodical. However, the change from Clark's storage coefficient to
Snyder's hydrograph shape coefficient appeared to have no direct correlation.

Choice of Cypress Creek HEC-1

Although Woodward's previous work culminated in the creation of
preliminary models for White Oak Bayou, Greens Bayou, Brays Bayou, and
Cypress Creek (all in Harris County), it was determined that all four of the
models needed to be updated prior to further use in this system. The Cypress
Creek HEC-1 model was chosen as a model to use during testing conditions.
The choice of Cypress Creek over other watersheds in Harris County stems
from several important facts. In late 1994, HCFCD and the Corps of
Engineers, Galveston District, completed work together on an updated
existing conditions model for Cypress Creek (a byproduct of the ongoing
federal project for the watershed). This model has been calibrated to five
historical events since 1973.

A key element in the use of the HEC-1 model for forecasting purposes
was discovered during the calibration process of the Cypress Creek model
(that is calibration to historical events). This element is the limiting of the
number of calibration parameters to as few as possible. In the Cypress Creek
calibration analysis by the Corps, the calibration parameters subject to change
was limited to one—the initial loss rate on the exponential loss record.
"Tuning" of this parameter actually accounts for two particular unknowns:
initial loss rate and residual storage. The fact that the main stem hydrograph
arrives later than tributary hydrographs in the Cypress Creek watershed
allows the main stem flood wave to use the tributaries for storage in a given
reach. However, without a two-dimensional hydraulic model to easily
quantify this residual storage, a simple method to account for the resulting
attenuation needed to be developed. It seemed adequate and convenient to
utilize the initial loss rate to account for all unknowns.

Another reason to use Cypress Creek as the test case is that the model is
a rather complicated hydrologic analysis. Since most of the upper reaches of
the basin are used for rice farming, ponding has been identified as a
significant factor which affects Clark’s storage coefficient \( (R) \). Through statistical analysis done for Harris County in the early 1980s, it was determined that \( R \) varies with different recurrence interval storms depending on the percentage ponding within a given subarea. This also means that \( R \) probably changes with seasonal variations on rice cultivation, although for simplicity’s sake, this thought was not pursued during this test case. Last, since the Cypress Creek model is so complex, it should provide an easy translation to other less complicated watershed models within the county.

**Model Set-Up and Execution**

The model set up consists of essentially five files: two template files, a configuration file, and two batch files. The first template file consists of the base HEC-1 file (excluding rainfall), which represents what is considered the existing conditions of the watershed. This file never changes during the course of the forecast.

The second template file consists of the edited base HEC-1 file. The file is edited by the first batch file discussed below.

The configuration file does two things. It tells the model from which rain gages it should extract rainfall data (usually based on a Theissen Polygon method); and, having previously established several "dummy" stream gages in the ALERT system, it tells the model to which dummy stream gage or set of gages to send the output data. This data is extracted from the TAPE21 file (produced when HEC-1 is executed).

The first batch file contains editing commands that modify the initial loss rates in the template file as necessary and then saves the edited template to a new template filename (see description of second template file, above).

The second batch file is a command file that handles the extraction of precipitation data from the ALERT data base, execution of the HEC-1 model, and the filing of the output data back into the ALERT data base. This file utilizes the previously mentioned Hec1_Data_Prep program.

The algorithm for establishing a reasonable crest prediction is as follows:

1. Edit the first batch file to base values for initial loss rates.

2. Execute the first batch file.

3. Execute the second batch file.

4. View graphical comparison of real-time rated stream gage data vs. dummy stream gage data for the most upstream stream gage in the watershed (graphic will appear in units of discharge vs. time).

5. If there is not a good correlation on the rising limb of the hydrograph, edit the first (upstream-most) initial loss rate in the first batch file.
(6) Repeat steps 2 through 5 until a good correlation is established. Then proceed to the next downstream gage.

(7) If there is not a good correlation on the rising limb of the hydrograph, edit the second initial loss rate in the first batch file.

(8) Repeat steps 2, 3, 4, and 7 until good correlation is established. Then proceed to the next downstream gage.

Once all the stream gages have been calibrated, a reasonable crest prediction has been estimated throughout the watershed. With a good rating curve for each gage, not only the time, but an estimated stage may be forecast.

Conclusions

As was stated previously, the model being used to develop this technique (the Cypress Creek HEC-1 hydrologic model) has been adequately calibrated to five significant historical storms. This calibration was accomplished by adjusting only the initial loss rates and yielded reasonable results when comparing peak discharge, time-to-peak, and runoff volume to those events. Therefore, it is expected that this forecast model will produce similar reliability.

Early tests on small rain events have provided quick answers. The cycle time for algorithm steps 1 through 5 is about five minutes, while the cycle time for calibrating the entire Cypress Creek watershed to the event in question is about 30 minutes.

This model will require a rather long testing period since it will rely on the unpredictability of storm events and so will be tested over the next two years to determine the effects of large and small precipitation events. In the meantime, as updated HEC-1 models become available for various watersheds in Harris County, these basins will also be input into the system for testing. After that, it will be determined whether or not this new HEC-1/ALERT tool is useful in the effort of flood forecasting in the county.

It should be noted that, as Woodward (1995) concluded, a forecast system is only as good as the data input into the system and the ability of the user to interpret the information resulting from the model. By far the best tool in any forecast technique is hydrologic experience and engineering judgment.

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Section 12

Coastal Hazards Management
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MASSACHUSETTS' EXPERIENCE THROUGH THREE PRESIDENTIALLY DECLARED COASTAL STORM DISASTERS, HAZARD MITIGATION, AND NEW INITIATIVES

James F. O'Connell
Massachusetts Coastal Zone Management

Introduction
Massachusetts has approximately 1,500 miles of coastal shoreline. Because of Massachusetts' location at the recessional end of the last major continental glaciation, its shoreline has an extremely varied geographic orientation with diverse geologic landforms of varying elevations. These variables make coastal pre-storm disaster planning, response coordination, post-storm recovery activities and hazard mitigation exceptionally challenging. Massachusetts' developed shore adds to this complexity and makes the storm-induced surge, waves, flooding and erosion associated with hurricanes and northeasters, relative sea level rise, and human activities issues of primary concern in coastal floodplain and hazards management.

Storm Descriptions
Three coastal storms which were declared Presidential disasters made landfall along the Massachusetts shore within 15 months of each other between August 1991 and December 1992: the first was a hurricane, the following two were northeasters. Hurricane Bob made landfall in August 1991 close to low tide and was classified as a 15-year statistical return frequency storm, and a strong category 2 hurricane. It tracked west of Buzzards Bay causing storm wind, wave, and flood-induced devastation, particularly to the western shore of Buzzards Bay, the south shore of Cape Cod, and the Islands of Martha's Vineyard and Nantucket. Hurricane Bob resulted in approximately 3,000 National Flood Insurance Program (NFIP) claims totalling approximately $43 million.

Two months later, shoreline areas not devastated by Hurricane Bob sustained extensive damage from the October 1991 Halloween Northeaster. According to FEMA's Interagency Hazard Mitigation Team Report, the highest observed tide in Boston was 14.29 feet MLLW, which places this storm between a 20 to 25-year storm. Approximately 4,500 NFIP claims
were filed totalling approximately $80 million. Despite being only an approximately 20- to 25-year storm, wave characteristics of this storm (height and particularly wave period) caused observed physical damage similar in magnitude to the 100-year storm, the Blizzard of 1978 (15.25 feet MLLW, resulting in approximately $20 million through 2,354 NFIP claims). The unusual wave characteristics of the 1991 Northeaster have raised questions about traditional methods of storm classifications based solely on surge heights without considering wave characteristics. Also in Boston, the December 1992 Northeaster resulted in a recorded storm tide of 14.19 feet MLLW, placing it in a range between a 15- and 20-year return frequency storm. Approximately 1,400 NFIP claims totaling approximately $15 million were filed.

Funds totaling approximately $39, $12, and $19 million, respectively, were expended in public assistance from FEMA, state, and local governments (75/12.5/12.5% cost-share) to rebuild publicly owned facilities as a result of the three storms, for a grand total public assistance expenditure of approximately $70 million.

These were the first major coastal storms to hit the Massachusetts shore in 14 years and marked the first time that Massachusetts’ regulations, codes and executive orders were tested on such a broad scale. No area of the Massachusetts shore escaped some degree of impact. Most structures located along the immediate shore that were not properly elevated and constructed to current standards and codes (e.g. Massachusetts State Building Code, NFIP), sustained some degree of damage, regardless of whether they were protected by seawalls or located on sandy soils or even on bedrock. Post-storm visual observations revealed that structures located in FEMA-mapped velocity zones of beaches, barrier beaches, and dunes were particularly hard hit.

Post-storm Response and Lessons Learned

State Rapid Response Storm Damage Assessment Team
Immediate assessment of the extent of post-storm damage is essential to allow the governor to determine whether to declare a state of emergency and/or petition the President for a disaster declaration. However, no immediate field storm damage assessment mechanism was in place in Massachusetts after Hurricane Bob. In response, the Massachusetts Coastal Zone Management (MCZM) Office formed the State Rapid Response Storm Damage Assessment Team. Team members are generally state employees assigned to key coastal areas that typically incur damage based on the type, track, and intensity of an impending storm. Members also generally reside in the assigned coastal area in order to facilitate immediate observations and receipt of post-storm damage assessments by the Massachusetts Emergency Management Agency even before the storm completely abates. This mechanism has worked successfully after all subsequent coastal storms. Detailed damage assessments coordinated by FEMA follow in the ensuing weeks and months.
State Regulatory Response

Following a Presidential disaster declaration, "emergency regulations" are immediately issued by state agencies that vary or relax normal regulatory procedures. For example, under the state Wetlands Protection Act (WPA) regulations (which protect the beneficial functions of all coastal landforms, such as dunes, beaches, barrier beaches, bluffs, saltmarshes, etc.), post-storm activities with no potential environmental impact, such as clean-up and removal of debris, clearing and minor repairs to roadways, and repair of structures less than 50% damaged where the septic system is not damaged, require written notification only. "Emergency Certifications" pursuant to the WPA regulations are required for activities with potential impacts, such as temporary repairs to coastal engineering structures, stabilizing structures more than 50% damaged, temporary replacement of sand for erosion control (beach scraping is not allowed), reestablishing navigation channels, septic system repairs associated with structures less than 50% damaged that comply with codes, and major repairs to roadways. All other activities require normal review and permitting procedures. Under the state Public Waterfront Act (regulating, in part, activities seaward of mean high water) repairs to all previously authorized structures were allowed to proceed without further authorization (similar to the Corps' advisory). An advisory issued by the state Board of Building Regulations and Standards, which oversees compliance of the state Building Code through local building inspectors, stated that if a foundation is destroyed even with the superstructure intact, the structure is considered more than 50% damaged and must comply with current elevation and floodproofing requirements (similar to NFIP requirements).

Since it had been 14 years since the last major coastal storm hit Massachusetts, which was before promulgation of major state environmental protection regulations, the state convened a Post-storm Rebuilding Policy Team as an opportunity to reflect on coastal building practices and their effects in coastal high hazard areas. "Storm Rebuilding Guidance" was formulated and issued to local authorities who implement state regulations and codes requiring strict adherence to all environmental and public health regulations. Before long it was apparent that upwards of 200 dwellings damaged by Hurricane Bob alone could not be rebuilt pursuant to this guidance.

Simply floodproofing or elevating structures on piles above the 100-year flood elevation in dunes or V-zones met most regulatory requirements for rebuilding storm-damaged structures. However, this did not resolve the major problem of numerous sub-standard sewage disposal systems (e.g. cesspools, 55-gallon drums) that were discovered. State officials determined that it would be a disservice to the citizens of the commonwealth, including the people who rebuild, to relax health and safety standards to a point that would allow continued pollution of marine waters and private well supply. Due to a high water table in most coastal areas, many septic systems required artificial mounding to meet the four-foot separation from the highest groundwater of the year to comply with public health standards of the State Environmental
Code, Title 5. However, state officials determined that it would irresponsible to allow mounding of a septic system in a FEMA-mapped V-zone of a dune, beach, or barrier beach knowing it is likely to be damaged or destroyed in a subsequent storm creating a risk of serious public health and environmental concerns, as well as interfering with the natural storm damage prevention and flood control function of dunes and beaches.

Because many of the damaged structures were built long before promulgation of existing regulations, "maximum feasible upgrade," particularly for septic system replacement, was allowed. However, mounded septic systems were not permitted in V-zones of beaches, dunes, and barrier beaches. In order for dwellings to be rebuilt in these circumstances, septic tanks were required to be elevated above the base flood elevation (i.e., within the dwelling itself) with a relatively compatible gravel-packed leaching trench allowed in a sandy/gravel substrate. (These criteria were allowed for storm rebuilding only: new solid structures, such as septic tanks and coastal engineering structures, are generally not permitted in dunes, beaches, or barrier beaches under the WPA regulations due to their adverse impact on the beneficial functions of storm damage and flood protection that these coastal landforms provide.)

To the best of the author's knowledge, all storm-damaged structures were allowed to be rebuilt. While not ideal in terms of managing coastal high hazard areas, significant progress was made in terms of enhancing public health and safety by eliminating many sub-standard sewage disposal systems from unstable V-zones of dunes, beaches, and barrier beaches, while balancing the fact that many structures were built long before existing regulations were promulgated.

Coastal Hazard Mitigation

A highly successful Hazard Mitigation Grant Program (HMGP) is coordinated by the state Flood Hazard Management Program. The HMGP Committee received 55 project applications totaling $7 million in hazard mitigation project proposals. Awareness and recognition of the need for hazard mitigation is, thus, well documented. However, only $2 million was available, so only 25 projects could be recommended for funding by the Committee. Projects such as dune restoration, culvert re-sizing to reduce retention time of flood waters, and innovative community retrofitting programs were funded. By far, the most successful mitigation efforts have been federal/state/local coordination of coastal storm damage property acquisitions from willing sellers. Acquisition is not hazard mitigation: it is hazard elimination! Twelve properties were purchased in the Town of Scituate, three in Falmouth, and seven in Revere, using primarily FEMA (Section 1362), and limited hazard mitigation grant funds. At the request of FEMA, the Corps of Engineers also conducted vulnerability assessments in selected areas. As a result, "sacrificial dunes" were constructed in four communities (Salisbury, Scituate, Duxbury (twice), and Sandwich) to provide
temporary protection from wave overtopping associated with a 5-year storm at a total cost of approximately $2,466,836.

**Current Hazard Mitigation Initiatives**

New state-wide sewage disposal system regulations (State Environmental Code, Title 5) have since been promulgated which, in part, prohibit new systems in V-zones of beaches, dunes, and barrier beaches. Replacement of storm-damaged septic tanks must be elevated above the 100-year flood elevation, where feasible. A Coastal High Hazard Area mapping project is currently underway at MCZM to map the most hazardous coastal areas. Multi-data layer, GIS mapping of data layers consisting of FEMA-mapped V- and AO-zones, barrier beaches, and areas exhibiting greater than one foot per year of erosion, all mapped on stable mylar, will be overlaid on 1994 aerial photographs. Performance standards to review proposed activities in "land subject to coastal storm flowage" pursuant to the WPA are also under discussion. Discussions to determine the appropriateness of the continued level of public expenditures for activities that encourage growth and development in coastal high hazard areas are underway. Finally, storm damage property acquisition from willing sellers, and coastal hazard notification to prospective shorefront property owners legislation is pending as well.

**Conclusion**

Massachusetts has learned much from our recent coastal disasters. Coastal high hazard areas are known and very predictable, yet population and construction trends continue to increase in these areas. Hazard mitigation techniques that minimize and eliminate threats to life, property, public health, and the environment are well known. It is apparent that the lure of the incredible beauty and excitement of living along the immediate shore will continue. So long as those who choose to live in known hazardous areas assume the associated financial risk, and ensure that the health, safety, beneficial function of environment resources, and property values of others are not compromised by their presence, they may enjoy their stay.
MANAGING COASTAL EROSION HAZARDS IN MAINE

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Introduction

Natural processes cause hazards when shoreline recession or flooding threatens coastal development. Change of the coastline itself is not hazardous until something of value is threatened. The major causes of coastal hazards are storm surge, sea-level rise, erosion, and inlet migration. In recent decades human activity has become a major cause of coastal erosion. Coastal Maine sea levels can become elevated one meter (three feet) under a storm's center and may persist for the duration of the storm. This elevation is superimposed on and is independent of the tides. The threat of coastal flooding and erosion is greatest when a storm surge is superimposed on spring or perigean high tides. Statistically, coastal flooding of 1.5 meters (five feet) above mean high water (MHW) should be expected in southern Maine once a century and 1.3 meters (4.5 feet) above MHW twice a century. Based on past storms, millions of dollars of coastal property damage result from 1.2 to 1.5 meters (four to five feet) of coastal flooding.

Shoreline changes, as a result of natural geologic processes, can lead to several types of coastal hazards. Most of these are from storm activity: beach erosion, coastal flooding and overwash, and new inlet formation. Shoreline engineering structures have even led to coastal hazards. Consequences of engineering include shoreline adjustments often faster than natural processes. Past attempts to prevent land loss have often resulted in beach loss and an increased risk of coastal hazards elsewhere.

Identifying Coastal Hazards

The most significant technical aspect of Maine Geological Survey (MGS) coastal hazard research is in the development of new methods of measuring shoreline change. As in customary shoreline change mapping, air photographs are interpreted and then digitized. Much of the interpretation is done directly on an analytical computer-driven stereoplotter at the University of Maine. This equipment allowed a 16x magnification of air photos (film diapositives,
Optical enlargement combined with stereoscopic viewing provides a sharp image for digitizing. A digitizing cursor, also seen under the stereoscopic view, traces the leading edge of vegetation, storm washover sands, and geologic environments. Because interpreting with the stereoscope is more accurate than scribing air photos directly, the more common steps of tracing followed by digitizing were reduced to one step. Combining steps reduced errors considerably. Aerotriangulation is used to link photographs from different years. Ground control points are used to transform the model to an earth coordinate system. These steps yield excellent precision for measurement of shoreline change. In fact, errors in comparing two shorelines from different years are almost always less than a meter (three feet) and only a few decimeters in the best cases.

Cultural features as well as shorelines are mapped with a geographic information system (GIS). Large-scale maps (1:4,800) are generated by the GIS to match existing MGS Coastal Sand Dune Maps and Flood Insurance Rate Maps (FIRMs). In addition to historical shorelines, geologic environments, and coastal flood zones, including AO-Zones, were digitized from Federal Emergency Management Agency work maps. This integrated data set in the GIS will be repeatedly used in the analysis of site-specific hazards.

Case Studies

Lubec Spit in eastern Maine, near the Canadian border, is a highly tide-dominated (5.6 meters or 18.4 feet range) coastal barrier system that has exhibited large shoreline adjustments related to spit elongation. Updrift beachface recession of 15 meters (50 feet) and spit elongation of 68 meters (225 feet) has occurred since 1957. A second study site, Seawall (Cape Small) Beach in mid-coast Maine, is an undeveloped, swash-aligned barrier beach system adjacent to the Kennebec River. Along the ocean-facing beach, where the shoreline is parallel to the breaking waves there is little evidence of longshore drift yet 14 to 23 meters (45 to 75 feet) of progradation was measured. Beach accretion occurred at this exposed site despite a period of net sea-level rise and major storms such as Hurricane Bob, the Halloween Storm of 1991, and numerous large northeasters of the 1970s. Tidal inlet migration at the adjacent Morse River resulted in as much as 88 meters (290 feet) of shoreline recession since 1953. The third study site, Camp Ellis Beach, along Saco Bay in southern Maine, has a partially engineered shoreline and is adjacent to the Saco River jetty. The shoreline receded 4 to 30 meters (13 to 100 feet) and resulted in repeated destruction of property since 1953, particularly next to the jetty. Dredging of the nearby Saco River provides a few hundred thousand cubic meters (yards) of sand as temporary beach nourishment every 5 to 10 years. Continued erosion at Camp Ellis Beach should result in an irregular shoreline with engineered portions protruding out to sea.
Coastal Hazards and Policy Choices

A coastal hazards policy must address the threats from (1) sea-level rise, (2) shoreline change, (3) inlet migration, and (4) coastal flooding. Each of these natural hazards is considered below along with policy directions that make use of a growing scientific database.

Sea-Level Rise

Historical sea-level rise along the Maine coast has been measured at tide-gauge stations and has risen erratically over the past several decades. Between 1912 and 1992 sea level rose at an average rate of 2.0 mm/yr (0.7 feet per century) in Portland (Lyles et al., 1988). Over the last few millennia (approximately 5000 to 2000 years before present), sea level as recorded in the geologic record of coastal Maine has risen at a slightly slower rate of about 1.4 mm/yr (0.5 feet per century) (Belknap et al., 1989). More recently (since 2000 years before present) the rate of rise slowed to less than 0.5 mm/yr (0.2 feet per century) (Kelley et al., 1995). The combined effects of regional coastal sinking and global warming may cause sea level to rise along the Maine coast at a rate of 2 to 10 mm/yr (0.7 to 3.3 feet per century) in the future.

Shoreline Change

The variability in erosion and accretion rates in Maine suggests, even at our preliminary stage in mapping, that a single erosion rate cannot be applied to beaches statewide. Instead, site specific data on historical trends must be applied to each beach or segment of beach. In the locations studied so far, a 100-year setback amount could be 10 to 100 meters (30 to 330 feet) landward of a natural segment of beach. Distances could be even greater for land adjacent to tidal inlets. In some locations this distance exceeds the width of the frontal dune and extends into the back dune geologic environment. This fact is significant due to recent changes in the Maine’s Natural Resources Protection Act (NRPA) that exempt back dune structures from development restrictions if they are on land above the present 100-year floodplain.

A policy might use setbacks from erosion-prone shorelines. To determine a setback distance it is necessary to assume that the past erosion rate will continue unchanged into the future. If Maine’s Coastal Sand Dune Regulations are followed either as guidance of the state’s intent, or the coastal hazard policy is included within the regulations, then there is an existing basis to consider the threat from erosion over the next century. A number of years multiplied by the long-term, average annual erosion rate could be used to calculate the setback distance. Several setback lines could be established from several years (e.g. 30, 60, 100) and a tiered approach to each zone used to create a more detailed policy. Following the Maine Coastal Sand Dune Regulations: (100 years) x (annual erosion rate) = (setback distance). A setback line could be mapped on existing Coastal Sand Dune Maps or on Coastal Hazard Maps for use in the permitting process of the
state’s NRPA. New development or improvements to existing development seaward of this line could be limited or required to meet certain standards.

In addition, erosion rate information has value in determining which existing dune structures are threatened by ongoing erosion. The data allow the assessment of how severe the erosion threat is and possibly how many years remain until the beach reaches a building foundation and possibly causes the collapse of the structure. With guidance from a policy (e.g., vulnerable in 10 years), structures threatened by erosion could be mapped and the threat made better known. If the methods and data generated by this project meet those acceptable to FEMA then it might be possible to develop E-Zones for the state. A policy that acquires threatened structures and restores beaches and dunes could help several areas in coastal Maine today.

**Inlet Migration**

Inlets, where streams and rivers pass through the dunes and enter the sea, are perhaps the most dynamic portion of the beach and dune system. Dunes and low energy beaches along the margins of tidal inlets are dramatically affected by changes in channel position and sand bars. As sand bars and channels shift position, erosion and accretion of adjacent dunes and beaches may take place rapidly. Over time there is exchange of sand between the dune, beach, and channel bars. Stabilization of inlet banks has often been undertaken in order to shelter coastal development from erosion. In most cases such coastal engineering disrupts natural movements of sand and can lead to unnatural accumulations of sand in some areas and accelerated erosion in others.

The dynamic nature of inlet margins makes projection of future shoreline positions difficult. Positions of past shorelines provide some guidance of the variability and rates of shoreline migration along inlet margins. In areas where jetties have been constructed there may be either erosion or accretion. In some places, accretion has been followed by erosion over a period of several decades as the shoreline has adjusted to the presence of the coastal engineering. Jetty construction (or removal) can cause rapid, and somewhat unpredictable, shifts in the position of the shoreline.

An inlet hazard policy should address the land along the margins of tidal inlets. These tidal shorelines are more unstable than most ocean-facing beaches and development along them often vulnerable. Disclosure of this erosion risk should be made by mapping and changes in public policy. Use of geomorphic evidence of an inlet’s past position could be used to supplement the erosion rate setback. Areas where new inlets could form should also be identified by geologists. Further, along existing inlets a minimum setback landward of past inlet positions could be used to add an additional distance for protection. This setback is necessary because the next time the inlet changes its course erosion could cut outside the historical erosion limit. The largest erosion rates measured in our studies are related to inlet migration. A comprehensive coastal hazard policy should address tidal inlets since they pose a substantial erosion threat to adjacent coastal development.
Coastal Flooding

Coastal flooding, particularly the storm overwash zone, where moving waters carry sand and debris, should also receive attention in a hazard policy. FIRMs designate these areas as AO-Zones. Geologic mapping of these areas has led the MGS to conclude that in numerous places storms overwash areas beyond the mapped AO-Zone. Some C-Zone (non-flood) areas have been flooded by recent winter storms. A coastal policy should not limit the hazard to the AO-Zone but also consider geological evidence for the definition of coastal flood hazard areas. Mapping efforts can address this but there will always be a need to have a policy that is flexible to take into consideration recent geologic evidence and storm damage. Because erosion and sea-level rise is occurring along many shorelines, there will be constant landward movement of the AO-Zones and new areas inundated by coastal flooding. Hence, a coastal hazard policy should not rely only on the mapping results but also allow for new geologic and flood evidence to be used in the determination of areas of potential property damage. Specific restrictions would have to be developed for these areas, such as limiting development and encouraging retrofitting of existing structures.

Conclusions

The recognition of coastal hazards from erosion and flooding is useful in directing public policy that may reduce the loss of property and life. Erosion rates could be used to determine a setback line in coastal sand dunes. New development could be concentrated landward of one or more setback lines in order to reduce future losses. Existing development can be identified that might be at risk of destruction by storms within a few years as a result of continued shoreline retreat. Through a federal, state, or local policy that targets structures in danger of collapse in storms, a plan for purchase and removal followed by dune restoration could be developed. In addition to erosion rates, policy change should include restrictions on coastal flood areas subject to storm overwash where moving waters are capable of damaging structures. In some areas, in part perhaps because of continuing erosion, coastal flooding affects areas landward of those identified by existing flood maps. A policy that considers the combined effects of continued erosion, sea-level rise, and moving coastal flood zones is needed.

A few precautions must be considered in adopting coastal hazard policies related to the categories above. First, setbacks can give a false sense of security to the public. The public may build landward of a setback line assuming that no storms can reach them. This simply is not true since a shoreline position could shift landward of a forecast. In addition, too much emphasis can be given to past trends. Past trends could change for the better or worse. Erosion rates could decrease (say from the addition of new sand to a beach) or increase (due to seawall construction, dredging or sea-level rise). A coastal hazard policy should consider (1) being restrictive and disclosing the known hazards and worst-case scenarios in order to prevent future losses.
and (2) being flexible to incorporate both natural changes in the beach and
dune system as well as recent geological investigations and findings.

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MAINE’S SHORELAND ZONING PROGRAM

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Maine Department of Environmental Protection

The State of Maine is blessed with tremendous natural resources. The state is 90% forested. It has thousands of lakes and ponds, and thousands of miles of coastal shoreline, from the sandy beaches in the southern part of the state to the rocky shores downeast. Maine’s economy is closely tied to those resources. Tourism and forest products are major industries.

In 1971 the Maine legislature, recognizing the value of the state’s shoreland areas, enacted the Mandatory Shoreland Zoning Act (38 M.R.S.A section 435-449). That law requires municipalities to adopt zoning ordinances for all shoreland areas. The original law defined the shoreland zone as all areas within 250 feet of the normal high-water line of ponds greater than 10 acres; rivers which drain a watershed of 25 square miles or more; and tidal waters. The law has since been broadened (1989) to include areas within 250 feet of the upland edge of coastal wetlands and non-forested freshwater wetlands 10 or more acres in size, and within 75 feet of the normal high-water line of certain streams.

The law further permits, although does not require, municipalities to extend the shoreland ordinance to structures built on, over, or abutting a dock, wharf or pier, or other structure extending or located beyond the normal high-water line of a water body or within a wetland.

The purposes of the shoreland zoning law are varied. Major purposes include maintenance of safe and healthful conditions; protection of water quality; protection of fisheries and wildlife habitat; protection of freshwater and coastal wetlands; and conservation of shore cover and natural beauty.

In order to assist municipalities in developing the required ordinances, and to establish minimum requirements for the local ordinances, the Department of Environmental Protection (DEP) has established guidelines for local shoreland zoning ordinances. The minimum standards are published as Department regulation, Chapter 1000, State of Maine Guidelines for Municipal Shoreland Zoning Ordinances. The Guidelines are published in the format of an ordinance so that the state’s smaller, rural communities need not develop their own ordinance language. The most recently amended Guidelines became effective on August 7, 1994.

Municipal shoreland zoning ordinances must be consistent with or no less restrictive than the DEP’s Guidelines. All shoreland zoning ordinances and
amendments to those ordinances must be approved by the Commissioner of the DEP before those ordinances and amendments become effective. The Commissioner, upon reviewing a locally enacted ordinance or amendment, may approve, disapprove, or approve with conditions that ordinance or amendment. Conditional approval occurs when an ordinance or amendment has a deficiency in relation to the minimum Guidelines, but can be made consistent with the Guidelines by attaching a condition to that ordinance or amendment.

Maine has 451 organized municipalities that are required to adopt shoreland zoning ordinances. However, not all of those municipalities comply with the ordinance adoption requirement. In those instances, the act requires the DEP to adopt a suitable ordinance for the delinquent municipalities through a formal rulemaking process, which includes opportunity for public comment. These ordinances are referred to as "state-imposed ordinances." Presently, there are 75 municipalities subject to state-imposed shoreland zoning ordinances. Municipalities with state-imposed shoreland zoning ordinances are required to administer and enforce the ordinances as if they were adopted by the respective municipalities.

The Department's Guideline ordinance establishes several shoreland districts. The most restrictive is the Resource Protection District. As a rule, most structural development is prohibited in this district. Residential, commercial, and industrial activities are not permitted.

An exception to the above prohibition was recently incorporated into the shoreland zoning law for residential dwellings under certain limited circumstances. Now, if a landowner's entire parcel is entirely, or nearly entirely, within a Resource Protection District, and that owner has no opportunity to build outside of the district, he or she may be able to obtain a permit by special exception for a single-family residence in that Resource Protection District if certain conditions are met.

The "permit by special exception" provision was incorporated into the shoreland zoning law in reaction to the "takings" argument. Although DEP does not believe that the establishment of a Resource Protection District results in taking of property, the state did not wish to place municipalities in the position of defending against a takings claim, pursuant to a state-mandated program.

What types of areas are required to be zoned for resource protection? The Resource Protection District includes areas within the 100-year floodplain; areas of two or more contiguous acres with sustained slopes greater than 20%; and areas within 250 feet of moderate and high value freshwater and coastal wetlands, as determined by the Maine Department of Inland Fisheries and Wildlife. Areas that meet the criteria for resource protection but are already significantly developed need not be zoned for resource protection. Instead, municipalities may zone those areas based on the current pattern of development. For example, a village area may be zoned as "limited commercial," even though it may be within the 100-year floodplain.
Other districts contained in the Guideline ordinance include the limited residential district, in which commercial and industrial activities are prohibited; the limited commercial district; the general development district, where industrial activities are permitted; the stream protection district, and the commercial fisheries/maritime activities district (CFMA). The stream protection district is established to maintain appropriate vegetative buffer strip and setback requirements along many of the state’s smaller flowing waters. The CFMA district was created to help protect the "working waterfront" from non-water-dependent uses. Only water-dependent uses are permitted in the CFMA district.

The heart of the shoreland zoning ordinance lies in its land use standards for various activities. For example, there are minimum lot size standards, as well as standards for principal and accessory structures; campgrounds and individual private campsites; roads, driveways, and parking areas; septic waste disposal; mineral extraction; agriculture; clearing of vegetation; timber harvesting; erosion control; and archaeological and historic resources.

Of all of the land use standards, perhaps the most important of those is the basic requirement that new land use activities in the shoreland zone meet required setback distances, and that new cleared openings to the water are not created (except for water-dependent uses). Except in the general development district, new structures must be set back at least 75 feet from the normal high-water line or upland edge of a wetland. Adjacent to ponds the setback requirement is increased by an additional 25 feet to provide for greater water quality protection.

Setback requirements apply not only to structures but also to roads, driveways, parking areas, campsites, gravel pits, agricultural activities, as well as other uses. Only through strict variance procedures can the setback requirements be reduced.

Without appropriate vegetative cover, setback requirements will not protect water quality, natural beauty, or habitat values. Therefore, the shoreland zoning ordinance sets specific limits on the type and amount of vegetation that can be removed within the shoreland zone. In fact, new cleared openings to the water are specifically prohibited by state law. Existing vegetation may be thinned by removing 40% of the volume of trees in a 10-year period, leaving a well-distributed stand of trees. But clearing in excess of that would result in a violation of the law.

Adjacent to ponds the vegetative clearing standards are even more restrictive. In order to protect water quality, natural ground cover and vegetation less than three feet high must be maintained. In addition, a point system is employed to ensure that cleared openings are not created. When a cleared opening is created by natural means, there are requirements for replanting.

Another important provision in the shoreland zoning law limits expansions of nonconforming structures to 30% of the floor area and volume of the structure as it existed on January 1, 1989. This restriction serves to limit loss of vegetated buffer area, and plays a role in the conservation of natural beauty.
In order to reduce the density of development in the fragile shoreland zone, the minimum lot area and shore frontage requirements are 30,000 square feet and 150 feet in tidal areas, and 40,000 square feet and 200 feet, respectively, in non-tidal areas. The maximum lot coverage by unvegetated surfaces in most districts is 20% and building heights are limited to 35 feet. The shoreland zoning ordinance also complements the floodplain program by requiring that the first floor elevation or openings of all buildings and structures including basements shall be elevated at least one foot above the elevation of the 100-year flood.

Permitting and enforcement of shoreland zoning ordinances are carried out by municipal code enforcement officers and planning boards. Local administration of the ordinance has its advantages in that the persons involved are more familiar the particular area. In addition, permit processing times can be shorter than through a state-administered program. Local administration has its disadvantages as well. In Maine, where small towns are numerous and the ordinance administrators and applicants know one another personally, there are instances where favoritism occurs. In addition, most planning board members are volunteers with little training in ordinance administration or environmental permitting, and the turnover rate of those volunteers is significant. Therefore, there is a continuous need for training programs. Furthermore, lack of training can, and does, result in a notable amount of inappropriate permits being granted.

Overall, Maine's shoreland zoning program is accomplishing the purposes set by the legislature in the early 1970s. Considering the amount of the shoreland area, the current locally administered program is providing reasonable protection of those areas, at a minimal cost to the state.
Section 13

Specific Issues in Floodplain Management
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BIOENGINEERING STREAMBANK STABILIZATION METHODS IN THE MIDWEST

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Introduction

Bioengineering methods are gaining more recognition as viable solutions to streambank stabilization problems. These methods combine engineering principles with extensive use of vegetation for erosion control of streambanks. The proper use and maintenance of these techniques provide more effective and ecologically sound results than traditional structural methods, such as concrete, rocks, and sheet piling. Since conditions at each particular site are unique, the use of a particular streambank stabilization method must be considered carefully. Stream dynamics, soil condition, nearby structures, surrounding land uses, and the cause of the erosion are some factors that may influence the method chosen. Simple maintenance ensures the integrity and longevity of the bioengineering stabilization solution.

Bioengineering methods are appealing because, when combined with a suitable vegetative buffer along a stream corridor, they provide effective streambank erosion control in addition to being ecologically sensitive and aesthetically pleasing. Bioengineered solutions benefit water quality, do not adversely affect the neighboring property, provide wildlife habitat, and return the stream to a more natural appearance over time.

Bioengineering methods are the focus of the streambank stabilization program in DuPage County, Illinois, one of the most rapidly urbanizing counties in the United States. The DuPage County Stormwater Management Committee has the authority to regulate and fund stormwater projects on a countywide basis, and the directives of the committee are executed by the staff of the Department of Environmental Concerns, Stormwater Management Division. Watershed plans are currently being developed for each of the major stream basins within the County. These plans identify regulatory requirements, maintenance needs, and capital improvement projects necessary to reduce and control the potential for catastrophic flooding within the County.
Because of the extensive development throughout the County, most stream corridors have been reduced to narrow widths barely containing the channels. Slope stability and erosion problems have increased over the last decade and failures are threatening utilities, roadways, structures and backyards. To address these problems, the County has implemented a comprehensive stream maintenance program involving debris removal and vegetative control along County stream corridors. The need for solutions to critical areas of erosion became evident during the maintenance activities and staff initiated a progressive program using bioengineering methods to address streambank stability problems.

Technical Solutions

The County developed a hierarchy of solutions to the erosion and stability problems. Vegetative and structural solutions have been in use for years and are well-documented. Bioengineering solutions, however, are relatively new and unproven in the Midwest. The County and its consultant, Rust Environment & Infrastructure, performed a comprehensive nationwide literature search for bioengineering techniques for streambank stabilization. Advantages, disadvantages, practicality, and preferred applications of numerous techniques were documented.

Numerous techniques were selected as appropriate solutions in DuPage County. These techniques were summarized on fact sheets which provided a sketch of the method, suggested uses, and installation guidelines. The following methods were selected:

Brush Mattress—Mats of live hardwood brush are fastened down over the eroded streambank with polyethylene net or jute rope. The live plant material establishes roots in the streambanks and the brush mattress rebuilds the bank by capturing sediment.

Live Fascine—Sausage-shaped bundles of brush are tied together and placed in trenches cut into the bank, parallel to stream flow, to rebuild an eroded streambank. The installation starts at the toe and proceeds upslope. Live willow or oak stakes, woody vegetation, and deep rooted grasses are planted between the fascines for slope stabilization.

Branch Packing, Live Cribwall, and Vegetated Geogrid—Each of these methods is used independently to rebuild a streambank after a slope failure. The rugged construction lends itself to use in high velocity areas. Layering of soil and live brush between geotextile fabric, cribwalls, or brush layers is used to rebuild a bank. Dead construction stakes and live willow or oak stakes are driven vertically to provide stability and revegetate the bank.

Coir Fiber Roll—A roll of tightly knit coconut fibers or similar material is set at the toe of bank to protect against further toe erosion and
eventual undermining of the entire streambank. The fiber roll is held tightly against the bank with construction stakes. Live stakes are sometimes driven through the roll to establish vegetation. Sediment from the stream flow is trapped over time to further rebuild the bank behind the roll.

A-jacks and Lunkers—Interlocking concrete structures shaped in the form of jacks (like the children's toy) or rectangular palette-like structures made from recycled plastics, are trenched in at the toe of a streambank for protection against further toe erosion. Backfill is placed on top of these structures and the slope is regraded and planted with woody vegetation, cover crop, and live stakes to stabilize the bank. Lunkers are used for supplementing fish habitat and are used in streams where the fisheries resource is a concern.

Vegetative Control—Invasive nuisance vegetation is removed and adequate sunlight and appropriate riparian vegetation are reintroduced. A common reason for streambank erosion, especially in urban areas, is invasion of stream corridors with trees and vegetation that shade the banks and provide inadequate bank stabilization through shallow roots. Restoration of approximately 50% ambient sunlight to the banks along with reintroduction of woody shrubs and grasses with deeper, more extensive root systems provides significant streambank protection. Some level of vegetative control is required for all of the above techniques. In some instances, vegetative control alone may provide sufficient stabilization.

Four of the selected methods are detailed in Figure 1.

Permitting

Streambank stabilization activities along a stream channel typically fall under the jurisdiction of one or more agencies who regulate floodplains/floodways, wetlands, and stream water quality. The regulatory permitting process varies in complexity with the extent of the construction activity in or adjacent to the channel. To simplify the procedure, the majority of bioengineered streambank stabilization activities expected to be undertaken by individual property owners have been included in the DuPage County stormwater permit. These activities, preapproved by the other state and federal regulatory agencies such as the U.S. Army Corps of Engineers and the Illinois Environmental Protection Agency, are less than 500 feet in length along the channel and are limited to restoring the eroded area to its natural channel cross section. More complex applications will require individual permits from all federal and state agencies.

To assist property owners, the County has developed a streamlined Streambank Stabilization Program packet that includes an introduction to the program, a description of the application procedure, permit submittal
Figure 1. Selected streambank stabilization methods.
requirements, and a streambank stabilization permit decision flowchart. Also included are copies of applicable state and federal permits, the fact sheets developed for each method with plant lists, references, and supplier/manufacturer lists, and a sample permit application submittal. These packets are available to residents interested in installing streambank stabilization practices on their property. In addition, County staff are available for consultation on individual projects.

Program Implementation

Critical to the implementation of the Streambank Stabilization Program is public involvement. Brochures have been developed to educate the public about stream corridors and their value. A video describing stream maintenance activities has been presented to school groups throughout the County. Questionnaires were sent to residents along selected streams to determine public perception of stream corridor values, such as wildlife habitat and visual and noise screens. As multi-property projects are identified, public meetings will be held to receive input from residents about their concerns and goals related to streambank stabilization. All of these public involvement activities aid in providing streambank stabilization services that are responsive to the community.

Suggested Reading

For additional information on this topic, the following list of publications related to bioengineering streambank stabilization methods is provided.


FISH WEIRS AND LOCAL NFIP COMPLIANCE: A NORTHWEST PERSPECTIVE

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Introduction

Fish habitat enhancement projects, which come in a variety of designs, are being installed on streams in the Pacific Northwest. Governmental agencies and local communities have been sponsoring projects that can help restore anadromous fish runs to our streams. The popularity of these projects seems to be on the rise. The need for them can be expected to increase as development pushes farther into the Cascade foothills, runoff and sedimentation increase, and salmon runs continue to decline. These projects may involve streambed filling, riprap (rock or bioengineered), culvert replacement, landscaping, and sometimes the construction of stepped weirs. These construction activities may change existing stream channel conditions, encroaching on the watercourse. In the parlance of the Federal Emergency Management Agency’s (FEMA’s) national program for floodplain management, these changes may amount to a watercourse alteration, as regulated by 44 CFR Section 60.3(7). If located in a FEMA floodplain, they would need to comply with community floodplain management ordinances and be floodplain permitted. If hydraulic analyses to estimate impacts on conveyance and 100-year base flood elevations (BFEs) are required, this adds more expense to a project’s design that even state agencies are now hard pressed to afford. These additional costs of complying with FEMA’s flood conveyance regulations may stall or undermine beneficial habitat enhancement projects, especially when the project is sited within a FEMA floodway and the rigorous standard for no rise in BFEs must be confronted.

Fish habitat enhancement projects highlight an inherent contradiction between FEMA’s primary regulatory mandate to maintain the flood conveyance capacities of a stream, and the agency’s ancillary charge to support natural and beneficial floodplain functions. Certainly, a stream alteration project that seeks to restore anadromous fish runs qualifies as a beneficial floodplain activity, but NFIP regulations define it as "development" subject to the same regulations as residential homes and bridges. The National Flood Insurance Program (NFIP) does not provide exemptions for functionally dependent, environmentally beneficial watercourse development.
Do FEMA policies give us any flexibility in these cases? Can we interpret our regulations in a way that lends support to these beneficial projects which aim to restore natural stream functions? What factors would give us justifiable cause to modify existing development regulations? This paper reviews the process for coordinated review that FEMA Region 10 developed with the Washington Department of Fisheries (now the Washington Department of Fish and Wildlife) to help ease the regulatory burden of permitting fish weir enhancement projects.

Support for Naturally Beneficial Floodplain Development

FEMA Region 10 would prefer to support and facilitate approval of fish enhancement projects that seek to restore natural functions, rather than overburden them with regulatory paperwork and expensive engineering analyses. Although we must view fish weir projects as "development," we do see real value in their installation. The greater the natural value of a floodplain, the more likely it is to be protected from development.

Fortunately, NFIP objectives appear to be evolving in a direction that supports this position. Historically, NFIP regulations have made primarily implicit reference to natural and beneficial functions as a benchmark for permitting appropriate floodplain development. Some examples include the regulations in Section 60.3(e) that encourage the retention of floodways as open undeveloped space, and prohibit alteration of sand dunes and mangroves stands, and the use of fill in coastal zones. Also, the NFIP denies flood insurance coverage to structures built over water and to new homes in Coastal Barrier Resource Areas. More recently, FEMA convened a task force to re-examine our long standing policy that allows filling of riverine floodplains. (This practice has had the effect of altering or sometimes destroying native riverine habitats). Also, FEMA's Community Rating System (CRS), established in 1990, grants credits toward flood insurance premium reductions to those NFIP communities that retain and preserve floodplains as open space.

Now FEMA has direct support, mandated by Congress in the 1994 National Flood Reform Act, for activities that help maintain natural and beneficial floodplain functions. Section 541 of this act officially adopts the CRS as part of the NFIP's statutory authority, and the original goals of CRS include encouraging the adoption of more effective measures to protect the natural and beneficial floodplain functions. Section 562 establishes a task force with members from FEMA, the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, and the Environmental Protection Agency, and charges them to recommend practices that reduce flood damage by protecting the natural and beneficial functions of floodplains.

The 1994 National Flood Reform Act provides direct legislative support for natural and beneficial floodplain functions. FEMA now has stronger leverage to implement NFIP regulations in a way that helps move habitat enhancement projects through the local floodplain permitting process.
Fish Weir Structures

Fish weirs first came to the attention of FEMA Region 10 while reviewing a Section 404 application from the Washington Department of Fisheries (WDF) for renewal of a five-year regional permit to install fish weirs in Washington streams. The stated purpose of the regional permit was "... to place fill material in conjunction with providing fish passage through culverts in waters of the United States within the regulatory boundaries of the Seattle District in Western Washington." We discovered that other FEMA regions were not actively monitoring compliance of fish weir projects with NFIP regulations, but nonetheless the key word "fill" roused our curiosity. If fill or riprap were being used in FEMA-mapped watercourses, it was likely that these projects were altering conveyance space. They would require a local floodplain permit and perhaps hydraulic analysis. A call to WDF revealed more specific information about the purpose of fish weir structures, and how they are designed.

Fish passage weirs help fish navigate past stream obstructions, such as culverts. WDF has been constructing fish passage weirs for about 15 years, and usually completes just two or three projects a year. Figure 1 shows the fish weir design approved under the Corp of Engineers regional permit #071-0YB-4-008100. This type of habitat enhancement project is limited to fairly small streams where fish passage can be improved by installing weir structures no longer than 25 feet wide (from bank to bank). As many as five individual rock-filled gabion weirs can be installed. Each weir can be only 2 feet high and can include one 3-foot-wide step. Restricted quantities of fill are allowed waterward of the ordinary high water mark in the streambed between the weirs, and riprap is permitted at weir ends and along shorelines for bank protection. Because WDF has found that the rock-filled gabions do not hold up well and collapse into scoured dissipation pools that develop beneath them, WDF now uses log sills anchored with concrete ballast blocks instead (Figure 2).

WDF conducts its own field inventories to determine where fish weirs are needed. Public works departments, tribal reservations, or citizen's organizations also may bring culvert passage problems to the attention of WDF. Because WDF does not own culverts, or the rights-of-way or private properties adjacent to a culvert, WDF designs and builds fish passage projects only under contract with the culvert owner. A local community will hold a contract only if they also own the culvert that is being restored, so local governments may or may not be actively involved in a project. WDF's contract holds the culvert owner responsible for obtaining necessary right-of-way access and for maintaining the project in proper working condition only after the first year. WDF guarantees the performance of its fish weirs for one year, then inspects them after first year winter flows and makes necessary repairs and site adjustments.

WDF engineers monitor stream flows for at least one year before drawing up final design plans, which are individually crafted for each site. Effects on flood elevations are calculated, but the analyses are not referenced
Figure 1. Typical installation of a fish weir.
Figure 2. Streambed log sill design detail. Source: Washington Department of Fish and Wildlife.
to 100-year flood events as required by FEMA's flood study specifications. Usually, old culverts are replaced by larger ones, which can reduce upstream constrictions and increase flood conveyance space, but WDF acknowledges that fish weirs create unavoidable backwater effects that cannot be fully corrected without additional channel alterations.

**Negotiating Toward Compliance**

This fish weir model brings to light several compliance issues wherever FEMA floodplains are involved. Most important to FEMA Region 10 were local community notification and involvement, maintenance of the flood-carrying capacity of the stream, and application of the floodway standard that prohibits any rise in BFEs. However, our overall goal was to help WDF to satisfy NFIP regulations as efficiently as possible at lowest additional cost. The HEC-II analysis normally required to verify no rise in floodway BFEs was of particular concern to WDF. Conducting the analysis and repetitive modifications of the site-specific weir designs could easily increase project costs by more than 15%. Fortunately, administrative procedures already in place at WDF serve adequately to address some compliance issues. The staff has FEMA flood maps on file and normally reviews them before moving forward with a project. Although WDF may not contact a community directly, local governments are notified about proposed projects via Corps of Engineers and Washington State Environmental Policy Act requirements. WDF estimates impacts on flood levels, and notifies adjacent property owners if higher flood elevations will result after weir installation. However, WDF hydraulic analysis procedures are not adequate for evaluating impacts to 100-year flood events, an important consideration in numbered A zones and floodways.

WDF initially proposed a blanket exemption for all fish weir projects, citing clearly legitimate factors commonly associated with projects such as the remote, rural location of the streams, which are seldom mapped by FEMA, the small size of the streams involved, and the negligible rise in flood levels they usually cause. We rationalized that a blanket exemption may make sense in an approximate A zone, but it certainly would not work in floodways. However, with the knowledge that WDF had installed one project in 1986 on a creek in a suburban Seattle community only 1/4 mile from a numbered A zone, we concluded that a case-by-case assessment would be the best approach.

The final regional permit issued by the Corps included a stipulation that read, "If proposed projects fall within special flood hazard areas mapped by FEMA, WDF shall consult with the local community and FEMA as appropriate about proposed fish weir designs when potential increases in 100-year base flood elevations are predicted by WDF." Only a few modifications to existing WDF procedures were required, and they were agreed to as interagency policy via letter. The small streams on which these projects are installed and the local stream expertise of WDF hydrologists strongly influenced our decisions. Generally, WDF was asked to consult with FEMA
and the local community during the feasibility analysis stage when greater than a one foot rise in BFEs is predicted in floodways or numbered A zones without floodways. It is hoped that this will reduce project delays, provide an opportunity for cost-sharing, and allow for coordinated flood data generation for flood map revisions, should the need arise. Projects that would result in a negligible rise of one foot or less in approximate A zones or numbered A zones without floodways could be permitted upon local government approval. The need for local government involvement and for accurate flood map reading was emphasized.

Conclusion

In recent years, new habitat enhancement designs have been introduced to re-meander streams or to place natural vegetative materials directly into watercourses. Because these projects can enhance floodplain values, they can reduce flood damage by discouraging floodplain development that is incompatible with a quality riverine environment. This approach falls right in step with the directives of the 1994 National Flood Reform Act. FEMA will continue to be challenged to interpret the development regulations under the NFIP in ways that facilitate the permitting demands of these creative enhancement projects.

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FLOODPLAIN MANAGEMENT ISSUES RELATED TO THE PERFORMANCE OF DAMS IN GEORGIA DURING TROPICAL STORM ALBERTO

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Introduction

As part of the Federal Emergency Management Agency's (FEMA's) response to flooding in the Flint River and Ocmulgee River basins during July 1994, FEMA formed a Dam Performance Assessment Team (DPAT) as a technical resource to support the Interagency Hazard Mitigation Team (IHMT). The DPAT's primary objective was to develop an understanding of the causes behind the failure of over 200 dams during Tropical Storm Alberto. This information along with recommendations from the DPAT, was then used by the IHMT to develop specific recommendations to mitigate the flood hazards related to dam performance in Georgia.

The DPAT identified a number of floodplain management issues related to the performance of dams in Georgia during Tropical Storm Alberto. Many of these issues have applicability outside of Georgia and should be considered by state and local floodplain managers when managing their programs.

Tropical Storm Alberto

Tropical Storm Alberto moved across northwestern Florida into southwestern Georgia on July 3, 1994. Over the next six days, the storm dumped as much as 27 inches of rain on portions of the Flint and Ocmulgee River basins
McCormick, Kula, Romano, and Bivins

(FEMA, 1994). The resulting flooding was the most severe in Georgia’s history. Extensive damage to dams, levees, bridges, roads, public facilities, and structures resulted. Thirty-one lives were lost in Georgia during the flooding and approximately 18,000 homes sustained flood damage. The estimated cost of repairs to infrastructure alone was $200 million.

The intense storms in early July 1994 contributed huge amounts of rain in short periods. For example, Americus, Georgia, reported 21.1 inches of rain on July 6, 1994, with a total of 27.6 inches from July 3, 1995, to July 7, 1995. Many other gages in the area showed 24-hour rainfall amounts of eight to 12 inches. These huge storm volumes resulted in flood discharges well above 100-year levels. Preliminary U.S. Geological Survey computations showed flooding on major streams as much as 40% above 100-year levels and on smaller streams as much as 150% above 100-year levels.

Overview of Dam Performance

The massive flooding in the impacted area resulted in a rash of dam failures during the storm. In excess of 200 dams are known to have failed. These range from small farm ponds with surface areas of a few acres to Lake Blackshear, a hydropower facility on the Flint River above Albany, with a surface area of 18,000 acres. These dam failures in turn contributed to the failure of bridges, culverts, and other dams downstream; increased the depth and duration of downstream flooding; and increased the hydrodynamic forces on structures in and near the downstream floodplain. In addition to increased downstream flooding when the dams failed, many impoundments caused flooding of structures in the reservoir pool behind the dam before failure.

Based on a sampling of the failed dams, many of the failures were found to be similar. In most cases, very high streamflows entered the lake causing the impoundment to rise. The spillway capacity was not adequate to control the rising pool and the water eventually overtopped the embankment, rapidly eroding its downstream face and leading to a complete breach of the embankment. In many of these cases, the outlet from the impoundment consisted of a single principal spillway with no emergency spillway.

In addition to spillway capacities, a number of other problems were:

- Broken or stuck gates on the spillway that could not be opened to increase the spillway capacity
- Poor flood warning systems
- Undefined operations procedures for gated spillways
- Lack of basic maintenance (e.g., mowing, control of burrowing animals)
- Poor embankment design (e.g., unsuitable soils, organic material, steep slopes)
Regulation of Dams in Georgia

Very few of the dams that failed were regulated by a governmental agency. The State of Georgia's Safe Dams Program regulates some of the dams. A few others are exempt from state regulation because they are regulated by a federal agency (i.e., Federal Energy Regulatory Commission). The remaining dams were unregulated. Some of the smaller unregulated dams were built with technical assistance from the Natural Resources Conservation Service. Other unregulated dams were built from plans prepared by engineers. In general, the remaining dams were not built from formal plans.

The dams that were regulated by the state or by the federal government appeared to weather the storm better than the unregulated dams. Problems with the regulated dams appeared to result more from a lack of upgrades to older regulated dams to meet state standards or from technical challenges unique to the particular facility (e.g., high tailwater conditions).

Floodplain Management Issues

Evaluation of the dam failures in Georgia during Tropical Storm Alberto brought to light a number of floodplain management issues. Many of these issues pertain to flood hazards in areas near impoundments and just outside of the 100-year regulatory floodplain.

In general, floodplain management has not historically focused heavily on the performance of dams. Dam safety has been treated as a separate function that has often been regulated by different agencies. As demonstrated in Georgia, however, dam performance can raise significant floodplain management issues. Discussions of a number of these concerns follow.

Flooding Due to High Reservoir Pools

In the case of some of the larger impoundments, high reservoir flood pools caused flooding of structures behind the dam. The most obvious example was Lake Blackshear, where hundreds of homes were flooded by the pool before the embankment was overtopped. These structures were above the FEMA regulatory floodplain but below the top of the dam. The flood flows on the Flint River were estimated to be 40% above the 100-year discharge. Few, if any, of the structures had flood insurance. Two techniques which might be considered to manage the risk of flooding due to high reservoir pools are: (1) restrict construction of structures below the top of dam elevation above dams through designation of a flood pool overlay zone; and (2) encourage greater participation in the National Flood Insurance Program for structures within the flood pool behind dams through education and other techniques.

Downstream Flooding Due to Spillway Releases

Flooding above the 100-year level can occur downstream of major impoundments even when the dam does not fail. For example, Lake Tobesofkee, a PL-566 dam near Macon, was forced to open the floodgates to
nearly their full-open position in order to avoid overtopping of the embankment. The resultant releases caused flooding of houses, including over 10 feet of flooding in a relatively new, $300,000+ home. This home had been built outside of the regulatory floodplain, and the owner was uninsured. The management of the gates during the storm was complicated by the need to balance flooding potential around the reservoir pool with the impacts of downstream releases. As evident during the Georgia flooding and during flooding in southeastern Texas in October 1994, the impact of gate operations on flood releases are not always well accounted for in the Flood Insurance Studies (FISs). Restrictions on construction within the floodplain below dams up to the spillway design flood may be appropriate in some cases through designation of a floodplain overlay zone. This would help reduce the flood hazard for new structures. In addition, increased participation in the NFIP for existing structures near the fringe of the regulatory floodplain would help mitigate the economic impacts of flooding.

Flooding in the Danger Reach During Failures

Floodplain management does not typically focus on the failure of dams as a major hazard. As demonstrated in Georgia, however, dam failures can have a significant impact on flood discharges during major storms at or near the 100-year level. In many cases, downstream property owners are not aware of this hazard. Dam safety is often regulated separately from floodplain management. Dam safety programs typically emphasize the dam owner’s responsibilities more than quantification and communication of hazards to downstream property owners. One approach to address this shortcoming would be to develop an overlay zone on the FISs covering the danger reach below major impoundments. Another approach would be to strengthen ties between floodplain managers and dam safety regulators. As is true for most performance issues related to floodplain management, increased participation in the NFIP for properties near the fringe of the regulatory floodplain would help reduce the economic hazards resulting from dams.

Cumulative Impact of Small Dam Failures in Series and Parallel

The hydrologic impacts of cumulative failures of small dams in series and parallel represent a major challenge for floodplain managers. Many small dams, such as farm ponds and subdivision ponds, are not designed to pass extreme events. A typical spillway design flood would be the 100-year storm. Many ponds are designed for even smaller storms. Consequently, failures of small dams during the 100-year storm would not be unusual. During larger storms, the number of failures can become very high as was the case in Georgia. Some of the most severe small stream flooding occurred near Americus, Georgia, and Montezuma, Georgia. In both cases, a number of dams failed upstream of the town significantly increasing the magnitude of flooding in town. In the case of Americus, major flooding occurred along Town Branch, where at least three dams failed in series and other dams failed in parallel. The resulting flood wave devastated parts of town, contributing to
loss of life. The hydrologic techniques typically used in FISs typically do not consider the impacts of impoundment failures. These techniques either extrapolate from gage records or from regional equations, neither of which account for the failure of dams. Accounting for the hazard of dam failures in the FIS methodology would be difficult, but in many cases the extra time and effort would be justified.

**Unregulated Dams**

The absence of regulations governing many of the dams in Georgia was a factor in the large number of failures. State regulators appear to have done a good job with the dams covered by their regulations, but available resources and state regulations have forced the Safe Dam Program to focus on the larger dams that pose the greatest threat to human life. The lack of regulatory oversight of other dams resulted in a number of problems. Many owners did not understand their responsibilities for routine maintenance, operation of floodgates, flood warning systems, and emergency action plans. In general, there was a lack of understanding of dam design issues related to spillway design floods, embankment material and slopes, and seepage control. The problem of unregulated dams was so severe in Georgia that FEMA had to develop its own standards for the reconstruction of failed dams eligible for participation in the Public Assistance program. In general, these standards followed the state’s requirements for dams but expanded them to cover much smaller impoundments. Reducing the number of unregulated dams and educating dam owners about their responsibilities represents an opportunity for floodplain and dam regulators to work closely together.

**Conclusion**

Dam safety and floodplain management issues are intimately related. As evidenced by the flooding in Georgia, dam failures for storms near the 100-year level can increase flood hazards. Opportunities exist to reduce this flood hazard by communicating the risk associated with dams through floodplain overlay zones for danger reaches, spillway design floods, and reservoir flood pools; increased participation in the NFIP for properties just outside the regulatory floodplain; education of dam owners and increased regulation of small- and medium-sized dams; and refined hydrologic techniques for FISs to account for hazards due to potential dam failures.

**References**

Federal Emergency Management Agency
FLOODPLAIN MANAGEMENT ISSUES IN CONDEMNATION CASES

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Introduction

As public improvements such as roadways, power lines, pipelines, and other utilities are constructed, there are often conflicts in obtaining rights-of-way or easements from land owners. When these projects cross floodplains, there can be additional conflicts and issues that add to the complexity of acquiring land. This paper demonstrates how basic floodplain management-related issues, concepts, and practices can have significant effects on the financial and physical outcome of condemnation cases for public projects. Four case studies will be briefly described from the perspective of floodplain and related environmental issues that affected the final settlements. The actual names of the cases are not being used, since legal appeals may be forthcoming.

Major Floodplain and Environmental Issues

The four condemnation cases that will be discussed each involved different issues, including:

- Floodplain and floodway delineations and modifications (revisions)
- Losses of "valley storage"
- Existing flood control improvements (levees, channels, diversion)
- U.S. Army Corps of Engineers' Section 404 permits
- Floodplain land reclamation potential—before and after project conditions
- Alteration of the watershed drainage area and/or natural flow patterns (diversion issue)
- Federal Emergency Management Agency (FEMA) approvals in the form of Conditional Letters of Map Revision (CLOMR)
- Devaluation of property values and effects of proposed projects on floodplain land values
- Differences of opinion on hydrologic/hydraulic parameters among various engineers
• Conflicts among city, state, and federal drainage designs of floodplain criteria
• Potential dangers and environmental hazards created by the project.

Case A—Petroleum Pipeline in an Urban Neighborhood

This condemnation case involved the construction of a high pressure petroleum pipeline along and parallel to a creek through a highly developed urban area. The drainage area at the point of contention was about 36 square miles (93 square kilometers) and the peak 100-year flood discharge was 25,000 cfs (708 cms).

The plaintiff was a major petroleum company and the defendant was a commercial property owner. The defendant claimed that the installation of the pipeline across the edge of his property created potential environmental hazards from the petroleum and limited his development potential of the floodway fringe.

Most of the discovery phase of the case centered around historical and hypothetical flooding, and the optimization of floodplain land reclamation. The 7.54-acre (3.1-ha) tract, most of which was a used car lot, had 97% floodplain and 57% floodway and potential land reclamation and development was very limited. Costs to reclaim the maximum of 1.8 acres (0.73 ha) were estimated at $1.76/ft². The city engineering staff became involved as witnesses because of the floodplain ordinances that had been adopted and affected the development of the property. The city required a re-study of the creek to update the FEMA data with fully developed watershed discharges before any review/approval of the proposed floodplain reclamation plan.

The case was settled out of court, and the basis of compensation seemed to have been driven by the proof of limited development potential for the condemned land, which was all within the floodway of the stream. The value of the floodway portion of the property was appraised significantly lower than the floodway fringe and non-floodplain property.

Case B—Highway Drainage Ditch in North Fort Worth

The Texas state highway department (TXDOT) condemned a portion of a large vacant tract of land in north Fort Worth, Texas, to excavate an improved channel for a stormwater drainage outfall from the proposed highway widening. The technical issues that were deliberated in this case included: differences of opinion on whether or not diversion of stormwater was being caused by TXDOT, historical diversions of stormwater caused by the construction of an 1873 railroad embankment, drainage area changes, disputed peak flood discharges, floodplain areas, and development potential of the property before and after the highway project.

Six different hydrologists studied the situation and came up with six different drainage areas, estimated peak discharges, flood elevations and floodplain areas, and conclusions on how the project would affect the property. Key elements of this case revolved around earlier Corps of
Engineers’ studies that did not include sufficient detail in this small upper watershed subarea, submittals to FEMA to obtain revised flood insurance rate maps, and the difficulty of correlating and comparing the different studies. Both the city and county engineering staff became involved as witnesses because of the floodplain ordinances that had been adopted and that affected the development of the property. The FEMA/Corps’ studies were based on undeveloped watershed conditions, while the city required fully urbanized conditions. The TXDOT drainage criteria also called for existing watershed conditions. TXDOT engineers and consultants for the property owner prepared extensive flood studies and reports with detailed HEC-1, HEC-2, and other hydrologic analysis programs used to quantify the problem and solutions. The approximate drainage area at the diversion point was about 121 acres (49 ha) and the peak 100-year discharge was 330 cfs (9 cms). The requirement for a grass-lined channel to convey the floodwater across the site was the major damage issue in the case.

The case was settled out of court and the agreement between TXDOT and the property owner was apparently influenced by the lost development potential of the property caused by concentrating the stormwater and providing a new channel across the site. Environmental issues were never a factor in this case.

Case C—Freeway Interchange Near Large Levee Project

For the construction of a freeway interchange, TXDOT had to condemn a very small portion of a large vacant tract of land that had been partially reclaimed from the floodplain by a levee project (Figure 1). The condemned parcel was 2.96 acres (1.2 ha) out of a total tract of 610 acres (247 ha). The parcel included 0.77 acres (0.31 ha) within the 100-year floodplain, and over 2.12 acres (0.81 ha) contained within an overlapping levee easement, leaving only 0.83 acres (0.34 ha) that was flood-free and developable. Significant issues during the trial were the existence of the floodplain land and levee easements that restricted the use of the property before the highway project, and the enhanced access to all of the remaining property in the "after" condition.

The defendants had originally received a large judgement in the county commissioner’s court, on the basis of loss of development potential and reduction of future highway access to the site. On appeal, the case was tried in a county district court by a jury of six and the award to the property owner was drastically reduced. The information related to the floodplain and levee restrictions as well as the enhancement of highway access had apparently not been clearly presented in the original hearing and were significant factors in the revised award.
Figure 1. Locations of condemnation cases C and D.
Case D—Large Highway Parcels at Major Interchange

This multi-million dollar case involved a major freeway interchange and two relatively large floodplain tracts that were part of a 215-acre (87-ha) tree farm and nursery included all of the floodplain and environmental issues listed above. (See Figure 1 for a map of the area with the proposed freeway project in place.) Witnesses included TXDOT engineers, city engineers, appraisers, land planners, and consultants for the property owner and TXDOT. The state prepared a full scale model of the interchange area, with the before and after project conditions, and consultants prepared voluminous studies and reports on their findings.

Since the condemned parcels were primarily in the floodplain and floodways of a major river and large tributary, the technical issues included encroachment potential for floodplain reclamation, FEMA coordination, Corps’ Section 404 permits, city ordinances (which would allow no rise on the flood elevation for any proposed projects), loss of valley storage, mitigation measures required by regulations, access to the highway, and local storm drainage diversion. The city’s floodplain ordinances and drainage criteria manual required fully urbanized 100-year flood discharges for design of drainage improvements and for elevations of property near floodplains. The state (TXDOT) uses 5- to 10-year design for storm drains and 50- to 100-year for bridges, utilizing existing watershed conditions. This difference of design criteria was a major point of contention during the case.

Potential development scenarios for both the before and after conditions were prepared, illustrated, and estimates of probable cost determined. Significant debate centered around the physical access to the site in the before and after conditions. The historical flooding of the existing access roads, as depicted by photographs, aerial photos, and videos, was a major factor in the arguments. The complexities of determining dollar values of floodplain land for the condemnation award were affected by questions related to access to property during floods for fire and police protection and the feasibility of filling large areas of the existing tree farm.

Environmental Impact Statements and Assessments by TXDOT were included in the case and the environmental impacts of the proposed project were hotly debated by both sides. The property owner’s proposed floodplain land reclamation project, which had received a FEMA CLOMA and a Corps’ Section 404 permit, also conformed to the Corridor Development Certificate criteria (NCTCOG, 1991) required on Trinity River projects. This criteria includes "no loss of valley storage on the 100-year flood and zero rise in the 100-year flood profile."

The trial lasted three weeks and resulted in a favorable conclusion for TXDOT. An appeal is possible, since so many technical and legal issues were objected to and ruled upon by the judge during the trial. Some examples include the exclusion of the expensive model prepared by TXDOT on a technicality, and the inability (restricted by judge) of the defense to argue about certain pre-project alternatives for development of the site. The state is now proceeding with seeking additional environmental and FEMA approvals.
Conclusions

This paper illustrates that government agencies and other entities with condemnation powers can be impacted by local floodplain management policies and practices when their projects are within floodprone areas. It also demonstrates the complex interaction of floodplain management with transportation, environmental issues, land development patterns, and property values. In each case, the local floodplain management programs and managers (cities) were involved and impacted by the deliberations and final results of these projects.

The different drainage and floodplain management criteria that is used by the various city, county, state, and federal agencies can cause significant differences in discharges, design dimensions, and reclaimable land, and affect the value of the property being acquired. The environmental regulations that relate to floodplain areas also tend to impact the potential for development and therefore the value of the land in condemnation cases.

References

Section 14

International Perspectives
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FLOODPLAIN MANAGEMENT IN NEW BRUNSWICK, CANADA

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Introduction
Floodplain management in New Brunswick has seen its ups and downs through the years. It has recently become an important issue to resolve due to increased compensation to victims and damage year after year. At first considered primarily an environmental issue, floodplain management is among the issues considered by an independent Commission on Land Use and the Rural Environment (CLURE). Now, floodplain management is part of an overall process of establishing a set of provincial land use policies. These policies are being developed to address issues identified by CLURE as being an indispensable condition to an overhaul of the community planning process in the Province of New Brunswick.

Floodplain Management
Flood damage has been a recurring problem in New Brunswick for nearly 300 years. Unsuitable development on floodplains has increased its severity in recent years (Environment Canada, 1986), due to a lack of planning in this area. The history of floodplain management can be separated into three specific periods: (1) before the flood of 1973, (2) consequences of the major flood of 1973, and (3) after the CLURE recommendations (1992).

Before 1975, flood damage reduction efforts were limited, partly because federal and provincial jurisdictions were trying to define their responsibilities (Environment Canada, 1993) and partly because decision makers did not perceive the severity and the importance of the issue. Perceptions changed as a result of the spring 1973 flood, one of the most widespread and damaging in the Province's history. During this period a major flood along the Saint John River, along which major cities are located, resulted in nearly $12 million (1973 dollars) (Inland Waters Directorate, 1973) in flood damage (very high for the province). The Province recognized that the issue should
be studied more closely and reports recommended for the first time that floodplain regulations be adopted by the municipalities to control future floodplain development and thus reduce compensation costs for flood damage.

In March 1976, a federal/provincial agreement on flood damage reduction was signed. Under its provisions, flood risk mapping was completed for 12 floodprone areas, where there was substantial existing development or considerable potential for future development. The federal and provincial governments were restricted from financial support of most new undertakings in areas of mapped and designated flood risk.

After the 1987 flood at Perth-Andover (northwestern part of the Province along the Saint John River) an Ice Jam Flooding Working Group considered remedial measures to reduce future flood damage. This gave impetus to a renewed effort within the provincial government to prepare a background report (Burrell and Stelling, 1990) and a draft regulation describing several floodplain management alternatives, and identifying activities that should be considered as part of a floodplain management scheme for New Brunswick.

In 1992 the independent CLURE was created to study the "status of land use issues in rural New Brunswick as they relate to the environmental and socio-economic problems and opportunities, and also to examine the current process used in rural land use plans." (Government of New Brunswick, 1993, p. 5). The Commission made over 180 recommendations on different community planning issues and most of them have been accepted by the Provincial Government. With respect to the protection of floodplains, CLURE recommended that the province undertake to do the following:

(1) Consider previous work done in the preparation of floodplain legislation and use it as a base for a provincial land use policy;

(2) Conduct consultation with groups and individuals who would be directly affected by such a policy;

(3) Improve mapping of floodprone areas along the Saint John and Miramichi rivers;

(4) Take careful consideration of the location, construction, and maintenance of individual septic disposal systems inside the floodplain; and

(5) Incorporate floodplain policies that conform to development plans (regional and local) (Commission on Land Use, 1993).

Proposed Floodplain Management Policy

Preparation of the Policy

In the past, the provincial interests in land use was not defined or protected in the Community Planning Act. To incorporate them, amendments permitting a
new structure for decision making and adoption of Provincial Land Use Policies were necessary. As a result, discussions relating to a specific land use issue are now held at an Interdepartmental Committee of Deputy Ministers. The roles of this Committee are to "... review and coordinate all land use and rural development issues and policies and make recommendations to the Policy and Priorities Committee of Cabinet" (Government of New Brunswick, 1993, p. 23). The Land Use Planning Branch of the Department of Municipalities, Culture and Housing was designated as secretariat to this interdepartmental committee.

A working group was formed to suggest a floodplain policy to the Interdepartmental Committee of Deputy Ministers. The Department of Environment was designated as the lead agency in preparing the policy in consultation with various departments directly affected. Presently, a draft floodplain policy has been accepted as a discussion paper by the Interdepartmental Committee, and further consultation will follow with planning commissions and development officers of the Province.

**Regulatory Aspects**

The policy is divided into two areas:

1. General principles and rationale incorporated into the "Provincial Policy for Development on Flood Plains," and
2. Guidelines included in the "Planning Guidelines for Development on Flood Plain."

The policy would apply everywhere in the Province as "the minimum acceptable level for development controls in flood risk areas."

Mapping of the Province to delineate the floodplain areas has been difficult. Lack of resources and information has produced a situation where only a small area of the Province has been mapped and the mapping is not always consistent. About 10% of floodprone areas in the Province have been delineated identifying two zones, the floodway and floodway fringe. Another 20% have been delineated with only one zone, the floodplain.

The land use controls outlined in the policy are linked to the availability of floodplain mapping. For example, if two zones have been delineated, a restrictive policy would apply in the floodway while more permissive development guidelines incorporating floodproofing requirements would be in effect in the floodway fringe. In an area with only one identified zone, the more permissive policy would apply to the entire flood envelope. Finally, for areas with no mapping, it is proposed that the more restrictive approach apply between the normal high water mark and an elevation 1.5 metres above that. This provision will apply until the area is adequately mapped, identifying both the floodway and the floodway fringe zones.
Figure 1. Floodplain delineation in New Brunswick.
And What Next

As mentioned previously, this draft policy has been recommended for public discussion by the Interdepartmental Committee of Deputy Ministers. During 1995, the Department of the Environment will consult with various affected groups in order to solicit comments and ideas. The formal adoption process of the floodplain policy pursuant to the Community Planning Act will be part of an overall public hearing process which includes all six provincial policies: Agriculture, Coastal Management, Settlement Patterns, Industrial and Commercial Sitings, Building Permit Approvals, and Flood Plains. Once provincial policies have been adopted, Planning Commissions will undertake the process of adjusting local development plans.

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The Commission on Land Use and the Rural Environment
Introduction
During the past several years the Japan Institute of Construction Engineering (JICE), a nonprofit organization within the Ministry of Construction, has studied floodplain management in several European countries and the United States. The objective of these investigations has been to evaluate strengths and weaknesses of worldwide floodplain management programs and to use this experience to strengthen the floodplain management system in Japan. For the past three years Stanley Consultants has assisted JICE with their investigations in the United States. This paper provides an overview of flooding problems facing Japan, the scope of field investigations conducted in the United States, experiences gained by JICE of international approaches to floodplain management, and the future direction of floodplain management strategies for Japan.

Present State of Flood Problems in Japan
The combination of mountainous areas occupying 70% of the total land area, which produce steep river gradients, and a climate dominated by an annual monsoon rainfall, exposes Japan to intense flood events that occur with little warning, allowing insufficient time for evacuation. It takes little time for runoff to descend from the uplands to lower reach channels and, with low infiltration and losses, generates extremely high flood discharges. An example
is the Tone River which has a catchment area only 1/10 of that for the Rhine, yet the Tone's equivalent design flood discharge is greater. The floodplain areas of Japan occupy only 10% of the total land area but accommodate 50% of the population and 75% of the nation's assets, all of which are vulnerable to flooding. The risk from floods is exacerbated by urbanization that has occurred in Japan in the past 50 years. Prohibitive land values in central metropolitan areas force construction in floodprone areas, which in most cases were formerly rice fields. Intense urbanization has also paved the natural landscape, further increasing the magnitude of runoff and decreasing the time to peak. Approximately 80% of all municipalities in Japan have suffered some form of flood or sediment disaster in the past 10 years. Although living at considerable flood risk, Japanese floodplain managers must also consider the lack of awareness in the general population to flood threats. Surveys in several urban river basins indicate that only 10 to 40% of residents living in floodprone areas were aware of their predicament.

The History of Flood Control in Japan

From the earliest times this agrarian society, based primarily on the cultivation of rice and its associated dependance on reliable water supply, has linked the Japanese population to their rivers while making them vulnerable to the ravages of flooding. Early flood control structures have been dated to the fourth century. Extensive utilization of the country's waterways including flood control, irrigation, and navigation works, progressed through the feudal periods of the 16th, 17th, and 18th centuries. However, it was not until the beginning of the modern era in the late 19th century that any national approach to flood control began. In response to major floods on a number of large rivers in 1885 and 1893, the 1896 "River Law" was enacted, which entrusted responsibility for river administration to the central government. Flood control is one of those administrative responsibilities which continues to the present day.

Flood Control Concepts in Japan

The traditional approach in flood control has been to rely almost solely on structural measures. These primarily consist of barrier construction (levees and floodwalls) between the flooding source and the floodprone areas. No strenuous attempts were made to limit development in the floodplain, which would have spared land owners from the direct exposure to flood risks and reduced the magnitude of flood discharges. The lack of available lands to develop flood control projects, the pressures of floodplain urbanization, and the high cost to implement traditional projects, make it necessary that Japan seek new approaches. These changing circumstances, particularly flood control methods that address urbanization, have led the Japanese government to look beyond their country in an effort to benefit from experience gained in other nations that have faced these same challenges. The policies being implemented today have come to include nonstructural measures and methods
to attenuate the magnitude of flood flows. Since land is such a vital resource to Japan, limiting development in the floodplain, or buyout and relocation programs, are not really viable. As such, flood control measures, besides the traditional response, will focus upon retention and detention storage, channel improvements, raising threatened buildings, laying down permeable surface paving, infiltration facilities, and land use modification in the upstream catchment. The implementation of comprehensive policies requires vast amounts of time and funds. There is a need today to develop attainable action programs, with specific target dates in the near future. Various combinations of policies should be developed, including such measures as the imposition of land use regulation in those areas where this is possible.

Flood control measures are being implemented through planning concepts covering entire river systems in accordance with the planning priorities determined by the importance of each river system; that is a holistic approach. However, recognizing that it will take a long time to complete all the planned facilities, provisional targets to be achieved in the first years of the 21st century have been established. Facilities are being constructed to guarantee a uniform level of safety throughout the country (minimum design corresponding to a 30- to 40-year probability rainfall).

A feature of floodplain management in Japan is the implied governmental responsibility for the natural resource under its control. Further responsibilities include providing "social security" relative to the damage incurred when any flood control measure design criteria is exceeded. There is no system of individual responsibility for flood damage relief. The Japanese government is very interested in elements of the flood insurance program in the United States, and similar programs in other countries.

Observations on the Present State of Floodplain Management in France

With the establishment of the Plan des Surfaces (PSS) in 1935, measures have been taken in France to promote the dissemination of information concerning flood risk areas and adoption of land use regulations to control development in the floodplain. Floodplain regulations are based not only on inundation depths (as in the United States), but also on the directions and speed of flood flows. The analyses in France embrace present and future land use plans. Besides promoting land use regulation practice, 1982 legislation provides for establishing a natural disaster insurance program. Under this program, additional premiums collected from all holders of fire and regular household insurance policies are used to automatically extend coverage to potential natural disaster victims, including those from floods. The payment for the claim is conditional on compliance with the applicable land use regulations.

Further, major floods throughout France in 1992-1994 have occasioned the establishment of the new Plans de Prevention des Risques (PPR). Principal missions of the legislation include building construction restrictions in flood risk areas, conservation of natural retarding areas, and restriction of
flood control work that is liable to adversely affect upstream and downstream areas.

Investigations Undertaken in the United States

Beginning in the fall of 1992, JICE has completed a series of field study tours and commissioned a number of reports on many aspects of floodplain management and flood control in the United States. Floodplain management issues were examined including land use regulation and the National Flood Insurance Program, and the planning and implementation methods for flood control programs. Additional issues examined include elements of water resource practices such as boat mooring and boat usage rights, dam construction practice and regulation, the environmental (National Environmental Policy Act) process, the legislative process relative to water resource issues, economic evaluation and project cost estimating practice, elements of construction claims, and construction management practices. The examination of laws and regulations was supplemented with detailed assessments of case studies. Field study tours were completed throughout the United States and included meetings with many representatives of federal, state, and local governments to discuss procedures and experience in the planning, design, implementation, and operation of water resource projects. The past three years have provided a wealth of natural disasters in the United States that permitted observations of the planning, response and recovery from disasters in this country. Delegations, with the generous cooperation of such federal agencies as the U.S. Army Corps of Engineers and the Federal Emergency Management Agency, and many state and local organizations, were able to observe this nation meeting the turmoil and challenges of Hurricane Andrew, the upper Mississippi floods of 1993, and the Northridge earthquake.

Observations on the Present State of Floodplain Management in the United States

The flood insurance program, including its community-wide approach, land use and development regulation in the floodplain, and flood mapping provisions, is seen as a comprehensive attempt to introduce, on a nationwide scale, a means of floodplain management in the United States. The voluntary nature of the actual insurance policy provisions of the program, and the low number of policies in place, appears to provide insufficient "social security" to the population in general. The concept of individual responsibility for protection against natural disaster, as opposed to that of the government protecting the group, is not widely practiced in Japan, or for that matter in the European countries assessed.

At the same time, flood control by means of structural measures (construction of levees, floodwall, etc.) is being implemented throughout the United States with the objective of providing a certain level of protection against a flood exceeding the design level flood, where such protection is
economically justified (benefit/cost ratio greater than one). It is perceived that property owners are left with their own resources if they do not fit this economically viable envelope. This perception of individual vulnerability and lack of "social security" is reinforced by consideration of the potential threat to developments within the protected zones that might be subject to flooding and failure from events exceeding the design criteria.

The U.S. situation compares to Japan where flood control facilities are being constructed with the objective to achieve, as the provisional target, a "National Minimum" level of protection for all vulnerable areas with little consideration to economics. The government continues to accept the burden of restitution and recovery should the protection fail. This concept of national "social security" can also be seen in France with the natural disaster insurance program where coverage, as a part of general insurance, has the role of providing social security. The role of current U.S. floodplain regulations to provide a disincentive for development in the floodplain has not, as yet, been recognized as a positive benefit in Japan.

**Flood Control Policy Objectives in Japan**

Conditions which are prerequisite to the introduction of land use regulation and flood insurance programs include the availability of choice concerning where to live and how to use the land. The choices available, especially in urban areas of Japan, are limited, making it difficult to apply many aspects of the programs found in Europe and America without significant modification. Nevertheless, it is the intent of the Japanese government to study the possible application of land use regulation and flood insurance. Specific consideration will be given to, among other aspects, the conservation of naturally occurring functions of flow retarding and detention areas in those floodplain areas where choices available are relatively diverse (areas other than agricultural land and densely populated areas) modeled on example systems found in Europe and America. The primary thrust for future floodplain management strategies in Japan will focus on a national master plan for all river basin systems, developing a phased implementation approach to balance need and available resources, implementing diversified flood control and floodplain management measures including structural and nonstructural projects, enacting land use ordinances, disseminating information through preparation of flood risk maps, and enhancing emergency communication and warning systems.
20. The objects of an authority are to establish and undertake, in the area over which it has jurisdiction, a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals.

This section of the Ontario Conservation Authorities Act has been in place, untouched, since the Act was passed in 1946. In nearly 50 years of administration and implementation of the Act by several departments of the Provincial government and the 38 partner Conservation Authorities, the interpretation of this section has varied substantially as approaches to conservation have changed with the development of new technological solutions to the problems of the day. The Credit Valley Conservation Authority (CVCA) is an excellent example of the evolutionary process still unfolding today.

All Conservation Authorities are guided by three basic principles: local initiative, cost sharing, and watershed jurisdiction. The idea of managing natural resources on the basis of natural boundaries instead of political boundaries was, and still is today, a central concept. The CVCA has jurisdiction over the watershed of the Credit River—a high quality, coldwater stream on the western side of the growing metropolitan Toronto region and a number of adjacent smaller tributaries that drain directly into Lake Ontario. All or parts of 11 municipalities fall within these watersheds. Formation of the CVCA in 1954 was brought about by those 11 municipalities making a request of the Provincial government. This requirement for local initiative is entrenched in the Act and was a major contributing factor in the success of Authorities during their formative years since the creation of these bodies was not dictated by a remote central bureaucracy. Rather, the creation of an "Authority" was an expression of the local community's recognition that something was wrong and reflected a desire to effect change.
Not only did local people take the initiative to establish Authorities, including the CVCA, to implement schemes to improve the community, but they also committed to sharing in the cost of these schemes both amongst the local municipalities within a watershed and between the local communities and the Provincial government. While the cost-sharing formula has undergone variations over the years, generally speaking costs are shared in roughly equal proportions between the Province and the local municipalities. The municipal share of program costs can be apportioned between the municipal partners in one of two ways. General Levy is raised on the basis of a formula which takes into account population and the tax assessment of the participants and is applied against the administration of the Authority and any projects deemed to have widespread, watershed benefits. Special Benefitting Levy is usually raised from one municipality when the benefits of a project are solely enjoyed by the residents of that municipality.

The strength of Authorities lies in their inherent ability to adjust to changing local circumstances and to design and implement programs to address the problems of the day. Southern Ontario is a diverse part of Canada with land uses ranging from modern day wilderness to cosmopolitan urban core, and Authorities are established in all of these communities. The CVCA is an interesting case study in that it was formed when agriculture was the predominant land use within the watershed but today it oversees communities experiencing the highest rates of growth anywhere in Canada and which will, in the foreseeable future, cover as much as 40% of the watershed. The CVCA programs have evolved in response to these changing demands.

The first activities of the CVCA were aimed at the establishment of a system of protected green spaces in the upper reaches of the watershed. Acquisition of land for public parks occurred primarily along the Niagara Escarpment, the most prominent landform in Southern Ontario, but also in the poor agricultural soils above the Escarpment for reforestation.

Hurricane Hazel ravaged Southern Ontario in October of 1954, centering on the Humber River, the watershed immediately adjacent to the east of the Credit River. As a result of this natural disaster, the focus of the CVCA’s programs shifted to the protection of the communities that had historically been situated along the river and its tributaries from flooding. A large scheme which envisioned the construction of a series of six flood control reservoirs was conceived and by the early 1960s, the first one was built. Additional land was also acquired for the construction of two others but the high cost of constructing reservoirs along with the competition for Provincial funds with other Authorities caused the abandonment of this scheme.

It was also about this time that the character of the watershed began to change with the onset of urban sprawl. Unprecedented levels of green field development forced the CVCA into setting its mind to solving the problems associated with the conversion of agricultural land to impermeable asphalt and roof tops. Still in a protective frame of mind, attention was shifted to moving the large volumes of water generated from development off the land and into the watercourses as quickly as possible, ushering in a period of intensive channel improvements of virtually every description. Concurrently, CVCA
adopted and began enforcing regulations which prohibited new development in identified flood susceptible zones. Floodplain modelling and mapping exercises were undertaken to predict what effect a storm similar to Hurricane Hazel would have on flows and flood elevations if it occurred again, centered on the Credit River. Development was then prohibited from this so-called Regional Storm Floodplain unless, through engineered means, damage to buildings could be prevented through floodproofing.

The transition from traditional, engineered solutions involving construction of flood protection works and channel improvement schemes for floodplain management began to change with the passage of a new Planning Act in 1983 and the subsequent declaration of Provincial Policy on floodplains in 1988. Through this change in policy at the Province, Authorities became responsible for assisting in the implementation of the policy by becoming involved in the process of land use change at the local level. In addition to administering its floodplain regulations, the CVCA also used its role as a commenting agency on local municipal planning documents to introduce a preventative approach to floodplain management. By requiring that flows emanating from developments be controlled to pre-development levels, attempts were made to limit the impact on the receiving watercourses and to protect downstream riparian landowners from increased flooding. By the 1990s, although the nature and scope of structural engineering works had been reduced through reasonably effective floodplain management techniques supported by the planning process at the local municipal level, the impact of source control of peak flows set the stage for new challenges in watercourse and watershed sustainability. Clearly, the regulation of peak flows to pre-development levels extended the duration of bank full flow conditions on natural conveyance systems and necessitated localized erosion protection for long term channel stability.

The popular environmental movement of the late 1980s limited the acceptability of construction-oriented engineering solutions for floodplain management. A resurgence of the interest by local communities in environmental matters, which had once spawned the Conservation Authority movement, dictated that a more holistic approach be taken in managing natural resources. The view of water as a waste product in need of disposal rapidly changed to the view that water was but one part of a natural system functioning even in urban communities. As a result, people became interested in not only watercourses but also the valleys through which they flowed, the upland woodlots that were connected to the valleys, and the groundwater recharge areas which fed the streams—the ecosystem approach.

In response to this new awareness, the CVCA developed a new watershed plan which dealt with the whole range of natural resource issues and community values, not simply issues of water quantity. Resulting from that Watershed Plan, a series of subwatershed studies have been completed as "building blocks" for ongoing integrated, watershed management. Through these subwatershed studies, detailed inventories of natural resources are compiled, the workings of the system are understood, goals are established for the management of land use change, and monitoring programs are
designed to follow the progress towards achieving the goals. This information is then integrated into the larger municipal decisionmaking process of community planning with the natural environment having been considered as a resource to the community rather than a constraint requiring a solution.

The ecosystem approach to natural resource management, including floodplain management, relies on detailed information that is easily accessible to a variety of decision makers. Impact assessments and modelling are important tools and communication with residents is imperative. The CVCA has found that a great deal of information exists in a range of formats, collected for a variety of purposes. Integration of existing databases is hampered by the fact that the various jurisdictions, agencies, and proponents generating information do so in their own information systems environments. Communication of the information to interested members of the community in graphic products can be difficult and expensive, and therefore, less effective.

GIS technology has the potential to deal with many ecosystem-based management issues. Desktop access to extensive databases organized geographically is essential if informed and timely decisions are to be rendered by front-line planning technicians on a day-to-day basis. As an analytical tool using graphic depiction of significant natural features, GIS systems assist planners in integrating the various layers of information that must be considered as a community develops. Access to powerful modelling tools using the same databases is also important if the impacts of large-scale land use changes are to be predicted and avoided or if the information collected through monitoring is to be useful in modifying programs and policies.

The evolutionary process continues for Ontario’s Conservation Authorities with the recent enactment of another new Planning Act and GIS technology will be critical to the ability of CVCA and other Authorities to meet the new challenges presented. In response to criticism that planning had become cumbersome and ineffective, with multitudes of layers and no clear direction, the new Act was designed to establish the Province as the major policy-setting body and the municipalities as the sole delivery agents, making local decisions within the context of broader public policy statements. In the first documents introducing the new Act, its policies and guidelines for implementation, the natural environment has been set on an equal footing with the traditional community planning issues and municipalities will be required to make decisions that are consistent with Provincial policies. While this is a positive change in terms of making planning more responsive and locally accountable, municipalities will now have to make sure their decisions will take into account not only the natural environment within their jurisdiction but also the downstream and ecosystem effects. The fundamental attributes of GIS—data management, data querying/presentation, and spatial analysis—will be essential in this regard. The emerging role for the CVCA will be to develop a natural resource database comprising specific data structured and formatted to promote "common ground" for information exchange and decisionmaking in the best interests of all of its 11 member municipalities.
Section 15

Nationwide Programs, Policies, and Impacts
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It is a real pleasure to be here at the 19th Annual Conference of the
Association of State Floodplain Managers. The Corps of Engineers has had a
long involvement with flood control projects and other flood damage
reduction measures through floodplain management. I want to share with you
some of the initiatives and policy changes that are underway that will affect
what the Corps does in the future.

The Corps, like many other federal agencies, is undergoing reinvention.
The first suggestion of this reinvention is reflected in the President’s FY1996
budget request to Congress. Additionally, the Corps is currently undergoing a
mission review and it is clear that there will be dramatic changes in the
Corps’ Civil Works (CW) Program. First, the Corps will have a small CW
program. It will do different things and it will do them in different ways.
Also, the terms by which the Corps provides its services may very well
change.

I want to focus on the changes in flood damage reduction policy as they
relate to the Corps’ CW program. These policy changes reflect broad
concepts that have been around in the professional community for many
years, but only with this administration have begun to be reflected in public
policy. I am thinking of such terms as "ecosystem management" and
"watershed plans" and concepts such as "sustainable development," "multi-
objective planning," and "holistic approaches." These terms and concepts,
familiar to many professionals, are being translated into action principles as
floodplain management is put in place. The principles recognize that
floodplains are part of a larger system—the watershed—and that sound
floodplain management requires consideration of forces both on and off the
floodplain that contribute to flood losses.

The administration’s approach involves these basic conceptual ideas and
translates them into actual policy. The first of the translations of policy which
regards flood control was in the President’s FY1996 budget. In that budget,
the administration proposed to change the criteria for federal participation in
flood control projects. I use the term "flood control" quite liberally because
we are really talking about traditional types of flood damage reduction
projects. The administration proposed three criteria to define projects of "national significance" that would warrant federal participation in the CW program. First, 51% of the floodwaters would have to come from outside the state; second, the benefit-to-cost ratio of the proposed project would have to be two-to-one or greater; and third, the non-federal share of the cost would essentially be reversed from the existing policy (which is 25% non-federal and 75% federal) to 75% non-federal and 25% federal. In addition, the administration proposed substantial expansion in the Corps Flood Plain Management Services Program and the Planning Assistance to States Program. These programs emphasize the application of Corps expertise to help others solve their own problems. However, they are integral parts of the Corps' total flood control mission and the increased emphasis on them reflects a significant shift in focus from the traditional flood control approach to the broader concept of floodplain management.

The total picture, the shift to floodplain management and the expansion of the Planning Assistance to States and Flood Plain Management Services programs was lost in the debate that followed the announcement of the President's budget. What indeed happened was that the reaction of the Congress and of the public, in general, centered on the criteria that had been announced regarding how the non-federal share was going to be defined for federal flood control projects. The larger vision, the rethinking, the reorientation of flood damage reduction policy, was lost in the notion that the changes in cost-sharing criteria would result in little or no federal participation in flood control projects. This caused considerable uproar and unhappiness. Frankly, the criteria were viewed as arbitrary and unfair and, as a consequence, the administration agreed to review them.

The criteria review process is now underway. There have been lots of ideas proposed as alternatives, including a very basic idea that federal participation in traditional flood damage reduction projects should somehow be tied to the commitment of the community, the state, or the region to sound floodplain management practices. That policy, by the way, was advanced by members of the environmental community and of this Association and I think it has much promise. It is also clear that the objections to the use of the higher benefit-cost ratio, the out-of-state source of water, and the increased non-federal cost share as criteria for establishing projects of national significance has been heard. Consequently, the policy the administration ultimately adopts maybe somewhat different from that which was articulated. The Corps' mission review, which is underway and in which some of you may be participating, will serve as the Corps' input for defining projects of national significance. That process should be completed in early June. The administration will probably articulate its position within the next few weeks so that there can be an effective dialogue with the Congress as it develops the FY1996 appropriations and also so as to set the stage for the FY1997 budget, which is underway.

It is important to note that the administration's new policy, as originally presented, was reflected in the President's FY1996 budget request. This means that projects and studies that were not in compliance with the new
criteria were not included. So, for the 1996 appropriations to reflect a
different policy, there obviously have to be some adjustments made.
Everyone recognizes that the total dollar amounts are unlikely to be changed.
In fact, both the House and Senate budget resolutions have adopted the
President’s recommendation with regard to the total amount for the CW
program. If different policies emerge, then there will be equal cost trade-offs.
The addition of a project or program will require the deletion of a
corresponding project or program of equal value, so the total cost
commitment not only in FY1996 but over the budget planning process,
remains the same. The bottom line is there will be substantial changes in the
CW program and it is through the mission review process that these changes
will be defined.

Also, it is important to note that the administration’s policy changes
proposed for flood control and in other areas of the program, including the
elimination of the storm damage reduction program and coastal programs of
the Corps, would achieve only about half the savings that were necessary to
realize the program budget totals for the CW program. The Corps’ mission
review would identify the additional savings necessary to achieve the required
budget reductions. With the additional changes being contemplated that are
not reflected in the President’s budget, it means that even further savings will
have to be identified. Additionally, we anticipate that whatever changes are
adopted will be immediate. There will be no phasing in or grandfathering
since it is necessary to realize the budget savings in the short run rather than
the long run. As an economist, I recall the words of John Maynard Keynes,
"In the long run, we are all dead." We are not, however, focusing on the
dead, but rather on the living and on the future of these viable programs.

Even with all this focus on reductions, it is important to keep in mind
that the administration strongly supports the expansion of the Planning
Assistance to States Program and the Flood Plain Management Services
Program. I urge you all to pick up a copy of our new brochure, which
outlines the scope of the programs and gives details and instructions on how
to use them. I am personally quite enthused about the Planning Assistance to
States Program as being an opportunity for the Corps to involve itself in
watershed plans. It is a very, very collectible program. Not only does it
allow the Corps to address the traditional on-floodplain activities, but it will
also allow the Corps to address off-floodplain activities, as well, with an eye
toward the entire watershed.

It is clear that the Corps programs will change. The specific directions in
which they will change remain to be defined. In any case, we are looking
forward to working with all of you, our customers, to help us shape those
changes and to get the biggest payoffs possible from what will be really
limited federal resource commitments through the CW program.
In *Life on the Mississippi*, Mark Twain wrote over the century ago,

> One who knows the Mississippi will promptly aver . . . that ten thousand river commissions, with the mines of the world at their back, cannot tame that lawless stream, cannot curb it or confine it, cannot say to it, "Go here," or "Go there," and make it obey; cannot save a shore which it has sentenced; cannot bar its path with an obstruction which it will not tear down, dance over, and laugh at.

To one degree or another, the same inexorable power described in Twain’s description of the Mississippi River has universal application to rivers and streams "from the mountains to the sea." Yet, while we cannot easily, if at all, control our rivers, there is an urgent need for us to find an accommodation with them. Floods in the United States in this century have caused a greater loss of life and property and disrupted more families and communities than all other natural hazards combined.

Two years ago, after touring the areas devastated by the Midwest floods, President Clinton committed to the American people that when a disaster hits their community, his administration would be there to help them respond and recover from that disaster.

The President’s commitment was also to make the delivery of disaster assistance more efficient and effective, and to work to rebuild those communities to be safer through mitigation so that future disasters would not have such a severe impact.

The Clinton administration and the Congress have, in the past two years, established the foundation for hazards mitigation by "reinventing" the Federal Emergency Management Agency (FEMA) with mitigation as its cornerstone, significantly increasing the funding previously available for post-disaster mitigation through the Volker Amendment to the Stafford Act, and reforming the National Flood Insurance Program (NFIP) to provide
mitigation grants and mitigation insurance. We have also integrated mitigation as a full partner with emergency response and recovery after disasters.

For example, in the Midwest, and in other subsequent flood disasters, with the significant increase in mitigation funds combined with Community Development Block Grant (CDBG) funding, we are working with communities to move people above the base flood elevation or permanently out of areas where we know they will be flooded again. FEMA’s investment of 404 Stafford Act mitigation funds is about $153 million. It is estimated that over one-and-one-third times the investment will be saved in federal disaster funds over the next few decades. This does not include state or local savings. In the State of Missouri alone, we will remove more than 4,300 structures from the floodplain. The state estimates it will save $200 million in future disaster costs over the next 15 years.

We have already witnessed benefits from this program in the flooding now occurring in Missouri. Some of the very homes we have acquired flooded again, but this time, no one was living there and the taxpayers saved spending additional millions.

Another example can be found in southwest Texas. Since 1978, Houston and Harris County have been among the most floodprone areas in the nation. For example, one subdivision in Harris County has been flooded 17 times. NFIP claims have totaled $180 million and $502 million for Harris County in the past 16 years. A FEMA hazard mitigation grant was combined with Corps of Engineers funds to complete a project a year ago that protected this chronically floodprone subdivision from last year’s devastating deluge, and saved taxpayers and the NFIP millions of additional dollars.

Increasingly, FEMA is joining with other federal agencies and state and local governments to develop local capabilities to implement mitigation. Our flood buyout efforts in the Midwest, Texas, Georgia, and California are succeeding because we are pooling resources from the Department of Housing and Urban Development’s CDBG program, the Economic Development Administration, the Farmers Home Administration, and the Small Business Administration.

In other areas, such as South Dakota’s Vermillion River Basin, we have worked with the National Park Service, the Corps of Engineers, and other partnerships with federal and state agencies and the private sector to develop a multi-objective flood mitigation plan to reduce the risk of future flood losses.

The 1994 document, A Unified National Program for Floodplain Management, recently transmitted to Congress by the President, notes that the purpose of floodplain management is to (1) reduce the loss of life and property and the disruption of families and communities caused by floods, and (2) to protect and restore the natural resources and functions of floodplains.

While it has some limitations, one of the most effective vehicles for floodplain management is the NFIP. It is the primary federal program that offers the best model for building local capabilities in land use planning to mitigate or reduce disaster losses. As you know, this program has been in
DEVELOPING LOCAL CAPABILITIES FOR FLOOD MITIGATION

effect since 1968 and it was amended in 1973 to require purchase of flood insurance as a condition of receipt of federal or federally backed financing for all structures in designated Special Flood Hazard Areas. The recent amendments signed by the President last fall, in addition to providing for mitigation grants and mitigation insurance, also provide for more effective enforcement of the mandatory purchase requirement for mortgage closings. With the new legislation, penalties for banks will now be in place for failure to follow the program. With this will follow an insurance policy base that reflects the true risk to a greater degree than ever before. At the same time, we will have taken a large step toward a more equitable situation where disaster costs will be more heavily borne by those at greater risk to the peril. These reforms will also provide for greater adherence to the floodplain management and land use provisions of the program that operate to reduce disaster losses. A bulletin on the progress of implementing the Flood Insurance Reform Act is available at the registration table of the conference.

Another important aspect of floodplain management under the NFIP is the Community Assistance Program—State Support Services Element. By providing matched funding to state governments for activities conducted by floodplain management officials, FEMA has successfully built a partnership that has had mitigation as its focus since 1986—really since 1980 under the CAP's predecessor, the State Assistance Program.

Today, 44 states, Puerto Rico, and now the Virgin Islands, participate in the CAP. Approximately 120 highly trained, dutifully conscientious state floodplain management officials identify, prevent, and resolve floodplain issues in the 18,000 participating NFIP communities "before" they result in suspension, probation, or other enforcement action by FEMA.

Let me take this opportunity to acknowledge and thank the state floodplain managers for your outstanding support of public awareness and education through the development of workshops, statewide newsletters, and other materials that promote the identification of flood hazards and which publicize flood hazard mitigation efforts carried out by a state or individual communities or homeowners. This is a critical element in our effort to promote partnerships for building safer communities.

The floodplain management/flood hazard mitigation partnership that has been built upon floodplain leadership in several states and which supports and encourages floodplain management programs of most of our state governments is an example of mitigation at its best. In this case, federal partnership with the state has resulted in demonstrably more effective floodplain management programs—without which claims payments out of the National Flood Insurance Fund would be insupportable to say nothing of the resultant danger to life and property from construction in high risk areas.

However, these and other important steps will not guarantee safer communities, without a comprehensive program to institutionalize natural hazard safety measures—mitigation—at all levels of government, with the private sector, and as a basic responsibility of every American.

While mitigation of natural hazards has been an important focus of programs within numerous federal and state agencies for some time, and
while progress has been made to varying degrees in mitigating the impacts of some hazards, there is an obvious need for a conceptual framework, establishing intergovernmental coordination, cooperation with the private sector, improvement of technical standards, evaluation of progress in mitigation, and the setting of long-term national goals.

Consequently, last year the President directed FEMA, under the leadership of Director James Lee Witt, to develop a national strategy to reduce the loss of life and property damage through eliminating or reducing the impacts of natural hazards. This pro-active policy, building upon past efforts to promote hazard mitigation, is based on the development of new partnerships for building safer communities—partnership involving all levels of government, public and private sectors, whole communities, and individual citizens and their families.

Encouraging the synergistic growth of those partnerships is the essence of the National Mitigation Strategy that will soon be announced by the President. The ultimate goal of this strategy is to significantly reduce the loss of life and property damage caused by all natural hazards.

With regard to reduction of flood hazard vulnerability specifically, there is a need to engender fundamental changes in federal policy and the public’s perception of flood hazard risks. All Americans must understand that flood hazard mitigation will reduce deaths, injuries, and economic losses; will prevent the loss of irreplaceable family possessions; will enable a quicker economic recovery because community infrastructure and critical facilities remain intact; can enhance agricultural production; is cost-effective; and reduces the disruption of the community’s social fabric. Flood hazard mitigation should be recognized as an important part of community development, and as an opportunity for each citizen, and public officials alike, to invest in a safer, more sustainable future.

The federal government, through stronger support of state floodplain management programs, can provide the leadership and facilitate coordination to achieve these goals by

- creating broad-based awareness and understanding of flood hazard risks, and support for actions to mitigate those risks;
- promoting partnerships among federal agencies, state and local governments, and the private sector;
- using a watershed and ecosystem management approach for floodplain management and water resources; and
- encouraging the protection and restoration of the natural resources and functions of floodplains.

Since most decisions about how floodplain lands will be used are made at the local level, sometimes with state guidance, it is critical for the federal government to encourage the development of local capabilities while
providing leadership where appropriate. The federal government is, after all, the principal provider of major nationwide programs that either require uniformity of approach (such as mapping of flood hazard areas) or are too sweeping for states or localities to take on themselves (such as national flood insurance or catastrophic disaster relief). Furthermore, because many rivers flow between the states, there is a need for a national level policy to ensure a watershed approach to flood hazard mitigation and resource protection.

In the past year, the Clinton administration has worked to prepare and implement such a policy. A floodplain management action plan based on the findings of the "Galloway Report" and fully consistent with the National Mitigation Strategy will soon be announced and released by the President. The Clinton administration recognizes the importance to the national well being, both economic and environmental, of protecting and restoring floodplain lands and waters. There is evidence that Americans, while still full of compassion and readiness to assist in time of true catastrophe, are becoming less willing to subsidize the costs of unwise floodplain occupancy as they become more knowledgeable about, and gain respect for, natural processes and ecological relationships. At the same time, it is clear that society will continue to demand housing, businesses, recreational amenities, agricultural production, as well as the aesthetic pleasures of beautiful landscapes, clean water, and fish and wildlife habitats that floodplains provide. The President's floodplain management action plan will provide the administration's vision for achieving long-term goals that will move the nation toward sound floodplain management that will help people, the economy, and the environment.

Mitigating flood hazards, protecting natural resources, and providing for economic development are not only mutually compatible and concurrently achievable, but will also enhance the quality of life for millions of Americans.

The alternative is to be condemned to the tragic cycle of build, flood, rebuild, flood again. The choice is clear. The choice is ours.
UPDATE ON ACTIVITIES OF THE FEDERAL INSURANCE ADMINISTRATION

Elaine A. McReynolds
Federal Insurance Administration

Background
The Federal Insurance Administration (FIA) handles the federal programs that offer insurance against losses from flood and crime, most notably the National Flood Insurance Program (NFIP). The NFIP is funded by the income from flood insurance policies (premium payments and a federal policy fee on each policy) that are sold under its auspices. The premiums go into the National Flood Insurance Fund, which is used to pay claims on flood losses during an average loss year. The federal policy fee goes toward the Mitigation Grant Fund and is also used for all program expenses, including all flood hazard identification and mapping and other floodplain management activities. It also includes all insurance operations expenses—those of the FIA and the Write Your Own insurance companies.

Reorganization
FIA has recently been reorganized to better reflect the intent of the National Flood Insurance Reform Act. We now have four divisions, each with separate, though related, responsibilities.

Financial Division—The financial division includes actuarial studies, budget preparation and execution, oversight of insurance financial processing and procedures, and fund investment.

Operations Division—The Operations Division is in charge of day-to-day insurance processing nationwide. This is accomplished by on-site monitors at our support contractors and a comprehensive audit program. Included within this division are the Bureau and Statistical Agent, the Direct Program, and the Audit Program.

Claims and Underwriting Division—This division develops claims policy; provides oversight of field claims operations; develops underwriting policy; processes the most difficult risks to rate (called
"submit-for-rate policies"); and writes and updates our formal rules and regulations.

**Marketing Division**—Our new Marketing Division coordinates lender compliance activities; is developing and implementing the FIA Marketing Communications Plan; manages our advertising campaign; is researching and developing the new telemarketing capability; and oversees training.

**Flood Insurance Goals**

James Lee Witt, director of the Federal Emergency Management Agency (of which FIA is a part) has asked for 20% growth in flood policies by the end of 1996. This goal is not limited to certain levels of flood risk. Floods happen at any time and in any place.

- If you live in a Special Flood Hazard Area, you have a 26% chance of experiencing a flood during your 30-year mortgage.

- About 1/3 of flood insurance claims paid are from outside SFHAs.

That is why it is important to meet, and exceed, the Director’s goal. We are using a three-strategy approach to achieving this goal: lender compliance, program simplification, and marketing.

**Lender Compliance**

The National Flood Insurance Reform Act of 1994 contains many provisions that deal with increasing lender compliance with the requirement for the mandatory purchase of flood insurance. One of these requires lenders who escrow for any other reason to also escrow the flood insurance premium. Another is that when lenders are found to have a pattern or practice of not complying with the law, they will have to pay a penalty of $350 per offense, up to a maximum of $100,000 per year.

FIA is working to establish a strong relationship with lenders, which not only will help them comply with the law, but also help us maintain flood insurance policies that have been purchased because a lender required it. The lapse rate of flood insurance policies is close to 20%. By working with the regulatory and lending industries, we should be able to reduce that rate, especially for policies that are not purchased voluntarily.

**Program Simplification**

FIA is taking steps to make flood insurance easier for insurance agents to write, and easier for the consumers to understand. There are five areas in which simplification is being considered.

(1) *Premium payments*

- Using credit cards, installment plans, or premium financing.
(2) Application and premium computation
• Creating a rating software clearinghouse;
• Developing a simplified rate table; and
• Developing a standard risk premium for pre-FIRM buildings.

(3) Elevation Certificate Requirements
• Establishing a no-certification rating option;
• Using ACORD standards;
• Developing a provisional rating for risks that would normally require an elevation certificate;
• Reducing the requirements for elevation certificates when rating;
• Developing a certification package; and
• Taking advantage of global positioning systems to determine building elevations.

• Rewriting the policy in an easy-to-read form.

(5) Risk Zone Information

Marketing
Our third strategy is marketing. FIA is working to increase awareness of flood insurance and educate people about the risk of floods through a major advertising campaign.

This campaign, which we call Cover America, will help people understand that they are at risk and that, to protect themselves, they should contact their insurance agent or company to buy a federally backed flood insurance policy. We will advertise nationally through television, newspapers and magazines, and radio. An icon will also be developed that insurance agents and companies who sell federal flood insurance can use to help consumers recognize flood insurance.

Another part of our marketing initiative is to develop a telemarketing facility. This facility will provide our customers with one place to go for information about the NFIP, including program information, policy status, flood manuals, agent start-up kits, Flood Insurance Rate Maps, and materials about the NFIP. We have also been working with the insurance industry to establish a referral system that will channel callers who want to buy a flood insurance policy to an agent or company that writes federal flood insurance.

One toll-free number for the program puts us in a better position to serve our customers, and makes it easier for them to get the information they need quickly and efficiently.

National Flood Insurance Reform Act
Several improvements to the NFIP were specified in the National Flood Insurance Reform Act, signed by President Clinton on September 23, 1994.
Amount of Coverage Available—Coverage for buildings and contents for single-family dwellings and nonresidential structures have both been increased (Table 1).

Table 1. Federal flood insurance maximum coverage limits.

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<tr>
<td>2-4 family</td>
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<td>$100,000</td>
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<tr>
<td>Other residential</td>
<td>$250,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>Non-residential</td>
<td>$500,000</td>
<td>$500,000</td>
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<td>(including small business)</td>
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Lender Compliance—Many provisions of the new act focus on lender compliance. There are now fines and increased audit requirements to ensure that lenders are requiring the insurance when it is called for.

Mitigation Insurance—Mitigation coverage was established, in part to help insureds whose homes or businesses are substantially damaged to elevate or relocate the building.

Disaster Assistance—A new requirement was passed that recipients of federal flood disaster assistance grants will now be required to purchase and maintain flood insurance.

Waiting Period—Effective March 1, 1995, there is a 30-day waiting period after flood insurance is purchased before the coverage is effective. The old waiting period was 5 days.
CORPS OF ENGINEERS
LOCAL ASSISTANCE PROGRAMS

Clark D. Frentzen
Robert W. Plott
U.S. Army Corps of Engineers

Introduction
The Corps of Engineers has a long history as the nation's public works agency. Best known for its flood damage reduction programs, the Corps conducts studies and constructs major flood control projects. The Corps also has programs for providing assistance to states and local government in flood mitigation, flood damage reduction and related technical assistance. These programs include the Flood Plain Management Services Program and the Planning Assistance to States Program. This paper summarizes the objectives, type of assistance available and how to request assistance for the various programs.

Background
Through the Flood Plain Management Services Program (FPMS) and the Planning Assistance to States Program (PAS), the Corps is authorized to use and provide its technical expertise to help those outside the Corps.

Through the FPMS program the Corps provides technical assistance in dealing with floods and flood plain related matters. Upon request and without charge, the Corps will furnish to Indian tribes, states, counties, cities, and related public agencies the flood plain information and assistance needed to plan for the prudent use of land subject to flooding from streams, rivers, lakes, and oceans in order to mitigate flood losses. FPMS assistance is also available to federal agencies and private persons on a fully reimbursable basis.

Through the PAS program, also known as the Section 22 program, the Corps provides technical assistance in the management of water and related land resources to help the states and Indian tribes deal with water resources problems. Upon request, the Corps will cooperate with states and tribes in the preparation of plans and studies for the conservation of water and related land resources. Assistance of up to $300,000 annually is available to any state or Indian tribe, within the limits of available appropriations. PAS studies and
activities must be cost-shared, with the cooperating local sponsor contributing approximately 50% of the cost. Requests for PAS should be made through the appropriate state or tribal coordinator for the PAS program.

Objectives

The objective of the FPMS program is to promote and support comprehensive flood plain management planning for all Indian tribes, states, and regional and local governments. This will help to encourage and guide these public agencies toward the prudent use of the nation's flood plains. The adjustments to current and proposed land use based upon multi-objective planning and the consideration of flood damage reduction potential create a basis for balancing the locational advantages and natural flood plain values with the hazards of flooding.

The PAS program objectives are to support states and Indian tribes in comprehensive planning for the development, utilization, and conservation of water and related land resources. The program is often utilized in developing or revising State Water Plans. Detailed planning and design cannot be accomplished under either program.

FPMS Activities

The FPMS program activities include a full range of technical services and planning guidance related to floods and flooding, flood plain issues, and related activities within the broad context of flood plain management. Services are generally funded by the federal government, although the involvement by project sponsors, who may furnish field survey and other data, maps, and historic flood information is encouraged.

Examples of technical services provided from the Corps under the FPMS program include flood formation and timing, flood stages, flood durations and frequencies, extent of flooding, flood flow velocities, development of regulatory floodways, and the analysis of flooding changes due to the obstruction of flood flows. The natural and cultural values of flood plains and the flood damage loss potential both before and after the employment of flood plain management measures may also be studied under the FPMS program.

Certain general planning assistance and guidance may also be provided under the FPMS program. Examples include assistance and guidance for implementing and meeting requirements of flood plain regulations; the development of flood warning and flood emergency preparedness plans and procedures; hurricane evacuation planning; and the analysis of flood proofing measures and flood plain evacuation/relocation proposals. Assistance in implementing or meeting the requirements of the National Flood Insurance Program may also be requested. The assistance can range from helping a community identify both present and future flood plain and related problems to the assessment of appropriate measures to reduce flood plain problems. This includes both flood modifying and non-flood modifying measures and the analysis of land use changes on flood plain values.
The Corps also publishes information and guidance on flood proofing to reduce flood damage, flood plain regulations, and other information on the importance of natural flood plain resources and values. These publications are prepared for the use of states and local governments in planning and regulating flood plains for the reduction of flood damage and future flood damage potential.

PAS Activities

The PAS program allows for a broader range of water resource related studies than the FPMS program. Typical activities studied include flood damage reduction, water resources development, water supply, water conservation and quality, erosion and sedimentation, hydropower development, comprehensive flood control maintenance plans, ecosystem management plans, watershed management plans, dam break analysis, seawall stability analysis, dredged material disposal strategies, and navigation. Studies vary in scope from site-specific investigations to comprehensive regional or statewide studies. The PAS program may also help states and tribes in support of their Coastal Zone Management Act or Flood Plain Management Services Programs when the primary purpose is to supplement basin-wide or regional planning for the coastal zone or flood plains. When a study takes several years, the Corps and sponsors may then write multi-year/multi-phase cooperation agreements for the completion of the study.

Requesting Assistance

Indian tribes, states, counties, cities, regional governmental organizations, and public agencies interested in receiving either FPMS or PAS assistance may contact their local Corps of Engineers office for additional information and further instructions on obtaining assistance. Telephone contact is usually all that is necessary for requests of readily available information and publications. Written requests for assistance are required when specific technical assistance and detailed studies are needed. The written request should include a description of the assistance desired and pertinent information about the location.
U.S. SMALL BUSINESS ADMINISTRATION:
DISASTER ASSISTANCE PROGRAM FOR YOU,
YOUR FAMILY, YOUR BUSINESS

Gretchen V. Fournier
U.S. Small Business Administration—Disaster Area 1

Introduction
The Small Business Administration (SBA) is a federally funded program that offers low-interest, long-term disaster loans to homeowners, renters, and businesses in the aftermath of a disaster. SBA issues applications, inspects damaged property, and provides the funds needed to rebuild lives.

Recently, SBA has taken several innovative steps to meet the needs of disaster victims. For example, in 1994 SBA made the loan process easier for customers: we simplified disaster loan filing requirements by reducing the amount of information needed; we doubled loan limits for homeowners and renters; we made Internal Revenue Service representatives available at disaster application centers to improve access to documents needed to complete loan applications; we expanded the Economic Injury Disaster Loan program to include owners of real estate; and we eased criteria for major source of employment loan applicants. With its mission of efficiency and tradition of commitment to personalized service, SBA continues to reduce the burden of disaster recovery.

Capabilities
The capabilities of the SBA disaster loan program are vast. Disaster loans from SBA are the primary form of federal assistance for private sector disaster losses and they help homeowners, renters, businesses of all sizes, and nonprofit organizations fund rebuilding. SBA’s low interest rates and long terms make recovery possible and affordable. In addition, SBA is permitted by law to increase disaster loans by up to 20% for mitigation measures that would protect the damaged or destroyed property from possible future disaster damage.
**Who Does the Helping**

In the wake of disasters SBA employees are immediately sent to disaster-damaged communities. SBA field employees include experienced loan officers and loss verifiers or construction analysts. The first contact individuals have with SBA personnel is usually in one of the local centers. Loan officers are prepared to issue applications and answer questions in a personal manner. Once an application is completed and returned to the SBA, a loss verifier contacts the applicant and schedules an appointment to inspect the damaged property. A team beyond the front lines includes executive administration, personnel, computers, public information, and legal staff. There are a number of SBA personnel in travel status at the onset of a disaster and the remaining staff supports the disaster effort from the Area 1 Office in Niagara Falls, New York, one of four Disaster Area Offices in the country.

**What is Offered**

There are three types of SBA disaster loans: Disaster Home Loans, Physical Disaster Business Loans, and Economic Injury Disaster Loans (EIDLs). For an individual, there is one basic loan, a Disaster Home Loan, which has two basic parts: personal property—up to $40,000 to help repair or replace disaster losses like clothing, furniture, automobiles, etc.; and real property—up to $200,000, to repair or restore primary homes to their pre-disaster condition. As previously mentioned, loans may be increased for mitigation measures. Renters may apply for personal property loans.

For business owners, there are two basic loans, Physical Disaster Business Loans and EIDLs. The SBA is authorized to make loans for as much as $1.5 million to a business of any size to repair or replace the business’ property to its pre-disaster condition. Repair or replacement of real property, machinery, equipment, inventory, and leasehold improvements may be included. EIDLs are working capital loans designed to help a business withstand the financial difficulties it suffered as the result of a physical disaster or as the result of an agricultural production disaster. If your business suffered economic injury, with or without actual physical damage, you may be eligible to apply for an EIDL. For SBA purposes, economic injury is the inability of a business to meet its financial obligations as they mature and/or to pay its ordinary and necessary operating expenses. These loans, however, are for small businesses and small agricultural cooperatives.

**Where You Find Us**

The Disaster Area 1 Office located in Niagara Falls, New York, is responsible for New York, New Jersey, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, Pennsylvania, Virginia, West Virginia, Maryland, Delaware, Washington D.C., Puerto Rico, and the U.S. Virgin Islands. There are three other Disaster Area Offices: Area 2 in Atlanta, Georgia; Area 3 in Fort Worth, Texas, and Area 4 in Sacramento, California. The SBA, created by Congress in 1953, was given a mandate to
provide financial assistance to victims of disasters. To better serve disaster victims, SBA immediately contacts local officials to set-up a location for Disaster Application Centers (DACs) and Outreach Centers. The public is informed and kept updated of SBA locations and services through local news, radio and television. In smaller communities, word of mouth, posters and handbills also help spread the word about SBA programs and locations.

*When we are Available*

The SBA responds immediately to the needs of disaster victims. Within hours of a declaration SBA employees are enroute to the disaster location. Outreach centers and workshops are opened as soon as physically possible. SBA loan programs, however, are designed to help individuals return their homes and businesses to pre-disaster condition after their immediate emergency needs have been addressed. Should individuals wish to contact the SBA prior to the opening of our offices there is always a toll-free phone number available for our Niagara Falls Office. Experienced disaster personnel are on-hand to answer questions over the telephone and issue applications through the mail. Visiting an SBA center in person, however, is strongly encouraged. Home and business loan applications are accepted generally for 60 days following the declaration date and longer if the situation warrants. EIDL applications are accepted from eight to nine months after the declaration. With EIDLs, it may take longer recognize that economic injury has been sustained, hence the longer filing period.

*Why SBA?*

The SBA disaster program is convenient and affordable. It is SBA's largest direct loan program, and the only SBA program for entities other than small businesses. Innovative measures established in the aftermath of prior disasters simplified the application process and increased the accessibility of personal assistance, making SBA loan assistance the right choice and, in some cases, the only choice an individual has to help recover from a devastating loss. The law gives SBA several powerful tools to make disaster loans affordable: low-interest rates (loans made to homeowners unable to obtain credit elsewhere are currently 4%, have long terms (up to 30 years), and in some cases, refinancing of prior liens. On average, 90% of SBA's borrowers qualify at the lower rate of interest. An excerpt from a letter from Mr. Joseph L. Goodman, of GOMUCO, Inc., a two-time SBA applicant, exemplifies SBA's commitment to improved customer service.

There is something important for me to pass on. I was a victim in the 1992 riots. My store burned down. And, of course, SBA was there to help. Thank you again and again; the people were great. But, the paperwork on the first loan almost killed me. This time the forms were simple, direct, short and to the point. Thanks for making the change. I don't know how I survived the process the first time,
and honestly, I was afraid to try this time. Thanks for eliminating all the unnecessary and irrelevant forms. Thanks for getting to the point . . .

How To Apply

Homeowners, renters and businesses can apply for an SBA disaster loan by contacting the SBA as soon as possible following a disaster declaration. If the disaster was declared by the President, individuals will register for assistance at a DAC or over the telephone by calling an established Federal Emergency Management Agency (FEMA) Teleregistration Hotline. FEMA will refer homeowners and renters to SBA when appropriate. Businesses may contact SBA directly either by calling SBA’s toll-free number or visiting an SBA Outreach Center. SBA encourages individuals to visit a DAC or Outreach Center personally to receive disaster loan applications and receive personal assistance from SBA representatives regarding filing requirements and program guidelines.

Frequently Asked Questions

How much can I borrow?

The amount of money which SBA will lend is based on the actual cost of repairing or replacing your destroyed home, personal or business property, minus any insurance settlements or other reimbursements or grants, subject to SBA limits.

I already have a mortgage on my home. I can’t afford a disaster loan plus my current mortgage payment. Can SBA refinance my mortgage?

In certain cases, yes. To be eligible for refinancing of a mortgage, SBA must determine: (a) that you are unable to obtain credit elsewhere; (b) that your property has been destroyed or substantially damaged and that the property will be repaired or replaced; and (c) that the amount to be refinanced will not exceed the amount of the real estate damage. An SBA loan officer can provide you with more detailed information on your specific situation.

What information do I need to submit for a home and/or personal property loan?

The necessary information is specified in the loan application and can also be obtained at the time you visit a DAC or Outreach Center. In all cases, it includes an itemized list of personal property losses with repair or replacement estimates of each item. There is an application form which asks standard questions about household income and debts.
Will SBA check the losses I claim?
Yes. Once you have returned your loan application, an inspector will visit you to confirm the extent of the damage, and help you with the damage estimate of the real property.

How soon will I know if I will get the loan?
Usually within days. However, it depends on how soon you file a complete SBA loan application. The SBA disaster relief program is not an immediate, emergency relief program such as Red Cross assistance, temporary housing assistance, etc. It is a loan program to help you in your long-term rebuilding and repairing. As a loan program, we have to know the cost of repairing the damage, be satisfied that you can repay the loan, and take reasonable safeguards to help ensure the loan is repaid. The SBA loan application asks for the information we need. The faster you can return it to us, with all the needed information, the faster we can work on it. We process all applications through to a decision as soon as possible. Applications are processed in the order received, so it is in your interest to file early. Be sure your application is complete because missing information is the biggest cause of delay.

Should I wait for my insurance settlement before I apply to SBA?
No. If you do not know how much of your loss will be covered by insurance or other sources, SBA will make a loan for the full amount of the loss. All you have to do is assign that portion of the insurance check to SBA that duplicates the amount of the SBA loan.

If my home is completely destroyed, can SBA lend me money to relocate my home somewhere else?
If you are unable to obtain a building permit to rebuild your home or replace it at its original site, the cost of relocating your home can be included in the loan amount. But, if you decide to relocate your home without being required to, an SBA loan can be obtained only for the exact amount of the damage. There are legal limitations involved with relocation guidelines. Individuals should talk to SBA representatives before making any firm relocation plans.

I’ve heard that SBA loan applications are complicated and hard to complete. Is this true?
No. Measures have been taken recently to reduce the filing requirements and reduce the paperwork involved in filing an SBA disaster loan application. The application form asks for common household and financial information. If you need help, SBA personnel are available to explain the forms and give
you assistance at no charge. You may use the services of an accountant or attorney if you wish, but it is not necessary.

**Do I need flood insurance to get a loan?**

If you are in a special flood hazard area, by law you must have flood insurance before we can disburse a loan. The amount of insurance required is the insurable value of the property in the special flood hazard area, not to exceed the maximum flood insurance available under the National Flood Insurance Act.

**Conclusion**

**Statistics**

In the wake of the Northridge earthquake; California flooding and mudslides; Alabama storms, tornadoes, and floods; Texas floods; and other recent disasters, SBA has approved 21,588 disaster home loans for over $483 million; and 6,580 disaster business loans for over $334 million to date for FY1995. In FY1994, SBA approved 99,181 disaster home loans for $2.4 billion and 26,680 disaster business loans for $1.6 billion; 58,644 disaster loans for $1.67 billion during FY1993, and another 23,417 disaster loans for $794.6 million in FY1992. In FY1991, SBA made 12,451 disaster loans for $365.3 million. In FY1990 SBA approved 51,970 disaster loans for $1.32 billion, mostly for the destruction of Hurricane Hugo in the Caribbean and the Carolinas and the Loma Prieta earthquake in the San Francisco Bay area. Since the inception of the program in 1953, SBA has approved over 1,286,821 disaster loans for nearly $22.7 billion. The Northridge earthquake, to date, tallies 122,789 loan approvals for over $3.949 billion.

**SBA's Role in Disaster Recovery**

The SBA plays a major role in stabilizing one of the biggest personal concerns after a disaster, re-establishing homes and business communities. When disaster victims need to borrow funds to repair uninsured damage, the low interest rates and long terms available from SBA make recovery affordable. By providing disaster assistance in the form of loans which are repaid to the treasury, the SBA disaster loan program helps reduce federal disaster costs compared to other forms of assistance, such as grants. Because SBA loan payments and terms are tailored to fit each individual's financial situation, SBA loans are the logical and affordable step to disaster recovery. According to Philip Lader, Administrator of the SBA, SBA's role in disaster recovery is "... serving the needs of the victims and assisting in their recovery. The women and men of SBA are committed to helping victims help themselves with the assistance of the Disaster Loan Program. SBA has helped homeowners, renters, and businesses large and small get on the road to recovery. SBA will stay on the job as long as necessary."
A LOOK AT THE EFFECT OF FLOODPLAIN MANAGEMENT REGULATIONS ON DEVELOPMENT PATTERNS IN TEN NORTHWEST COMMUNITIES

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Introduction

As a result of the National Flood Insurance Program (NFIP), local governments in Oregon and Washington have had floodplain management regulations on the books for 10 to 15 years. While the rate of development in the floodplain has escalated with climbing populations, it had been hoped that the local floodplain ordinances would have a demonstrable and beneficial effect in diverting some development to safer locations and reducing flood losses. But finding information to support that assumption has been difficult.

The paper explores the sort of information needed to evaluate and back up land use management measures. It examines the effect of such measures on building patterns in 10 communities in Oregon and Washington. Not an exhaustive or scientific study, it experiments with one possible approach to a more scientific undertaking. While focusing on floodplain management, this practice study is intended to have broader implications for management and information needs relevant to other types of sensitive lands.

To isolate the effect of regulation from other factors—unrelated physical, social, and economic attributes of developed areas—it is necessary to look at development that has occurred in places that are comparable except that some are subject to regulation and some are not. The NFIP provides a good basis for this comparison because it requires regulation only within the 100-year floodplains identified on the Flood Insurance Rate Maps (FIRMs). The lines between the mapped floodplains and adjacent unregulated areas are "hard" in terms of regulation, but "soft" in terms of real flood potential for several reasons. First, the NFIP estimates and maps 100-year floodplains based on hydraulic and hydrologic analyses that are substantiated by real-life evidence only where there is a recorded flood of similar magnitude. Second, especially

1This paper is excerpted from a larger study.
2"Communities" are incorporated cities, towns, and unincorporated counties.
in rural areas, the level of analysis can be somewhat cursory. Third, the FIRMs are typically produced at a small scale and fail to show gradations in topography. Finally, the maps for many areas have not been updated to reflect changes to the land since the 1970s or early 1980s. Their liability to imprecision and inaccuracy means that the mapped floodplains—the regulated areas—may or may not fully correspond to natural floodplains.

This ambiguity, however, serves this study's purpose of discriminating between regulatory impacts and those of natural conditions, actual topography and flooding. Areas immediately adjacent to the mapped floodplains, while perhaps equally likely to flood, are not affected by floodplain management regulation and therefore are good control areas. The intent is to differentiate between the amount, type, and value of development taking place in regulated areas as opposed to that in unregulated but otherwise comparable areas outside the mapped floodplain.

**Methods**

The study uses two methods for examining regulatory impacts on development: (1) interviews with planners in 10 NFIP communities in Oregon and Washington, and (2) test comparisons of two planners' interview responses with actual development patterns around floodplains in their jurisdictions (Snohomish County, Washington, and Jackson County, Oregon). The study outlines information needs and suitable criteria for distinguishing regulatory impacts. These form the basis for the interview questions and the development comparisons, which seek to corroborate the planners' interview responses with hard evidence of development in and immediately adjacent to mapped floodplains. For selection of suitable development areas, the comparisons draw on the two counties' geographic information systems (GIS). For characterization of development trends in the selected areas, the comparisons rely on parcel data from the counties' tax assessor databases. The study concludes with a few ideas about how GIS could be used to discern benefits of land use regulation by assimilating parcel data with digital orthophoto and planimetric floodplain maps.

**Information Needs**

The interviews and development comparisons attempt to distinguish benefits and costs normally expected to result from floodplain regulation. They are grouped under three categories: environmental, economic, and individual safety and well-being, as follows.

- Environmental benefit of increased open space. By deterring floodplain development, regulation can add and preserve open space near

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1From *A Unified National Program for Floodplain Management.* Discussed further in Burby et al., 1988:186-196.
waterways. Because floodplains often coincide with riparian, wetland, and steep slope areas, floodplain regulation also can protect these sensitive features. In addition to such ecological advantages, undeveloped floodplains are natural flood regulators that contain overflow, lower flood levels, and minimize the area of inundation.

- **Environmental benefit of reduced pollution and hazardous contamination.** By shifting industrial, commercial, and residential activity away from floodplains, regulation can reduce surface and groundwater pollution and dispersal of stored hazardous materials during flooding.

- **Environmental cost of filling in the floodplain.** Elevation of buildings on fill is permitted under most floodplain regulations, and widely practiced. Fill in the floodplain can destroy wetlands, vegetation, and habitats.

- **Environmental damage (cost) at sites to which potential floodplain development was diverted.**

- **Economic benefit of reduced flood damage.** Regulation can reduce damage by removing private and public property from flooding.

- **Economic benefit of reduction in disrupted commercial activity.** By shifting commercial activity out of floodprone areas, regulation can lessen business losses due to disruption from flooding.

- **Economic benefit of increased land value adjacent to floodplains.** By preventing building or making it more costly to build in the floodplain, regulation can drive up the value of buildable land adjacent to the floodplain. Additionally, the conservation of open space and natural beauty in the floodplain as a result of regulation can make adjacent property more desirable and valuable.

- **Economic program cost.** This is the cost to local, state, and federal government of administering the regulations.

- **Economic cost of decreased floodplain land value.** This results from lowered development potential due to increased cost of construction or prohibitive zoning.

- **Individual safety and well-being—benefit from reduced number of people exposed to risk of injury and death.** Regulation can reduce risks to people by removing them from the hazard.

- **Individual safety and well-being—increased cost of construction.** This is the added cost to individuals, developers, and construction firms of meeting building requirements in the floodplain or of building outside the floodplain that are not covered by insurance or government programs. Nationally, the increased cost of construction in the floodplain averages 3 to 6% of the construction cost. In creating the NFIP, Congress considered the cost of building to higher regulatory standards as a factor in discouraging building in the floodplain.

The interviews and development comparisons look for measurable indicators of these benefits and costs: the density and type of development, infrastructure, property market, and history of flood damage in the regulatory floodplains and adjacent areas of the subject communities.
The Communities

Planners responsible for administering local floodplain management ordinances were interviewed in Bend, Madras, Grants Pass, and Jackson County, Oregon, and in Bellevue and Snoqualmie and Lewis, Snohomish, Spokane, and Whatcom counties, Washington. Communities believed to have strong floodplain management programs were selected in order to highlight the effect of regulation, although the communities vary in how zealously they enforce their regulations. The study areas also range in size and nature of development, encompassing mid-size cities and rural agricultural counties. The communities have healthy growth rates, steadily adding new buildings to older development dating back to the turn of the century.

The Interviews

The interview questions centered on regulatory outcomes, but also treated public information on flood hazard, via the FIRMs, as an integral aspect of the regulation. The planners were asked if, since joining the NFIP and getting the maps, the communities had changed their comprehensive plans and development/zoning codes to eliminate any uses or reduce density in the floodplain or floodway, beyond what is minimally required under the program. Principally due to state codes that exceed the NFIP regulatory standards, all the communities have. Since 1993, Oregon has required that the lowest habitable floor of all single-family structures in the floodplain be elevated to one foot above the base (100-year) flood elevation. Washington prohibits new residential development in the floodway. Both state codes have been enacted since the NFIP and presumably are attributable to its regulatory criteria and publication of flood hazard areas.

Most of the communities have independently adopted additional restrictions, but the planners cited environmental concerns and actual floods as the chief inducements for tighter controls. One community has long prohibited (since before the NFIP) any development in the floodplain, period. Another city prohibits fill in the floodplain for environmental reasons and to maintain floodwater storage capacity. One of the counties allows no new lots entirely within the floodplain. Several communities have riparian setbacks 20 to 100 feet from waterways. All of the communities have recreational open space zones—parks, greenways, bike paths—within their floodplains. Three of the counties use agricultural and/or forest zoning to substantially restrict development in their remaining unbuilt floodplains.

Most of the planners surmise that there would be a lot more residential, industrial, and especially commercial development in the floodplain without the NFIP regulatory criteria and maps. Yet only half find increased cost of construction to be a deterrent, and usually not a prohibitive one; the other half notice no effect. The planners also are evenly divided over whether the regulations and maps have decreased floodplain property values or not.

Overall, most of the planners think that market demand for floodplain property outweighs the increased cost of construction and identification of
flood hazard by the regulations. The planners generally find that development diverted from the floodplain shifts to property adjacent to the floodplain, where available, rather than entirely away. The attraction of river views is the most commonly mentioned reason for this. Still, only one planner believes that adjacent property values have risen as a result of the regulation and mapping. And when questioned whether demand for floodplain property comes from high, middle, or low income brackets, the planners gave mixed responses. In some floodplain areas, demand is from people who can afford expensive river-view lots and the increased cost of construction. In others, floodprone land is not considered desirable, and is cheap.

Lastly, the planners were questioned about damage to buildings in floodplain and adjacent areas during the last big flood in their area. In those communities which had experienced major flooding since adopting the NFIP regulations, there was significantly less damage to buildings constructed to the regulatory standards than there was to buildings pre-dating the regulations. However, a few of the planners noted that there was damage to post-regulation houses in areas where the maps were inaccurate or imprecise.

The Development Comparisons

Snohomish County, Washington, and Jackson County, Oregon, were chosen for the development comparisons (between the planners’ interview responses and actual development patterns) because both have areas with comparable development in and immediately adjacent to the regulatory floodplain, both are in the process of developing GISs, and both were willing to participate in the study. The period of time in which both counties have been participating in the NFIP is representative of the other communities in the study and of most communities in Oregon and Washington. Snohomish County adopted regulations consistent with NFIP criteria and received a FIRM in 1984, Jackson County in 1982. The study summarizes each county’s GIS capability, the process by which floodplain and adjacent development are compared in each, and the comparison results. A brief summary follows.

Snohomish County

The study compiles and analyzes information on 2,224 parcels in a 7-section area that cross-sects the mapped floodplain and adjacent land. Of the parcels analyzed, 353 are in the mapped floodplain. The study area in and outside the floodplain is zoned for residential, commercial, and industrial use. Parcel data analyzed include the year any principal building was built, the assessed land value, the assessed building value, land use, and acreage.

Even allowing for significant standard deviations in the land and building assessed values, comparison of the floodplain and adjacent parcel data shows a development pattern consistent with the county planners’ responses. Development density in the floodplain is substantially lower than in the adjacent areas. There are fewer and larger parcels and fewer buildings in the mapped floodplain of the study area. Land and building assessed values are
lower in the floodplain than in the adjacent areas, bearing out the planner’s belief that the value of most floodplain property is reduced and that development is predominantly from lower income groups. The mean assessed land value for the floodplain parcels ($17,109), probably the best indication of regulatory impacts, is 45% of that for the adjacent parcels ($37,763). The mean assessed building value for the floodplain parcels ($39,505) is 64% of that for the adjacent area parcels ($61,904). Although lower in value, the average floodplain lot (7.25 acres) is larger than the average adjacent lot (1 acre), and the maximum floodplain lot (158 acres) is much larger than the maximum adjacent lot (20 acres). Most of the floodplain parcels are use-coded as “undeveloped land.” In contrast, most of the adjacent parcels are coded as single-family residential use.

Interestingly, the parcel data imply a trend for delayed development in the floodplain. Mean building dates are about 15 years later in the floodplain (1955) than in the adjacent parcels (1940), and development in both is ongoing. This trend, which predates the regulations by many years, seems to evidence an early local appreciation of the flood hazard that has more recently been overcome by development pressures.

**Jackson County**

Due to Jackson County’s distance from FEMA’s office in Seattle and a malfunction of the county’s computer network, this data set is much more limited than that for Snohomish County. Assessed land and building values were inaccessible at the time of the study. Parcel data analyzed for a 1-section area transecting the mapped floodplain and adjacent areas include year built, factor classifications of building types, and lot acreage. The entire section is zoned for residential use.

A Jackson County neighborhood established well before the NFIP exhibits a later development shift into the floodplain. The area’s most recent construction is there, and the mean age of the floodplain buildings (1961) is younger than that of the adjacent buildings (1949). As in Snohomish County, this trend began before floodplain regulation. Overall development patterns in Jackson County appear to demonstrate the interviewed planner’s belief that the regulations have decreased floodplain development on the whole. The study area is bordered to the north, south, and west by floodplains that, according to the planner, have been zoned as either "exclusive farm use" or "forest resource" as a direct result of the floodplain regulations.

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5This zoning allows one agricultural structure per 40 acres or one forest resource structure per 160 acres.
Conclusion

The interviews and development comparisons evidence the anticipated environmental, economic, and individual benefits and costs associated with diminished development and increased open space in the floodplain. A pattern seems to emerge of less development density, lower property values, and later development in the regulatory floodplain than in adjacent land.

But it remains difficult to tie these benefits and costs directly to regulation. The trend for later development in the floodplain is a cause for concern. If early development respected the floodplain, and post-regulation growth is pushing development in, then the minimum level of regulation required under the NFIP is not effective in diverting new development. Only where the minimum federal standards are combined with additional land use measures, as in Jackson County’s agricultural and forest zoning, do they appear to have a significant impact.

The study does not completely isolate the effect of floodplain management regulation. The interviews and development comparisons brought other potential influences to light: frequency of flooding; tax assessor practices; cultural, environmental, and economic incentives to devote floodplain land to parks and agriculture; and the regulation of coincident natural features such as wetlands and riparian areas.

GIS enables an association of tabular (parcel) data with maps that could provide a key to evaluating the effect of regulation. Digital orthophoto and planimetric maps converted from aerial photography allow a pinpointing of land features and the exact location of buildings not possible with most parcel maps. Thus, GIS can give better focus to development patterns relative to regulatory and actual floodplain (or other sensitive area) boundaries.

Further, GIS can help to discriminate the effects of land use regulation from other factors through its capability to model land use change over time. Maps of parcel data at 3- to 5-year intervals would allow tracking of development trends with respect to the adoption of different regulations, new zoning, and floods. With orthophoto or planimetric mapping, planners could overlay the location of development relative to the changing perimeters of land use codes and zones, the inundation areas of floods, and the areas of any other influences. Interval mapping can capture the relationships—and non-relationships—in time between development, regulation, and other factors.

Finally, a GIS can help to illustrate the benefits of land use regulation and costs of inadequate regulation. Scenario models to project flooding (or earthquakes or erosion or loss of wetlands . . .) can graphically represent the risks of building in sensitive areas. Depending on the coverages used (e.g. site geology, vegetative cover, assessed building values) a GIS can show environmental, economic, and individual vulnerability.
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THE COMMUNITY RATING SYSTEM: A TOOL FOR IMPROVING LOCAL AND STATE FLOODPLAIN MANAGEMENT PROGRAMS

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Background
The Community Rating System (CRS) provides a reward for property owners in those communities which participate in the National Flood Insurance Program (NFIP) and which undertake activities that exceed the minimum requirements of the NFIP. In such communities, property owners receive a discount of at least 5%, and up to 25% at this time, on their insurance policies exclusive of policy constants. Property owners are informed that their premium costs are lower because of their community's floodplain management program. Local and state floodplain managers can use this fact to improve their programs in a number of ways.

The NFIP was implemented in 1968 to provide flood insurance for buildings because such insurance was not generally available at a reasonable cost. In exchange for the availability of this insurance, a community had to agree to manage new development in ways that were expected to reduce damage to that new development. Later, community participation became a prerequisite for many forms of federal disaster assistance to the community. Many of the more than 18,000 communities that currently participate in the NFIP do so because they cannot afford to forego federal assistance in a disaster.

Although the floodplain management requirements of the NFIP provide a great deal of protection for new development, many floodplain managers have recognized that additional measures can further reduce flood damage potential and/or meet other floodplain management objectives. The position of the Federal Insurance Administration (FIA) has always been that a community may adopt higher standards for floodplain management as long as the NFIP minimum requirements are met on a building-by-building basis. Through the CRS, a broad range of activities has been identified that exceed the minimum requirements for community participation in the NFIP, and an incentive has been provided for communities to undertake such activities. These activities and ways that the CRS may be used by communities and states to strengthen
their programs are discussed below. Over 900 NFIP communities are currently participating in the CRS.

The Community Rating System


The objective of the CRS is to reward those communities that are doing more than meeting the minimum NFIP requirements to help their citizens prevent or reduce flood losses. The CRS also provides and incentive for communities to initiate new flood protection activities. The goal of the CRS is to encourage, by the use of flood insurance premium adjustments, community and state activities beyond those required by the National Flood Insurance Program to:

- Reduce flood losses, i.e.,
- reduce damage to insurable buildings,
- prevent increases in flood damage from new construction,
- protect public health and safety,
- reduce the risk of erosion damage, and
- protect natural and beneficial floodplain functions.
- Facilitate accurate insurance rating, and
- Promote the awareness of flood insurance.

The CRS has identified 18 activities that may receive CRS credit because they meet this objective. Some of these 18 activities include numerous elements. For example, the activity titled "Higher Regulatory Standards" provides credit for 11 elements, including regulations for foundation requirements and the protection of floodplain storage requirements. These 18 activities are divided into four series of activities, "Public Information," "Mapping and Regulatory Activities," "Flood Damage Reduction Activities," and "Flood Preparedness Activities." For more detailed information on the CRS and credit for the activities and elements, copies of the latest CRS Coordinator's Manual are available at no cost from:

Flood Publications
NFIP/CRS
P.O. Box 501016
Indianapolis, IN 46250-1016

To participate in the CRS, a community submits an application with required documentation for each activity to its regional office of the FIA, Federal Emergency Management Agency (FEMA). The application and all procedures are in the CRS Coordinator’s Manual, and also in the Short Form Application, available at no cost from the address above. The application is reviewed for completeness by the FEMA region and forwarded to ISO
IMPROVING PROGRAMS WITH THE COMMUNITY RATING SYSTEM

Commercial Risk Services, Inc. (ISO), a contractor, for verification of the credit. ISO reviews the documentation provided for each activity and schedules a meeting with the applicant to verify certain activities in the field. Based upon the verified credit, the community is given a CRS classification that is used to determine the flood insurance premium discount to be provided to its property owners.

An NFIP community that has not applied for CRS classification, or does not have at least 500 verified credit points is a Class 10 community. A community with 500 to 999 credit points is a Class 9 community. Classes continue in 500-point increments. Within any CRS community with a Class 9 or better classification, all property owners receive at least a 5% discount on their premiums. Within Class 8 or better communities, properties within the Special Flood Hazard Area (SFHA) as defined by the Flood Insurance Rate Map (FIRM) receive an additional 5% for each class improvement. For example, in a Class 5 community (the best CRS classification verified to date), flood insurance policies within the SFHA (A and V zones) receive a 25% discount, and other properties receive a 5% discount.

It must be pointed out that the CRS by itself will not generally provide sufficient financial incentive to undertake CRS activities. That is, the cost of implementation of enough activities to attain a Class 9 classification, or to improve a CRS classification, will usually be far higher than the total of all NFIP premium reductions. The CRS will usually provide only an additional incentive to implement a floodplain management activity that has been identified by the community as necessary for its overall objectives in floodplain management.

Incentives for Improving Floodplain Management Programs

It should be apparent that the CRS provides two incentives for improved floodplain management programs:

- Communities that participate in the CRS are an elite group in terms of floodplain management; and
- Property owners who purchase NFIP insurance provide a constituency within CRS communities that may favor improved floodplain management activities.

Currently, fewer than 900 communities have been verified as Class 9 or better within the CRS. Therefore, each CRS community is within the top 5% of all NFIP communities in terms of floodplain management. Only 216 communities are Class 8 or better, putting them within the top 1% of NFIP communities. While it can be argued that the CRS is not a complete way to rate community floodplain management, it is the only system in use, and CRS communities have justifiable "bragging rights." This in itself can be used by the floodplain management staff to request approval for higher standards and funding for new activities. Does Tulsa, Oklahoma, have the
best community floodplain management program in the country? Tulsa is the only Class 5 community in the CRS. Similarly, for one reason or another, some states have a disproportionate number of CRS communities. About 25% of Arizona's NFIP communities are in the CRS, compared with only 5% nationwide. Does Arizona have a better-than-average state floodplain management program?

Concerning the second incentive: Many communities are somewhat reluctant participants in the NFIP. Participation brings with it a regulatory burden for the community. In many cases, it precludes development of portions of the floodplain, and it increases the cost of development in other parts of the floodplain. These are important considerations where the community desires to increase its tax base, and where development is seen as an important economic factor for the community. The cost of flood insurance is a burden on property owners. However, the fact that much federal disaster assistance is dependent upon participation in the NFIP, combined with the restrictions on many mortgage lenders makes participation virtually mandatory.

The CRS provides feedback to an NFIP policy holder within a CRS community that his/her premium has been reduced because of the community's floodplain management program. One South Carolina community estimated that each CRS classification is worth almost $250,000 per year to its property owners. That fact can be used to encourage elected officials to adopt higher floodplain management standards and implement new programs.

It should be noted that verification of CRS credit is not predicated on implementation of an activity by the community. If an activity or element is effectively implemented within the community, the community will receive credit for that activity or element, with appropriate documentation, regardless of who implements it.

For example, a minimum NFIP requirement is that all new buildings be elevated or floodproofed to the base flood elevation (BFE). A community may receive CRS credit for requiring that the floors of all floodplain buildings be elevated a specific amount above the BFE, even if it is only complying with a requirement imposed by the state. Similarly, a requirement of a county, drainage district, flood control district, or other entity may be credited by any community which can document that the requirement is implemented within its boundaries. For this reason, states and other governmental entities can use the CRS as an incentive for standards, programs, and other activities they may want to implement for their own reasons.

One of the easiest ways for a community with a large number of insured properties to use the CRS to support both ongoing and new floodplain management activities is to obtain the insurance data from its FEMA region and use it to support its budget. For example, suppose a community has 10,000 NFIP policies and the annual premium for those policies totals $3 million. The floodplain management staff of the community determines that its current activities are eligible for 400 CRS credit points. The community is
developing a geographic information system (GIS), but has no plans to enter floodplain data because it will cost $50,000. The floodplain management staff points out that adding the data to the GIS would add 100 points in CRS credit. That would provide about $150,000 in savings to 10,000 flood insurance policy holders in the community. Although the cost comes from the community’s revenues and the savings goes to the property owners, the owners will be told that the savings is a result of the community’s actions.

A state program can use insurance data in a similar way. Suppose a state is adopting a water quality program to meet requirements of the environmental protection agency. The legislature accepts that it must meet the minimum standards, but the state water quality staff wants higher standards adopted. They want to regulate new development to prevent increased runoff from the 100-year storm in order to reduce turbidity in the rivers of the state, thereby protecting the state’s fishery resources. They argue that the higher standard will provide up to 225 points of CRS credit for all of the state’s communities, which will make it much easier for their communities to attain Class 9 or improve their classification to better classes. This has the potential to reduce insurance premiums 5% for almost all NFIP policies in the state.

Some Suggestions for Increasing CRS Credit

*Look for activities that are already being implemented.*

Relative to the broad range of activities eligible for CRS credit, most floodplain managers deal with a relatively narrow range of activities. The CRS coordinator for a community, a state NFIP coordinator, or staff at county and regional agencies seldom look at the broader aspects of floodplain management. Consider that all of the following may be implementing activities at the community, regional, or state level which are eligible for CRS credit:

- Building permit staff
- Flood control staff
- Stormwater management staff
- Library staff
- Public information staff
- Engineering staff
- Zoning staff
- Data management staff
- Parks and recreation staff
- Public works staff
- Planning staff
- Rights-of-way acquisition staff
- Emergency management staff
- Dam safety staff
- Water quality staff
- Coastal zone management staff

All of these and more, depending on the organization at different levels of government, may have ongoing programs that are eligible for CRS credit. The first thing a person should do in order to maximize CRS credit for his/her community(ies) is take an inventory of ongoing activities eligible for credit.
Many states and other agencies have regulatory programs in effect that are appropriate for CRS credit for some or all communities within their boundaries. If these programs have been in effect for some time, many communities may not know that they are eligible for CRS credit for them. For example, if a state has a statutory requirement for freeboard (elevating structures above the BFE), some communities within the state may not know that that requirement is not a minimum requirement of the NFIP. In other words, they are already implementing the activity, but they do not know that it is creditable. Similarly, a county may have developed a flood warning system and assisted all communities within the county to adopt effective emergency response plans. With appropriate documentation, any of these communities could receive a substantial amount of CRS credit. Many communities have a periodic newsletter which is always looking for information. In some cases, a community may receive around 200 CRS credit points for providing information about the community’s flood hazards, flood insurance and related topics.

*Make sure all communities eligible for credit are aware of its availability.*

In the case of state and regional agencies, the only thing needed for communities to receive the credit they deserve is for the implementing agency to make sure that its communities know about the credit.

**References**

Federal Emergency Management Agency

THE FEDERAL EMERGENCY MANAGEMENT AGENCY JOINS HANDS WITH THE AMERICAN SOCIETY OF CIVIL ENGINEERS TO PROMOTE FLOOD HAZARD MITIGATION

Clifford Oliver  
Federal Emergency Management Agency

Harry Thomas  
Stilson & Associates Inc.

Introduction

The American Society of Civil Engineers (ASCE) has made a major commitment to flood hazard mitigation over the past several years. This commitment has resulted in a developing close working relationship with the Federal Emergency Management Agency (FEMA). Two major developments have resulted from this collaborative effort. The ASCE-7 Standard, "Minimum Design Loads for Buildings and Other Structures," is being revised to include flood loads, and a new ASCE Standard, "Flood Resistant Design and Construction for Buildings and Other Structures," is being completed. Both standards will include mandatory language suitable for code adoption and non-mandatory commentary portions.

Flood hazard criteria in these standards were developed with financial and technical support from FEMA and are intended to provide further assistance to communities in their desire to meet or exceed the National Flood Insurance Program (NFIP) minimum requirements found mostly in §60.3 of the NFIP regulations (44 CFR, Chapter 1, Subchapter B).

ASCI Load Standard

ASCE is completing its effort to include flood loads in the only national load standard in the United States. ASCE-7 Minimum Design Loads for Buildings and Other Structures is the premier national consensus standard that provides the requirements for dead, live, soil, wind, snow, rain, earthquake, temperature, and now flood loads and their combinations. This standard is suitable for citation or inclusion and is often cited or included in building codes and regulations which govern design documents. The structural load
requirements provided by this standard are intended for use by architects, engineers, and those engaged in preparing and administering local codes and ordinances. The new flood load provision will be available in the 1995 revision to the standard, expected to be available late this year.

**ASCE Flood Protection Standard**

ASCE is also in the process of completing a brand new standard, Flood Resistant Design and Construction for Buildings and Other Structures (herein known as the Flood Protection Standard). This standard will provide instruction on how to design and construct buildings and other structures in conformance with the flood loading requirements of the ASCE-7 loads standard. The standard, as presently constituted, meets or exceeds the NFIP requirements for those subjects addressed. It is intended to serve the same audience and purpose as the ASCE-7. This new standard will cover such subjects as:

- Definitions
- Load Combinations
- Classification of Structures (based on threat to safety)
- Siting Requirements
- Elevation Requirements (including freeboard based on building classification)
- Foundation Requirements
- Geotechnical Requirements
- Detailed Requirements for the Use of Piers, Posts, Columns or Piles
- Detailed Requirements for Breakaway Walls
- Requirements for Structures Located in High Risk Flood Hazard Areas (such as alluvial fans, mud slides/flows, erosion-prone, ice and debris flows, and high velocity areas)
- Enclosures Below Flood Level
- Design Requirements for Structures
- Flood-Resistant Material Requirements
- Floodproofing Requirements
- Requirements for Protecting Utility Systems
- Requirements for Safe Egress and Ingress to Floodprone Structures
- Requirements for Accessory Structures.

This paper will provide insight into how these standards will affect future revisions to the model building codes and how the standards can be adopted.
by states and communities into their building codes and floodplain management ordinances.

The standard, as presently constituted, meets or exceeds the NFIP requirements for those subjects addressed. Table 1 summarizes where the new standards exceed the NFIP requirements.

**ASCE Consensus Process**

ASCE standards are developed under a consensus process that allows all interested parties to provide input. A prestandard will first be balloted by the Standards Committee responsible for developing the standard and then by the ASCE membership. At this point the prestandard becomes an ASCE Standard. The standard is then forwarded to the American National Standard Institute (ANSI), where it is sent out for national balloting (allowing all interested parties to comment). Persons may vote to affirm, affirm with comments, or negative. Negative votes must be accompanied by an explanation and specific proposed alternative language. The Standard Committee may consider the supporting technical data submitted with the negative ballot persuasive and make the proposed change, or consider the supporting technical data and declare the negative vote to be non-persuasive. In either case all voters will be notified of the Committee's decision.

**ASCE Flood Committee**

ASCE has also formed a Flood Resistant Design and Construction Standards Committee (known as the Flood Committee) that will be responsible for, among other things, the maintenance and further future development of the new ASCE Flood Resistant Design and Construction Standard. This committee is open to both ASCE and non-ASCE persons. ASCE should be contacted by those interested in participating in this endeavor. This committee will be consulted by FEMA on a myriad of flood hazard mitigation issues.

**In the Future for ASCE and FEMA**

ASCE has begun an effort to have the three model building code organizations—Building Officials and Code Administrators, Southern Building Code Congress International, and International Conference of Building Officials—adopt the pertinent flood load provisions into their codes. Once the flood protection standard is completed, ASCE will move to have the model code organizations adopt the standard either in body or by reference.

With civil engineers being a critical member of the floodplain management community, both FEMA and ASCE expect our relationship to grow and continue to be mutually beneficial to all involved.
Table 1. Summary of ASCE provisions that exceed National Flood Insurance Program minimum requirements.

### Summary of ASCE-7 Provisions That Exceed the NFIP Minimum Requirements

<table>
<thead>
<tr>
<th>CFR Citation</th>
<th>NFIP Minimum Requirement</th>
<th>ASCE Provision</th>
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<tbody>
<tr>
<td>§60.3(a)(3)(ii)</td>
<td>Structures must be designed and adequately anchored to resist flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy. In Coastal High Hazard Areas, wind loads (as prescribed by code) will also be taken into consideration.</td>
<td>Section 5 of the prestandard requires that hydrostatic, hydrodynamic and impact loads be determined. Specific formulas are provided for hydrodynamic loads and guidance is provided on how to calculate impact loads. Section 2 of the prestandard requires that flood loads be combined with other loads including, live, dead, earthquake, wind, snow, rain, soil, and temperature for all flood prone structures.</td>
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### Summary of ASCE Flood Protection Prestandard Provisions that Exceed the NFIP Requirements

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<thead>
<tr>
<th>CFR Citation</th>
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<th>ASCE Provision</th>
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<tr>
<td>§60.3(e)(S)(iv)</td>
<td>Requires manufactured homes to install with their lowest floor below the Base Flood elevation.</td>
<td>Requires manufactured homes to meet the same floodplain management requirements as all other structures.</td>
</tr>
<tr>
<td>§60.3(c)(12)(ii)</td>
<td>Requires communities to regulate all development with the FEMA-identified Special Flood Hazard Area.</td>
<td>Requires flood-resistant design and construction for all structures located in the 100 year floodplain not just those in a FEMA-identified Special Flood Hazard Area.</td>
</tr>
<tr>
<td>§60.3(c)(2)(3)</td>
<td>There are only two recognized categories of structures: residential and non-residential. No freeboard is required for either type of structure.</td>
<td>Requires that structures be broken into four categories based on the nature of occupancy. With freeboard required for the lowest floor of critical structures such as hospitals.</td>
</tr>
<tr>
<td>§60.3</td>
<td>There are no additional design and construction requirements for structures built in areas subject to alluvial fan flooding, flash floods, mudslides/flows, ice jams, high velocity flows, non-coastal high velocity wave action, and where erosion is known to occur.</td>
<td>Creates a High Risk Flood Hazard Area which is where alluvial fan flooding, flash floods, mudslides/flows, ice jams, high velocity flows, non-coastal high velocity wave action, and erosion are known to occur. In these areas, more stringent design and construction are prescribed.</td>
</tr>
<tr>
<td>§60.3</td>
<td>There is no specific prohibition on pier foundations.</td>
<td>Bars the use of pier foundations in high velocity wave zones and high risk flood hazard areas.</td>
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Table 1. (cont.)

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<thead>
<tr>
<th>CFR Citation</th>
<th>NFIP Minimum Requirement</th>
<th>ASCE Provision</th>
</tr>
</thead>
<tbody>
<tr>
<td>§60.3(3)(4)</td>
<td>There is no requirement that an emergency operations plan be developed, but a professional designer must certify the design.</td>
<td>Requires a flood emergency operations plan when floodproofing requiring human intervention is used.</td>
</tr>
<tr>
<td>60.3(c)(3)(4)</td>
<td>There is no restriction on the use of human intervention for floodproofing.</td>
<td>Bars the use of floodproofing requiring human intervention in areas with less than two hours warning time.</td>
</tr>
<tr>
<td>§60.3(a)(3)(ii)</td>
<td>Service facilities must be designed or located so as to prevent water from entering or accumulating within system components.</td>
<td>Requires freeboard for most categories of structures for all utilities and mechanical and electrical systems.</td>
</tr>
<tr>
<td>§60.3(a)(3)</td>
<td>There is a performance requirement that tanks be anchored to resist flotation, collapse and lateral movement.</td>
<td>Requires tanks to be secured against 1.5 times their potential buoyancy.</td>
</tr>
<tr>
<td>§60.3(e)(4)(ii)</td>
<td>There is a performance requirement that V zone foundations must be anchored to resist flotation, collapse, and lateral movement due to the effect of wind and water loads.</td>
<td>Requires an assumed minimum scour depth of 5 feet for V zone foundations.</td>
</tr>
<tr>
<td>§60.3</td>
<td>There are no additional requirements for structures threatened by mudslides of mudflows.</td>
<td>Bars the placement of structures in areas known to be prone to mudslides and mudflows.</td>
</tr>
<tr>
<td>§60.3</td>
<td>There are no erosion-based set back requirements.</td>
<td>Bars the placement of structures in areas prone to both riverine and coastal erosion by requiring a 30 year set back.</td>
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<td>§60.3(e)(2)</td>
<td>There is a performance requirement that V zone foundations must be anchored to resist flotation, collapse, and lateral movement due to the effect of wind and water loads.</td>
<td>Requires an assumed minimum scour depth of 5 feet for V zone foundations.</td>
</tr>
<tr>
<td>§60.3</td>
<td>Only performance requirements must be met. There is no linkage to existing building codes and standards.</td>
<td>Ties the design and construction of flood-resistant structures to existing standards developed by such groups as the American Concrete Institute.</td>
</tr>
<tr>
<td>§60.3(a)(2)</td>
<td>No freeboard is required</td>
<td>Requires freeboard when floodproofing certain classes of structures.</td>
</tr>
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References

American Society of Civil Engineers

American Society of Civil Engineers
FLOODPLAIN MANAGEMENT
FOR THE NEXT SIXTY YEARS:
IMPLEMENTING A UNIFIED NATIONAL PROGRAM
FOR FLOODPLAIN MANAGEMENT

John McShane
Federal Emergency Management Agency

Introduction

Floods in the United States have caused a greater loss of life and property, and have disrupted more families and communities, than all other natural hazards combined. The loss and degradation of the natural resources and functions of our riverine floodplains, especially from flood control projects, have also been significant. Pursuant to Section 1302(c) of the 1968 National Flood Insurance Act, the U.S. Water Resources Council established a Federal Interagency Floodplain Management Task Force in 1975 to carry out the responsibility of the President to prepare for the Congress proposals necessary for a unified national program for floodplain management. In 1976 the Task Force completed, and has subsequently updated, the report, A Unified National Program for Floodplain Management, which sets forth a conceptual framework and makes recommendations on how best to achieve the goals of floodplain management.

Due to the magnitude of the great Midwest flood of 1993, the Executive Office of the President established an interagency Floodplain Management Review Committee to determine the major causes and consequences of the flood and to evaluate the performance of existing floodplain management and related watershed programs. The Review Committee prepared a report, Sharing the Challenge: Floodplain Management Into the 21st Century, which, coincidentally, was completed concurrently with the 1994 update of the Unified National Program document. Sharing the Challenge espouses the need for a more coordinated, watershed approach to floodplain and water resources management and the need for the states to carry out their responsibilities relative to protecting the health and safety of the people.

These two reports complement and reinforce each other by the commonality of their findings and recommendations. For example, both urge the formulation of a more comprehensive, "unified" approach to protecting and managing human and natural systems to ensure the long-term viability of
riparian ecosystems and the sustainable development of riverine communities. Both reports also recognize that effective floodplain management will reduce the financial burdens placed upon all levels of government to compensate property owners for flood losses caused by unwise land use decisions. This paper focuses on the paradigm shift in the formulation and implementation of federal floodplain management policies and programs that will reduce flood losses, protect natural resources, and ensure the functional integrity of floodplain systems into the 21st century.

A Unified National Program for Floodplain Management

The Federal Interagency Floodplain Management Task Force commenced an update of the Unified National Program document before the 1993 floods and was developing long-term goals and a new conceptual framework during the summer of 1993 just as the Mississippi, Missouri, Illinois, and other rivers were reclaiming their floodplains. Although representing a diversity of agencies with varying missions and goals, the Task Force members agreed that the purpose of floodplain management should encompass two co-equal goals: 1) reducing the loss of life and property, and the disruption of families and communities, caused by floods; and 2) protecting and restoring the natural resources and functions of floodplains. The 1994 Unified National Program document also includes long-range goals with supporting objectives to be achieved by 2020 and promotes the implementation of floodplain management activities that are both environmentally sound and fiscally responsible. In March 1995 the President transmitted the Unified National Program to the Congress and underscored the need for a new approach to floodplain management by writing:

[The Unified National Program] urges the formulation of a more comprehensive, coordinated approach to protecting and managing human and natural systems to ensure sustainable development relative to long-term economic and ecological health . . . Effective implementation of the Unified National Program for Floodplain Management will mitigate the tragic loss of life and property, and disruption of families and communities, that are caused by floods every year in the United States. It will also mitigate the unacceptable losses of natural resources and result in a reduction in the financial burdens placed upon governments to compensate for flood damages caused by unwise land use decisions made by individuals, as well as governments.

It is anticipated that the Unified National Program will be implemented largely through existing programs of the federal, state, and local governments. Within the framework of the program, and the reality of budgetary constraints, it is intended that stakeholders within all levels of government and the private sector will work together in mutually beneficial partnerships to achieve the goals of floodplain management.
Sharing the Challenge: Floodplain Management into the 21st Century

In early 1994, an interagency Floodplain Management Review Committee was established by the Executive Office of the President to determine the causes of the Midwest flood disaster and to take a hard look at federal policies and programs relative to the goals of floodplain management. The Committee’s report, Sharing the Challenge: Floodplain Management Into the 21st Century, often referred to as the "Galloway Report," contains some 90 recommendations for improving floodplain management programs and activities. After the release of the Galloway Report, staff from the Federal Emergency Management Agency and other federal agencies developed implementation plans for each recommendation. A number of these recommendations have since been implemented as a direct result of the National Flood Insurance Reform Act signed by the President in September 1994.

Because of the high level of interest across the nation in implementing many of the recommendations of the Galloway Report and the recent transmittal of A Unified National Program for Floodplain Management by the President to the Congress, the Executive Office of the President determined that a Floodplain Management Action Plan was needed.

The President’s Floodplain Management Action Plan

To further reduce flood hazard vulnerability in the nation there is now general agreement that fundamental changes are needed in federal floodplain management policy and the public’s perception of flood risks. All Americans also need to understand how and why flood hazard mitigation will reduce deaths, injuries, and economic losses; will enable quicker economic recovery from floods when community infrastructure and critical facilities remain intact; is cost-effective; reduces disruption of the community’s social structure; and can protect natural and cultural resources. Flood hazard mitigation needs to be recognized as an important part of community development, and as an opportunity to invest in a safer, more sustainable future.

Although public officials and citizens alike are becoming more aware of the benefits of flood hazard mitigation, more needs to be done to ensure that the multitude of vital functions carried out by natural floodplains are also protected and, where possible, restored. These functions include providing natural flood storage and conveyance, promoting aquifer recharge, protecting water quality, controlling erosion and sedimentation, and preserving fish and wildlife habitats to maintain biodiversity, to mention a few.

The federal government has a significant role in this effort in that it can provide the overall policy, establish long term goals, and facilitate coordination to encourage agencies, states, communities, businesses, and individuals to undertake actions to reduce the vulnerability to flood hazards and protect natural and cultural resources, both routinely and in the recovery phase following a disaster. These goals can be achieved by federal leadership and good example that:
• Creates broad-based awareness and understanding of flood hazard risks, and support for actions to mitigate those risks;
• Promotes coordination among federal agencies, state, and local governments, and the private sector;
• Uses a watershed and ecosystem approach for floodplain and water resources management; and
• Encourages the protection and restoration of the natural resources and functions of floodplains.

It is anticipated that this Floodplain Management Action Plan will be announced and released by the President in July 1995.

Conclusion
The Administration recognizes the importance of protecting and restoring floodplain lands and waters to the national well-being, both economic and environmental. There is evidence that Americans, while still full of compassion and readiness to assist in times of true disaster, are becoming less willing to subsidize the costs of unwise floodplain occupance as they gain more knowledge about, and respect for, natural processes and ecological relationships. At the same time, it is clear that society will continue to demand use of, and access to, the amenities that floodplains provide. There is now consensus on the need for a unified approach to managing human activities and the natural resources and functions of floodplains. The Unified National Program and the President’s Floodplain Management Action Plan provide the Administration’s vision for effective floodplain management and for achieving long-term goals that will help people, provide for sustainable economic development, and ensure the viability of riparian environments into the 21st century, and beyond.

References
Clinton, William J.
1995 Correspondence transmitting A Unified National Program for Floodplain Management to the U.S. Congress.

Executive Office of the President

Federal Interagency Floodplain Management Task Force
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<td>81-450</td>
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For larger orders, contact the center for shipping and handling charges. All orders must be prepaid in U.S. dollars drawn on a U.S. bank. Visa, MasterCard, American Express, and Diners Club cards are accepted. Proforma invoices will be provided upon request.

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