The Realities of Floods – A Multi-Disciplinary Review of Flood Management Issues

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Preface

The papers included in these Proceedings were prepared for presentation at the 1995 Seminar, *The Realities of Floods – A Multi-Disciplinary Review of Flood Management Issues*, sponsored by the U.S. Committee on Irrigation and Drainage. The Seminar was held in St. Louis, Missouri, on March 30 - April 1, 1995.

The 1993 Mississippi River Basin Flood generated a profound critical review of the policies and practices of government agencies for flood protection and floodplain management in the U.S. Furthermore, environmental ramifications of structural and non-structural approaches to flood protection were receiving growing attention in policy development and community responses.

The Seminar was therefore initiated to provide a forum for open discussion of the emerging flood management policies, considering political, institutional, engineering, environmental and economic perspectives.

Lectures by invited speakers focused on four themes:

- Politics of Floods
- The Flood Management Milieu
- Management of Floods
- Where Do We Go From Here?

Eleven papers from invited lecturers are included in the Proceedings.

In addition, nine case studies received in response to a Call for Papers, and presented during the Seminar Poster Session, are included.

Also featured in the Proceedings is a Keynote Address by Brigadier General Gerald G. Galloway, who headed the Interagency Floodplain Management Review Committee appointed by President Clinton in the aftermath of the 1993 Mississippi River Basin Flood. He summarized the recommendations made by the Committee and presented to the President. Special lunch and dinner speeches by flood management experts are also included in the Proceedings.

The U.S. Committee on Irrigation and Drainage and the 1995 Flood Management Seminar General Chairman extend their appreciation to the speakers, authors, participants and session moderators.

Peter J. L. Gear
Seminar General Chairman
San Francisco, California

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Sharing the Challenge

Brigadier General Gerald E. Galloway[1]

I am here today to talk about "Sharing the Challenge." We have all seen headline after headline after headline dealing with the flooding that has taken place in this country and overseas over the last two and a half years. We've seen photographs of the State Capitol Building of Missouri with the high water flooding the city's air field and cutting off access to the city. We all recognize the individual trauma that went on as home after home was destroyed by the flooding. We recognize the trauma. Major structures failed or were overtopped, with a loss of protection. Our spirits were buoyed by people who said, "not to worry, we are in charge." In some cases they were in great shape, and in other cases, the levees overtopped. We must figure out how to deal with all flooding.

This flooding led the White House, in the fall of 1993, to say, "There are problems in the floodplain." (Slide 1 – see appendix following this paper for text of slides referred to in this presentation) First, we still have people and property at risk, even though, since 1936 and actually longer in the case of the lower Mississippi Valley, we have been working to ameliorate flood damage problems. Second, we should recognize that as we have worked in the floodplain, we have put ecosystems at risk. Third, who is in charge? There are many agencies of the federal, state and local governments involved. How do you pin down who has the ultimate responsibility for floodplain management? Given this situation, the White House said, "we need an independent group to look at this issue," and formed an interagency Floodplain Management Review Committee, which consists of 31 individuals representing many facets of the federal government. The Committee was given the charter to go out and investigate the situation.

The Committee was tasked to determine, first, what caused the Flood of 1993; and second, how are the national floodplain management programs working; and then, what should we do about them? Should we continue our programs? Should we make changes? Should we do this internal to the federal government or through cooperation with the states? What direction should we go? (Slide 2) This report was to be a quick response effort and we finished the report in less than six months. It initially generated a lot of interest here in the Mississippi/Missouri region and we have had a lot of follow-up interest, through the country and overseas, especially following the great European floods of this year.

A blinding flash of the obvious is the conclusion that the flood of 1993 was a major rainfall event. (Slide 3) I had the good fortune to brief the

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Vice President of the United States on these conclusions. Many people expected the Committee to say that the levees caused the flood. Others said the loss of wetlands caused the flood. Still others said that when you build casinos on the Mississippi and Missouri Rivers, the floods represent the Lord punishing you for these actions. At lease one of these three could be the answer. Well, the actual answer was that it was a significant rainfall event. I pointed out to the Vice President that the six Great Lakes were severely taxed during that period and he asked, "Six Great Lakes?" You can see the Great Lake of Iowa sitting out there in the western part of that state, with soil-wetness imagery from NOAA. The sensors perceived that western Iowa and southern Minnesota were in fact at the same moisture level as the Great Lakes. Now that certainly is an overstatement, but it tells you that it rained and it rained and it rained. The rain filled every little pore in the soil. It filled every ditch. It filled every channel, and it filled every river. The river flowed down hill. The water rose and we had a flood. Now that says that the area was extremely wet. In fact, many of the damages that I will mention took place in the areas that were under this severe inundation. Then, when the waters went down hill, they created record flooding on the Missouri and the Mississippi. You had upland damages taking place where there was tremendous rainfall and then the accumulated rainfall went into the river bottoms and caused the river to flood. It was more than a simple river flood. It was excess rainfall throughout the basin.

There are other conclusions. (Slide 4) The first makes sense to many people. It became a political issue to say that major flooding will continue to occur. It caused a lot of people some grief. Some felt that since we just had a hundred year or five hundred year flood, we should not expect another one soon. We have a hundred years or two hundred years to wait. It was important from the Committee's standpoint that we make the point that floods will continue to occur. A lot of people still do not believe that. A lot of people in decision-making positions still do not understand. They really believe that we have taken care of all the problems and more flooding will not occur until the next century.

The costs were extensive. We still have not completed all the accounting. We are, however, talking $12 to $16 billion in damages. These were only monetary damages. We still have not totaled up the non-monetary damages, the impacts on people's lives: the trauma, the displacements, the eventual migration out of the region of individuals who were harmed, and of course the deep personal trauma of those people whose homes were under water for sixty, ninety, one hundred and twenty days. We got some indications during our study that there had been an increase in spousal abuse, child abuse and disruptive behavior on the part of children. That investigation needs to continue and the Public Health Service is looking at that subject. So the losses go far beyond the quantitative impacts. The flood damage reduction projects of the Corps of Engineers and the old Soil Conservation Service and the existence of the National Flood Insurance Program prevented about $19 billion in damages. In other words, the reservoirs, the levees, and other programs that had been in place since 1936 reduced the amount of flooding that took place, and prevented the cities of Kansas City and St. Louis and other areas from being inundated with a loss of more than $19 billion.

On the other hand, many non-federal levees did not work as well. There are lots of local levees. Some individuals created levees by reinforcing wind rows in their fields. A lot of these local levees failed during the flood of 1993 and failed in a catastrophic manner. When they failed, the material underneath the levee (a blow hole) and in the levee was spread across the land behind the levee. There are places on the Missouri River that are still under six to eight feet of the sand that was carried out of the river and out of the levee on to land. Some of this land will probably never be put back into agriculture. What was expected of these levees? What did people understand about the level of protection that they had? Were the levees located in places that allowed the river to flow by? A number of people believe that the big levees, the main stem levees, caused the 1993 floods. As I indicated earlier, the flood was a hydrometeorological event.

Many levees were overtopped. Essentially all the levees on the Missouri were overtopped. On the Mississippi, several levees also overtopped. When levees overtopped, there was a slight drop in the hydrograph at the time of the overtopping; however, the rise then resumed. There is very little flood storage behind the levees. Levees did not substantially increase the flood flows. However, anything you do in the flood plain that constructs the flow or changes the nature of the flow is going to have effects upstream and downstream, and these effects must be considered.

One effect we're concerned with is the loss of wetlands. (Slide 5) We have lost a tremendous amount of wetlands. Conventional wisdom says that we lost all of these wetlands in the last 20 years through "modern" development. Yes, there is some development, but recognize that the Midwest itself was cleared over a period that dates back to the middle of the last century. So the loss of wetlands is not something that has suddenly happened. The loss of wetlands has increased runoff.

Human activity also has caused habitat loss. This may be from flood control activities or it may result from general development. Many people have asked, "if we had had more wetland 'sponges' out there, would we have had less flooding?" The answer is quite obvious – yes. A wetland does act as a sponge. Upland treatment does retain water and keep it from flowing downhill. Wetlands cut the peak off major flows; however, in the case of the 1993 flood, the flood flows were so massive that the storage available was too little. A slight increase in storage – perhaps 500,000 acres – might have shaved the peak off the flood, but would not have changed its overall characteristic. However, for the more frequent floods, the five, ten and fifteen year floods, wetland restoration, upland treatment and watershed management have tremendous payback. At every single place the Committee went in the bottomland, the first suggestion heard was to protect the bottoms from the people of the upland who are sending all this water down. There is tremendous support for doing something about upland treatment, wetland restoration. It is not, however, the only answer to the problem of flood damage reduction.

These rules are all familiar to you, but important to review. (Slide 6) In looking for a solution, the Review Committee tried to frame the solutions in light of these rules. It seems rather obvious that water does flow downhill. Water does not respect boundaries. It does not understand politics. It is something that you love part of the time and hate the rest of the time. There is a lot of debate over who controls it and what responsibilities rest with what individual who are in this business of water.

How then do you handle basic level problems? The Committee proposed two fundamental principles. First of all, if you are going to have an adequate floodplain management program, you have to share the responsibilities among all those people involved in the process. (Slide 7) That means at the federal level, at the state level, at the local level, and of great importance at the level of the individual who lives in the floodplain. You must share responsibilities, and share the costs. It is important for the nation to recognize that if you live in a high risk area, you should share in the cost of preventing damages to you and the others who live in this high risk area. The federal government cannot go on its own in floodplain management. It must share that responsibility and must share the cost of funding the floodplain with all of the levels of government and all the people who live in the floodplain.

The second principle is to use every means available to reduce damages. (Slide 8) Yes, several techniques have been successful in the past and we should continue to use them. We have others that have not been tried, not been given the opportunity. We should also use these. We should put everything on the table and come up with a strategy to reduce damages in using all of the tools available. Let me walk you through this principle.

First, avoid use of the floodplain if you do not need to use it. (Slide 9) If you have development that is going to take place in a region and there are two sites, one in the floodplain and one location outside of the floodplain, choose the site out of the floodplain. In many cases the floodplain land is cheaper because it is frequently flooded land. But the long term costs of using the floodplain are high and are borne by the nation at large. If you are not in the floodplain, you will never be flooded; you will never have to seek flood protection. Obviously, if you are trying to build a port, if you are looking for water-based recreation, if you are seeking rich alluvial soil, you may be in the floodplain. But if you do not need to be in the floodplain and you do not need to build this

230-home development, do not do it. It will prevent future damages and will save everyone a lot of money.

Second, if you are going to have people living in the floodplain, you ought to minimize the damages that they will incur. (Slide 10) There are several ways to do this. If you can shave the peaks off the flood, if you can keep the water below the top of the levee by catching the water where it falls – upland treatment watershed management makes a great contribution. There are many exciting initiatives in the wetlands arena.

The Natural Resources Conservation Service PL566 programs can just make a difference in the upland areas. If upland treatment does not take care of the problem, and it probably would not, then the next level would be to floodproof those facilities that are going to remain in the floodplain. If something is going to be subject to the attack of flood waters, then protect it against those damages. There are many ways of doing that, from elevating the structure to providing waterproofing of the structure itself. A next level would be a voluntary relocation. If people are at risk and it is cheaper to move them than to protect them, then pay the cost of that relocation.

The Committee was amazed by the response in the Midwest following the 1993 flood. If you had asked floodplain residents in 1992, whether they would volunteer to move, the answer would have been no. That is just not what people want to do. They would want you to build a levee or something to protect them. As you all know, today, here in the Midwest, more than 8,000 homes in more than 120 communities are up for sale or have been relocated or demolished as a result of post-flood federal programs. It runs from a few homes in some communities, to an entire community. Valmeyer, across the river in Illinois, is moving out of the floodplain and onto nearby high ground. More recently, in Texas and in the northern California area, the cry for relocation exists. The people would like to carry this on. While voluntary relocation, three years ago, would have been something that no one would have considered, today it is very feasible.

When you cannot do anything else, then invest in levees and floodwalls. Decide what flood you are trying to protect the community against, and then, if the economic, environmental and social cost and benefits support it, provide that level of protection.

Also, where damages are occurring, make sure that you have systems to provide the early warning. (Slide 11) A lot of people were surprised they were going to be flooded. They claimed that they did not know the flood was coming down the river. Insurance is another way in which you can mitigate damages and I will talk about insurance later.

Lastly, educate the population. As I have traveled the Midwest, I have met people, time and time again, who told me that since the big flood in 1993 was a "hundred year flood" there would not be another one in their lifetime. They also told me that they thought the levee would protect them from all floods. They did not understand the big picture. They just did not understand floods. If people are going to remain in the floodplain, they must understand the problems of the floodplain.

Let me now discuss the problems the Committee saw and the recommendations it offered in response.

There is a need to provide more natural areas in the floodplain. (Slide 12) We have lost the opportunity to acquire much of this land because we have not been as organized for the job as we could be. We have proposed increased flexibility in the way in which the federal government handles post-disaster activities. Instead of going out immediately and deciding to rebuild a damaged levee, the government needs to discuss options with the landowners. Do they want to turn land over to environmental use? ... to wetland reserve? The "systems" should allow all options to be considered; right now they are not.

We have to get all agencies seeking to acquire land on the same sheet of music. Interestingly, we discovered a case where federal agencies and state agencies were bidding against each other for farmland. We need coordination of these activities.

Last, if we are going to buy land, we ought to do it on a programmatic basis. As most of you understand, the federal government reacts to disasters. If you have disasters three years in a row, then you get three years of funding. If you do not have a disaster, then there are no funds available to you. It is important to acquire land over time. As a result of the 1993 flood, interest in more than 100,000 acres has been acquired. The individuals who owned the land felt it was marginal for agriculture but of use for the environment. There are more than 60,000 acres still on the table that people would like to have acquired or have some interest taken by the federal government.

The bottom line is important, because a headline in the *St. Louis Post Dispatch* on the day the report was issued, said, "Clear the Floodplain!" That is not what the report says. Later the *Post Dispatch* retracted the headline. What we said is, if landowners want to participate in the land program, they should be able to do so.

What was initially suspected about government organization is probably true. We are not well organized. (Slide 13) Federal, state and local responsibilities are not well defined. We need a federal act that defines the levels of responsibility at state, federal and local levels and those of the individual citizens.

We need an executive order by the President to reaffirm that the federal government should set the example in floodplain management. It was continuously brought to our attention that federal agencies were building in the floodplain in violation of federal rules and regulations. The federal government should set the example.

There also needs to be, at the Washington level, a focal point for activities dealing with floodplain management. There are river basins that face significant interstate issues. We are sitting in the middle of one. There must be a mechanism to bring state people to the table with the federal government to help deal with the issues. Upriver basin states are concerned about too little water. People in Missouri are concerned with too much water. How do you balance the demands? Who gets the states together? What is the mechanism?

The structure that we have in place does not permit us to adequately consider nonstructural approaches to flood damage reduction. (Slide 14) There needs to be change in federal guidelines. The current document *Principles and Guidelines* is focused on economic return. There needs to be more collaborative planning. By collaborative planning, I do not mean that one agency consults another. We should pull a study team together to take on a project. For example, employees from the Fish and Wildlife Service and the Department of Agriculture, sit down at the same table with the Corps of Engineers and work together. It has got to be people working together, not just coordinating and consulting.

There must be more effort put into watershed planning and management.

Regarding insurance, the Committee believed that the National Flood Insurance Program is not as effective as it could be and should have been. (Slide 15) We recommended several things. The stars (see appendix) indicate that the recommendations were incorporated into the Flood Insurance Reform Act of 1994. There was a waiting period for insurance of five days under the old system. If you could see a flood coming down river, you could decide whether it was going to get to you. Then you would buy insurance. Not a wise move. If, from the federal standpoint, we had a 30-day waiting period, we would have saved $82 million in insurance costs during the flood of 1993. The waiting period now has been increased to 30 days. Mitigation insurance helps people who have substantial damage improve their property; not just repair what they had and leave it at the same level of protection. Mitigation insurance was part of the Insurance Act and has increased lender compliance. This directs the attention of the lending agencies toward ensuring that people in the floodplain who hold mortgages do, in fact, buy insurance, which they are not now doing in many, many cases.

What else can we do? FEMA is working on marketing of flood insurance. The number of people who held insurance in the Midwest ranged from five to forty percent. We would like to have a hundred percent of those eligible buying in. One way to push insurance is to give very limited disaster support following a flood to those who could have bought insurance but did not. It is wrong to have somebody who bought insurance receive almost the same support as someone who took no precautions. Those who are damaged again and again should pay higher rates. Three percent of the structures insured under the NFIP account for 40 percent of the losses. Requiring people who live behind levees that protect them from less than the standard project flood to buy insurance also makes education and fiscal sense.

Here in the Mississippi-Missouri Basin there is need for a comprehensive floodplain management strategy — a systems approach. (Slide 16) What you have today is a loose amalgam of 8,000 miles of federal, state, local and private levees, some reservoirs and a wide variety of agencies with overlapping and underlapping responsibilities. Some group needs to be put in charge of developing the master plan.

Science and technology have the potential to provide great assistance to those who must manage the floodplains. (Slide 17) The vast potential to use Geographic Information Systems (GIS) as tools in floodplain management can occur if the federal government will serve as a clearing house for the vast array of data that is collected by all levels of government. At the same time, small investments in science offer the potential for major improvements in flood and weather forecasting, flood state determination and development of data needed for conduct of flood fights.

In sum, the report of the Floodplain Management Committee does not call for the abandonment of human activity in the floodplain, nor does it condemn levees. It does call for federal, state and local governments, as well as individuals affected by flooding to jointly share the responsibilities and the costs of developing long term flood damage reduction and floodplain management programs. It also urges that in carrying out these responsibilities, those involved should take full advantage of all methods and techniques for floodplain management. (Slide 18)

Working at odds with each other, we will not succeed. Working together, we can solve the problems of our nation's floodplains.

Appendix

Slide 1
National Floodplain Problems
- People and Property Remain at Risk
- Fragile Riverine Ecosystems are at Risk
- Division of Responsibilities for Floodplain Management is not Defined

Slide 2
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- Recommend Legislative Initiatives

Slide 3
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Slide 4
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Slide 8

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Slide 10

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Slide 11

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Slide 12

Problem/Recommendation

Problem: More Natural Areas Needed in Floodplain. Opportunities Lost to Acquire These Areas for Environmental Purposes

Recommendations:

- Increased Flexibility in Post Disaster Acquisition
- Increased Coordination of Federal Acquisition
- Programmatic Acquisition – FROM WILLING SELLERS

Slide 13

Problem/Recommendation

Problem: Floodplain Management Effort Not Well Defined/Organized

Recommendations:

- Floodplain Management Act
- Executive Order
- Water Resources Coordinating Element
- Basin Commissions

Slide 14

Problem/Recommendation

Problem: Appropriate Consideration Not Given to Structural/Non-Structural Approaches

Recommendations:

- Revised Principles and Guidelines
- Collaborative Planning
- Improved Watershed Planning and Management

Slide 15

Problem/Recommendation

Problem: NFIP is Inefficient and of Limited Effectiveness

Recommendations:

- Increased Waiting Period*
- Mitigation Insurance*
- Improved Lender Compliance*
- Improved Marketing of Flood Insurance
- Limited Disaster Support to NFIP Non-Participants
- Surcharged Repetitive Losses
- Insurance Behind Levees

*Covered in Flood Insurance Reform Act of 1994

Slide 16

Problem/Recommendation

Problem: Upper Mississippi Basin Lacks Integrated Management and Flood Damage Reduction System

Recommendations:

- Systems Approach
- Centralized Management
- Appropriate Federal Levee Support

Slide 17

Problem/Recommendation

Problem: Technology is Not Being Leveraged for Floodplain Management

Recommendations:

- Support Database Development
- Exploit Science/Technology

Slide 18

Summary

- The Report Does Not Recommend Clearing Floodplain of Human Activity
- The Report Does Not Condemn Levees
- The Report Seeks Full Consideration of All Approaches to Floodplain Management
- The Report Seeks Better Coordination of Federal, State and Local Floodplain Activities

INTERNATIONAL PERSPECTIVE OF FLOOD MANAGEMENT CONCERNS

William A. Price[1]

ABSTRACT

The following is a summary of information presented by the author at the March 30 luncheon meeting of the 1995 USCID Flood Seminar. Expanded populations in the flood plains of river basins in which seasonal monsoonal climates prevail are placing large numbers at risk. This paper provides comments regarding flood management concerns and activities in developing countries, primarily in South and East Asia, including information on some actions being taken and others that are not. The remarks were accompanied by graphical overheads, some of which are included in the following.

INTRODUCTION

Thank you for inviting me to make a presentation to the participants of this Flood Management Seminar. The USCID has been very perceptive in identifying this topic for a seminar, and the location and participants are well placed to give us a wide range of information to think about. The floods of the central United States in the summer of 1993 were given broad news coverage internationally as well as in the stateside news media. As I travel to many countries and work with technical staff involved in water resources management, I found many of these people were very interested in the 1993 flood events and frequently discussed them in relation to their own situations. Just recently the Western European countries also experienced damaging floods, and we look forward to the analysis and possible lessons from that experience. Both are a reminder that the term "flood management" has to be used almost as a figure of speech, for who can really manage a flood when it is in the process of bearing down upon us? Maybe after four days of rain, it looks like a 1-in-25 year flood situation, but when that is followed by another week of even heavier rain, we all of a sudden have a 300-year flood to deal with. Where are there any management possibilities in those situations? What we really mean, of course, is upgrading our management capabilities to minimize the impacts of all levels of floods.

INTERNATIONAL CONNECTION TO THIS SEMINAR

As a member of the technical staff of the World Bank, I have become familiar with a number of situations around the world in which mitigation of the impacts of floods has become a very important component of various countries' water resources management activities. Today I would like to share some of the issues and problems that face developing countries regarding approaches to flood plain management, and to describe some of the flooding conditions they face.

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I am in the Asia Technical Department in the World Bank, which provides support to a number of technical areas in the two Asia Regions. I will make most of my comments in relation to Asia which is certainly not the only region of the world with developing countries, yet with over half the world's population, and being a region where "monsoon" is a household word, awareness of the impacts of floods is well developed. The citizenry and their governments have been constantly seeking ways to mitigate the impacts of floods. Some of the approaches being put forward are very costly and are in competition with other sectors for scarce financial resources. Often high risks must be accepted, and the expertise representative of those of you at this seminar is needed to help these countries evaluate such risks in relation to the benefits that can be derived from flood protection measures.

Flood Issues in Asia

I would like to present some information that, while general, is important to the assessment of policy and actions in flood control of specific regions. I have brought along a few graphics to help me describe these items. Figure 1 shows the population history and projection of Asia region with China's contribution identified separately. The estimated increase over the next 25 years is on the order of one billion people which is just about what the total population in this region in was in 1940. You all are quite aware of the lead time required for large physical projects, or for major policy changes. As an example, if part of a plan for flood reduction were to be a large flood control dam, 25 years is not out of line as the time from start of planning to implementation. The point is that there will be more and more people exposed to the dangers of floods just from the standpoint of demographics. In China, a significant portion of the very productive agricultural lands lies in the flood plains of river valleys. The Chinese government has a policy of limiting the movement of the rural population to their large cities, therefore, the number of people in these rural areas who are exposed to flooding is probably greater there than in other countries where a larger degree of urbanization is occurring. And with the recent development boom in China, the importance of these flood plains to keeping up with food production figures very prominently in their policies and investments. China, as well as the other Asian countries, has not seen fit in the past to institute major flood zoning restrictions to limit property development or residential occupancy in the flood plains. This is in part because they have few other places that the people can live and still produce the grain and other food crops needed.

Southeast Asia Monsoonal Climate

In southeast Asia, the monsoonal climate is very prominent and presents flooding conditions almost annually. With almost three-quarters of the rainfall occurring during the four months of monsoon season, it is natural that the river discharges mirror this seasonal pattern. It is also typical for this volume to come in just a handful of major storms. Figure 2 presents the long-term average monthly discharge for the Ganges River at the border between India and Bangladesh. I am sure you all have read about or heard reports of the massive floods in this region of the world, and this tremendous seasonal disparity of flow is more prominent than most places. The country of Bangladesh not only receives the massive monsoonal flow from the Ganges plain of India, but also from two or three other central rivers, and then the mighty Brahmaputra that has a drainage area extending significantly into China. It is typical that the Ganges basin runoff peaks two to three weeks after the Brahmaputra as shown in figure 3, the illustration of the long term hydrograph of both rivers. However in 1988, the Brahmaputra runoff was late while the Ganges was on time, and the peaks nearly coincided. The result was a discharge level and flooding condition that had never before been observed in Bangladesh. The combined flow in Bangladesh resulted in flood waters covering an estimated 46 percent of the total land area of the country. Yet despite this massive flooding, the loss of life was surprisingly small (1,500) and the total agricultural production for that year was only 15 percent below normal. With more advance warning systems, combined with improvements in key transportation and emergency services, the people of Bangladesh could significantly improve their flood mitigation capabilities.

There are some who blame these Bangladesh floods on deforestation in the Himalayas, and others come forth with proposals to build flood levees from the Bay of Bengal to the mountains. Both are based on misconceptions and show lack of understanding of the probabilistic nature of flood return intervals and the geomorphology of the region, as well as the fact that where levees are constructed, it also rains heavily in the flat areas behind the levees, six to eight feet during the monsoon. The inability to drain those areas is as great a problem as the river flows. Other countries have been trying to assist Bangladesh in developing a suitable approach under an initiative called the "Bangladesh Flood Action Plan." Yet the diversity of opinions in the technical communities of the donor countries, the difficulties in dealing with the probabilistic nature of flooding, and the other tremendous needs of the poverty-stricken populous in this area, has not resulted in a well-defined approach. The international community is also struggling with reaching a definite conclusion of "global warming." One of the impacts commonly agreed upon is that if global warming happens, there will be a greater frequency of extreme climatic events such as large flood-producing storms.

The World Bank has been attempting to assist in the formulation of water resources development strategies of other Southeast Asian countries such as Vietnam, where the management of the waters of the Mekong Basin is of tremendous importance. Again, as illustrated in figure 4, there is a large seasonal variation in flow conditions in this sub-region and large flood potentials, yet the flood management issues are not as significant as in Bangladesh, India, Pakistan, or China.

Flood Management in China

Let me now come back to some of the situations in China where the considerations for flood management and investments in flood control facilities are probably greater than for any other location served by the World Bank. China has a very long history of working diligently to harness the resources of it rivers. This is due to the extreme variability, year to year, of the rainfall patterns which typically result in hundreds of sub-regions experiencing droughts in a given year while others are having floods. A few years later those situations are nearly reversed. Despite having a good long-term average rainfall and runoff, this inconsistency of the rainfall pattern creates a need for storage facilities to assure a more dependable supply of water for agricultural production, and just as important, flood storage capacity to protect populated areas. China today has approximately 86,000 storage dams, which is as many as the combined total in the rest of the world. They are continuously planning and constructing more, almost every one is a multipurpose facility, and storage to minimize flood impacts is a common feature.

Yellow River Basin

One such project under construction with fund assistance from the World Bank, is the Xaiolangdi Project which forms a 12.1 billion cubic meter (10,600,000 acre feet) reservoir on the Yellow River. This will be the nearest to the Yellow River outfall of any reservoir to date, and over a third of the capacity is dedicated to flood storage. Over the years the North China Plain has developed into a highly productive agricultural area and annually the flood levees are raised higher and higher to protect this land from the high flows of the Yellow River. With this confinement, the heavily silt-laden flows deposit the river's bedload within the levees, and there are now places where the average bed of the river between levees is as high as 10 meters above the surrounding intensely cropped plain. (See figure 5 for illustration and details.) A breach of this embankment would not only flood millions of hectares and threaten thousands of lives, but it would be extremely difficult to recapture and contain the river within the levee system again. At the present time the degree of protection is for approximately the 60-year flood, and after the construction of Xaiolangdi Dam, this will be raised to over a 1-in-100 year return interval. Along with other flood events mentioned in figure 6 is one of the most devastating floods from the Yellow River, one that we rarely read about in either hydrologic journals or in western history books, yet it was basically man-made. It occurred in 1938, which is quite recent in hydrologic time, during the war between Japan and China. To thwart the advancing, and heavily mechanized Japanese forces, the Chinese army breached the Yellow River levees during high flow and sent a wall of water gushing out into the flood plain. The Japanese advance was halted but at the cost of approximately 890,000 Chinese peasant farmers' lives. A natural breach today would put at risk a tremendously greater population than existed in 1938.

FLOOD HANDLING CAPABILITY OF DAMS

Although the World Bank is not providing financial assistance to the giant Three Gorges Project initiated by China on the Yangtze River, the primary purpose is to protect some 200,000,000 people who are exposed to flooding in the lower portion of the Yangtze Basin. The potential severity of storms in this region is exemplified by a storm that piled up against the east slopes of the mountain ranges in Hunan Province in 1975. It has only been in the last year that outside entities have reported that two large dams were overtopped and were breached during this storm, estimated to be in the order of magnitude of a 2,000-year storm, and both dams failed at nearly the same time. Human Rights Watch/Asia recently reported that approximately 85,000 people died in the resulting flood. One must remember that a 2,000-year flood in any densely inhabited area will result in a tremendous number of casualties, so it is difficult to estimate the number that would have perished had the dams held and merely passed the 2,000-year inflow on downstream. It is reported that another 140,000 died as a result of disease, lack of food, and the perils of the massive waterlogged region that persisted for weeks after the flood.

Dam Safety Programs

This leads to the relationship between general flood management policies and practices to flood operations and safety of dams. Within the last four years, the World Bank has promoted and funded stand-alone Dam Safety Projects in India and Indonesia and has held discussions in a number of other countries in Asia. The technical approaches to sizing and design of the flood handling capability of dams and the analysis of the impacts of flood operations and consequences of a dam failure has improved greatly in the past decade. Some of the older facilities were designed to far more lenient criteria than today and there are greater populations and high valued development occurring in the partially protected valleys downstream. The technique of risk assessment and of evaluation of damage and loss of life potentials are being continually upgraded and made more meaningful by experienced engineers and scientific personnel like those of you in attendance at this seminar.

Risk Assessment

In closing, I urge you to make public such advances in the methodologies of evaluations by holding more seminars and including the international community, as well as by writing about and publishing these approaches in the various technical journals. This will assist in making the necessary technology transfer to developing countries. I am very pleased to see the trend in the United States toward risk assessment and cost/benefit evaluation of regulatory policy. This is vitally needed in the developing countries where they must apply very limited financial resources across very broad sectors. Until some of their other vital economic and social investments are made and the standards of living greatly improve, these countries may have to continue to take greater risks in their "flood management" programs.

Thank you again for your kind attention and for giving me the opportunity at this seminar to outline some of the issues of flood management in developing countries.

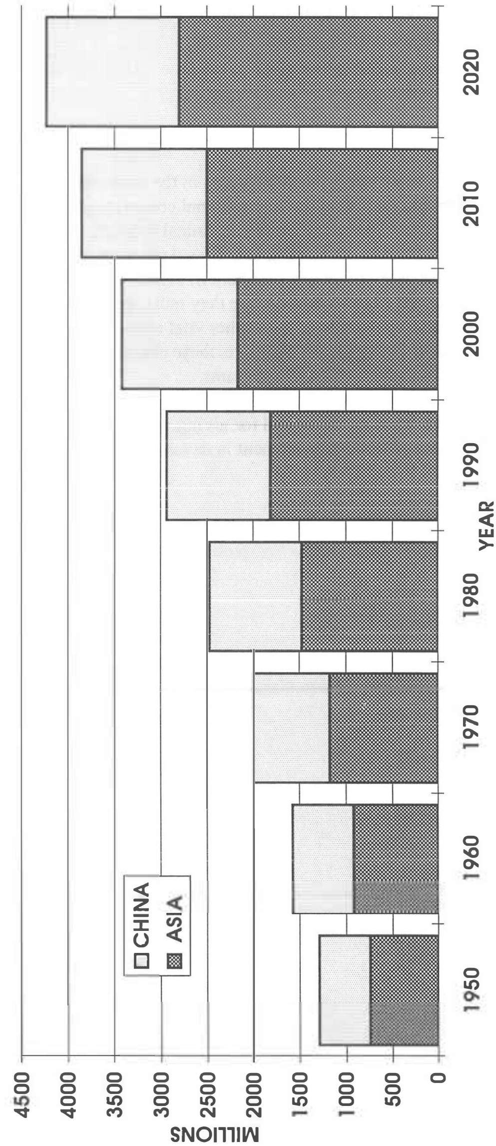


Fig. 1. Population of Developing Countries - Asia Region

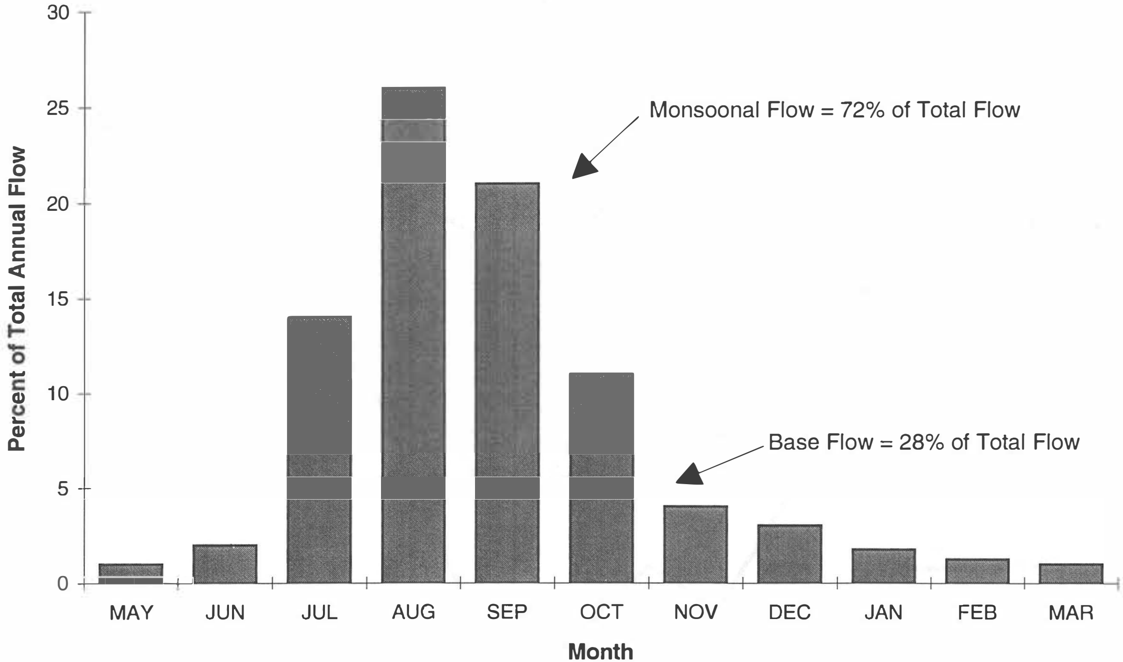


Fig. 2. Average Monthly Distribution of Flow of a Monsoonal River

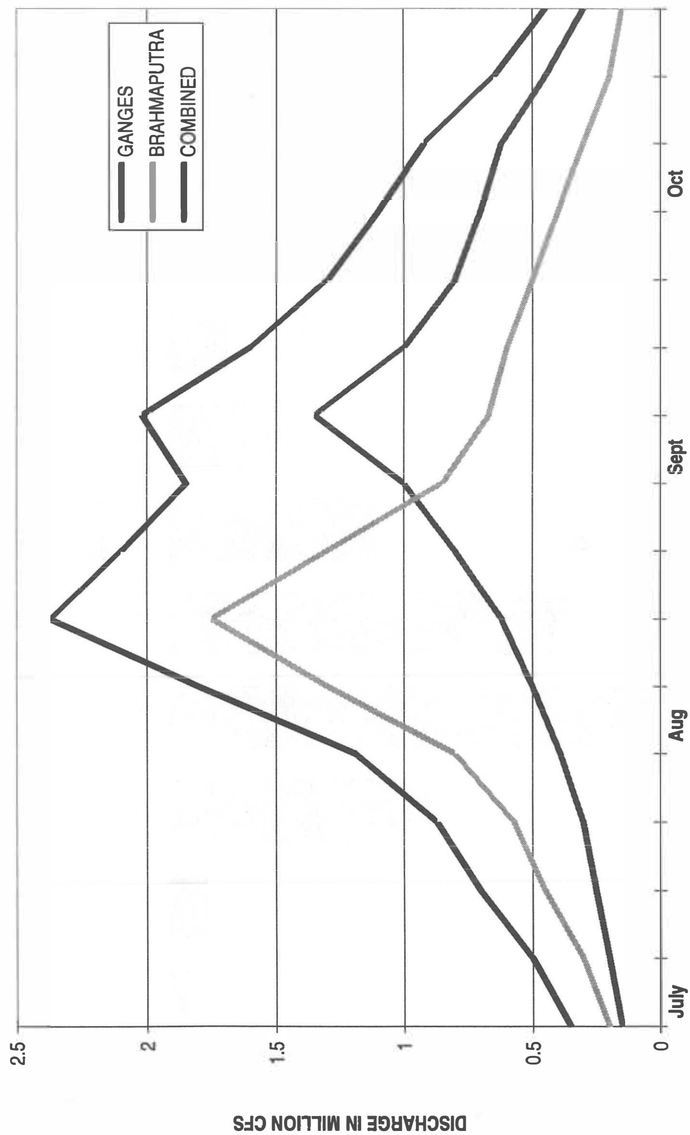


Fig. 3. Typical River Flow Pattern in Bangladesh

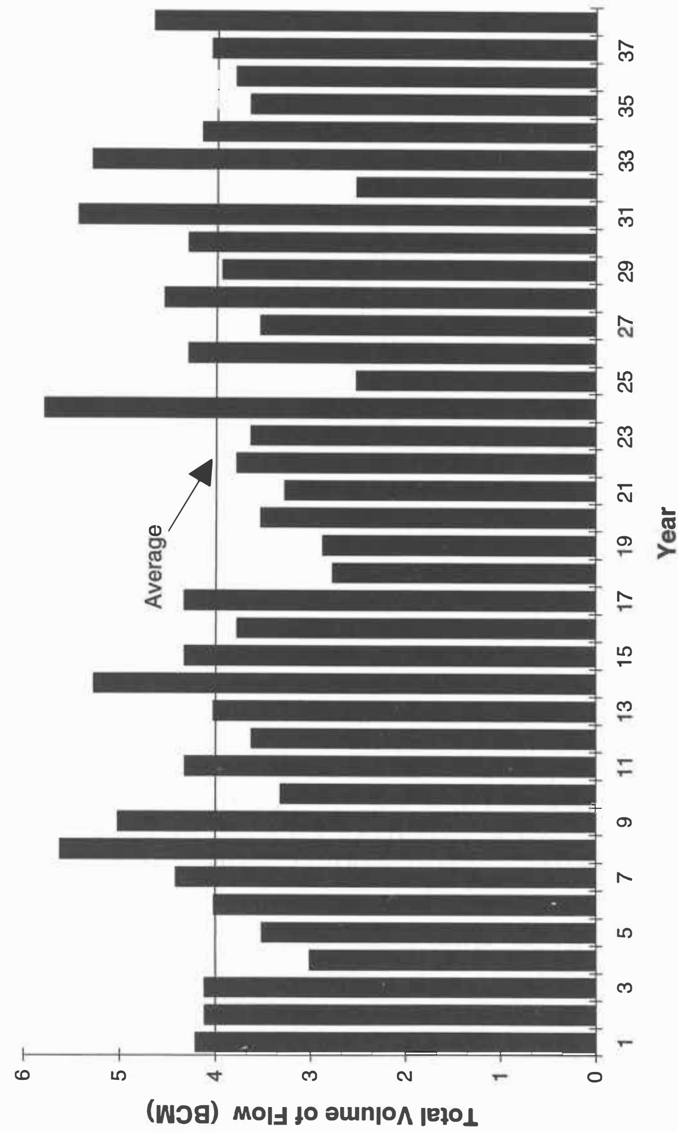
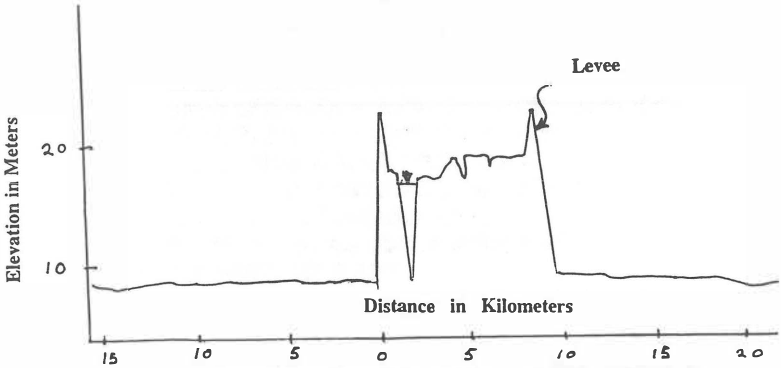


Fig. 4. Annual Flow Variation of a Monsoonal River

Fig. 5. The Yellow River Time Bomb



LOWER YELLOW RIVER CROSS SECTION

- THE LOWER YELLOW RIVER BASIN LEVEES EXTEND 1,396 KM AND PROTECT AN AREA OF ABOUT 120,000 KM^2 AND CONTAIN A POPULATION OF OVER 100 MILLION.

- THE PRESENT DEGREE OF PROTECTION IS ABOUT A 1-IN-60 YEAR REOCCURRENCE LEVEL.

- THE XIAOLANGDI DAM NOW UNDER CONSTRUCTION WILL INCREASE PROTECTION TO ABOUT A 1-IN-100 YEAR LEVEL AND WILL ALLOW REGULATION OF FLOWS TO MANAGE THE SEDIMENT TRANSPORT.

- THE 4.1 BILLION CUBIC METER (BCM) FLOOD STORAGE AT XIAOLANGDI WILL BE PART OF THE PLANNED BASINWIDE SYSTEM OF 29 RESERVOIRS THAT WOULD PROVIDE OVER 49 BCM. THIS WILL BE ABOUT 110% OF THE LONG-TERM AVERAGE ANNUAL FLOW.

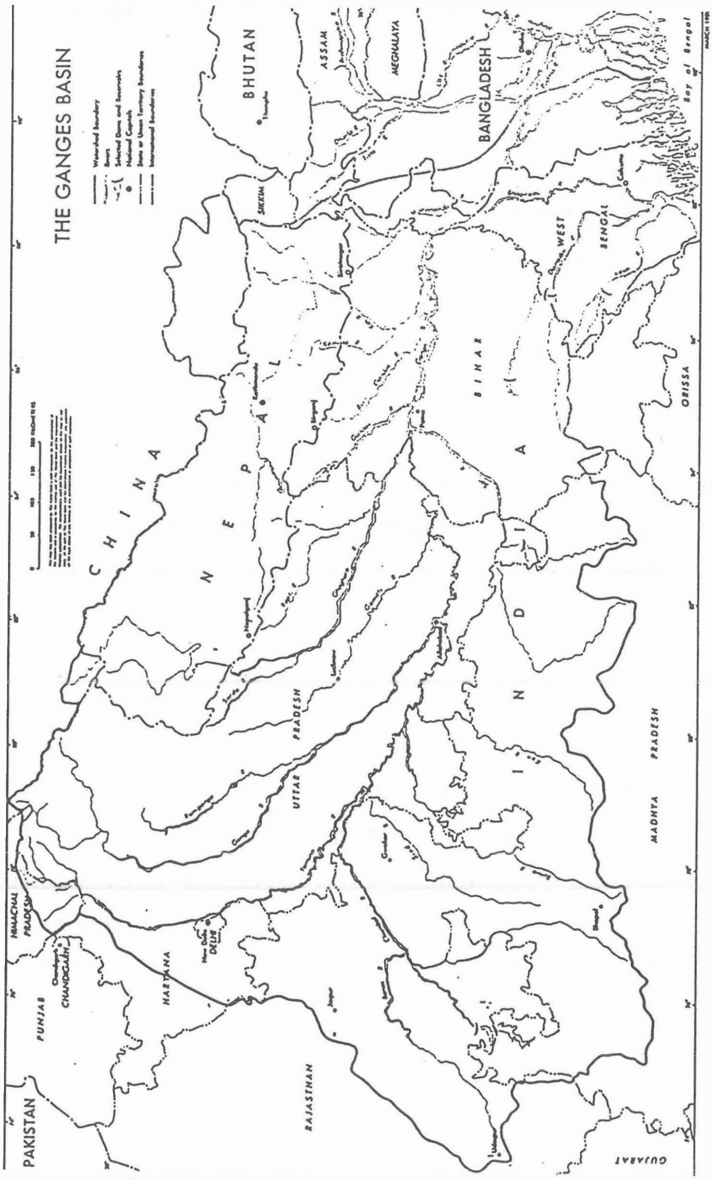
Fig. 6. Floods on the Yellow River

- IN 1843 A FLOOD OF 33,000 CMS (ABOUT 1-IN-1,000 YEARS) BROKE THE RIVER LEVEE NEAR KAIFENG AND THE RIVER ESTABLISHED A NEW COURSE ALONG ITS PRESENT ROUTE. FATALITIES UNKNOWN.

- A 1933 FLOOD BREACHED THE DIKE IN 54 LOCATIONS INUNDATING 11,000 KM^2 AND KILLING 18,000 PEOPLE.

- IN 1958, THE LARGEST NATURAL FLOOD OF THE CENTURY -- 22,000 CMS -- OCCURRED BUT THE DIKES HELD. THERE WAS SERIOUS FLOODING IN THE NORTH CHINA PLAIN OUTSIDE THE RIVER LEVEE

- IN JUNE 1938, DURING THE CHINA/JAPAN WAR, YELLOW RIVER LEVEES NEAR KIAFENG WERE BREACHED DELIBERATELY BY THE LOCAL CHINESE ARMY IN A DESPERATE ATTEMPT TO HALT THE ADVANCING JAPANESE. THE RESULTING FLOODING SUBMERGED OVER 1.3 MILLION HECTARES, AND LEFT 12.5 MILLION HOMELESS. AN ESTIMATED 890,000 PEOPLE WERE EITHER DROWNED OR DIED OF DISEASE AND HUNGER.


THE GANGES BASIN
CHINA
NEPAL
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UTTAR PRADESH
MADHYA PRADESH
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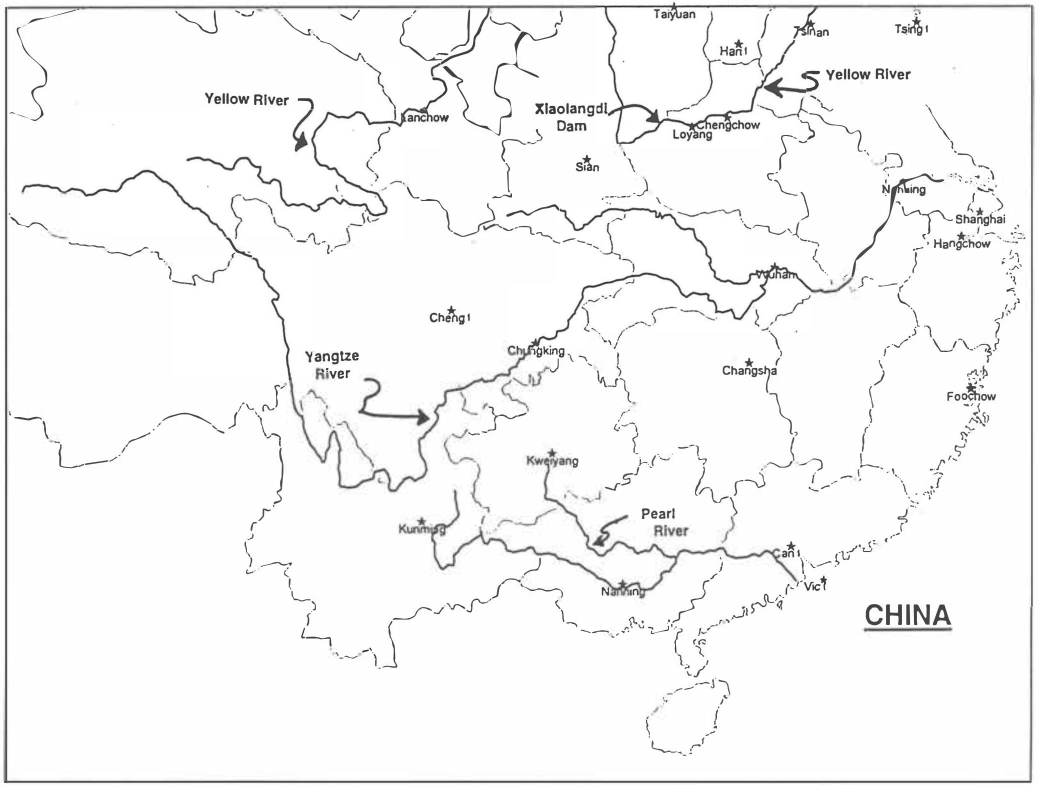
GUJARAT
Bay of Bengal



Taiyuan
Tsinan
Yellow River
Yellow River
Xiaolangdi Dam
Chengchow
Loyang
Sian
Shanghai
Hangchow
Yangtze River
Chungking
Changsha
Foochow
Kweiyang
Pearl River
CHINA

The Great Flood of 1994
the disaster that did not happen

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James T. Lovelace[2], P.E.; and Dave Busse, P.E.[3]

Abstract

Truman reservoir in central Missouri and Mark Twain Lake in northeast Missouri were both built after the flood of 1973. The contribution to flood control of these projects is examined relative to the 1994 flood at St. Louis. Other projects in the Corps' St. Louis District are also considered in this analysis. Conclusions are drawn on the savings that these projects have brought to the Mississippi Valley area, and the lack of positive press coverage.

Introduction

Headlines during April of 1994 were concerned with the start of baseball season. They might have covered stories such as these:

ST. LOUIS - It's been less than a year since the "Great Flood of 1993" and the city is experiencing the second greatest flood in history. Agricultural levees damaged during the 1993 flood, repaired on an interim basis were unable to hold flood waters back again this year.

CAIRO - Surges of water from the Mississippi joined here with those of the Ohio threatening to submerge that part of southern Illinois known as "Little Egypt."

CHESTERFIELD - For the second straight year the Chesterfield levee overtopped destroying all that was repaired in 1993.

NEW MADRID - The New Madrid floodway is on the verge of being activated. The floodway has not been activated since the 1937 flood. Over 52,600 hectares (130,000 acres) will be sacrificed to reduce flood heights for about 64 kilometers (km) (40 miles) along both the Mississippi and Ohio Rivers.

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WASHINGTON, DC - The Federal Emergency Management Agency reports that within the St. Louis area over 1.9 billion dollars have occurred due to the second great flood in only two years.

These things could have happened, but they didn't.

The rains that fell over Missouri and Illinois were of such magnitude to cause severe flooding on the lower Missouri River and the Mississippi River from St. Louis Missouri to Cairo, Illinois. That's what would have happened had these rains fell two decades earlier. However, since the Flood of 1973 (previously the highest flood before the Great Flood of 1993) a couple of flood protection reservoirs were built. These projects were Truman reservoir in central Missouri and Mark Twain Lake in northeast Missouri. These two reservoirs played a major role in controlling the flood of 1994.

The Basin

The valley threatened by the flood of 1994 is among Americas greatest assets. In the course of its 3,701 km (2,300 mile) journey to the Gulf of Mexico it varies considerably. It is traditionally broken into three parts: the Upper, Middle, and Lower Mississippi. Between the mouth of the Missouri and the mouth of the Ohio, the river is known as the Middle Mississippi. Its largest tributary is the Missouri River, which drains 1,370,880 km^2 (529,300 square miles).

The Rainfall Event

In April of 1994 are large rainfall event occurred over parts of Missouri and Illinois. As illustrated in Figure 1, the rainfall totals for April of 1994 were very heavy. As can be seen it was fortunate that the heaviest of these rain fell behind Corps reservoirs.

The Actual Flood

The stage at two locations on the Mississippi River illustrates best what occurred and then later what could have occurred. The St. Louis gage reached 11.6 meters (m) (36.6 feet) April 1994. The Cairo gage reached 16.6 m (54.3 feet) on April 17. These stages are critical in 1994 unlike what they would have been in previous years. The damage from the Great Flood of 1993 to the agricultural levees below St. Louis were not fully repaired.

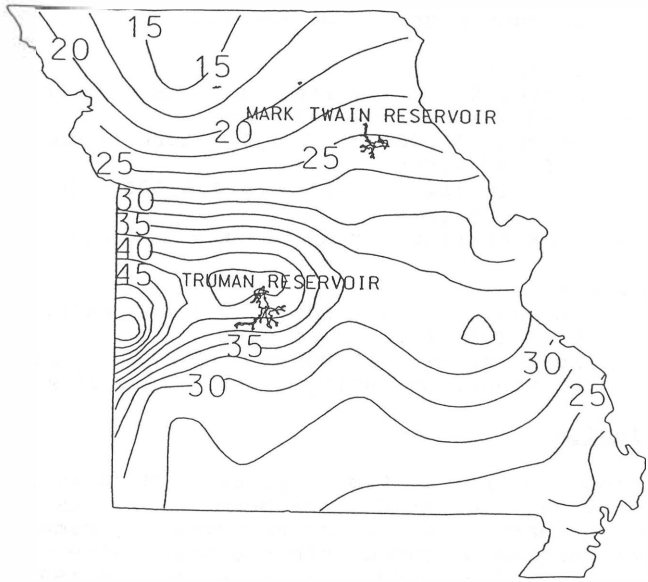

Figure 1. Missouri Precipitation in Centimeters

The Theoretical Flood

Truman and Mark Twain Reservoirs held back a significant amount of the deluge that occurred over Missouri in April. These two reservoirs and to a lesser extent the other reservoirs in the basin prevented a large flood. In fact, the St. Louis gage would have reached 14.5 m (47.5 feet) (3.3 m [10.9 feet] higher than the actual crest). This would have been the second highest flood at St. Louis exceeded only by the Great Flood of 1993.

The Ohio River Basin's flood control system also played a part. Combined with the Upper Mississippi/Missouri flood control system a stage at Cairo of 18.6 m (61.0 feet) was prevented, a difference of 2.0 m (6.7 feet) over the actual crest.

Reservoir Benefits

Reservoir benefits were especially pronounced in the Corps' St. Louis District, which manages the Mississippi from Hannibal, Missouri to Cairo, Illinois where the Ohio River joins the "Father of Waters". Within the district, reservoirs prevented flood damages of 1.9 billion dollars. The table below list the contribution of the two most significant reservoirs.

Mark Twain Lake
- Stored 5.8 m (19 feet) of flood water
- Used 39% of flood storage
- Stored 432,000 m^3 (350,000 Acre-Feet) of flood water
- Peak inflow = 2,123 m^3/s (75,000 cubic feet) per second (cfs)
- Peak outflow during event = 1.4 m^3/s (50 cfs)

Truman Lake
- Stored 6.4 m (21 feet) of flood water
- Used 49% of flood storage
- Peak inflow = 11,000 m^3/s (387,000 cfs)
- Peak outflow during event = 14.2 m^3/s (500 cfs)

Conclusion

The flood control system in place in Mississippi Valley has provided a great deal of benefits to its inhabitants over the years. Two of the reservoirs (Truman and Mark Twain) that were placed into operation after the 1973 flood proved instrumental in reducing the 1994 flood. As opposed to the 1973 or 1993 flood this flood got very little press coverage. Major successes of engineering structures or systems don't seem to warrant much attention. The engineering profession must learn to "celebrate" its successes. As Congressman Dicks said at a recent subcommittee hearing, "Quiet professionalism is no longer in vogue."

The aforementioned discussion represents the views of the authors and are not necessarily the views of the Corps of Engineers.

RISK-BASED ANALYSIS FOR FLOOD DAMAGE REDUCTION PROJECTS

Earl E. Eiker[1]

ABSTRACT

The recent emphasis on partnership between the Federal government and local sponsors in the development of flood damage reduction projects has promoted considerable interest in the application of risk-based methods for project analysis. Project formulation by such an approach in generally considered to be more objective in establishing a good balance between cost and risk. This paper describes a risk-based method for project analysis.

INTRODUCTION

Flood control is one of the primary missions of the U.S. Army Corps of Engineers. Through its Civil Works program, the Corps carries out Congressional directives to plan, design and operate various flood damage reduction projects throughout the country.

In planning and designing flood damage reduction projects, the Corps requires information on discharge/frequency, stage/discharge, and stage/damage relationships. Such information is obtained from observed and measured data, or is estimated by various synthetic procedures and modeling techniques. The information is frequently based on short periods of record and small sample sizes, and subject to measurement errors and inherent limitations and assumptions associated with the analytical techniques employed. These estimated values are, to various degrees, imprecise or inaccurate and thus induce uncertainty in key variables and decision making parameters.

Risk-Based Analysis (RBA) is a method of performing studies in which uncertainty in technical data is explicitly taken into account. With such analyses, trade-offs between alternatives, risk, and consequences are made highly visible and quantified. The overall effect of risk and uncertainty on project design and economic viability can be examined and conscious decisions made reflecting an explicit tradeoff between risk and costs.

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FORMULATION AND DESIGN OBJECTIVES

Flood damage reduction projects are formulated to provide safe, efficient and reliable protection to lives and properties in flood prone areas. Projects are formulated by analyzing flood plain damage potential, and damage prevention performance and cost for a range of project sizes and configurations. The plan selected is based on maximizing net economic benefits consistent with acceptable risk and functional performance.

The engineering task is to balance risk of design exceedance with flood damage prevented, uncertainty of flood levels with design accommodations, and provide for safe and predictable performance. The task is made difficult because economics dictate that less that complete protection be accepted, risk of capacity exceedance is real and must be planned for because it may occur within the life of the project, and uncertainty in flood levels exists because of imperfect knowledge. Risk-Based Analysis enables risk issues and uncertainty in critical data and information to be explicitly included in project formulation.

TRADITIONAL APPROACH

Traditional engineering practice in the Corps was to first develop the discharge/ frequency data for the project by applying adopted Federal interagency guidelines (Bulletin #17B) when gaged data were available, and by rainfall-runoff models, such as HEC-1, when watershed modelings was appropriate. Uncertainty was considered by making an adjustment, using expected probability, to the frequency curve in order to correct for bias because of a short record length.

Based on the discharge frequency information, several levels of protection for the project were then selected for analysis. The next step was to perform water surface profile computations using, for example, HEC-2, along the study reaches for the selected levels of protection to develop stage/discharge data. When flow was complex or circumstances unusual, unsteady flow and/or two dimensional model computations were needed. Models were calibrated with observed high water-marks, available rating curves at stream gage locations, and published guidelines. Uncertainty was sometimes considered by performing sensitivity analyses to evaluate the results of reasonable adjustments of model variables. The outcome of sensitivity analyses resulted in adoption of model coefficients to ensure that computed water surface profiles were conservative. In addition, for levee/floodwall projects hydraulic uncertainty was traditionally addressed by the addition of freeboard to the design water surface profile.

The stage damage curve provided a summary statement of damages as a function of river stage. Damages are highly sensitive to a variety of factors, such as mapping accuracy, first floor elevations, type of structures and contents which are important in describing the variation in damage but rarely empirically verified. Uncertainty was sometimes considered by performing sensitivity analyses.

The discharge/frequency, stage/discharge and stage/damage data were then combined to develop the damage/frequency curve which was used to determine the flood damage reduction benefits for each level of protection selected for evaluation. The selected project was the one that reasonably maximized net flood damage reduction benefits. Only projects with acceptable performance were considered in the evaluation. Risk (or risk aversion) was characterized relative to a unique degree-of-protection for the selected project.

RISK-BASED ANALYSIS

Risk-Based Analysis has many similarities to traditional practice in that the basic data are the same. Best estimates are made of discharge/frequency curves, water surface profiles, and stage/damage relationships. The difference between traditional approaches and RBA is that uncertainty in technical data is quantified and explicitly included in evaluating project performance and benefits. Using RBA, project performance is stated in terms of reliability of achieving stated goals. Also, adjustments or additions of features specifically to accommodate uncertainty, such as adding freeboard on levee/flood walls, are not necessary.

Figure 1 is a conceptual schematic of the problem from a risk-based perspective. The hydrologic relationship that characterizes risk of flooding is depicted in the upper left corner of Fig. 1. Uncertainty in corresponding peak discharge may be described by applying accepted statistical procedures for determining confidence limits, and is illustrated in the upper right corner of Fig. 1. This uncertainty is represented by a probability distribution of discharge error about the discharge frequency curve.

Flood stage uncertainty corresponding to discharge is represented in the lower left corner of Fig. 1. At a gage location, study of field measurements compared to the adopted rating curve and stages computed with a calibrated numerical flow model can provide the basis for quantifying the uncertainty. For the case where there is no gage at a site and few high water marks recorded for flood events, study of nearby gage records, sensitivity of stage to calibrated model coefficients, and professional judgement must form the basis for quantifying uncertainty. Because of imperfect knowledge about the channel roughness, flow regime, bed form, flow debris and models used to analyze river hydraulics, there is uncertainty in the stage for a given discharge. This uncertainty can be represented by a probability distribution of stage error about stage/discharge rating curves.

Flood damage uncertainty corresponding to stage is reflected as shown in the lower right corner of Fig. 1. A probability density function representing possible statistical error in damage estimate for stage is superimposed on the stage/damage function. This reflects that there is uncertainty in the flood damage that would result should a given stage occur in the flood plain because of imperfect knowledge about the nature and mix of improvements, elevation of improvements, and physical structure and content damage potential. This uncertainty can be represented by a probability distribution of damage error about stage/damage curves.

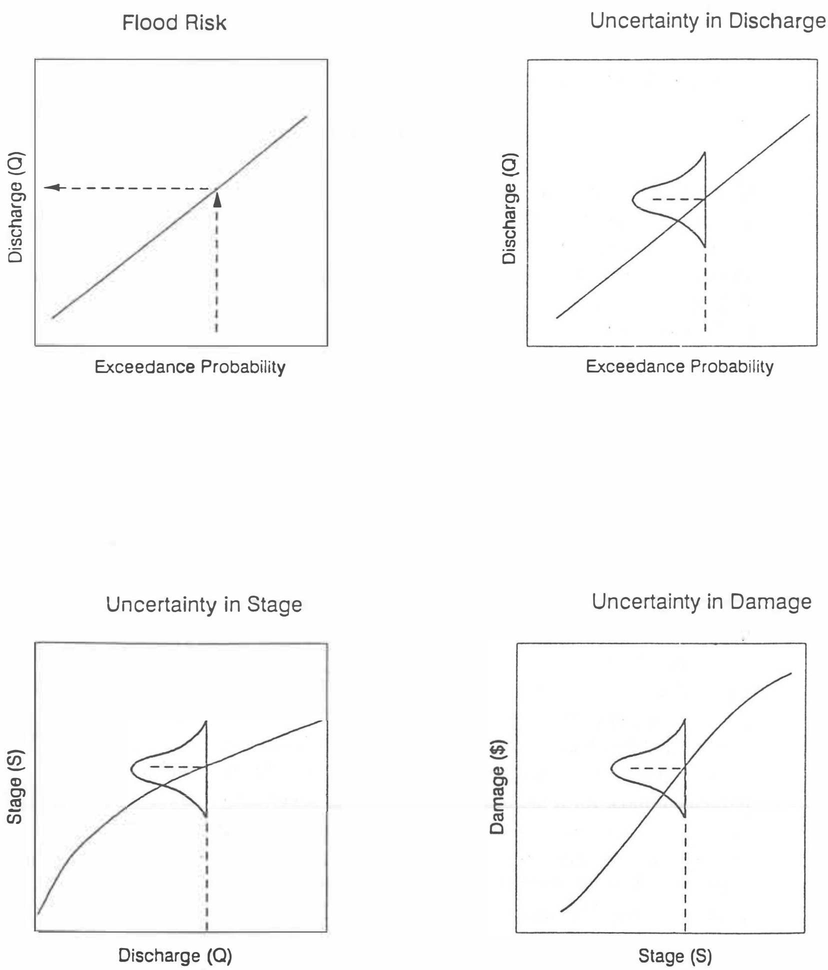

Figure 1. Uncertainity in Discharge, Stage, and Damage

The basic steps to carry out the process are:

a. Develop best estimates of discharge/frequency curves, water surface profiles (stage/discharge ratings), stage/damage relationships for the without project conditions,

b. Develop statistical description of uncertainty for each of the above relationships,

c. Nominate alternative project capacities; compute costs and flood damage prevented; array results and select the best plan according to economic and other appropriate criteria; and

d. Make appropriate refinements to ensure project performance and function and to minimize residual risk; such as providing design features to address settlement and construction tolerances and to control overtopping location and management of subsequent flooding for levee projects, and operational accommodations required for reservoir storage, channel, and diversion projects.

The above steps are repeated as needed for each alternate measure evaluation, or combinations of measures to enable comparison of project alternatives. Step c brings together all the elements to determine the selected project capacity. To correctly incorporate uncertainty in the several elements, they must be allowed to interact with one another. For example, the possibility of error for higher flows (or lower flows) must be allowed to couple with the full range of possible stage and damage errors. Because of the nature and complexity of the error distributions, the interaction cannot be uniquely accomplished analytically. An alternative approach is to use Monte Carlo simulation as given by Benjamin (1970) and Palisade corporation (1988). In this approach, the basic relationships and error distributions are sampled by exhaustive trial to allow the interactions to take place. For a given size project, various combinations of the parameters are evaluated (approximately 5,000 samples) and for each interaction success or failure is established. Other project sizes are evaluated, and a matrix describing economic outputs, reliability and performance for each is produced. The matrix forms the basis for final selection of project size.

The results of the RBA portion of the analysis are probability distributions of the various parameters (design flow, stage, and residual damage) as a function of project capacity. The expected cost and benefit can then be computed and the project capacity selected according the appropriate criteria. Tabulations of the likelihood of project capacity exceedance for flood events enables characterizing risk-exceedance and performance. The RBA framework explicitly quantifies the reliability and performance of a given project design. This reliability and performance is reported as the protection for a target percent chance exceedance flood with a specified reliability. For example, the analysis might show that a proposed levee project is expected to contain the one-half percent (0.5%) chance exceedance flood, should it occur, with a ninety percent (90%) reliability. This performance may also be described in terms of the percent chance of containing a specific historic flood.

SUMMARY AND CONCLUSION

Imperfect knowledge of the "true" nature of the hydrology and hydraulics in an area creates uncertainty in project designs and in the estimate of their reliability. Additionally, uncertainties in expected damage with and without the project influence the selection of an alternative plan for design. The RBA procedures described in this paper provide an approach to explicitly quantify the uncertainties associated with discharge/frequency, stage/discharge and stage/damage reduction projects. The method uses the same basic data as that used in traditional practice, but has the distinct advantage of providing considerable information regarding expected project reliability and performance. Goals and objectives of project studies are not compromised by the new method, rather they are enhanced due to the ability to consider a much wider range of project alternatives.

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PUBLIC ATTITUDES AND POLITICAL RESPONSES TO CRITICAL EVENTS ON MAJOR RIVER SYSTEMS

J. Edward Brown[1]

ABSTRACT

Hydrologic extremes such as the flood of 1993 in the Upper Mississippi River Basin as well as the drought that visited the Missouri River Basin in the late 1980's create conditions where both governmental policies and the resulting responses to the events are subject to scrutiny. It is important for professionals in government and the private sector to recognize these major tragedies as an opportunity to debate and implement plans to reduce the impact of similar future events. It is difficult to get public support for effective measures because memories of problems fade due to the infrequency of their occurrence. Unfortunately, major changes in policy take time. The activities following disasters such as the floods in 1993 indicate a desire to work to reduce future damages

Effective changes in policy regarding floodplains must be done locally, with basic guidance from state and federal entities. It is important that policies which minimize losses from these events be developed in balance with private property rights. They must then be articulated and implemented while the public's memory of the realities of a disaster is still fresh.

INTRODUCTION

It has often been noted that people exhibit a cyclical interest in water issues. That interest appears to be directly correlated to the amount of water available. Either drought or flood can create conditions that result in threats to public health and safety, endanger homes and other structures and at least inject enough inconvenience into our lives that everyone stops to take notice. Floods by their speedy arrival tend to raise the people's interest in

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water to a fever pitch. Unfortunately this keen level of awareness usually ebbs with the stage of the river. Concern for drought is often flushed away by the first good rain. Public concern for the consequences of these events usually evaporates long before improvements in policies can be implemented.

One feature of the floods of 1993 and the drought that occurred in the Missouri River Basin was the energy that they generated in terms of action to evaluate and modify governmental policy related to the rivers.

THE FLOOD OF 1993

The extent and duration of the flooding in 1993 kept the disaster in public view. The level of concern that was manifested at the time gave a clear call for governmental involvement. The following items illustrate the activity on the part of federal, state and local governments in response to the flood.

National Response

On August 26, 1993, members of the President's Cabinet and members of Congress convened a Midwest Flood Disaster Housing Work Session. The meeting included a review of flood response, stories of the damages to cities, and identification of future actions. At the end of the meeting over $100 million in assistance was handed out to the nine states affected and about half a dozen large cities.

White House concern for the flood of 1993, the need to review the government response to floods, and the need to assess the management of flood plains on major river systems gave rise to the Administration's Floodplain Management Task Force. Shortly thereafter, the Task Force created the Interagency Floodplain Management Review Committee. The committee was given the task of evaluating available information to determine the major causes and consequences of the flooding. The committee was composed of representatives from agencies with floodplain and flood response authority. Brigadier General Gerald E. Galloway was selected to lead the effort within an extremely short time frame.

The initial phase of the committee's work focused on outreach. Governmental and private organizations with an interest in or responsibility for flood response and floodplain management were all consulted to secure information. The report of the Committee entitled "Sharing the Challenge: Floodplain Management into the 21st Century", made numerous recommendations. The report called for more centralized, coordinated floodplain management to reduce the need for assistance in emergency conditions. It also recommended shared responsibility for floodplain management among all levels of government. Regarding structures, it suggested the need for a balance between flood control structures and areas such as wetlands intended to retain water during smaller events.

The committee's work attracted a lot of attention and generated high expectations by the time their report was released. It was the first major product of the federal government in the aftermath of the flood. The personal consultation noted earlier, created a sense of genuine interest in making things work better. The level of anticipation surrounding the report caused many to believe that the report would have a real impact on current policies.

Some of the recommendations of the Galloway Report such as those which call for consideration of the appropriate levels of protection for floodplain areas have been the subject of concern and vocal opposition by agricultural interests. Their worries were based on the belief that the report recommended the wholesale purchase of land to avoid rebuilding levees. At the same time, some farmers were calling for the speedy repair and even raising of the level of protection of all agricultural levees. Delays in levee repair as policy issues were considered contributed to the sense of frustration as landowners saw the prospect of being vulnerable in the coming spring.

The report suggests land acquisition should only be a part of a solution to floodplain problems. The report concludes that wetlands restoration could be an effective measure for reducing the impact of smaller floods, but not one like the flood of 1993.

In any event, The Galloway Report recommends that land must only be acquired from willing sellers.

Higher levees to provide protection for agricultural areas under all flooding conditions raise questions of feasibility due to the cost of such an undertaking, and could have major implications for existing levees protecting urban areas. Consistent, higher levees also yield an ecosystem confined to a channelized environment. Isolated wetlands are no longer connected to the river and cannot provide productive benefit to riverine fisheries even though they are wetlands.

After the flood, willing landowners were given an opportunity under the Emergency Wetlands Reserve Program to dedicate all or part of their land subject to future flooding. In some areas applications far exceeded available funds. In 1994 certain landowners found themselves with the opportunity of participating in a number of federal programs including a mitigation program on the lower Missouri as well as state land acquisition programs. The result was confusion caused by seeming competition between government programs. The response of landowners was to delay decisions in some cases with the hope that another offer would arrive with even better terms. The need for coordination of these programs became evident, and over time the problem has been resolved.

The Corps of Engineers is currently engaged in its own assessment of the 1993 flood and an evaluation of systems and responses to flooding. The report at the completion of the assessment is due in the summer of 1995. The plan is expected to use the data from all sources to evaluate response to the 1993 flood event and to use modeling to extrapolate the information to consider the possible impact of increasing wetland acreage or raising levees. This analysis may prove useful as a starting point for future efforts to modify policy on the management of the floodway. It is difficult to say how far-reaching the impact of this evaluation will be.

The draft Water Resources Development Act of 1994 and other bills in the Congress last year such as the draft by Senator Baucus of Montana were responses to the flood and the Galloway Report. The provision of additional money for purchase of lands, reactivation of the Water Resources Council and plans for management changes on both the Mississippi and Missouri Rivers all generated a great deal of interest.

Regional response

The Upper Mississippi River Basin Association(UMRBA) has been following the activities in Washington, DC closely. The association worked with the Galloway Committee as well as Congressional staff to address concerns in the Water Resources Development Act. The basin association paid most attention to the call for a new institutional framework for the river. In recent years, management of the river has been accomplished almost by default. The Corps has direct authority to maintain navigation and has historically done so. The Mississippi has been recognized as a multi-purpose river by everyone including the Congress in the 1986 Water Resources Development Act[2]. While other federal agencies have authority related to the river, none have more impact on its character than the Corps' ability to plan and construct levee and navigation improvements on the river. Recently the states and basin interest groups have been discussing the need for a management structure to provide support for the natural resource base of the river which benefits not only fish and wildlife interests but also recreational/tourism objectives. The UMRBA has also completed several projects under contract with the federal government that have benefited from interstate and interdisciplinary coordination. Finally, the Environmental Management Program, designed to restore and enhance fish and wildlife habitat on the Mississippi, serves as a vehicle for partnership; but has also uncovered instances where federal program overlaps prevent decisive action.

The Galloway Report, the Congress and environmental groups all had ideas about how the river should be managed to achieve their own ends. The upper basin states were considering organizational changes as a means to support eco-system objectives. The UMRBA

[2] Section 1103 of the 1986 Water Resources Development Act, (PL99-662), November 17, 1986.

decided to invite anyone interested in the river to join in an evaluation of alternative institutional arrangements for river basin management. On November 30 and 31, 1994, nearly 200 people from federal, state and local government, as well as representatives of public interest groups met to consider several different institutional models from other river basins including the Chesapeake Bay, the Delaware River Basin, and The Tennessee Valley. The previous federal basin commissions, the more informal "Coastal America" approach and the existing state-driven organization were also evaluated during the session.

Since the conference, the UMRBA members have been considering the options and the advice of those who attended. Their conclusion is to be a formal recommendation to the basin governors. The report is likely to be completed in the next month or two. The difficult task is defining a new management framework, which identifies appropriate roles for each entity and protects states' interests.

The directors of the floodplain management programs in the Mississippi River Basin states have been coordinating closely with the basin association as a task force of the UMRBA to advise basin state representatives on issues related to floodplain management and flood response. The flooodplain managers are currently discussing potential areas for basin-wide agreement on issues related to management of the floodway, levee construction and flood response. It is difficult to predict whether the effort will succeed given the differences in programs between the states.

State and Local Actions

The state's response to the flood received substantial public approval, which reflects well on both the floodplain management and emergency response programs. Over the longer term, efforts continue to improve policies and limit future flood impacts. It has been estimated by the state that in total, over a thousand structures will be bought out or elevated to avoid future losses. The efforts in the communities noted below are the result of combined state and local cooperation.

City of Davenport: Some of the earliest footage of the flood showed the ball park at the City of Davenport as well as the downtown area by the river. National media interviewed officials and at one time the Governor was asked why the country should pay for Davenport's losses when other cities had installed flood walls and suffered no damage. The question avoided the issue of the cost of constructing flood protection. In addition, Davenport desires to maintain the integration of the city with the river and the ease of access that is lost with many flood control measures. While flood damage was a problem, the extent of the damage was not as great as the national news clips would suggest. There still is no plan for a flood wall. Structures along the river are being removed and the cost of future floods should be substantially reduced.

City of Des Moines: The drama of losing the Des Moines water plant, and later images of helicopters flying in sand bags to at least temporarily restore the integrity of the levee around the plant are etched in the minds of those who lived through it. The choppers returned later to remove the main pumps for cleaning and repair. For a short time two hundred and fifty thousand people received a personal lesson on the value of safe drinking water and the benefits of modern sanitation and fire protection.

The emergency reconstruction of essential services in Des Moines was accomplished smoothly. The levee protecting the water treatment plant has been repaired and raised by several feet. Substations for power distribution have been upgraded. Coordination and communication procedures for future events have been reviewed and improved.

A flood gate has been installed to protect a substantial section south of downtown Des Moines which was flooded when water came out of the Raccoon River, around a flood wall and ran along a railroad track to inundate an area populated by many commercial and industrial operations. In a move likely to reduce future residential losses it is estimated that approximately eighty homes will be bought out from the hardest hit areas.

Since the Des Moines water treatment plant is not only in the flood plain, but uses surface water as a source, the managing board began to consider a second plant at a different site to increase the system's reliability in times of flood or contamination of the source of water. Amazingly enough, when that plan was made public within a year of the flooding, it was quite unpopular due to its cost. At the present time the water works staff is working toward a creative alternative plan that calls for a smaller second plant. In addition, a pilot project is about to get under way which will involve pumping treated water into an aquifer for later use. Underground storage obtained from off-peak supplies is expected to provide for emergency capacity at lower cost than a larger second plant.

<u>City of West Des Moines:</u> In the suburb of West Des Moines, a Corps of Engineers flood control project has been planned for years on the Raccoon River and a tributary known as Walnut Creek. Channel improvements, levees and flood walls are all part of the solution for Walnut Creek. Construction of levees on the Raccoon itself were scheduled later, which was fortunate since the flood of 1993 caused some redesign of the project. While many homes were damaged by the flood, fewer buy outs occurred with the knowledge that the flood control project was close to being constructed.

<u>City of Cherokee:</u> This city in western Iowa sustained a large amount of damage due to the number of structures at risk in the flood plain. There is a potential for nearly two hundred homes to be acquired or elevated. One interesting development for Cherokee and other cities is an offer by the US Park Service to assist them in planning parks along the river to maintain consistent use of areas that have been bought out. While there are no federal dollars to implement projects, free technical assistance gets plans going.

<u>City of Chelsea:</u> This small town suffered flood damage five times during the summer of 1993 which led to the decision to try to relocate on higher ground. While about 80 families were considered likely to move, time has reduced the chances that they will do so. A first site under consideration was found to be

home to an endangered species of turtles. People have begun to wonder about how the move might impact them, and they are more comfortable with staying where they are. At this point only about 40 families are still firmly resolved to move out.

Looking at the state as a whole, one feature of the flood that bears comparison is the relative damage that occurred to houses affected by flooding. Missouri had the most homes that were flooded and bought out.

An article in the Fall/Winter edition of the publication "Watermark"[3] contains information regarding flood insurance claims for areas affected by severe weather in 1993 and 1994.

The three states affected most severely by the 1993 flooding in the Mississippi River basin were Iowa, Illinois and Missouri. Iowa had the least amount of insurance claims and Missouri the most. While it may be hard to compare numbers of structures, comparison of damages per structure may be more useful. The damages per structure in Iowa averaged $19,663 versus an average of $32,318 in Missouri--a difference of 64%.

Of the three states, Iowa has historically had the most restrictive flood plain management regulations and Missouri the least restrictive. There is a strong likelihood that the lower per structure damages in Iowa are due in part to the fact that Iowa has required structures constructed in a flood plain to be elevated or otherwise floodproofed to at least one foot above the 100 yr. flood for over 30 years. Missouri's flood plain management requirements are essentially those standards imposed on individual communities participating in the National FloodInsurance Program. Many of these communities did not join the NFIP until sometime in the late 1970's or early 1980's. The NFIP did not strictly enforce these standards in participating communities until the later 1980's. Therefore, there are many extremely floodprone structures in these communities.

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[3] "Watermark" is a publication of the National Flood Insurance Program of the Federal Emergency Management Agency.

Extrapolation of data to structures not in the insurance program leads to the conclusion that Iowa's regulations may have prevented as much as $70,000,000 based on differences in damage per residence. This analysis would not include damage to bridges, roads, and other public costs.

Looking at the total result of governmental responses to the flooding in the Mississippi River Basin during 1993, it is clear that much progress has been made toward reducing the likely impact of future events. The level of cooperation between governmental entities was commendable. The majority of the successes however were tied to specific projects in particular communities. Much of the recommended change to overall national policy is still only under consideration.

MISSOURI RIVER SYSTEM MANAGEMENT

Perhaps one of the most beneficial features of the floods of 1993 was the experience on the Missouri River. The Missouri River Basin was at the end of the longest and most severe drought since the drought of the 1930's when it received an increase of about 14 million acre feet above the prior year into storage due to precipitation levels during 1993. With 75 million acre feet of storage capacity in the Missouri River system, it can absorb a large inflow even during normal years. The storage of all this water at a time when the reservoirs were relatively low, however, meant that the water was welcomed rather than being the source of concerns that one or more of the reservoirs would come close to capacity. All of the people in the Missouri basin were beneficiaries of this return to more normal storage for many reasons. People in cities along the Missouri down to and including St. Louis were spared the additional burden of significant releases from the reservoirs. Water supply, recreation, navigation and hydropower could again enjoy the benefits of normal levels. Another major benefit of the return to normal storage was the reduction in tensions between upper and lower basin states due to competing needs for water.

The Missouri River Basin covers approximately 529,000 square miles including portions or all of 10 states along with 9,700 square miles in Canada. The basin originates in the Rocky Mountain region and encompasses much of the Great Plains and ends at the confluence with the Mississippi near St. Louis. During the course of its travels, the Missouri flows from mountainous areas with peak elevations of up to 14,000 feet to an elevation of about 450 feet above mean sea level at the mouth. Annual precipitation is highly variable and ranges from eight inches in the western reaches to 40 inches in the southeast portion of the basin. The extremes in climate result in major differences in crops, livestock production, dependence upon irrigation, commercial activity, population distribution and other features to the extent that different portions of the basin have developed unique characteristics that directly relate to their location in the basin. The common thread is their use and dependence upon flow in the Missouri River.

The Master Manual is the foundation of the operating plans for the Missouri River System. The term "system" is appropriate given the extent to which the river has been modified from its natural state. The plan for modifying the river evolved as a compromise between competing plans of the Corps of Engineers and the Bureau of Reclamation in 1944. The Pick/Sloan plan which resulted, provided storage to reduce the threat of downstream flooding. The lower river was channelized to utilize stored water to support navigation in times of lower inflow. In the upper basin, irrigation was planned to open up agricultural land that was otherwise limited to dry land farming for crops like corn and soybeans.

Over time circumstances changed, particularly in the upper basin states. Irrigation development never materialized as costs increased and the nation no longer needed the crops that these projects promised. As a counter balance the reservoirs have emerged as recreational resources larger than had been anticipated at the time that they were designed and constructed.

Until the late 1980's the system as completed served the needs of the basin states without basin-wide conflict. In the early 1980's, the resource was considered so plentiful that the upper basin states and the Bureau of Reclamation explored marketing opportunities. A proposal to market water out of the basin in the form of a coal slurry, known as the ETSI Pipeline Project, became a case before the Supreme Court of the United States as lower basin states including Iowa challenged the Bureau of Reclamation's marketing plans.

While the position of the lower basin states prevailed, the upper basin states continued to look for ways to use the resources of the Missouri to fuel economic development. The governors of Montana, Wyoming and North and South Dakota called for a negotiation of representatives of the basin governors to identify allotments of water that each state might utilize without interference from another basin state. After several months of intensive dialogue, it became obvious that an agreement could not be reached. Tribal water rights and their relationship to the allotments among the states was not addressed at the time and remain an issue that has taken on increasing importance.

In 1988 drought began to dominate the Missouri River basin as noted earlier. This drought was the first real test of the Missouri System since it was completed. As the reservoirs began to drop early in the drought, resort owners began to complain, because some of their facilities had been built in locations that were sensitive to changes in reservoir levels. The outcry soon reached upper basin Governors and Congressional offices. Before long, the Dakotas and Montana were a frequent stopping place for Assistant Secretaries of the Army, Senators and Congressmen as well as a host of others from Washington. With public exposure came Corps assistance in the construction of extensions to boat docks and ramps, but some locations were clearly not functional. On the whole however, economic losses to reservoir recreation were only on the order of 10% during the drought. Little concern was generated for downstream impacts. The reservoirs were functioning exactly as planned in the Master Manual. It quickly became obvious that following the plan would not satisfy upper basin states and their elected representatives.

Meetings of the basin governors were initiated by the upper basin states. Their view was that drawdown of the reservoirs had to be stopped, and there was little sympathy regarding the consequences to downstream uses. In 1989, the upper basin governors requested and the Corps committed to a review of the Master Manual to determine whether the plan could be changed to reduce the impact of drought on the reservoirs and their uses.

For the next five years, the Corps spent approximately $12 million to evaluate nearly 400 different options for system operation using a complex modeling approach. This process allowed the Corps to evaluate how different methods of operation would retain or deplete reservoir supplies during drought. Because of the Corps' own principles and guidelines documents, the analysis focused on a comparison of national economic development values. The analysis found little difference in value for the options modeled.

Over the years of study, fish and wildlife values have become the focus of interest in competition to economic values. For some time the Corps has operated the reservoir system so that the releases from the system would have less impact on the piping plover and the least tern--two endangered species that are found in the basin. More recently the pallid sturgeon has been listed and other fish species may be added in the future. Endangered species add to the equation for system operation because of the mandates of the Endangered Species Act to consider actions which jeopardize the species' continued existence. The focus of the conflict between support for endangered species and management for economic uses lies in mimicking the natural hydrograph. Since the massive storage capacity in the system is designed for flood control, it logically eliminates the impact of heavy spring inflows. In addition downstream uses rely heavily on the steady release of water throughout summer and fall. In Spring, there is not much difference between flows needed to support uses and flows which would begin to result in flooding. This is quite different from the natural hydrograph of the Missouri where year-to-year changes could be quite dramatic.

During the summer of 1994 the Corps released the study report as a draft Environmental Impact Statement and twenty supporting technical volumes. The centerpiece of the report was a new option which was put forth as a "preferred alternative". The preferred alternative included several features which appear intended to placate upper basin interests and to satisfy concerns for endangered species. The proposed alternative called for additional flow in the spring to mimic the natural hydrograph and a resultant reduction in the length of the navigation season from eight to seven months. Because of other features of the plan which modified how navigation is supported by the system, the navigation season often would fall to less than seven months.

It was clear that upper basin interests had more to gain with the alternative and they supported the plan except to call for a higher permanent pool. With the first release of the plan, lower basin states realized that the preferred alternative would increase the risk of downstream flooding. Agricultural interests noted that the plan could also prevent landowners from using interior drainage systems. Higher water tables combined with tributary flooding were believed to reduce productivity on thousands of acres with an unacceptable frequency.

On further study it also became evident that the Corps had underestimated the impact that a shortened Missouri River navigation season would have on Mississippi River navigation. Concerns for Mississippi navigation are more critical to Iowa and Missouri because the majority of their export grain moves to market on the Mississippi. Further, it was pointed out that Missouri River navigation is also dependent upon the ability to move cargo beyond St. Louis.

All of the above factors contributed to the controversy that eventually overtook the preferred alternative. Approximately 600 of a total of nearly 3,700 people provided testimony to the Corps at twenty-four hearings within the Missouri River Basin and eventually along the Mississippi as well--all the way down to New Orleans. As word of the plan and the Corps' hearings spread, agricultural interests mobilized. By the fall of 1994, when the hearings were held, farmers as well as their political representatives were out in force to declare the preferred alternative a disaster. Few issues have seen such acrimony and such extensive resort to political maneuvering. At one time or another, nearly every governor and every congressman representing a portion of the basin has written to the Corps or the President about the plan. State legislatures have adopted resolutions supporting their state's view. At the last minute the Environmental Protection Agency added its view that the Draft EIS was totally inadequate. While the comment period is now over, the matter has not been put to rest. The Corps has been evaluating the comments that were received and considering its next move

With this conflict as a back drop it may seem impossible to look for a solution. Even without all the rhetoric, it is a complex task. The Corps will have a difficult time resolving the matter. Several new studies are needed, and even then there is no assurance that the selected alternative will survive unchallenged.

The States and Tribal representatives in the basin have come to realize that there may well be no acceptable, lasting solution without a consensus on their part. Within this context, since about November of 1994, the Missouri River Basin Association began discussing how it might initiate a consensus building process. At this point the states and the tribes are committed to make the effort with the help of a facilitator.

CONCLUSION

Both the Mississippi River flooding event and the Missouri River drought demonstrate the level of the public's concern for major incidents and their desire to see action. The difficulty of making fundamental changes in public policy dictates a prompt and highly visible response once the period of crisis is over. The floods of 1993 brought quick action at all levels of government as illustrated by the examples discussed in this paper. The buyouts, preventive measures and improvements will serve urban areas well during the next flood. The ultimate fate of federal review of key national policies is yet to be determined. The shift in parties in the Congress and the resulting new agenda may overshadow the need to complete this work.

On the Missouri, time may become an ally of those who prefer the status quo for the Master Manual. Flooding, and not drought, is now the matter of greatest importance to the basin. While the evaluation of the problem and alternative solutions has taken a long time, the process and the proposed solution have created continued controversy and maintained a high degree of public awareness as a result.

In the case of either river basin, the measure of the effectiveness of public and private efforts will be the extent to which people impacted by the next events can see that the response to the problem is quicker and more organized. In the alternative, hopefully someone will observe that the resulting devastation is clearly less than it would have been absent the physical changes that have been made.

NEW REALITIES FOR FLOOD MANAGEMENT POLICY

Edward R. Osann[1]

ABSTRACT

The Bureau of Reclamation has undergone a transition from a construction-oriented agency to one focusing on water resource management. The agency is redefining its approach to water resource management, including flood damage reduction, to be responsive to both environmental and economic needs. New political realities have influenced Reclamation's approach. Deficit reduction priorities dictate that Reclamation will not be building anymore new dams, will be divesting itself of local projects, and will be calling for more local participation and responsibility. Upcoming changes in Reclamation's approach to flood damage reduction will be reflected in facilities, operation, hazard mitigation, and flood recovery activities.

INTRODUCTION

When many people think about flooding and flood management, the Bureau of Reclamation does not jump to mind. Most people know us as the largest supplier of water in the 17 Western States, delivering each year about 30 to 35 million acre-feet of water for agriculture, municipal, industrial, and domestic uses. But many Reclamation projects serve multiple purposes, including flood damage reduction, hydropower generation, recreation, and fish and wildlife protection and enhancement. And Reclamation has the principle responsibility for managing Federal flood protection works on the Lower Colorado River.

Reclamation as a Water Resource Manager

Over the last two years, the Bureau of Reclamation has undergone a transition from a construction-oriented agency to one focusing on water resource management. As part of that transition, which continues today, we are redefining our approach to water resource management issues -- including flood control.

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These decisions must be responsive to both environmental and economic needs. At the same time, we are being challenged to manage the natural resources and the physical structures entrusted to our care with an increasingly limited budget. Within the past two years --

- Our annual budget has been reduced by nearly $100 million;
- The number of employees has been reduced by 20 percent;
- We have approved buy-out offers from an additional 700 employees, which will soon bring our personnel reduction to 25 percent.

But reinvention at the Bureau of Reclamation has involved more than just curtailment -- it has involved empowerment as well. Also within the past two years --

- We have transformed our largest office, in Denver, from a "corporate headquarters" to a technical service center that must be competitive to sustain its workload;
- We have transferred day-to-day decision-making to our regional and local offices, transforming our front line staff from narrowly focused "project managers" to more broadly responsible Area Managers, who are charged to be problem solvers within their respective geographic areas;
- We have reviewed every internal regulation and instruction we have -- a pile of bureaucratic dicta that stacked up to be 10 feet high. Two feet of these regulations have already been trashed (actually recycled). The remainder -- nearly 8 feet -- will be reduced to about 6 inches of guidelines, not regulations.

Under the Administration's second Reinvention of Government Initiative, just announced by the President and Vice-President earlier this week, more changes are in the works. In particular, Reclamation will undertake an aggressive effort to review scores of projects and facilities where title is currently held by the Federal government, for potential transfer to States or water users. We will retain title to those facilities where significant national or interstate interests make a compelling case for Federal ownership, and seek to transfer title to facilities of purely local interest.

The New Politics of Flood Management

First and foremost, let me address the most important aspect of the new politics of flood management: deficit reduction. Over the last two years, this Administration has made a major commitment to deficit reduction, and it is paying off. As a nation, we've made remarkable progress addressing many of the key economic problems we faced:

- The deficit has been cut in half as a share of the economy;
- More than 6 million new jobs have been created, 93% of them in the private sector;
- Unemployment has been cut by 20%;
- We have had growth without damaging inflation: In 1994, the real Gross Domestic Product increased 4% -- the largest annual increase since 1984 -- while the core rate of inflation was 2.6%, the lowest level in almost 30 years.
- This has brought the so-called "Misery Index", which is the combined measure of unemployment and inflation rates, to its lowest level in twenty-five years in 1994.

Clearly, major challenges remain, and further deficit reduction is planned -- thoughtful reductions that will allow for targeted tax relief for the Middle Class. But with the 104th Congress having campaigned on cutting Federal domestic programs even further, two things are certain for Federal water resource agencies --

- In the future we will have even fewer staff; and,
- In the future we will have even less money.

Speaking for the Bureau of Reclamation, the implications are clear:

- We will not be building any large new dams; and,
- We will be divesting ourselves of local projects;
- We will implement the Administration's call for more local participation and responsibility for flood damage reduction at all stages -- planning, financing, implementation, and maintenance.

Relationship Between Floodplain Management and Water Resource Management

Let me turn to the relationship between water resources management and floodplain management. Floodplain management is one aspect of watershed management, which itself is a subset of water resource management. Flooding must be considered in the context of the watershed, the floodplain, and the river. It is not surprising that many of the problems with the Nation's historic floodplain management practices identified by General Galloway hold true for water resource management in general.

Reclamation is responding to some of these problems by approaching water resource management using watersheds as the appropriate geographic boundary, but using "problemsheds" to guide selection of the appropriate size of the watershed to confront. How our approach differs from the past is that we are not continually committing Federal dollars to construct new facilities. Rather, we look first to the operational changes in basins and river systems that are needed to ensure that competing water resources interests are fairly and intelligently addressed.

There is an important distinction to be made here, if it hasn't come out already. The focus is no longer solely on flood control, but on floodplain management. The 1994 Unified National Program for Floodplain Management asserts that the goal of sound floodplain management is to reduce the vulnerability of the Nation to flood damages, while concurrently enhancing and preserving the natural and beneficial functions of the floodplain. Reclamation's mission and principles, stated in our basic reinvention document, the Blueprint for Reform, are not only compatible but completely consistent with this perspective. With the Blueprint, the Unified National Program, and the Galloway Report as our guides, Reclamation will develop and implement innovative solutions, in partnership with others, to tackle contemporary water resource problems in Western States and communities.

Naturally, as a water resource manager we must address issues associated with flood damage reduction. Our new approach to flood damage reduction is evolving. Because we no longer have a major construction mission, our approach to floodplain management concentrates on the following areas:

- operations and maintenance of our facilities,
- hazard mitigation,
- flood damage recovery, and
- the need to develop and maintain partnerships for these efforts.

Let me briefly address each of these areas.

Facility Operation

Some flood control activities have ignored the fact that flooding is a natural phenomenon to which many species are not only adapted, but rely upon. Nowhere is this more evident that in the streams of the West where, because of flood control and water diversions, the riparian corridors of vegetation are severely degraded. In some locations where banks are rarely overtopped, cottonwood seedlings no longer germinate and the existing trees are dying of old age. Farmers and ranchers who value cottonwoods for shade, wind breaks, and breeding habitat for birds that keep insect populations down, recognize the significance of the loss of cottonwood stands and, in some areas are asking for periodic flood flows. Similarly, numerous fish rely on the backwater habitats created by spring floods. In response to these concerns, Federal and local agencies with flood control responsibilities find themselves creating or allowing small controlled flood events. In many areas ranchers, farmers and environmentalists are joining together to ask for new approaches to traditional flood control -- this is part of the new flood politics.

Hazard Mitigation

Let me turn to hazard mitigation. Like all facility managers, Reclamation has a responsibility to ensure the safety of the public that could be affected by operation or failure of our facilities. In light of this obligation, Reclamation recently completed a detailed survey that revealed that fewer than 10% of the communities downstream of our facilities have dam-specific emergency evacuation plans. Fewer than half of these downstream communities have any generic all-hazard emergency operation plans at all. In response to that finding, Commissioner Dan Beard announced in February a new effort to provide immediate technical assistance to downstream communities that wish to establish dam-specific emergency evacuation plans. This help includes providing inundation maps, flood travel times, technical expertise, and review of local dam-specific plans. Reclamation will help local jurisdictions conduct exercises to verify the effectiveness of these plans. $1.4 million is budgeted this year for that purpose, and we plan to continue this program as long as their are communities who need this assistance.

This effort is just part of the $100 million we will spend in FY 96 on dam safety. In the last ten years, we've tripled dam safety as a percentage of our budget from about 4% to 13%. Public safety has to be a paramount concern for our organization.

Flood Recovery

Now let me address the third fundamental area of Reclamation's review of its approach to floodplain management -- flood recovery. The nation's response to and recovery from the 1993 Midwest flood broke new ground in many ways. Federal and state agencies came together to not only expedite recovery, but to ensure that recovery did not result in recreating flood damage risks. Opportunities to change the way of doing business were sought -- over 8000 family homes in more than 120 communities were removed voluntarily from the floodplain. Federal programs purchased, from willing sellers, easements or the title to 100,000 acres of flood-prone farmlands for use in conservation efforts. (Were sufficient funds available, federal and state agencies would have been able to acquire more than 60,000 additional acres from willing sellers.) These endeavors not only limit losses to floodplain occupants, but limit repetitive federal outlays associated with recurring floods as well. They also serve to protect and enhance the natural environment that exists in floodplains and rivers. The current fiscal realities, coupled with increased environmental awareness and concern, are driving such activities to become the norm.

Reclamation is developing policy that builds on the lessons learned from the Midwest flood:

- We will work more closely with FEMA and the Corps of Engineers during response and recovery;
- We will seek input from federal and state resource agencies during recovery;
- When appropriate, we will participate in the Interagency Hazard Mitigation Teams that after a flood, identify opportunities to reduce hazards;
- We will look for opportunities to create habitat during the repair of flood damaged infrastructure;
- We will evaluate flood induced changes in channel morphology for opportunities to reconnect rivers to their floodplains; and
- Where floods create habitat, such as scour holes, we will strive to maintain that habitat.

Partnerships

Clearly, water resource and floodplain management cannot occur in a vacuum. Reclamation has adopted partnering with stakeholders as both desirable and necessary to achieve sustainable solutions for water resource management. Partnering not only seeks the active involvement of stakeholders in defining needs and establishing goals but also provides a means to leverage increasingly limited fiscal and staffing resources. Partnering not only encourages local involvement but builds local responsibility. The federal government cannot be the sole party accountable for floodplain management; citizens and local governments must exercise their share of responsibility to avoid vulnerability to floods, be prepared for and respond to floods, and recover from flood events.

Partnering enables the federal government to contribute funds and expertise to address problems of floodplain, watershed, and water resource management while enabling state and local governments to have a fiscal stake in the outcome. Without this stake, few incentives exist for them to be fully involved in floodplain management and to make responsible and difficult decisions. Both partnering and increased non-federal cost-sharing are realities of the new politics of water resource management, in general, and floodplain management, in particular.

Conclusion

The Bureau of Reclamation has come to appreciate the significance of ecosystems and recognizes that the tremendous changes in and loss of riparian and aquatic habitat in the West have brought about severe ecological consequences. Reclamation is striving for better ways to manage water resources.

Reclamation concurs with the vision articulated in *Sharing the Challenge* -- we believe that the vision articulated for floodplain management holds true for water resource management as well. Our efforts are consistent with the themes articulated in the report. It is also our experience that attention to water resource management varies widely among and within federal, state, tribal and local governments. Yet we firmly believe that water resource management is a shared responsibility in which all stakeholders must participate to solve complex challenges. It is only through sharing responsibility and accountability that sustainable management can be accomplished.

ENVIRONMENTAL ASPECTS OF FLOODS AND FLOOD MANAGEMENT

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Abstract: Wildlife and human use of floodplains relative to function and values is discussed along with an overview of the effects of the 1993 Midwest Flood on natural resources. Public perceptions, federal policy, and the role of the Fish and Wildlife Service in floodplain management decision-making is also provided.

When discussing environmental aspects or natural resource features, we occasionally speak in terms of functions and values. We would say that floodplains function as habitat for fish and wildlife, they function as agricultural production areas, and/or they function as flood attenuation zones, as examples. Each of these functions has value then, in terms of tangible economic value such as sportfishing, commercial fish harvest, food and fibre production, or prevented flood damage. They also have intangible values, such as biodiversity, natural heritage, cultural heritage, and community cohesion. These are a few of the environmental aspects - interactions of wildlife, fish, AND people - that must be considered in flood management decisions.

National goals for a stable food supply have been manifested as public policy and Congressional action, resulting in the dominance of agricultural production as the primary function of floodplain lands in the Mississippi Basin. In order to serve this societal goal, the habitat and flood attenuation functions had to be reduced. This isolated large areas of the floodplain from their rivers, and resulted in losses of the range of beneficial functions and values associated with inundation of undeveloped floodplain. Lets' consider some components of the Mississippi floodplain and the effects of flooding on those component resources.

Public and private lands along the Illinois, Mississippi, and Missouri, contain a variety of habitats created by riverine processes. Trees, wetland plants and aquatic plants all exist in response to a combination of elevation, soil type, and hydrology. On floodplains, a change of elevation of 2 feet will find you stepping up from silver maple and ash to a mixture of oaks, walnut, and pecan. Very small differences in the frequency and duration of soil saturation - hydrology - will make very large differences in plant species in and around open water areas. As discrete and delicately balanced as these habitats seem sometimes, we remember that they have developed in response to those seasonal indelicacies in river discharge, known as floods. With the development of these habitats and the seasonal cues of temperature and flow, fish assemblages evolved that take advantage of flooded terrestrial habitats for spawning and nursery use.

Floods generally occur as spring and fall events, even the 1965 and '73 spring floods were up and down before the growing season was in full swing, and flood effects were minimal and fairly well accepted as a reality of river resource management. The flood of 1993, however, lasted through the spring and through most of the growing season over large parts of the Mississippi Valley.

In terms of wildlife, on both public and private land, thousands of acres of forested land, farmland, and non-forested wetlands were unusable during the lifecycles of many species. Initially, it was hoped that floodplain forest species would rebound as they had from events past, but a year later, the toll on forest resources is still growing as those trees not outright drowned during the event continue to succumb to stress and disease. Non-forested wetlands were impacted by sedimentation, resulting in a different mix of wetland vegetation available to floodplain wildlife. The usual flood periods, both spring and fall, occur during the dormancy period for trees and during periods of migration or other cyclic movement of wildlife. Because the 1993 event duration extended from the dormancy and migration period through much of the growing and breeding season, many species dispersed to adjacent upland areas and unflooded drainage district units. Other species that require emergent, or non-forested wetlands for nesting such as king rail, least bittern, American bittern, coots and pie-billed grebes, were simply out of luck in the Mississippi bottoms below Quincy, Illinois. As of 1994, these birds had not returned to Missouri's Ted Shanks Wildlife Area. Dispersal and concentration puts wildlife in competition with those species already occupying suitable habitat, and contributes to disease, stress, and overall mortality. Wood ducks which nest in tree cavities fared well during the nesting period, but traditional brood habitats in forest understory and lotus beds were unavailable, causing these birds to disperse throughout the floodplain. Bag information for 1993 indicated that adult-to-juvenile harvest ratios were similar to previous years. This actually means that there was no net effect on the flyway wood duck population. Because the water was so high for so long, aquatic and wetland vegetation that other waterfowl species rely on during the migration were not available in the floodplain. It was noted that they dispersed widely along the flyway in search of food rather than concentrating in the river corridor. Effects on our colonial nesting birds primarily great blue herons and American egrets were varied. In Pool 16, nest trees have been unaffected so far, and remain available to that colony. During the flood, foraging habitat was greatly expanded for these species, and predator access to nesting colonies was limited. Where the flood killed large, open canopy trees such as those for the nesting colony on Denmark Island in Pool 24, herons and egrets have abandoned the area. Although... the same numbers of foraging birds were observed during 1994, leading the local wildlifers to conclude that the birds have successfully nested elsewhere without aggregating into an identified colony as yet.

Overall, habitat changes have resulted in shifts in ranges for local populations of squirrel and turkey, which relied on mast-producing timber, but deer have responded well to the new conditions. The flood opened up the forest floor to sunlight, and provided a new seed source, so resource managers anticipate shifts in the plant communities throughout the Mississippi. 1994 observations of large tracts areas where trees were killed revealed substantial new growth of herbaceous forage and tree seedlings. With the proper hydrologic conditions, these areas of thick groundcover will provide excellent deer forage and seed sources for migrating waterfowl for several years, until tree species overshadow the groundcover.

The net effects on natural resources remain to be evaluated over the long term. To summarize, typical flood effects on wildlife and the effects of the '93 event, were life cycle interruption, dispersal and competition leading to mortality, and habitat loss. The flood caused shifts in wildlife range in response to changes in the plant community, and It is likely that future managers will note this event as resetting of the biological clock, much in the same way a forest fire opens up a forest to provide a mix of young vigorous growth among remaining tracts of older growth.

In terms of fisheries, the sustained high water throughout the spawning season into the late summer resulted in greater year classes of most species of both commercial and sport fishes. Young of the year fish were provided access to nutrient sources enriched by inundation of terrestrial floodplain habitats. Competition for resources was reduced, adding to greater survival of larval and juvenile fish. In some areas, habitat gains were significant in terms of creation of off-channel habitat. In other areas, gains only lasted for the duration of the event, following which, scour holes such as these were filled to form foundations for levee reconstruction. To summarize, our riverine fish communities largely benefited from completion of life cycles historically keyed to flooding, they benefited from dispersal and reduced competition within and between species, increased nursery habitat provided greater survival of young fish, and they benefited simply by increases in habitat. In much of the river, even where scour holes were not filled in by levee reconstruction, deep holes are anticipated to have a relatively short life due to sedimentation.

Following the flood, Fish and Wildlife Service policies regarding refuge management in floodplains were called into question by many who consider us to be opponents of flood control...basically, if its okay to use levees to protect natural resource values, why can't levees be used to protect other human values. In response to the first issue, the Service is not an opponent of flood control. We are a proponent of sound floodplain management, but in the federal water resources planning process, we can be neither an opponent or proponent of specific development projects engaged through federal funding. To address the second issue, I need to briefly explain our use of levees in the context of wildlife management. The Upper Mississippi River National Wildlife and Fish Refuge, The Mark Twain National Wildlife Refuge, the Illinois River Refuges, Swan Lake and DeSoto on the Missouri all contain levees. These structures were all inherited, that is they were in place at original design heights at the time of acquisition. The FWS employment of these structures at our river refuges, and refuges elsewhere, is directed at recapturing portions of the natural hydrologic cycle to achieve invertebrate production for the spring migration and seed production for the fall migration. Thus, our levee or berm use is aimed more toward water retention rather than exclusion. This is intended to mimic flood cycles to gain optimum habitat response. Most of the mainline levee portions on Refuge lands now have water control structures installed to gain gravity inflow, and interior levees that serve to retain water at critical points in the migration. Our drainage works and pump use is employed where artificially high water tables limit germination of moist soil plants.

The flood caused the FWS to reevaluate floodplain wildlife management strategies in terms of ecosystem function. That is, how can we work with the river and its processes. For the most part, we have been trying to maintain those processes. In one area, the Clarence Cannon Division, we are reconstructing damaged levee portions as spillways to allow the river access to the area during high water events. By providing for controlled overtopping, we anticipate a contribution to flood attenuation as well as reducing damage to internal refuge infrastructure. At Chautauqua Refuge on the Illinois River, we are setting back 8,000 feet of levee by a quarter mile to increase the floodway and add uncontrolled floodplain habitat. In some places the only solution is to protect an area from further perturbations brought about by altered sedimentation patterns and impoundment, like Lake Odessa. Overall, our policy is to restore floodplain and river seasonal connectivity wherever possible. As one of our managers describes it, we must resort to further artificial means to manage resources in an artificial system. What is natural versus artificial? Artificial generally refers to the leveed floodplain, stabilized higher water levels from navigation system maintenance, and the need to recreate seasonal wetting and drying of floodplain habitats that would occur in an unregulated river ecosystem.

As I mentioned, the range of habitats and organisms occupying floodplains have developed in response to the physical and chemical dynamics presented by biannual flood events. The most visible example being migratory birds, whose spring migrations coincide with invertebrate protein production in permanent and ephemeral wetlands, and fall migrations which key with inundation of seed and tuber sources to provide the fats and carbohydrates necessary for overwintering. Spring spawning in river fish is also cued to the higher flows and temperatures occurring during flooding. Throughout this process, nutrients are being cycled on the inundated floodplain, forming a base link in our food chain, and the foundation for ecosystem function and health. Ecosystem planning must include consideration of these processes. Which then begs the question: What is ecosystem management and how is it different from traditional management?

Besides labeling the Service as flood control opponents, many have expressed concern that ecosystem management is a program of this agency designed to take ownership or control away from floodplain landowners against their will. During our 1994 field season, our agency staff encountered several landowners who had heard that the FWS was somehow part of a larger movement to restore wetlands at the expense of agriculture throughout the river valley. For the record, ecosystem management is not a "program" of this agency, it is an extension of traditional fish and wildlife management that centers around our own land base within given ecosystems and focuses on partnerships with other agencies, groups, and individuals to maximize or leverage the resources of those groups to achieve enhancement of biodiversity throughout the nation. We recognize that private landowners have an interest in wildlife stewardship, yet also are subject to economic realities of land management. Ecosystem management does not compromise private property rights. And, as I mentioned previously, it is not intended to replace traditional management activities on our Refuges. Regarding floodplain land acquisition, the FWS deals only with willing sellers...there is no agency agenda to force people off floodplain lands, and there are current laws preventing such action. The main problem with acquisition, by any agency, is that lands offered for acquisition including those under the Emergency Wetland Reserve Program, far exceed the both the staff and funds available to FEMA, the NRCS, and FWS for such acquisition, and acquisition is proceeding at a painfully slow pace for those individuals currently involved.

To close out with our role in floodplain management, our interaction with agencies responsible for flood damage reduction planning and construction involves project alternative analyses, wherein we seek the least ecologically damaging alternative within an array of alternatives designed to solve the problem. Our opposition to portions of a given project, such as borrow site selection, does not mean that we are opposed to flood control in general. Somewhere in the flood of rhetoric that followed the original flood, FWS missions for habitat conservation have been portrayed as anti-agriculture leading to a large communication gap between ourselves and the public. Because our mission includes fish, wildlife, AND people, we cannot ignore or discount human interaction with other ecosystem components. We recognize the value of floodplain agriculture to maintenance of wildlife populations. Floodplain croplands provide seasonal cover and food for a variety of species, and fill critical gaps in wildlife food requirements when natural food sources fail. Remaining sloughs and oxbows provide fish and wildlife habitat. Part of our annual joint duck banding efforts with the states takes place on private lands in the floodplain...we couldn't trap 'em if they weren't growing 'em. For floodplain inhabitants, no flood is good, but the Fish and Wildlife Service recognizes that the flood of 93 was without parallel in terms of human suffering and economic hardship. During the flood, our agency made staff and equipment available for emergency assistance, following the flood, we participated on FEMA's interagency Hazard Mitigation teams, Corps of Engineers levee rehabilitation teams and SCS coordination teams for the Emergency Wetland Reserve Program. The effects of this flood will be felt for years to come as communities and individuals make choices about their livelihoods and lifestyles in flood-prone areas... and the federal government evaluates its policies and programs for flood control.

Our agency's habitat conservation mission continued throughout the post-flood period with an ongoing effort to assist individual landowners. In response to the flood, Congress provided the FWS with funds for habitat restoration on private lands in the floodplain. This funding will remain available through this October and is to be used specifically on floodplain lands for actions similar to those under our Private Lands program. Our funds can be pooled with those from other agencies or groups. Rather than seeking an easement, landowners are asked to sign a development agreement indicating their intent to limit alteration of the affected parcel. This agreement is variable depending on landowner preferences, but 10 years would be typical. The types of habitat targeted for restoration are wetlands, forested, and aquatic habitats, in any combination as desired. Here is a before, and after a successful restoration. This restoration assistance is available through these offices.

As previously noted, society and public policy have driven past land use decisions. As societal goals have evolved, so has an awareness of the natural and beneficial functions of floodplains. This has likewise manifested itself in public policy, specifically with the 1977 Executive Order for Floodplain Management and individual state statutes; and generally within the larger contexts of the Clean Water Act and the National

Environmental Policy Act of 1969. These policies have run headlong into those previously embodied policies for flood control and agricultural production. Because these policies have some divergent features, and are administered by an array of government agencies, they are not easily reconciled during federal water resources planning. The net result has been substantial confusion on the part of the general public and floodplain property owners themselves regarding the roles and responsibilities of the federal government in flood control. Although that confusion is fading along with memories of the 1993 event, I believe that this conference will contribute to keeping floodplain management issues on the front burner at all government levels and within the professional community. I want to thank the US Committee on Irrigation and Drainage for this opportunity to discuss resource issues and our agency's role in floodplain management.

FLOOD DAMAGE CONTROL ALTERNATIVES
(STRUCTURAL AND NON-STRUCTURAL APPROACHES)

David W. Miller[1]

ABSTRACT

Major floods which have recently occurred in Europe, Asia, and the United States have shown that enormous damages can result even when flood control structures have performed as designed and prevented greater devastation. Lessons learned from these floods have accelerated efforts to integrate non-structural approaches with structural measures.

This paper reviews a range of projects that rely on structures to control flood waters. The paper also draws on observations presented by the Interagency Floodplain Management Review Committee whose study of the 1993 flood on the Mississippi and Missouri Rivers led to recommendations for improving non-structural programs.

INTRODUCTION

Floodplains have always offered advantages for development. Rivers provide transportation, recreation, water supply, and waste removal. The fertility of floodplains encourages agriculture, and their flat topography stimulates development of towns, railroads and highways.

Floodplains are frequently developed as if the threat of flooding did not exist. The inevitable result is that property located in floodplains suffers periodic damage. Two approaches to reducing these damages are 1) relocate development to otherwise less advantageous areas away from floodplains, or 2) install structural measures and implement non-structural practices to confine looding and to minimize damages from floods that cannot be contained.

STRUCTURAL FLOOD CONTROL

history of flood control in this country, levees, dams, and easures have received much greater emphasis than have non-

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structural measures. The first flood control project in the United States was built by plantation owners along the Mississippi River near New Orleans in 1717. As more extensive measures were required to protect expanding urban areas, floodplain inhabitants joined forces to install flood control reservoirs and levees. In 1879, the United States Congress assumed some responsibility for flood control in creation of the Mississippi River Commission, and in 1917 Congress initiated programs of levee construction along the Mississippi and Sacramento Rivers.

Miami Conservancy District

An example of an early flood control project that continues to operate successfully is the Miami Conservancy District in Ohio.

On March 23, 1913, the Miami, Stillwater and Mad Rivers swept through Dayton and surrounding communities in the Miami Valley. More than 360 lives were lost and property damage exceeded $100,000,000. On March 20, 1914 a hearing was scheduled before the Ohio Conservancy Court to determine whether the Miami Conservancy District should be organized, and in June 1915 formation of the District was authorized. The District adopted an Official Plan Flood (OPF) for design of flood protection measures with a discharge roughly 40 percent greater than the 1913 flood.

Five hydraulic fill dams were constructed as retarding basins with un-gated outlet works and uncontrolled emergency spillways so that water would be stored only when inflows exceeded the capacity of the outlet works. Fifty miles of levees were also constructed in Dayton and other communities along the Great Miami River. In November, 1922, less than ten years after the date of the disastrous flood, the major flood control works of the Miami Conservancy District had been completed.

During the past 70 years, flood storage in any of the Conservancy District reservoirs has not exceeded 30 percent of maximum capacity and discharg along the levees has not been more than about 60 percent of the chann capacity. Nevertheless, questions regarding the ability of the Distric structures to safely pass the Probable Maximum Flood have led to enlargement of spillway capacity at three of the dams.

In 1992, Harza completed an assessment of the impact of e the existing flood control works and surrounding communit Weather Service DAMBRK flood forecasting computer mo determine peak discharges and river stages at levees along River for storms centered at 10 locations in the District.

were analyzed for all floods. The first case assumed all levees were raised to prevent overtopping. Under this condition flood peaks were transmitted downstream with little attenuation except at reservoirs. The second case assumed existing conditions at all levees. Under this case, when levees were allowed to overtop, flood peaks were reduced allowing downstream river reaches to effectively contain flood flows.

Additional routings were performed for three storms that appeared to be critical for the levees. These routings simulated sequential raising of levees in a downstream progression. The results of these simulations indicated that significant overtopping occurred at most levees when storms were centered on critical locations. However, when levees were allowed to overtop, storage of floodwaters behind the levees reduced flood peaks and the extent of overtopping downstream. The study also noted that while significant reaches of the river are not protected by levees, these reaches are characteristically narrow and result in little attenuation of peak flows. Therefore, the effects of overtopping of upstream levees on downstream peak discharges are significant.

Ross Barnett Reservoir

The Miami Conservancy District flood control structures were designed for the purpose of protecting property from flood damage; the ability of District dams to perform this mission was maximized by designing structures with pools that are normally dry. By contrast, the Ross Barnett Dam and Reservoir were designed principally for water supply and recreation, two missions that require maintaining high reservoir elevations.

A 1982 study recommended expanding the missions served by Ross Barnett to include flood protection for Mississippi's capital, Jackson, located some six miles downstream on the Pearl River. The 1982 study recommended releases from Ross Barnett sufficient to allow a maximum drawdown of 1.7 feet when predicted inflows exceeded 15,000 cfs. Use of the original flood operation procedure, based on inflow forecasts every 12 hours, reduced estimated maximum reservoir releases during the 15-year flood from 65,400 cfs to 51,700 cfs and lowered estimated damages caused by the 15-year flood by $15.8 million. Since development of the original recommendations for the flood control plan, reservoir operation has been improved through experience in operation and modernization of the flood forecasting system.

Ross Barnett Dam and Reservoir achieves the operational flexibility necessary to balance its water supply and recreational functions with its capability to control flooding by including features that were not required on dams constructed by the Miami Conservancy District. In particular, the gated spillway on Ross Barnett permits operators to draw down the reservoir in advance of anticipated floods and to regulate reservoir level and discharge to absorb, attenuate, and pass flood peaks.

In addition to a gated service spillway, Ross Barnett Dam includes a fuse plug located near the left abutment of the dam. This structure is designed to begin failing when water levels threaten to overtop the dam. If completely washed out, the fuse plug is sized to pass the same flow as the fully opened gated spillway so that if lake levels begin to fall as the fuse plug fails, the spillway gates can be closed to reduce the volume of water being discharged downstream. Flood flows released by Ross Barnett are contained within a system of levees providing Jackson with a further level of structural protection.

Comparing the approach to flood control used in design of the Miami Conservancy District's facilities with the approach implemented at Ross Barnett illustrates an evolution from single purpose projects to projects where structures are intended to combine flood protection with other missions. Structural features at both the Miami Conservancy District and at Ross Barnett are supplemented by non-structural programs to minimize flood damages. The integration of non-structural measures with structural facilities represents a further step in the evolution of flood control.

APPLICATION OF NON-STRUCTURAL MEASURES

Recent floods that have struck North America, Europe, and Asia have resulted in major damages even when flood control structures functioned as intended and prevented damages from reaching much higher levels. The loss of life and damage to property caused by these floods have accelerated a shift from reliance on structural measures alone to approaches that combine use of existing structures with active non-structural programs.

Sharing the Challenge: Floodplain Management into the 21st Century (the Galloway Report) prepared by the Interagency Floodplain Management Review Committee headed by General Gerald Galloway of the U.S. Military Academy examined the effects of the 1993 flood in the Upper Mississippi and Missouri River basins and reported recommendations in response to what was learned. The principle recommendation of the Galloway Report was to change the nation's strategy for reduction of flood damages from reliance on structures to full use of all structural and non-structural means.

The Galloway Report estimates that in the Upper Mississippi and Missouri River Basins, existing flood damage reduction projects and floodplain management programs worked as designed and greatly reduced damages to population centers, agriculture, and industry. The report estimated that flood control structures that were put in place as part of the 1936 Flood Control Act and those that were built by local communities and individuals prevented over $19 billion in potential damages and that watershed projects built by the Soil Conservation Service saved an estimated additional $400 million.

Flood insurance

An important observation presented in the Galloway Report is the need to share the financial risk of urban and agricultural floodplain development equally among all levels of government and private citizens. Among the non-structural mechanisms used to manage the risk of flood damage is flood insurance.

In designing a flood insurance program, the ideal is that premiums accurately reflect the risks so that developers and owners are aware of the true costs of building in a floodplain. A danger is that if premiums are too low or if benefits are paid to people outside of the pool of policy holders, flood insurance will encourage unwise development.

The Interagency Committee found that the National Flood Insurance Program (NFIP) had been ignored by many local governments and private citizens because, in some instances, communities not participating in the NFIP continued to receive disaster assistance. This has led to a perception among floodplain residents that purchase of flood insurance is unnecessary because owners of flooded lands receive compensation from the federal government whether or not they participate in the NFIP. The consequence of this restitution is that those who own property in floodplains retain the rewards that f. accrue from the generally favorable location while transferring the risks of ...od damage to the general public.

...agency Committee recommended improving the marketing of flood ...d reducing the amount of post-disaster support paid to those who

For most of the ...to buy insurance but did not. To provide a safety net for those

other structural m... ...od damages but were not NFIP participants, the Committee ...ments be reduced to a level needed to provide for immediate ... welfare of the flooding victims who were unable to afford

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Company, 233 S

Buyouts

In cases where the real costs of flood insurance are high relative to the value of the property being insured, a second, more radical measure to limit damages in flood plains is to buy out properties replacing the buildings with land uses that will not be extensively damaged by flooding.

The Galloway Report recommended a dramatic expansion of the amount of funds available for buyout of flood-damaged properties. Prior to the 1993 flood, about $5 million a year was set aside for buyouts and mitigation to acquire and protect the most flood-prone rural and agricultural lands. Under a 1993 law, the Federal Emergency Management Agency can now set aside 15 percent of the cost of federal disaster aid for mitigation measures. This measure was actually put into practice during and after the flood of 1993 when the Administration established buyouts of flood-damaged properties as the first priority for mitigation funds during the flood. By the end of April of 1994, the federal government had approved applications from 61 communities for acquisition or relocation of 4,181 buildings. This initiative presents a turning point in flood recovery policy, since it is the first time that buyouts have been attempted on such a large scale.

The work of the Interagency Committee emphasizes the benefits of flood management strategies that link structural and non-structural measures. The report also underscores that a successful implementation of non-structural programs depends on a clear understanding of how landowners and residents are likely to respond to proposed programs. In this respect, lessons learned from the Mississippi River flood of 1993 can be augmented by observations drawn from the 1992 flood on the Jhelum River, a tributary of the Indus River in Pakistan.

JHELUM RIVER FLOOD

In September 1992, the spillway of Mangla Dam in Pakistan successf... passed a flood of over 900,000 cfs matching the spillway's design... Passage of this flow was a tribute to the spillway's design and... likelihood, averted failure of the dam. Nevertheless, enormou... experienced downstream of the dam and concerns were rai... whether these damages had been exacerbated by operation... gates. The general conclusion drawn from analysis of the... potential for reducing the flood peak through reservoir op... overwhelmed by the magnitude of the storm.

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In addition, it appears that much of the destruction may have resulted as an unintended and ironic consequence of the dam's previous success in controlling flooding. Having observed the reduction of flood peaks that followed completion of Mangla Dam, thousands of people settled in the floodplain, an influx that greatly increased the consequences of the 1992 flood.

While the 1992 flood caused extensive damages immediately downstream of Mangla Dam in Punjab Province, farther downstream, in Sindh Province, flood damages were much less severe. To a large degree, damages in the Sindh were reduced because flooding in the Punjab absorbed peak flows. Damages were further reduced by a flood fighting strategy intended to protect the Sindh's extensive irrigation system. To prevent flood waters from damaging key diversion structures spanning the Indus River, river crests were reduced by diverting flow into irrigation canals and spreading the flood waters throughout the irrigation system. This approach was successful as the only breaches in irrigation canals occurred where embankments were deliberately cut to discharge flows at points where flooding was judged to result in relatively minor damage.

While a consequence of spreading flood flows throughout the irrigation system was inundation of farm land, particularly land in the downstream reaches of canals, towns and villages were spared extensive flooding and none of the key irrigation or flood control structures were damaged.

CONCLUSION

Property and lives in floodprone areas are inherently at risk from flooding. Structural measures to control flooding have succeeded, in many instances, in minimizing frequent floods and in enabling people to safely inhabit areas that would have been vulnerable to these floods. However, as was illustrated by the Jhelum River flood, protection against most floods may engender a dangerous illusion of security against very large floods. As experienced in the Upper Mississippi and Missouri River flood, along with destruction, major floods leave in their wake the sense that the structures people believed would protect them had failed and that other approaches are needed.

An important contribution of the Galloway Report is the perspective that flood control structures of a scale adequate to protect against events such as the 1992 Jhelum River flood or the 1993 Upper Mississippi and Missouri River floods would dwarf existing facilities in size and in cost. Therefore, the strategy for striking a reasonable balance between the benefits and risks of floodplain development may lie neither in building more and larger structures, nor in abandoning structural approaches altogether, but in recognizing the capabilities and limitations of flood control structures and in complementing the protection offered by these structures with well conceived programs of non-structural measures.

THE IMPACTS OF THE NATIONAL FLOOD INSURANCE PROGRAM ON FLOODPLAIN DEVELOPMENT

Michael F. Robinson[1]

ABSTRACT

The National Flood Insurance Program (NFIP) has played a critical role in fostering the growth of state and community floodplain management programs. Prior to the establishment of the NFIP in 1968 the theories and practices of floodplain management were well known, but only a few states and several hundred communities regulated floodplain development or had established floodplain management programs. Flood insurance is only available in states and communities which adopt and enforce floodplain management regulations that meet or exceed minimum criteria established by the Federal Emergency Management Agency (FEMA). Federal agencies are prohibited from providing financial assistance for the acquisition or construction of buildings in the designated flood hazard areas of communities which do not participate and flood insurance purchase is required as a condition of receiving federal financial assistance or loans from federally insured or regulated lenders in those that do. The combination of flood insurance availability and the limitations on federal assistance have resulted in nearly all floodprone communities participating in the program and regulating floodplain development. This paper discusses some of the programs successes and failures as well as the NFIP's impacts on floodplain development. The paper also discusses recent legislation and other changes in the program which should further reduce the nation's potential flood damages.

INTRODUCTION

For the last several years there has been an on-going national debate on how to fund and reduce the impacts of disasters due to natural hazards. Since 1989 there has been an unprecedented series of floods, earthquakes, hurricanes, wildfires, and other events. Damages have been well in excess of $100 billion and federal expenditures for FEMA alone have exceeded $10 billion. These damages and the costs to all levels of

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government for the response and recovery efforts has inevitably led to an on-going reevaluation of this nation's disaster related policies and programs.

In response to the Midwest floods of 1993 the Clinton Administration established the Interagency Floodplain Management Review Committee which developed the report "Sharing the Challenge: Floodplain Management into the 21st Century" which Brigadier General Gerald Galloway discussed earlier in the conference. The Clinton Administration is currently developing an Action Plan to implement many of the recommendations and actions in that report. In response to the Midwest flood, Hurricane Andrew, the Northridge Earthquake and other recent disasters both Houses of Congress have issued reports by bi-partisan task forces on how to reduce disaster costs. Government is being reinvented as a result of the National Performance Review. All-hazard insurance is being promoted by some as the answer to disaster costs and legislation establishing such a program has been introduced. There is a new emphasis on mitigation as the way to reduce these costs-not only for floods, but also for other hazards such as earthquakes and hurricanes. Whatever the result of these efforts, the way the nation prepares for and responds to disasters will change.

In this context it is particularly important to review both the successes and failures of the NFIP. The NFIP was the nation's first and, to date, only effort at taking a comprehensive approach to reducing the impacts of a natural hazard. The program is built upon a unique linkage between mitigation, insurance and the availability of federal financial assistance for acquisition or construction of buildings. The program was born as a result of a policy debate that is very similar to the one that is occurring today for all hazards. The lessons learned from the implementing the NFIP can make a valuable contribution to designing and implementing a comprehensive insurance or mitigation program for all natural hazards.

BACKGROUND OF THE NFIP

As are most advances in flood control or floodplain management, the NFIP was established in response to a series of flood events--in this case a series of hurricanes and riverine floods that occurred in the early and mid-1960's. Flood insurance coverage was generally not available from the private sector and flood damages appeared to be escalating despite billions of dollars invested in flood control. The resulting National Flood Insurance Act of 1968 had a number of purposes, the most significant of which were:

-to better indemnify individuals from losses through the availability of flood insurance,

-to reduce future flood damages through community floodplain management regulations, and

-to reduce costs for disaster assistance and flood control.

Although the NFIP has made substantial progress toward achieving these purposes, they continue to be of concern both for flood and other natural hazards. When we look at the NFIP we need to judge its success or failures in the context of these purposes.

The NFIP was an innovative program that represented a far sighted attempt to join insurance and floodplain management. The key provision of the act is Section 1315 which prohibits FEMA (at that time the U.S. Department of Housing and Urban Development) from providing flood insurance unless the state or community adopts and enforces floodplain management ordinances that meet minimum criteria established by regulation. This is the quid pro quo on which the program is based and was to be the impetus for the establishment of floodplain management programs nationwide. A critical component of the program is the massive effort undertaken to identify and map the nation's floodplains to create broad based awareness of the flood hazard and provide the data necessary for community floodplain management programs and to actuarially rate flood insurance.

The concept behind the program is that the communities would join the NFIP to make their citizens eligible to purchase highly subsidized flood insurance for existing buildings. It was recognized that insurance for many of these buildings would be prohibitively expensive if the premiums were not subsidized. It was also recognized that most of these floodprone buildings were built by individuals that did not have sufficient knowledge of the hazard to make informed decisions.

Even though premiums for policies on existing buildings were to be subsidized, floodplain occupants would pay for at least part of the cost of the insurance and that they would no longer need disaster assistance so there would still be some cost savings. In exchange for the availability of this subsidized insurance communities would protect new construction through adoption and enforcement of community floodplain management ordinances. Owners of these new buildings (those built after FEMA had identified flood hazards in the community) would pay actuarial rates for flood insurance that fully reflected the risk to the building. Over time the existing floodprone buildings would be upgraded or replaced by new buildings that were protected from flood damages. The subsidy to the existing buildings would eventually disappear and the program would become fully actuarial. At the time no one knew for sure how long it would take for this to occur, but it clearly would take well into twenty-first century before the numbers of these buildings were significantly reduced.

The NFIP was not very successful in its first years. Subsidized insurance by itself was not sufficient to ensure community participation. Similarly, purchase of flood insurance by individuals was voluntary and few policies were purchased even though the premium was highly subsided. Individuals either did not know about the availability of flood insurance or did not believe that their risk of flooding was sufficient to warrant the purchase of a policy. By the end of 1972 only a few thousand communities were eligible and only 95,000 policies were in force.

In 1972 Tropical Storm Agnes caused severe riverine flooding along the east coast. Almost no one was insured and disaster costs were the highest ever. It was clear that NFIP had not achieved its purposes and the program would require major changes. In response Congress passed the Flood Disaster Protection Act of 1973 which contained two key provisions that have been the driving forces behind the NFIP since:

- In communities that did <u>not</u> participate, Federal agencies and, at first, federally insured or regulated lenders were prohibited from making grants or loans for acquisition or construction of buildings in designated flood hazard areas, and

- In communities that did participate, Federal agencies and federally insured or regulated lenders had to require flood insurance on all grants and loans for acquisition or construction of buildings in designated flood hazard areas.

This was the turning point for the program. Thousands of communities joined the NFIP over the next several years and the policy base began to grow. These same concepts for leveraging insurance purchase through federal assistance are again being considered as Congress searches for ways of establishing insurance programs for earthquakes and other hazards.

By 1995 over 18,500 communities had joined the NFIP, including nearly every community in the nation with significant flood hazards. Approximately 160,000 square miles of floodplains have been mapped in over 20,000 communities at the cost of nearly $1 billion. Over 2 million buildings have been built in accordance with community floodplain management ordinances that meet or exceed minimum NFIP requirements with reductions in potential flood damages exceeding $569 million annually.

NFIP FLOODPLAIN MANAGEMENT REQUIREMENTS

The basic requirements of the NFIP are fairly straightforward. Residential structures must be elevated to or above the 100-year or base flood elevation (BFE). The 100-year flood is a flood that has a 1 percent chance of occurring in any given year. Nonresidential structures must be elevated or floodproofed to the BFE. The flood carrying capacity of the floodway portion of the floodplain must be preserved. Finally, structures in Coastal High Hazard Areas (V-zones) must also be protected against additional hazards from wave impacts.

FEMA monitors enforcement by communities of floodplain management regulations and provides technical assistance to communities. If communities do not adequately enforce their floodplain management regulations they can be placed on probation or suspended from the program. FEMA or states on behalf of FEMA conduct Community Assistance Visits (CAVs) to several thousand communities a year to review their floodplain management programs and provide technical assistance. FEMA also monitors enforcement by communities through applications for flood insurance which often identify buildings that are clearly in violation of NFIP minimum floodplain management requirements.

Generally, FEMA has found a fairly high level of compliance with the basic elevation requirements of the program. The main floors of nearly all new buildings are at or above the 100-year flood elevation and development for the most part has been kept out of floodways. The problems identified most often are in three general areas.

First, there are significant problems with enclosed areas below elevated buildings. These problems primarily occur in coastal areas or along major rivers subject to deeper flooding. Buildings are often elevated a full story both to meet elevation requirements and to provide parking underneath the building. Under NFIP regulations and most community ordinances, these areas can be enclosed and used for parking, access and storage. However, the enclosures often are illegally converted to living areas without the knowledge of the community. This greatly increasing the potential for damages. These provisions are so difficult for the community to enforce that the NFIP has had to limit its exposure to loss by limiting flood insurance coverage for these areas.

Second, there are significant problems enforcing the programs requirements for substantially improved and substantially damaged buildings. A substantial improvement is an improvement to a building, such as an addition or rehabilitation, the cost of which equals or exceeds 50 percent of market value. Substantial damage means that the building has been damaged and the cost of restoring the building to its before damage condition would equal or exceed 50 percent of the market value of the structure before the damage occurred. Substantially damaged and substantially improved buildings must be brought into compliance with the floodplain management requirements for new buildings.

Historically, compliance with these requirements has been a problem. Both substantial damage and substantial improvement are difficult to calculate and subject to abuse. Often the building official depends on repair estimates or market value appraisals provided by the permit applicant. The building official may doubt the accuracy of a cost estimate or appraisal, but is reluctant to challenge what is submitted without evidence to the contrary. After a disaster, local officials are often overwhelmed with demands for permits and this compounds the problem.

However, the most serious problem with enforcing substantial damage requirements has been that people who have been substantially damaged often do not have the money necessary to both repair the building and bring it into compliance with community floodplain management regulations. Local officials have been reluctant to enforce the requirement knowing that this is the case and that people may be forced out of their homes.

In recent disasters FEMA has provided resources to support community permitting efforts. More importantly, funds are now available to help individuals to meet the requirements. The funds available through the Stafford Act Section 404 Hazard Mitigation Grant Program were greatly increased by Congress in 1994 and for the Midwest floods Congress appropriated funds for the Community Development Block Grant program. The Small Business Administration (SBA) will now loan money for mitigation. And beginning on October 1, 1996 there will be flood insurance coverage to pay the cost of mitigation. With these changes, the dynamics of substantial damage may change. People will want to protect themselves if they can get financial assistance to do so.

Finally, some communities do not have full-time staff or the technical capability necessary to administer floodplain management ordinances or, for that matter, most other regulations. Much of the technical assistance efforts by FEMA and states must be focused in these communities. Due to change overs in local officials there is a constant need for training and other support for these communities. Fortunately, these same communities often have very little floodplain development compared to larger communities.

FLOOD INSURANCE AND FLOODPLAIN MANAGEMENT

There are now over 2.9 million flood insurance policies in force with coverage exceeding $291 billion. The written premium for this coverage is $955 million annually and the average premium for a policy is $291. Cumulatively, over a 25 year period the NFIP has paid claims on 538,603 losses for a total of $5.6 billion. Much of the $5.6 billion paid out in claims would have been borne by the taxpayer through disaster assistance from FEMA and other federal, state, and local agencies or through loss of tax revenues resulting from casualty loss deductions and other deductions on federal and state income taxes. The remainder would have been borne by individuals and businesses.

The insurance aspects of the NFIP have important implications for floodplain management. Post-FIRM construction (construction built after the date of the initial Flood Insurance Rate Map for the community) is charge an actuarial rate that fully reflects the risk flooding. This is an important point. The NFIP may make new development in flood hazard areas less risky, but it does not subsidize it. Only Pre-FIRM (existing) construction pays a chargeable rate that is subsidized.

Because new construction is actuarially rated, the NFIP contains an internal set of incentives and disincentives that help assure that community floodplain management regulations are enforced and buildings are adequately protected from flood damages. Buildings built in compliance with community floodplain management regulations pay premiums based on flood insurance rates that are in most cases significantly lower than the subsidized rates charged pre-FIRM buildings. Buildings built in violation of community floodplain management regulations generally pay much higher rates which can exceed thousands of dollars a year for buildings built substantially below the required elevations.

The success of the program in reducing flood losses is evidenced by the loss experience for the years 1978 through 1992. During this period, the policies on post-FIRM buildings resulted in a $248 million surplus in premium income less payments for losses and the expenses for administering the program. During that same period, the pre-FIRM policies or subsidized policies generated a $667 million deficit. However, much of the deficit on the pre-FIRM polices pre-dates a series of rate increases in the early 1980's intended to make the program self-supporting for the historical loss year. And in fact this has been achieved. Since 1986 the NFIP has been entirely funded through premium income including all administrative expenses and floodplain management costs. The NFIP borrowed money from the Treasury for a brief period last year but that money has since been repaid.

TABLE 1. Recent Flood Events Ranked by Dollars of Claims Paid (as of 5/95).

Hurricane Hugo	9/89	$374 million
Nor'easter	12/92	$338 million
Midwest Flood	6/93	$260 million
March Storm	3/93	$208 million
Houston Floods	10/94	$192 million
Hurricane Andrew	8/92	$163 million
Halloween Storm	10/91	$141 million

Source: Federal Insurance Administration

That the program has been self-supporting is all the more remarkable if one looks at the unprecedented series of flooding events this nation has undergone since Hurricane Hugo (see Table 1). The Midwest Flood of 1993 is only one of several large flood events that have occurred since 1989. During these years there appears to a shift in the nature of claims that are being paid. Prior to 1989 most claims were for riverine or stormwater flooding. Since 1989 coastal storms such as nor'easters and hurricanes seem to predominate. This may be just a series of bad years or may reflect the higher percent of properties subject to coastal flooding that are insured and the higher building values in these areas.

Information on flood insurance policies provides useful data on the progress of the program in protecting the nation's stock of existing floodprone buildings. Of the 2.8 million policies, 58.6 percent pay actuarial rates and 41.6 percent pay rates that are subsidized to some degree. The actuarially rated policies include the 26.8 percent of the policies that are outside of the mapped floodplain in what we call B, C, or X zones. These policies are generally in the 500 year floodplain (areas that have .2% chance of flooding each year) including areas behind levees or are in areas with localized drainage problems that are not designated as 100 year floodplain.

TABLE 2. Breakdown of the NFIP Policies by Zone and by Rating

Actuarially Rated Policies	
Zones AE,AO,AH,AOB,AHB	31.3%
Zones V,VE	.5%
Zones B,C, and X	26.8%
	58.6%
Subsidized Policies	
Pre-FIRM	38.8%
Zone A99	2.4%
'75-81' Post-FIRM V,VE	.4%
	41.6%

Source: Testimony of Francis V. Reilly

Table 2 provides data on two key issues related to NFIP policies within the 100 year floodplain (policies for the various A and V zones). First, policies in V-zones or coastal high hazard areas represent only a small percentage of the policy base. These are the policies subject to significant wave impact during a hurricane or other coastal storm and are generally the buildings subject to increased risk due to coastal erosion.

Second, the table is an indicator of progress toward achieving the purposes of the NFIP. In the early years of the program almost all of the policies in A and V zones were subsidized. Now, nearly 20 years later, there are almost as many policies in these zones paying actuarial rates based on elevation as are subsidized. This shift has occurred as a result of depreciation and natural attrition among floodprone buildings, the redevelopment of floodprone areas, the construction of flood control projects by the U.S. Army Corps of Engineers and by local government, NFIP substantial improvement and substantial damage requirements, and mitigation projects by States, communities, and individuals. Twenty years from now even fewer policies will be subsidized and eventually the program will be fully actuarial or at least reach the point where the remaining subsidized policies are small in number and do not represent a severe liability on the program.

Data on flood insurance claims indicates that, as of 1994, there were 69,000 buildings that have had two or more flood losses on which claims have been paid since 1978. A few of these buildings have ten or more claims. These repetitive loss buildings account for 43% of all claims payments. The long term success of the program will largely depend on how it deals with these buildings. The chronic problem areas for repetitive losses throughout the history of the program have been the Houston and New Orleans, and, to a lesser degree, the St. Louis metropolitan areas. However, in the last five years or so we have had a series of nor'easters and other coastal storms that have resulted in a concentration of repetitive loss buildings along the New England and Mid-Atlantic coasts.

The data on repetitive losses is both disturbing and hopeful. These buildings represent a serious drain on the National Flood Insurance Fund. However, they do represent an opportunity. If properly focused on these buildings, the mitigation programs that are now available can be focused on these buildings and result in significant reductions in NFIP claims and overall flood damages. The problem is not the total universe of buildings with subsidized flood insurance. It is the much smaller group of pre-FIRM buildings that are subject to the severest risk. The long term value of the Midwest Buyout program which will acquire or elevate over 8,000 flood damaged buildings is that it will make a significant dent in the Midwest component of the repetitive loss problem.

NFIP AND DEVELOPMENT

One controversial issue throughout the history of the NFIP has been whether the program causes or discourages floodplain development. During the Midwest flood this issue surfaced again in newspaper articles which criticized the NFIP for causing development in Midwest floodplains and increasing the flood damage. However, the data from flood insurance policies clearly indicates that this has not been the case in the Midwest. If anything, there has been a significant drop in the number of buildings being built in Midwest floodplains.

TABLE 3. Construction Dates of NFIP Insured Buildings in the Floodplains of Nine Midwestern States (as of 1/31/94)

Years	Number of Insured Buildings
Before 1950	15,207
1950-1959	14,459
1960-1969	12,087
1970-1979	14,846
1980-1989	4,425
1990-1994	1,303

Source: Federal Insurance Administration

Table 3 shows the construction dates of buildings currently insured by the NFIP in the floodplains of the nine Midwestern states impacted by the 1993 flood. There appears to be a fairly constant amount of development through the 1950's, '60's, and 70's. Then for the 1980's, when the NFIP began to take hold, there is only one third as many of the insured buildings built as in the previous decades. Extrapolating the 1990's numbers out to the year 2000, you get a still further reduction. In fact over 93% of the buildings insured in the floodplains of the nine Midwestern states in January of 1994 were pre-FIRM meaning that they were built prior to the issuance of the first Flood Insurance Rate Map for the community.

From this data it appears that the NFIP in conjunction with state and community floodplain management programs does work to discourage development. Where there are alternative locations to develop and if people have full knowledge of the hazard, they will avoid floodplains. NFIP and state and community floodplain management programs appear to be discouraging new development in these floodplains by:

-identifying and mapping the flood hazard,

-informing property owners of the flood hazard through the permit process and the mandatory purchase requirement,

-ensuring that communities regulate floodplain development,

-internalizing the economic costs of floodplain occupancy through increased construction costs and flood insurance premiums, and

-protecting over 9,000 square miles of floodways.

This is probably not the case on the coast (particularly barrier islands) or in highly urbanized areas. Land in these areas is too valuable and is likely to be developed regardless of the flood hazard or any increased costs. Some have argued that the availability of flood insurance, while it does not subsidize new development, may facilitate it by reducing risk and making lenders more willing to provide financing in floodprone areas. While this may have been a factor in some situations, there probably would have been the same or almost as much development if the NFIP had not been established and much of the development would not have been designed and built to minimize flood damages.

LEVEES

Another area of controversy, particularly as a result of the Midwest Flood, has been levees. The NFIP does not credit most agricultural levees as providing flood protection since they do not meet the elevation and structural requirements of the program. NFIP floodplain management requirements and the mandatory flood insurance purchase requirement apply behind these levees.

The NFIP did credit the Monarch Levee at Chesterfield, Missouri as providing 100-year protection and removed the area behind that levee from the floodplain. As a result, millions of dollars in new construction occurred that was not protected from flood damages, much of which was not covered by flood insurance. The levee failed and catastrophic damages resulted. There is an unresolved issue as to whether the NFIP should be crediting this type of levee or what should be the minimum level of protection. This issue is particularly for undeveloped areas where very little development was at risk prior to the construction of the levee.

NATIONAL FLOOD INSURANCE REFORM ACT OF 1994

The most comprehensive changes to NFIP since the Flood Disaster Protection of 1973 were contained in the National Flood Insurance Act of 1994 which was signed into law last September. The Act was at least 5 years in the making and includes many needed changes to the program. The Act represents a collaboration among all NFIP constituency groups. Most of provisions of the Act were supported and, in some case, even suggested by FEMA. However, it is something of a misnomer to say the Act actually "reforms" the NFIP. The basic program remains the same. There are several significant provisions of the legislation that directly impact floodplain management.

The legislation authorizes the NFIP to provide insurance coverage for the costs of complying with community floodplain management regulations-known as mitigation insurance or increased cost of construction coverage. This is a key provision since it will ensure that if homes are substantially damaged by floods, policyholders will have the funds to elevate their homes or otherwise comply with the local ordinance. If this coverage had been in place during the Midwest flood, several thousands of properties would have been brought into compliance immediately without waiting for the buyout program.

The Act establishes a Mitigation Assistance Program that provides grants to states and communities to do mitigation plans and projects. Funding is up to $20 million a year with a 75/25 cost share. This will allow FEMA to fund community projects to elevate, relocate, acquire, or floodproof floodprone buildings, allowing it do mitigation at times other than after a declared disaster.

The Act codifies and expresses Congressional support for the NFIP Community Rating System which provides discounts on flood insurance premiums in those communities which have floodplain management programs above and beyond NFIP minimum requirements. This program has been on-going for several years and has been quite successful. Currently over 800 communities participate that represent 56 percent of all NFIP policies.

In addition, the legislation includes a number of provisions aimed at increasing compliance by mortgage lenders with the mandatory purchase requirement and other measures to increase coverage. Although not directly related to floodplain management, these provisions should strengthen the program by expanding the policy base and providing the funds necessary for enhancing floodplain management programs.

WHERE DO WE GO FROM HERE?

The 1994 update of the Unified National Program for Floodplain Management transmitted by President Clinton to Congress earlier this month establishes as a national goal, that we reduce the risk of loss life and property by one half by the year 2020. This is an ambitious goal, but it is achievable.

The NFIP and state and community floodplain management regulations have generally been successful in minimizing flood damages due to a 100 year flood to new buildings. However, achieving the Unified National Program goal will also require that we substantially reduce damages to the existing stock of floodprone buildings. Considerable progress will be made in this area.

Now that additional funding is available for mitigation projects through the Stafford Act Section 404 Hazard Mitigation Grant Program and through the new NFIP Mitigation Assistance Program, the number of these projects will greatly increase. And certainly mitigation insurance, when it is implemented, will bring large number of substantially damaged insured buildings into compliance with community ordinances.

Flood damages will never be eliminated, but can be reduced to the point where only minimal disaster assistance is needed and nearly all residual costs can be borne through a fully actuarial flood insurance program.

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PLANNING, ORGANIZING, AND RESOURCING

FOR FLOOD MANAGEMENT

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ABSTRACT

The U.S. Army Corps of Engineers (USACE) has a long history of flood management. The Midwest Flood of 1993 provided a severe test of our ability to manage and respond to a major flood event. This benchmark event provided the impetus to identify and test new paradigms for interagency cooperation and coordination.

The Deputy Director of Civil Works (Forward) provided the mechanism to coordinate flood recovery activities across the three Corps Divisions and five Districts significantly involved in the event. The DDCW (Fwd) office was successful and is likely to be used in future events of this magnitude. Similarly, the interagency levee repair coordination process streamlined the delivery of Federal assistance to the affected area.

INTRODUCTION

The Midwest Flood of 1993 was a benchmark event. It drew national attention to the Mississippi River basin and maintained that interest for months. The images of devastation and economic disruption have left the network newscasts but the impact of the summer of '93 is still very real. Were it not for the Midwest Flood of 1993, we might well not be at this conference. With certainty, were it not for the Midwest Flood of 1993, the subject of the keynote address would not have been, "Flood Plain Management in the 21st Century".

The summer of 1993 provided a full-scale test of our ability to manage and respond to major flood events. Record and near record summer rains fell on soil saturated from previous seasonal precipitation. Spring snowmelt combined to produce flooding along major river systems and their tributaries over a region encompassing all

Percent of Normal Rainfall
July 1993

Missouri River Basin	462 %
Mississippi River Basin	433 %

Fig. 1. Rainfall far exceeded reasonable expectations.

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or most of nine states in the upper Mississippi River basin. River levels exceeded flood stage at approximately 500 National Weather Service river forecast points. Record flooding occurred at 95 forecast points throughout the region. At 45 U.S. Geological Survey (USGS) streamflow gaging stations the peak discharge rate exceeded that of the 1-percent annual chance (100-year) flood value. Not only extensive in magnitude and area, the 1993 flood was prolonged in time. Many locations remained above flood stage for weeks and some for five consecutive months. This lengthy inundation delayed the start of recovery operations and added substantially to the challenges of flood recovery.

HISTORICAL PERSPECTIVE

Defining as it is, the Midwest Flood of 1993 was not a new experience for the U.S. Army Corps of Engineers. Our water resources and flood control history dates to 1824, when Congress directed Lieutenant Robert E. Lee to survey the Mississippi River at St. Louis. The disastrous flood of 1927 resulted in Congressional authority for the Corps to develop control works on the Lower Mississippi. In 1936, following floods on the Ohio and other rivers, Congress gave the Corps a nationwide mission in the Flood Control Act of 1936. With authority from that act and a series of flood control and water resources development acts that have followed, the Corps built basin-wide and local protection projects across the nation. Comprised of dams and reservoirs, channel improvements, flood walls, levees, floodways, diversions, pumping stations and the like, these projects have prevented flood damages that average $ 15.4 billion per year and saved countless lives.

1824 -- First Navigation Work Authorized
1879 -- Mississippi River Commission Created
1917 -- First Federal Flood Control Projects Authorized
1928 -- Mississippi River & Tributaries Project (Cairo, IL to the Gulf)
1936 -- Nationwide Flood Control Mission
1944 -- Flood Control Act
1960 -- Flood Plain Management Services Authorized

Fig. 2. History of Corps Involvement in Flood Control

The flood control structures in the upper Mississippi River comprise a vast integrated system. The seventy-six reservoirs installed by the Corps, in concert with the system of levees and other structures combine to store, retard and control runoff. The dams and reservoirs have an aggregate capacity of almost 40 million acre-feet and control a drainage area of 369,143 square miles. During the 1993 event, floodwater storage reduced flooding along dam protected streams. Water control management was executed by hydraulic and hydrologic engineers in the USACE Division and District Reservoir Control Centers. Over time, flood waters filled the water storage projects well above their spillway levels and kept them there for extended periods of time. This extreme volume of flood water effectively neutralized our flood management ability and moved the Corps to a role of emergency flood response.

CORPS AUTHORITIES

Congress has added emergency response authority to our flood control construction and operation mission. Today, we fulfill responsibilities under Public Law 84-99, as amended, (Flood Control and Coastal Emergency), Public Law 93-288, as amended, (Robert T. Stafford Disaster Relief and Emergency Act) and several others.

The Flood Control and Coastal Emergency Act (FCCE) authorizes Corps assistance in a variety of areas including: disaster preparedness, flood and coastal storm response, emergency drinking water and rehabilitation of flood control works.

<u>Typical ESF #3 Missions</u>

Debris Removal
Construct Temporary Access Routes
Preliminary Damage Assessments
Structural Evaluation of Buildings
Emergency Power Generation

Fig. 3. Corps emergency missions in support of the Federal Response Plan are widely varied.

The Federal Response Plan (FRP) implements interagency effort for Stafford Act assistance. It facilitates the delivery of Federal assistance to the States to help them deal with the consequences of all types of significant disasters; not just floods. It is the product of input from 28 Federal departments and agencies. The Federal Emergency Management Agency (FEMA) is the lead agency for the FRP. The Department of Defense (DOD) is the lead agency under the FRP for Emergency Support Function #3 (Public Works and Engineering). The Corps has DOD responsibility to plan and execute the ESF #3 mission. During a flood, our missions on behalf of FEMA include: engineering, design and construction, and contract management, e.g. debris clearance, temporary housing, emergency bulk water supply, and temporary restoration of public facilities.

LESSONS LEARNED

Because of the Corps experience in flood emergency response, a number of mechanisms were already in place when the 1993 event began. Policies and procedures, developed years before, and trained staff allowed the Corps to effectively carry out its emergency response activities, including its functions in support of the interagency Federal Response Plan team.

With each new disaster, we strive to apply lessons learned from previous events. For example, in 1988 the River Industry Executive Task Force was created to respond to the adverse impacts of severe drought on the towing industry in the Mississippi River basin. In 1993, that same task force (seven representatives of the towing industry, two from the Corps and one from the U.S. Coast Guard) was instrumental in setting procedures for the resumption of river traffic on the Mississippi following lengthy closure during the disastrous flood. The procedures included test tows, size and speed limitations, and "no wake" zones. The resumption of river traffic was critical to the Midwest and national economies. At the same time, renewed river traffic posed great risk to the already saturated and weakened levees and to dozens of local communities. The Task Force set a high standard for cooperation and trust between the navigation industry, flood control sponsors, and the communities and states involved.

Another successful aspect of the Corps response to the Midwest Flood of 1993 was creation of a regional coordination office in St. Louis. The Deputy Director of Civil Works (Forward) provided the mechanism to coordinate flood recovery activities across the three Corps Divisions and five Districts significantly involved in the event. The office was successful and is likely to be used in future events of this magnitude.

Successful Flood Management Responses:

Deputy Director for Civil Works (Forward)
Interagency Levee Rehabilitation Task Force
River Industry Executive Task Force
Reservoir Operations
Innovative Floodfight Techniques

Fig. 4. Successful lessons learned during the Midwest Flood of 1993 will be repeated in the future.

During the Midwest Flood of 1993, the Corps implemented a new interagency levee repair coordination process with FEMA, the Soil Conservation Service, and the U.S. Fish and Wildlife Service. Levee repair coordination was located in the Disaster Field Offices in the flood area. The coordination process streamlined the delivery of Federal assistance, however, it can be improved with more advance planning among the agencies involved.

PREPAREDNESS

Planning and organizing for emergency flood management, response, and recovery are not distinctly separate actions. Rather, the two phases overlap. Preparedness is a key. Training exercises test the plan and the organization before either is needed for a real-life event. A FEMA sponsored hurricane exercise will do just that, beginning May 9, 1995.

The scenario for the exercise, named Exercise RESPONSE 95, is a slow-moving category 4 (winds 131 - 155 mph) hurricane (Jennifer) developing off the coast of Haiti. All of the Gulf states from Florida to Texas are threatened before Hurricane Jennifer makes landfall on May 10, at the Pearl River in Mississippi. The scenario includes tornadoes, power outages, major flooding and overtopping of the New Orleans levee system. The impact on New Orleans includes 18 - 20 foot flood waters within the city.

Participants include all of the signatory agencies to the Federal Response Plan, state and local governments, industry and volunteer organizations. At the Corps, over 200 men and women, both military and civilian, will participate. These will include representatives of the affected Divisions and Districts, Headquarters USACE, the 249th Engineer Battalion (Prime Power) and our Remote Sensing/GIS Center.

Objectives for the Corps include evaluating the interface between our Flood Control & Coastal Emergencies (P.L. 84-99) mission and the missions we execute under the Federal Response Plan (P.L. 93-288), and our ability to deploy advance teams, such as our Prime Power Teams, before landfall. We will also test new communications technologies, Remote Sensing/GIS resources and deployment of mobile command and control trailers (Forward Area Emergency Support Trailers (FAEST)).

Our preparedness for flood management operations is not static. Much of the change is driven by our need to take advantage of new technologies, increased demand for service and assistance, and the ever constrained resources to meet these demands.

The Midwest Flood of 1993 demonstrated our need for real time data from the flood area. The decision making process hinged on our ability to assimilate and graphically present information. Since 1993, we have moved to establish a strong remote sensing and geographic information systems (RS/GIS) organization. The Center, located at our Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire, is a Corps center of expertise for the integration of remote sensing, geographic information and data models. It provides disaster related services to other Corps labs, Divisions, and Districts for image acquisition and map creation. Their activities include image analysis, spatial analysis, inundation maps, situation maps and data fusion; the integration of data from a variety of sources (sensors, spatial analysis and models).

Displays produced by the RS/GIS Center are widely varied. Weather radar images locate storms off the California coast. Water equivalent maps for the California mountains compare the water equivalent in the snowpack to the climatic average to determine the likelihood of flooding compared to the historic record and the likely effect of another rain event on the snowpack. Merged products can combine a Landsat image with vector data on roads to produce a single graphic. Another merged product combines a photograph of the Missouri River digitally scanned into a database with vector data from a spatial database. The resulting display simulates the inundation that would occur in the event of failure of a flood control dam.

The requirement for more information, graphically presented, drove the need for new facilities to gather and present the current status of an emergency operation. In January, 1995, the Headquarters opened a new Emergency Operations Center. Timely, accurate decisions by the Corps senior leadership require timely, understandable, and accurate information. The new EOC allows us to take maximum advantage of electronic communication technologies ranging from high frequency radio and facsimile to the movement of data and messages from computer to computer workstation via satellite.

The facility has two local area networks (LAN), wide area network (WAN), connection to the Internet, and a variety of Department of Defense networks. Information is presented on large video display screens from a variety of digital and video sources. Planning and resourcing for flood management in the 90's and beyond requires access to the Weather Channel, the Cable News Network (CNN), other commercial information "vendors", and FEMA's own emergency response satellite channel.

Recent years have seen numerous large-scale natural disasters and increased reliance on the Corps for response and recovery operations. Already fully engaged in the day-to-day Corps mission, these events put significant strain on the Corps staff. A unique program was created in 1991 to provide a mechanism to meet the need for short term trained managers to execute the expanded disaster related missions of the Corps. The Reservists in Support of Disaster Relief Operations (RESDRO) program gives the Corps access to Army Reservists. Volunteers are listed in a nationwide database. As recently as January, Reservists were activated for the California floods. Activation orders were issued on Sunday evening and by Monday morning, Reservists were at work in District, Division, and FEMA offices in the flood area. This program has brought over 100 highly trained and experienced men and women to support disaster operations like Hurricanes Andrew and Iniki, the Midwest Floods of 1993, and the Northridge Earthquake.

The Corps is an active participant in the flood operations training of local officials and residents. We provide technical assistance on floodfight techniques and recently initiated a cooperative training program with FEMA.

It is often said that, "Prevention is worth a pound of cure." That is certainly the case with levees. The Corps works closely with sponsors to ensure desired protection is delivered when needed. We have an active inspection program to ensure that levees are well maintained and able to provide the protection we expect. Animal burrows, erosion and rutting from recreational vehicles pose a serious threat to the performance of flood control works. Pump stations and gates are inspected to ensure reliable operation when needed.

RESOURCING

Resourcing the plan and the organization is, in the 1990's, the greatest challenge. The U.S. Army Corps of Engineers is doing its part to contribute to the down-sizing of the Federal government. The challenge is obvious. We, like all other Federal departments and agencies, must find new innovative and creative ways to do more with less. Even though our resources of money and personnel continue to reduce, our mission is expanding into new areas with the Nation relying on us for increasingly complex solutions. Fortunately, our third resource, time, is unchanged. The Corps, like each of you, has the same amount of time; no more, but no less.

CONCLUSION

We rely on a talented and dedicated staff of professionals to develop new and better ways to meet the challenges of the future. The innovative use of new technologies, like RS/GIS, will support our decision makers. We seek more State involvement in flood fight decisions and levee repair applications. During the recovery process, interagency teamwork must expand. Support to affected communities must be a seamless Federal-state operation to the greatest extent practical. Training, education, and joint Federal, State, and local exercises will help to insure that emergency services are provided in a timely, efficient, and cost effective manner. We must all make a sincere

PREPAREDNESS CHALLENGES

New Technologies (real-time data, RS/GIS)
Fiscal and Personnel Constraints
Training (Federal, state, and local)
Interagency Cooperation and Planning

Fig. 5. The Corps relies on a talented and dedicated staff of professionals to develop new and better ways to meet the challenges of the future.

commitment to these crucial preparedness activities if we are to be truly ready for the next major disaster.

PREDICTING FLOW RESISTANCE DUE TO VEGETATION IN FLOOD PLAINS

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PREFACE

The following paper is based on a research project funded by the U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS.; Project Name - Flood Control Channels; Work Unit Title - Stability of Vegetative Cover in Flood Control Channels; Work Unit No - 337A3; Federal Contract No - DACW39-94-K-0009.

ABSTRACT

To calculate flow or depth in a flood plain, it is necessary to accurately determine the flow resistance. Past research has made considerable progress in predicting the roughness of uniform channels based on both theoretical and experimental investigations. However, to determine the flow resistance associated with flood plains and over-bank flooding, the effects of vegetation must be considered. Over-bank flow typically submerges many types of plants and shrubs.

Research has been conducted on vegetation such as dense layered grasses and on the rigid blockage of cylindrical tree trunks. Very little has been studied on the resistance effects of plants and shrubs that are submerged by turbulent flows. The flexible stems and varying shapes of the plant's leaf mass, greatly complicate the understanding of resistance.

A better understanding of the effects of submerged vegetation will allow engineers to combine function, aesthetics and natural habitat in the design and development of flood plains.

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INTRODUCTION

The purpose of this study was to investigate the effect of vegetation, particularly ground cover plants and shrubs, on flow resistance. Two types of testing were conducted at the Utah Water Research Laboratory utilizing a large wide flume and a smaller sectional flume. The primary objective of the study and the large flume testing was to determine the head loss and resistance coefficients from plants in test conditions as close to in situ as possible. The variables that were studied included: flow velocity, flow depth, plant geometry, drag force, plant density and spacing, plant distortion and bending, sediment movement, and scour of bed material.

It is not practical or feasible to test every type and size of plant in a large flume with varying plant densities and spacings. A methodology is needed that will use either field measurements or the simpler sectional flume testing of single plants to predict head loss and resistance coefficients. The methodology should also have the basis by which resistance can be predicted for different combinations of plant types and sizes.

The objective of the sectional flume testing was to determine a correlation between drag force, geometric and bio-mechanical plant properties. The overall goal of the sectional flume testing was to develop a methodology by which the vegetation resistance could be predicted from a field survey of plants and plant characteristics.

BACKGROUND

The most commonly used equation for flow resistance is the Manning's equation (Equation 1), and *n* represents the Manning's resistance coefficient.

$$V = \frac{1.486}{n} R^{2/3} S^{1/2} \qquad (1)$$

The mean velocity V of flow is in feet per second; the hydraulic radius R is in feet; the slope of the energy grade line S is in feet per feet; *n* is Manning's resistance coefficient; and 1.486 is a unit conversion for English units, in $ft^{1/3}$/sec.

The resistance coefficient for vegetation n_{veg} was developed in this study for application with the 1956 Cowan method (Equation 2) for additive resistance.

$$n = \left(n_o + n_1 + n_2 + n_3 + n_{veg}\right) \cdot m_5 \qquad (2)$$

Where, n_o is a base value for straight, uniform, and smooth channels in natural materials; n_1 is an additive value to n_o which accounts for surface irregularities; n_2 is an additive value which accounts for variations in channel geometry in a cross section; n_3 is an additive value which accounts for obstructions; n_{veg} is an additive value which accounts for vegetation; and m_5 is a correction factor for the meandering or sinuosity of the channel. It is important to note that the coefficient n_{veg} used in Cowan's (1956) method and in this paper is based on the net effect of the vegetation. Many of the published values for vegetation resistance include the base resistance n_o of the channel bed. It is important to note that the coefficient n_{veg} used in Cowan's (1956) method and in this paper is based on the net effect of the vegetation. Many of the published values for vegetation resistance include the base resistance n_o of the channel bed.

It is common knowledge that the presence of vegetation in a channel or flood plain will effect the sediment transport and the erosion in the channel and flood plain. Vegetation will certainly reinforce and strengthen the soil surfaces through the development of root systems. Vegetation can also impede the movement of the contact portion of the bed load (ASCE 1960), and prevent or stabilize bed forms.

Another common understanding is that the presence of vegetation increases flow resistance and results in the reduction of flow velocity from increased depth. The reduced velocity, Li and Shen (1973), will then reduce the sediment transport of the channel and reduce the forces necessary to cause scour and erosion. Past studies on transport and scour have not included the effects of the leaves and branches of plant foliage. Plant foliage could form a layer or blanket that would divert flow beneath the foliage and increase velocities along the channel bottom.

TEST SETUP

Two flumes of the Utah Water Research Laboratory were used for the plant tests of this study. The large flume, 8 foot wide by 6 foot deep by 500 foot long, was used to measure flow resistance for groups of uniform sized plants with varying plant density. A sectional flume, 3 foot wide by 3 foot deep, was used to measure drag force of individual plants. There were four different groups (Table 1) of plants tested in the large laboratory flume and ten species (Table 2) of plants tested in the sectional flume. All of the plants tested were broadleaf deciduous, vegetation commonly found in most USDA zones. Table 1 includes the plant density, average dimensions, and plant characteristics of the plants tested in the large flume. Table 2 includes the average dimensions and characteristics of the plants tested in the sectional flume. Where H is the total height of the plant, W_P is the width of the leaf mass, D_S is the stem diameter, H' is the height of the leaf mass, E is the modulus of plant elasticity, and I is the area moment of inertia of the stem.

The plants tested in the larger flume were placed in staggered rows along the 50 foot length of the test section. The spacing selected for the plants was based on the typical spacing (Kadlec 1990) of 1½ to 2 plant diameters for emergent plants. The plant density was calculated as the number of plants per unit area. The plants tested in the sectional flume were placed in a single row of 4 to 5 plants along the centerline of the flume. A single plant was instrumented for determining drag force in each flume. The test plant in the larger flume was located in the center of the 50 foot by 8 foot test section. The test plant for the sectional flume was the downstream plant, with 4 plants located upstream. The test setup for the sectional flume allowed for a more accurate measurement of plant approach velocity V_P and drag force F_D.

With the exception of the plants used to test for drag forces, all of the plants in the large flume were placed intact, with root structure and original soil, into a 8-inch deep test bed of clay.

Table 1 Dimensions and Characteristics of Plants in Large Flume

Plant/Runs	H	W_P	D_S	H'	Plant Density	# of Plants Tested
Dogwood	20"	9"	3/8" one stem	13"	0.4983 per sf	192
Dogwood	20"	9"	3/8" one stem	13"	0.2215 per sf	96
Elderberry	28"	14"	3/8" one stem	20"	0.2500 per sf	117
Euonymus	8"	10"	1/4" two stems	8"	1.190 per sf	480
Euonymus	8"	10"	1/4" two stems	8"	0.5289 per sf	280
Dogwood	38"	26"	1" two stems	30"	0.1111 per sf	45
Dogwood	38"	26"	1" two stems	30"	0.0494 per sf	23

Table 2 Dimensions and Characteristics of Plants in Sectional Flume

Plant/Runs	H	W_P	D_S	H'	E (lbf-ft^2)	I (ft^4)	# OF LEAVES	LEAF SIZE
Dogwood	20"	9"	3/8"	13"	4.4833E6	4.6813E-8	50	3" long ½" wide
Euonymus	8"	10"	1/4" 2ea.	8"	8.6388E6	9.2471E-9	90	2" long ½" wide
Arctic Blue Willow	22"	12"	½"	20"	2.4921E6	1.5890E-7	140	2" long ½" wide
Norway Maple	28"	12"	½"	12"	3.3993E7	3.4321E-8	140	2" long ½" wide
Common Privet	32"	10"	½"	27"	8.2297E6	1.4795E-7	275	1.3 " long 3/8" wide
Blue Elderberry	21"	18"	1"	16"	5.4921E5	2.3673E-6	175	2.5" long 3/4" wide
Pink Pussy willow	36"	10"	3/4"	10"	2.3107E6	7.4901E-7	90	1.5" long ½" wide
Sycamore	36"	8"	0.4"	33"	5.7380E7	6.8872E-8	23	6" long 6" wide
Western Sand Cherry	29"	6"	1/3"	20"	6.0107E7	1.9953E-8	100	2" long 1" wide
Staghorn Sumac	30"	10"	½"	12"	1.0616E7	1.0235E-7	140	2" long ½" wide

TEST PROCEDURES

The flow resistance of the plants in the large flume was determined by first measuring the water surface profile above the test plants. The procedure to calculate n_{veg} for the plant resistance, involved an initial estimate of a total Manning's roughness coefficient to best fit the gradually varied backwater curve along the test section. From the total Manning's n, the value of n_b for the bed roughness and plant resistance was determined by correcting for the effects of the flume side walls (ASCE 1977). The coefficient n_b is the resistance of both the bed roughness and the vegetation (n_o+ n_{veg}). Finally, the resistance coefficient n_{veg} for the net resistance of the vegetation was determined by subtracting the bed resistance n_o from n_b.

Velocity measurements were taken just upstream of the test plants that were used to measure drag force. Measurements of the plant approach velocity V_P were taken at the depth of and just upstream of the center of the leaf mass. Drag forces were measured with a load cell attached to a platform that supported a single test plant.

RESULTS AND ANALYSIS OF LARGE FLUME TESTS

There were eight different test series completed in the large flume using different plants types, plant heights, plant spacings, flow velocities, and flow depths. The first series was performed on only the bed, without vegetation, to determine the bed roughness. A Manning's *n* (corrected for wall effects) of approximately 0.02 was found for the soil bed. Table 3 presents a sample of 9 of the 52 test runs and results from the large flume.

Table 3 Large Flume Test Results

Plant	Yo depth ft	Avg V fps	Fd lbs	n veg	Plant density per sf	Plant approach V_P fps
20" Dogwood	3.35	1.93	0.375	0.042	0.4983	1.20
20" Dogwood	2.35	3.25	0.875	0.034	0.4983	3.20
20" Dogwood	1.69	3.47	0.875	0.030	0.2215	4.40
28" Elderberry	3.13	1.00	0.450	0.044	0.2500	0.60
28" Elderberry	2.32	1.70	0.550	0.033	0.2500	1.80
8" Euonymus	3.88	1.05	0.05	0.048	1.1901	0.40
8" Euonymus	1.61	2.68	0.25	0.032	1.1901	1.20
38" Dogwood	4.25	2.00	5.80	0.079	0.1111	0.80
38" Dogwood	3.89	1.14	3.18	0.088	0.0494	0.70

Kadlec (1990) proposed that the flow resistance from vegetation is the result of the total forces, F_B, produced by vegetation on the channel bottom. The net bottom vegetation force is then equal to the sum of the drag forces from each plant and can be equated to the net bottom shear force produced by the plants. The plant density P_d is the average number of plants or plant stems per unit square foot. The net vegetation shear stress ($\tau_o = \gamma RS$) is equivalent to total drag forces divided by the area of channel bottom, and is equivalent to the average drag force F_D times the plant density (Equation 3).

$$F_D \cdot P_d = \tau_o = \gamma \cdot R \cdot S \qquad (3)$$

Equation 3 can be used to relate the hydraulic radius to drag force, plant density, and slope. Manning's equation can be modified to the form of Equation 4 to show the relationship (in English units) of Manning's n with drag force, plant density, and slope.

$$n = \frac{1.486}{V}\left(\frac{F_D \cdot P_d}{\gamma}\right)^{2/3} S^{-1/6} \qquad (4)$$

The results of Table 3 show a 1:1 correlation between Manning's n calculated with Equation 4 and with the actual measured values of Manning's n. Equation 4 is important because it allows a semi-empirical calculation of n_{veg} based on the more fundamental determination of drag force. The purpose of the sectional flume testing was to develop a theoretical and fundamental relationship of drag force with plant characteristics so that the resistance could be calculated for combinations of different types and sizes of plants.

From observations of the test plants as they distorted and changed shape (Figure 1), it was hypothesized that resistance or drag force will be the combination of form drag and boundary roughness of the distorted leaf mass. Dimensional analysis was used to formulate a relationship of n_{veg} with plant and flow characteristics. A multiple regression analysis of the dimensionless π terms resulted in the relationships of Equations 5 and 6.

$$n_{veg} = 4.91 \left(\frac{gH'}{V^2}\right)^{0.29} \left(\frac{D_S}{H'}\right)^{1.47} \left(P_d H'^2\right)^{0.28} \qquad (5)$$

$$n_{veg} = 4.91 \frac{g^{0.29} D_S^{1.47} P_d^{0.28}}{V^{0.58} H'^{0.62}} \qquad (6)$$

The parameter gH'/V^2 is a plant Froude number, D_S/H' is a slenderness ratio, and $P_d H'^2$ is a plant density ratio. Equation 6 shows that n will increase with an increase of P_d and D_S, and n will decrease with an increase in V and H'. Increasing plant height without increasing stem diameter made the plant more flexible, therefor reducing resistance. The relationships of Equations 5 and 6 had a regression fit of $R^2=96\%$, and a maximum data scatter to the equation of $\pm 16\%$. This is an acceptable curve fit because the accuracy of the resistance measurements was about 10%.

By combining Equations 4 and 6, Equation 7 can be used to calculate drag force F_D from the flow and plant variables of Equation 6.

$$F_D = \frac{8.79}{1.486^{3/2}} \; \frac{\rho g^{3/2} V^{0.5} S^{0.38} D_S^{2.0}}{H'^{0.75} P_d^{0.63}} \qquad (7)$$

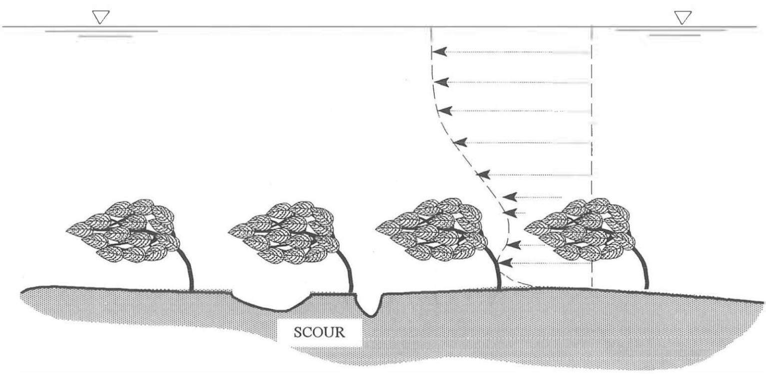

Figure 1 Sketch of Plant Bending and Bed Velocities

Equation 7 is not dimensionally correct. Drag force F_D is in the units of lbs, velocity V is in units of fps, stem diameter D_S and effective plant height H' are in units of feet, and the plant density P_d is in units of plants per unit ft^2. Eliminating $1.486^{3/2}$ from Equation 7 will change the equation to metric units.

The plant approach velocity V_P was measured in both the sectional and large flumes. A dimensional analysis and regression was performed on the velocity data and variables for the large flume. Equation 8 is the relationship of the plant approach velocity V_P with the mean velocity V for the channel.

$$\frac{V_P}{V} = 1.0287 \left(\frac{gH'}{V^2}\right)^{.685} \left(\frac{Yo}{H}\right)^{.337} \left(n_{veg}\right)^{-.605} \left(P_d H'\right)^{-.239} (S)^{.579} \tag{8}$$

Where H is the plant height, Yo is the flow depth, H' is the effective plant height, and P_d is the plant density (plants / unit area). Equation 8 had a regression coefficient of R^2 = 79%. The accuracy of measuring V_P in the large flume was only 15 to 20%.

RESULTS AND ANALYSIS OF SECTIONAL FLUME TESTS

The plants tested in the sectional flume were tested with both their leaf masses intact and with their leaves removed. The drag force was reduced by as much as 50% for some of the plants without leafs. A comparison of drag forces measured in both flumes demonstrated the validity of using the sectional flume to simulate drag forces produced by multiple plants in larger groups. Over 100 test runs were made of the ten plant species tested in the sectional flume.

Dimensional analysis and multiple variable regression were performed on the data and plant measurements from the drag force tests. The analysis determined that the following plant variables could be used to predict drag force: plant height H, effective plant height H', total leaf area TL_A, stem diameter D_S, plant approach velocity V_P, fluid density ρ, plant modulus of elasticity E, and the area moment of inertia of the plant stem I. Equation 9 is the relationship between the drag force F_D on a single plant and the geometry and characteristics of the plant. The regression analysis had a regression coefficient of R^2=89% and a maximum scatter of predicted values to actual of 16%.

$$\frac{F_D H'^2}{EI} = 100.24 \left(\frac{H}{H'}\right)^{1.45} \left(\frac{\rho\, TL_A V_P^2}{E D_S^2}\right)^{0.8} \left(\frac{H'}{D_S}\right)^{0.15} \left(\frac{H'^2}{TL_A}\right)^{0.89} \qquad (9)$$

The parameters of Equation 9 then represent the ratio of drag force to bending force, the ratio of effective plant height, the ration of bending resistance, the ratio of plant flexibility, and the ratio of plant blockage. The total leaf area TL_A is determined by multiplying the total number of leaves by the average leaf area. The modulus of elasticity E is determined (Equation 10) by measuring the force F_{45} to bend the plant by an angle of 45 degrees. The 45 degree bending angle is measured from the base of the plant stem to the center of the leaf mass.

$$E = \frac{F_{45} H^2}{3I} \qquad (10)$$

CONCLUSIONS

An important observation was that the plants easily bent with flow, and the leaf mass trailed downstream forming a streamlined, almost teardrop shaped, profile. The leaf mass changed with velocity and became more streamlined with increased velocity. This observation explains the significant decrease in Manning's n_{veg} with velocity. It is important to note that the leaf mass can not be considered a rigid area of blockage, and that any apporximation of a constant Manning's n_{veg} to predict stage will be invalid .

Another important observation during the testing was that the leaf mass or layer of foliage diverted flow beneath the foliage layer. The flow resulted in significant velocities along the channel bottom which caused general scour and increased sediment transport. Even the clay test bed suffered significant erosion at channel velocities of 4 fps. The bed velocities were sufficient to transport and move the largest sizes of gravel. The ground cover plants did not produce increased bottom velocities, but the plants and exposed bed between plants, experienced local scour from three dimensional vortices formed from the flow above the plants.

Mathematical relationships were developed to predict the vegetation resistance coefficient n_{veg} from the tests conducted in the large and sectional flumes. Equations 5 and 6 were developed from the testing conducted in the large flume with four plant types and varying plant densities. The tests conducted in the large flume were all with plants of uniform dimensions and spacing. The next phase of testing with combinations of different sized plants will determine if and how Equations 5 and 6 can be used with non-uniform plants.

Equation 9 was developed from the sectional flume testing. Equation 9 is more fundamental and is semi-empirical as compared to Equation 6 of the large flume testing. To predict resistance from Equation 9, the plant approach velocity must be known. More testing will be necessary to develop the equations and methods to determine V_P.

Only 4 plant groups were tested in the large flume. It is planned to test other types of plants and combinations of different sizes and types of plants in the large flume. Tests of individual plants in the sectional flume will also continue, and the methodology to predict Manning's n_{veg} from plant characteristics and density will be further refined.

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IDEAL FLOOD MANAGEMENT PRACTICES

JANET C. HERRIN[1]

INTRODUCTION

I am pleased to be a member of this distinguished panel of experts that have come together today to discuss where we go from here. Where we go depends in part on where we have been and what we have learned. As a result, my talk will progress through three areas: (1) the history of flood management at the Tennessee Valley Authority (TVA) and lessons learned, (2) future flood management strategy at TVA, and (3) some thoughts on ideal flood management practices.

TVA

TVA is a wholly owned government corporation which was established by an act of Congress on May 18, 1933. All powers of the corporation are vested in its three member Board of Directors, which is appointed by the President.

Much of TVA's success can be attributed to two things. First, TVA has taken the best of both the public and private sectors. It has the flexibility and autonomy of the private sector and access to the resources of the Federal Government. Second, by being located in the region, TVA's Board provides centralized program planning, policy and decision-making for the Agency.

The Tennessee Valley watershed covers over 40,000 square miles in parts of seven states--Tennessee, Virginia, North Carolina, Georgia, Alabama, Mississippi, and Kentucky. The Tennessee River drains into the lower Ohio River, and shortly downstream, into the Mississippi River.

Rainfall in the Tennessee Valley is relatively uniform throughout the year and averages about 52 inches. Runoff is about 40 percent of rainfall and varies from 75 percent during flood season from January through March to 25 percent in the late fall. While runoff averages about 22 inches per year, it can deviate in any year as much as 50 percent above or below normal.

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HISTORY OF FLOOD MANAGEMENT AT TVA

Historically, TVA has adopted a twofold approach to flood management--keep water away from the people and keep people away from the water. We have attempted to keep the water away from the people through our reservoir operations program and keep people away from the water through our floodplain management program.

RESERVOIR OPERATIONS

TVA owns and operates 54 water control structures in the watershed. These projects are operated as an integrated river control system. Our goal is to operate such that the benefits derived from integrated system operation exceed the benefits that would be derived from operation of each project individually.

Most of the TVA reservoirs are multipurpose meaning they were designed to meet several specified objectives. This results in many, often conflicting, demands on the overall system. These demands include navigation, flood control, hydropower, water supply, water quality, recreation, fisheries, and aquatic ecology.

The reservoirs are operated on an annual cycle with a late summer/fall drawdown to provide downstream flow augmentation for water quality, navigation, and power generation and evacuation of flood control space. The flood control space is maintained throughout the winter when the threat of flooding is greatest. The reservoirs are allowed to fill in the spring as the threat of flooding decreases. However, some flood control space is maintained at most tributary projects throughout the summer. Maintaining minimum downstream flow and dissolved oxygen level of releases from TVA's projects is a year-round commitment. Recreational levels are a primary operating objective during June and July.

My talk today will focus on the flood control benefit. Flood damages avoided by the existence and operation of the TVA system is just over 4 billion dollars. Ninety percent of these averted damages have been at Chattanooga, the primary flood control beneficiary in the Valley. In 1994 alone, over 1 billion dollars in damages were averted in two flood control operations. TVA also provides a flood control benefit along the lower Ohio and Mississippi Rivers in cooperation with the U.S. Army Corps of Engineers. Operation of Kentucky Dam has prevented over 150 million dollars in damages on the Ohio and Mississippi Rivers over the last 50 years with over 42 million dollars in 1994.

FLOODPLAIN MANAGEMENT

Temporary storage behind dams is not always feasible or cost beneficial and seldom provides full protection. To supplement its series of dams and reservoirs, TVA implemented a floodplain management program in 1953.

The program was based on a partnership between TVA and local government. TVA's role has historically been as a provider of flood hazard information, technical assistance, flood damage reduction planning, and financial assistance for project implementation. Local government was responsible for controlling land use in the floodplain by adopting floodplain regulations. These regulations ensured that the flood hazard was taken into account in development of the floodplain.

TVA'S flood hazard information has taken two forms. One form is the full study sponsored by TVA or the Federal Emergency Management Agency (FEMA) that describes the extent and severity of flooding in the community. It serves as the basis for exploring solutions to flood problems. The second form is site-specific flood information requested by community officials, developers, or citizens to evaluate proposed development and avert future flood losses.

Technical assistance has enabled local administrators to develop, administer, and enforce floodplain regulations. It has included workshops, seminars, and pamphlets that describe how to interpret and use technical flood data and understand the National Flood Insurance Program and Executive Order 11988.

Flood damage reduction planning and project implementation has included evaluation and demonstration of feasible structural and nonstructural measures. Structural measures have included dams, channel modifications, and levees and floodwalls. Recently, structural measures have fallen out of favor because of the potential adverse environmental consequences and the false sense of security that structural measures instill in floodplain occupants.

Nonstructural measures have included adoption of land-use regulations to control development in the floodplain, emergency warning and response systems to alert floodplain occupants, floodproofing to prevent water from entering and damaging floodplain structures, and relocation of communities out of the floodplain.

FUTURE FLOOD MANAGEMENT STRATEGY AT TVA

TVA will continue to use its twofold approach to flood management--keep water away from the people and keep people away from the water. However, public demands and the products the public expects continues to evolve at a rapid pace.

RESERVOIR OPERATIONS

TVA will continue to operate an integrated, multipurpose river control system. However, demands on the system are increasing daily. In 1991, TVA completed its Lake Improvement Plan that elevated recreational and water quality considerations above hydropower considerations under some circumstances. We expect to see increased emphasis in these two areas.

The increased demands on the system are forcing TVA to operate the system "closer to the edge." We are being called upon to quantify the risks and tradeoffs we face in optimizing system benefits. Ultimately, we will be forced to take more, better-understood risks.

FLOODPLAIN MANAGEMENT

In 1994, TVA's Water Management organization undertook a refocusing effort to determine where to use its limited resources most effectively. We chose to concentrate on those activities where we have direct authority, unique expertise, and the best opportunity to make a difference. We have focused our floodplain management program on the lands and projects that TVA holds in stewardship, the floodplains along the rivers and reservoirs regulated by TVA's dams, and selected projects where TVA has a special interest. In those areas, TVA now takes a proactive approach to promote wise use of the floodplain and prevent development that adversely impacts operation of the river system for flood control. Requests for site-specific technical assistance to communities in day-to-day administration of local floodplain management programs along unregulated streams are referred to the state coordinator or FEMA.

CLEAN WATER INITIATIVE

TVA is taking a new approach to river cleanup called our Clean Water Initiative (or CWI). The goal is to make the Tennessee River system the cleanest and most productive river system in the United States. We believe the approach and delivery are applicable to many water resource issues including flood management, so I will take a few minutes to describe the initiative.

The Tennessee River watershed covers over 40,000 square miles. To begin to work in such a large area, we divided the watershed into 12 subwatersheds, ranging in size from 2,000 to 6,000 square miles. TVA works in these subwatersheds to evaluate the water resource condition and to develop and implement clean-up projects.

The key elements of this approach are watersheds and partnerships. Most water resource issues are related to the human use of the land and demands placed on the water. The challenge then is how to deal with the multiple demands and impacts on the river system.

The way TVA is doing this is through River Action Teams (or RATs) assigned to each of the 12 subwatersheds. Each RAT is a small, multidisciplinary, self-managed team to do the "science" of linking land and water resources, and to bring about action, by informing and involving people--the residents of the watershed. Our teams are made up of a biologist, environmental scientist, engineer, and communication/education specialist. The communication/education specialist is an integral part of each team because they help our "scientist" to de-technify the data and to present information in a manner that is understood and useful.

In all aspects of our RAT work, we try to involve local residents and volunteers in an effort to know, get involved in, and take ownership of their watershed. Activities include stream monitoring, classroom projects, installation of alternative Best Management Practices (BMPs) on farms, and river cleanups, to name a few.

IDEAL FLOOD MANAGEMENT PRACTICES

Ideal flood management practice must avail itself of all possible technologies to effectively decrease loss of life, damages, and loss of the natural resource. This means that ideal practices must include a combination of structural and nonstructural approaches. Floodplain regulations can prevent future unwise development and use of the floodplain while structural and other nonstructural approaches can be used to solve existing floodplain problems.

In today's competitive world, ideal flood management practice must be based on partnerships among all government levels and the public. Partnerships involving local and state governments, increase their capability to effectively and efficiently address flood management issues. Partnerships including the public raise individual awareness and ownership. Partnerships involving non-federal governments and the public shift responsibility from the Federal Government as it continues to downsize and cut budgets.

Ideal flood management practices must be based on a watershed approach. Good upstream practices will not push flood management problems downstream. In addition, flood management becomes part of a broad water management program designed to both meet the needs and gain the support of all watershed residents.

Ideal flood management practice must be integrated into overall natural resources planning. It may be possible to couple environmental protection and flood loss reduction strategies or develop all hazards mitigation plans. As part of a multiobjective plan to meet a variety of community needs, flood management has a better chance of receiving the support and funding it needs to be successful.

PRACTICAL FLOOD MANAGEMENT POLICIES FOR THE FUTURE

Carroll M. Hamon*

ABSTRACT

Flood management, through both structural and non-structural measures, is a concept that has generally replaced the practice of 'flood control', but implementation has been slow. The Interagency Floodplain Management Review Committee's report, "Sharing the Challenge: Floodplain Management into the 21st Century", June 1994, reinforces this concept and suggests that floodplain management should be implemented from the bottom up. It also recognizes four levels of responsibility in flood management, (1) Local, (2) State, (3) Federal, and (4) Individual Citizens. Practical policies for implementing flood management practices at each of these levels are needed. There is a role for each to play. Local governments with control over land use must exercise that authority to reduce development in flood hazard areas. States can support local efforts by adopting minimum standards that must be achieved in local floodplain regulations and by providing technical assistance. The Federal Government can continue the National Flood Insurance Program and aid in removing existing development from high flood hazard areas. Individual citizens can become better informed about flood risks and take rational actions to avoid flood hazard areas. By working together, significant achievement is possible.

INTRODUCTION

"Flood Management' is a concept that has been too long in coming. Not long ago the concept was 'flood control' with the idea of storing or restricting flood waters to defined channels and keeping them away from the works of man, or where man wanted to construct more of his works in floodplains carved over the millennia. When the floods came, and they did in spite of our best efforts, we encouraged those that were ravaged to "fight the good fight" and through the help of government and charitable organizations aided them in rebuilding their lives and property back in harm's way -- back in the flood hazard area. In fact, only a few years ago the federal government would provide financial help for people to rebuild in the floodplain -- but with no help for flood proofing. In the

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recent past, only very limited funds were available to help flood victims escape and rebuild out of the floodplain. Now, some funding will be made available from a mitigation fund in the September 1994 NFIP reform bill that can be used for flood proofing and other mitigation measures.

Although it has been three decades since we began to realize that all floods could not be 'controlled' and that it made good sense to try to 'manage' floods by combining structural measures of control with non-structural measures that included preventing development in the primary floodway, progress has been slow. The National Flood Insurance Program became available in 1968 and established some standards for development in the floodplain and provided the incentive of flood risk mitigation through purchase of subsidized flood insurance. That program is a good effort on the part of the Federal Government that has been underutilized, and is sometimes misused.

Society can learn and make positive change as a result of disaster. Let's hope that will happen as a result of the Midwest Flood of 1993. A good start has been made by the President's Interagency Floodplain Management Review Committee June 1994 report titled, Sharing the Challenge: Floodplain Management into the 21st Century -- more commonly known as the "Galloway Report" after U. S. Brigadier General Gerald E. Galloway who headed the Committee. The report has generally been well received and proposes a blueprint for change in the way the nation addresses flood management. It proposes an approach to floodplain management that is a sequential strategy of avoidance, minimization, and mitigation. It recognizes four levels of responsibility in flood management, (1) Local, (2) State, (3) Federal and, (4) Individual citizens.

LOCAL POLICY

The Galloway report suggests that floodplain management should be implemented from the bottom up. "The basic tenet of reducing vulnerability is to avoid risks as much as possible in the planning stage. Moving people out of harm's way or limiting development in the floodplain lessens risks from flood damages". Most people agree. This must be accomplished at the local [city, county] level. As citizens, we constantly clamor for control over our activities to be at the lowest level of government. But, at that level, it is often the most difficult to implement because of neighbor regulating neighbor, and special economic and social interests that are brought to bear on local officials. On the other hand, local officials know the most about the needs of their communities and therefore are in the best position to take rational actions. They have control over land use and must exercise that authority in flood management decisions. There must be a concerted effort in the future at the national and state levels to encourage, support, and finally require that flood management actions are taken at the local level to minimize flood risks to life and property.

STATE POLICY

States can support local control over flood management by adopting minimum standards that must be achieved in local floodplain regulations, such as has been done in the National Flood Insurance Program, but tailored to the state's unique situation or regions of the state.

States should require a local approach to flood management that integrates flood control through structural measures with non-structural actions to avoid floodplain development and provide for mitigation where development is allowed or already exists. Since a carrot often works better than a stick, a practical policy for States to encourage proper local actions might be for States to provide technical assistance to local entities during planning and design either directly or through financial assistance, contingent upon compliance.

States could also have a significant impact on flood damage reduction through a policy of continuous education and outreach to individual citizens with regard to flood risk and management. A better informed citizenry is going to make better individual and collective decisions regarding flood management. The effort must be continuous because situations, potential development locations and people are continually changing.

FEDERAL POLICY

The federal presence in flood management must be maintained -- possibly at some lesser financial level such as presently being considered for intra-state flood control projects -- but nevertheless at a substantial level. The federal government has a responsibility for maintenance of the health, safety, and welfare of the people. Since floods threaten each of these areas it is in the national interest to shoulder some of the responsibility for flood management. If there is reduced federal help in flood control in the future, it should be reduced in a scheduled manner over a long enough period to allow state and local officials to prepare.

Although difficult, federal policy must not allow flood victims to have their cake and eat it too. The example in the Galloway report of the Chesterfield area in Missouri where those who had not purchased flood insurance were allowed to purchase, and then collect, insurance five days in advance of an advancing flood that was obviously going to overwhelm existing protective levees. Or the instances in California in January 1995, where families that received federal aid in a 1986 flood canceled their flood insurance after the flood, reasoning that it was the "100-year flood" and that a similar flood was not likely to happen again in their lifetime. But, flooding was worse in January 1995 and after a Presidential visit, those flood victims were able to receive federal financial help again in less than nine years, although they had dropped their insurance in violation of the program. Most will use those federal funds to cleanup, rebuild, and remain in the vulnerable floodplain to repeat the cycle at some unknown but certain future date.

INDIVIDUAL ACTIONS

As responsible citizens we each have a responsibility to become informed about flood risks to the areas in which we live. Citizens should take the time to determine the flood risk to an area where they live or intend to live, much as they would other aspects of the area, such as transportation facilities, school systems, and shopping . Of course they can be greatly aided in this by the state providing information and education to its citizens on a continuous basis as suggested earlier. A good place to start would be at the elementary school level, possibly connected to geography, which is being reintroduced in most schools.

Finally, it can generally be agreed that there is a shared responsibility for proper flood management among all levels of government and the individual citizens. We must work together on practical ways of reducing flood risk. The 'Galloway' report's suggestion of avoidance, minimization, and mitigation is a strategy that should be followed with practical policies for achievement.

INTEGRATED FLOOD MANAGEMENT - A PLAN FOR THE FUTURE

Harry E. Kitch, P.E.[1]

ABSTRACT

The Flood Plain Management Assessment of the Upper Mississippi and Lower Missouri Rivers and their Tributaries (FPMA) draft report, developed by the U.S. Army Corps of Engineers addresses many of the impacts and issues resulting from the Great Midwest Flood of 1993. This paper presents several of the key conclusions and findings from that draft report. A framework of physical, educational, and institutional considerations is suggested to guide future actions in the Nation's floodplains.

INTRODUCTION

I appreciate the opportunity to be here in St. Louis to speak to this distinguished group at this Flood Management Seminar sponsored by the U.S. Committee on Irrigation and Drainage.

First, the tile of this talk "Integrated Flood Management" does NOT support the presumptuous position that one can "manage" floods. "Integrated Flood Management" IS a consideration of all aspects of a flood problem - hydrology, hydraulics, ecology, land use, economics, institutional and political frameworks, personal priorities and business preferences. We must use a systems approach to provide us with a reasonable definition of the most "prudent" use of our rivers and adjacent floodplains. Here, "prudent" is defined as the socially optimal combination of uses of a river ecosystem, including adjacent floodplain lands, that maximizes the economic and environmental benefits to the nation. Today our national perspective and value system are different from those of 1928, 1936 or 1944. As we consider a balanced approach in seeking the best use of our floodplains, we must be conscious of the past development and look toward our future with a holistic point of view. We must remember that in making decisions about the best use of a floodplain, we are really making investment decisions. This applies equally to deciding to build a levee, offering flood insurance, or dedicating an area to wetlands. To have any hope of reaching a solution that can address all of the diverse needs within our river basins and that can be implemented, we must consider the physical, institutional and educational aspects of integrated flood management.

This paper will briefly discuss the draft conclusions presented in the US Army Corps of Engineers The Flood Plain Management Assessment of the Upper Mississippi and Lower Missouri Rivers and their Tributaries (FPMA)[2] draft report which was designed to address many of the impacts and issues resulting from the Great Midwest Flood of 1993. This paper then presents a framework for the future which can be used to organize and assess our future actions for integrated flood management.

FLOOD PLAIN MANAGEMENT ASSESSMENT

As of this writing, the draft report, which was distributed on March 30, 1995 for public review and comment, is being finalized for release in early July.

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The Assessment was conducted by the Corps of Engineers over an 18 month period. Many federal and state agencies were involved including: three division and five district office of the Corps of Engineers; the National Resources Conservation Service (NRCS) (formerly the Soil Conservation Service); the Federal Emergency Management Agency (FEMA); the U.S. Environmental Protection Agency (USEPA); the U.S. Fish and Wildlife Service (USFWS); the nine states affected by the 1993 Flood (Minnesota, Wisconsin, Iowa, Illinois, Missouri, Kansas, North Dakota, South Dakota, Nebraska); and the general public. The Assessment was to "... be accomplished on a broad and conceptual basis, using a systems approach to floodplain management." This study effort was designed to complement the early work prompted by the 1993 Flood, most notably the Interagency Floodplain Management Review Committee Report[3], better know as the " Galloway Report". The Galloway Report set forth the Committee's recommendations on "...changes in current policies, programs, and activities of the federal government that most effectively would achieve risk reduction, economic efficiency, and environmental enhancement in the floodplain and related watersheds."

Because of the large geographic area affected by the flood and due to the short time and limited funds available to conduct the Assessment, it focused on the 1993 Flood by making a comparison of a wide array of: alternative policies and programs; structural and non-structural measures and the effects of activities in upstream watersheds and on wetlands. Given the broad scope of the Assessment, subsequent investigations may find specific cases and situations that differ from this study. However, it is believed that the overall trends and conclusions presented in the Assessment will remain valid even if more detailed studies are conducted.

FLOOD PLAIN MANAGEMENT ASSESSMENT - KEY FINDINGS

The following paragraphs highlight the key findings and conclusions from the draft report.

Can't Totally Eliminate Risk of Flooding

" Floods are a natural and recurring phenomenon, and the risk of flooding can never be totally eliminated. (Chapter 1)"

Structural Protection Worked Well in Urban Areas

"Corps reservoirs performed well, reducing flood peaks by several feet in most locations. Structural flood protection (urban levees and flood walls) performed well where in place and performed as designed in protecting large urban centers. The General Accounting Office concluded that "most Corps levees performed as designed and prevented significant damages". (Chapter 1)"

"The total damages prevented by reservoirs and levees have been estimated at $11 billion and $8 billion, respectively. (Chapter 3)"

In 93 Flood 40% of Flooded Buildings Outside the 100 yr Floodplain

"More than 40% of the buildings that were flooded in the summer of 1993 were outside the 100 year floodplain. More than 31 % of the NFIP claims from 1978 to 1987 were for damages outside the 100 year floodplain."

Most (80%) Agricultural Losses Not From Overbank Flooding

"Approximately 80 percent 1993 flood damages related to crops were not caused by overbank flooding and would not have been affected by any projects or changes in floodplain management policies. The best and perhaps only option to address these damages is a rational program of flood or crop insurance. (Chapter 3)"

Conversion of Farmland to Wetlands Would Not Have Reduced Stages in 1993

"Converting floodplain agricultural land to wetlands would not have reduced stages in the 1993 Midwest Flood. There are floodplain resource values that could be enhanced if targeted conversions meeting specific criteria were achieved; there would be a cost in terms of foregone agricultural production. Agricultural use of the floodplain is appropriate, if the residual risk of flooding is understood and accepted within a logical system of crop insurance and flood damage reduction measures. (Chapter 6)"

Upland Wetlands Restoration May Reduce Local Flooding

" Wetlands may reduce local flooding in the uplands by up to 25% where contributing areas are small. Restoration of such wetlands would not have impacted flooding in the lower floodplain reaches because most depressional areas were already full of water throughout the watershed, as normally occurs during major flood events. (Chapter 6)"

"The potential to reduce flooding with further upland measures varies. In the watersheds that contributed the greatest percentage of runoff, wetlands and revised agricultural practices would have had minimal effect for the 1993 event. Major structural flood control storage reservoirs would be required to achieve the additional 10 percent volume reduction used for the analysis. (Chapter 6)"

"Restoration of upland wetlands would have had localized flood reduction benefits, but little effect on mainstems for the 1993 Midwest flood. For smaller, more localized flood events, this action could have a beneficial impact related to flood stage reductions. Other benefits of such an action appear related to water quality, wildlife habitat, and groundwater recharge values that go beyond flood damage reduction benefits. (Chapter 6)"

Systematic Evaluation of Hydraulic Impacts Important

"The importance of evaluating hydraulic impacts systemically was made clearly evident by the results of the unsteady state hydraulic modeling. Changes that affect the timing of flood peaks or the "roughness coefficients" of the floodplain can be as significant as changes in storage volume. (Chapter 6)"

Floodplain Zoning & Regulation for Critical Facilities

"State and local floodplain zoning and regulation could be most effective in determining the siting of critical facilities that have the potential for releasing harmful elements into the environment when flooded. (Chapter 8)"

Acquisitions Lead To Significant Long Term Savings

"More emphasis is being placed on flood hazard mitigation measures, especially acquisitions of flood-prone structures, as an action that will avoid repeated Federal disaster expenditures and other costs associated with areas of widespread and potentially substantial repetitive flooding. (Chapter 8) "

Accept Risk Through Actuarially Sound Flood Insurance

"Actuarially sound flood insurance coverage would better assure that those who invest, build, and live in the floodplain accept appropriate responsibility for the damages and other losses that result from floods. (Chapter 8)"

Mitigation to Avoid Repeated Disaster Expenditures

"Future disaster assistance and insurance needs could be significantly reduced if the problem of repetitively damaged structures is firmly addressed."

Localized Levee Setbacks Increase D/S Stages and Forested Floodplain Similar to Levee Constriction

"Hydraulic modeling has shown that localized levee setbacks can increase flood stages downstream by creating a new bottleneck, and that a forested floodplain can increase stages similar to a levee constriction."

Significant Stage Increases If Agricultural Levees Raised

"If the agricultural levees along the Middle Mississippi River had been raised and strengthened to prevent overtopping in the 1993 event, the flood stages on the Middle Mississippi would have been an average of about 6 feet higher. (Chapter 6)"

Agricultural Levee Removal Doesn't Always Reduce Stage & Flow

"Modeling results demonstrated that agricultural levee removal does not always provide uniform stage and discharge reduction. When levees are overtopped, they act as detention dams, skimming volume off the peak portion of the hydrograph. When levee are removed, the flow continues downstream in the enlarged floodway. As a result, higher flows may be experienced downstream at critical facilities and urban areas, causing increased stages at these locations. (Chapter 6)"

Upland Measures Result in Varied Flood Reductions

"Hydraulic modeling of reducing the runoff from the upland watersheds by 5% and 10% resulted in average stage decreases of about 0.6 and 1.3 feet, respectively, on the Mississippi and Missouri Rivers upstream of the St. Louis area. However, wetland restoration measures would not have been capable of achieving this level of runoff reduction for the 1993 event due to the extremely wet antecedent conditions. (Chapter 6)"

Limited Agricultural Areas Suitable for Conversion to Wetlands

"The extent and magnitude of floodplain acreage suitable for conversion or restoration is considered to be quite small in comparison with floodplain acreage that would be continued to be farmed."

Seem To Be Shifting From Disaster Aid to Mitigation

"A shift from dependence on disaster aid to flood hazard mitigation (floodproofing, elevating, or acquiring and relocating out of the floodplain) and flood insurance appears to be occurring."

"The Federal philosophy of floodplain management recognizes that flood damage avoidance measures should generally be the first defense against flooding, complemented by structural flood protection where justified, with flood insurance to cover the residual risk of flooding. (Chapter 2)"

The Flood Plain Management Assessment also identified several areas that additional efforts could contribute to enhancing our floodplain management efforts and understanding.

"a) More extensive inventory and mapping of levees and other structures in the floodplain"

"b) More extensive inventory of critical facilities in the floodplain"

"c) More extensive data and hydraulic modeling of upland watershed areas that have the greatest potential for flood damage reduction"

"d) Additional hydraulic modeling (non-steady state) with more detailed mapping and for portions of the main stem rivers not yet modeled and the larger tributaries"

"e) real-time, non-steady state hydraulic model for predicting flood crests in future flood emergencies."

What have we learned from this Assessment and the other efforts resulting from the Great Flood of 1993? First, we must place more effort on avoiding flood damages, especially from future development. Secondly, we must protect existing development in an effective and environmentally sound manner. And, lastly, we must address the residual risk of flooding through various mechanisms so that those that choose to take the risks, pay for them. It is encouraging to see that we as professionals and the agencies we work for and the Nation are making some significant changes in the way we deal with flooding problems. We can organize what we have learned from the Flood of 93 into three areas that will serve to focus our future actions to improve our response to the continued threat of flooding.

PHYSICAL - EDUCATIONAL - INSTITUTIONAL -- A FRAMEWORK FOR THE FUTURE

Physical

The first part of the framework embraces the physical aspects of integrated flood management. Here we consider the location, extent, and make up of the flood plain. The environmental and social characteristics must be described. The hydrological characteristics of the river - storage and conveyance- as well as the water quality aspects are important to understand. In order to gain a full understanding of the complex interworkings of the floodplain, we must collect and organize the data that are needed to describe and quantify the characteristics of the basins. Although our recent studies have found a great deal of data in the areas affected by the Flood of '93 but accuracy, incompleteness, and incompatible formats make the task of creating a consistent, accurate hydrologic picture of the basins a daunting one. The Assessment has pointed out some of the additional data needs, particularly for description of land use and institutional relationships. There are many agencies at all levels of government as well as other water oriented organizations that are involved in attempting to collect, store, and organize these data. Leadership is needed to ensure that these efforts are complementary and to avoid misusing scarce resources.

We also need to develop and expand our tools used to analyze all the data being collected. There are many mathematical models that have been created to help analyze the hydrologic data but additional effort is needed to expand the areas covered by these models. We also need to do more work on the ecological aspects of the flood plains. All the data collection and modeling will help us to do a better job at predicting the consequences of future flood events. However, and more importantly, we will begin to have the tools that are necessary to better guide our future use of the floodplains.

Educational

In spite of many years of efforts, the risk from floods is still not fully realized. People still continue to develop in the flood plains. Improvements have been made, and we are seeing significant changes in the response to the Flood of '93 from previous events. We are also beginning to take a more holistic view of the flood plains and consider the trade-offs among economic, social and environmental values.

However, our profession must continue to do more to educate our government officials and the general public about the risks of living and working in the flood plains. We must apply risk based analyses to planning and design problems to improve the quality of the decisions made about contemplated projects or programs. Having done that, our recommended decisions must be explained to the general public in terms that relate to their lives and not as some abstract concept. This is nowhere more important than explaining the residual risk to those who are behind structural flood protection measures such as levees or flood walls.

Institutional

Finally, we must all subscribe to a concept of prudent use to decide what combination of uses of flood plain lands maximizes economic and environmental benefits to the Nation. Of course, local and regional views are likely to differ from a national view which further complicates any institutional arraignment designed to integrate the uses of flood plains. A decision making framework must be developed that will acknowledge the full range of uses of the floodplain and the economic, social and environmental benefits that are derived from those uses. This framework must include all levels of government, special interest groups and the public, giving full recognition to states rights in land use control.

CONCLUSION

We are beginning to make some important national and regional decisions about our floodplains. We have some information on how the existing floodplain infrastructure performed during the last flood and are improving our ability to predict future events. Agencies and the public are considering a much wider range of alternative approaches to the prudent use of the floodplain than we have in the past. Now, we need to be able to construct a decision framework that properly values our National, regional, local and individual priorities. But given the wide differences in points of view that exist today, it is unlikely that any decisions will be made easily. The final outcome will be driven by environmental and economic concerns and the constraints imposed by the national deficit.

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Summary and Conclusions

Peter J.L. Gear[1]
General Chairman

By the middle of 1993, there had been an extraordinary succession of devastating floods in the world. The Great Flood in the Mississippi basin was followed by major inundations and devastation in Pakistan, in Nepal, in Bangladesh, and in China. This sequence led the Dutch organizers of the 15th Congress of the International Commission on Irrigation and Drainage, held in The Hague, in late September, 1993, to introduce a special day-long session on floods. This session attracted major interest, not the least because of a USCID-assembled multi-disciplinary panel of speakers from the U.S. reporting on the Great Flood. Their commentary, besides reporting on the events of the flood itself, indicated the emergence of challenges to conventional approaches and the initiation of constructive discussion which could have significant impact on flood management policy in the U.S. Thus was sparked the concept for this USCID-sponsored Seminar.

In the period since the Great Flood, there has indeed been a remarkable stream of rethink on how to approach flood protection, and where, in what form and if, to provide it. Perhaps the key representation of this is the 1994 "Galloway" Report, in fact entitled "Sharing the Challenge: Floodplain Management into the 21st Century." General Galloway's Task Force has produced an insightful summary of options, ideas and recommendations for updating and rationalizing reassessments of flood protection, flood management, and flood insurance in the U.S. In its multi-disciplinary, multi-audience investigation of the Great Flood, the Task Force identified a widespread will to discuss, change, and resolve. Thus the theme for this Seminar that USCID selected back in 1993 – "A multi-disciplinary review of flood management issues" – has proved particularly topical, while the time elapsed since then has permitted the presentations at the Seminar to report on a substantial amount of accrued, practical material on the complex issues involved.

In the Seminar's Keynote Address, Genera Galloway provides an adroit review and commentary on the dynamics of the creation, reception and recommendations of his Task Force's Report. This in turn provided an ideal setting for the compendium of the subsequent papers which cover a broad spectrum of involved interests – Federal, State and local politics; institutions; environment; flood insurance; engineering; structural and non-structural controls; technology; public and community relations; education; flood response planning and implementation. Of special significance to the content is the amount of

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senior professional and practical experience that is represented. While certainly much material is related to the Great Flood and its aftermath, papers from California (which itself was just starting to dry out from major flooding), from TVA, and from overseas, provide important broadening perspectives.

As underlined by General Galloway in his presentation, and emphasized in many other papers, the political will is emerging (or is in place already) in the U.S. to mobilize a significant rationalization in handling floodplain loss prevention and mitigation, and to empower and make accountable State and local authorities, communities and involved individuals. FEMA has already emerged with improved incentives, capabilities and controls. The evolving or potential changes in the flood management responsibilities of the USBR and of the U.S. Army Corps of Engineers are further changing greatly the parameters of approach, transferring responsibilities, effort and costs to the State and local authorities, and to communities. The rationalization and coordination of these changes will prove a testing time, especially with concurrent requirements for budget cuts. Especially, it will impose the requirement for full consideration of multi-disciplinary effects, including social, environmental, and political, as well as economic, objectives, in cost/benefit evaluations and in decision-making. Achieving consensus among the disparate parties will remain a challenge, but real participation of the parties in the process will permit the result to be, and be seen to be, more democratic as well as more balanced.

This Seminar has been one of the first to concentrate on broad flood management issues; it should not be the last. As evidenced by the long list of Cooperating Organizations which supported it, the high-level interest which it received, and the dynamics of the discussions themselves, such a forum was needed. It will be valuable for it to be reconvened within a reasonable period, particularly to learn of evolutionary experience in:

- effective floodplain management criteria, policies and application
- the integration of the environmental, political and social objectives and risk assessment into the cost/benefit analyses
- approaches to community involvement
- the effectiveness of flood insurance conditions and qualifications
- the integration or retrofitting of non-structural approaches into existing structural-based planning for flood management
- institutional coordination, authority, and cost and risk sharing
- data base management technology, recording and sharing information
- criteria for application of protection; level of protection.

The realities of the experience of the Great Flood of 1993 and of its aftermath, the cooperation and teamwork between directly- and indirectly-involved groups and individual, and the current political shifts, have generated great energy and perhaps a unique opportunity for the advancement of multi-disciplinary solutions to flood plain controversies. Our mutual challenge now is to improve the methodology for involving affected individual s and groups to mobilize coherent, multi-disciplinary communications, to motivate constructive reappraisal and realignment of decision-making processes and criteria, and to maintain interest in and maximize the momentum for coordinated and better solutions.

Acknowledgements
Following approval of its concept by the Board of USCID, under its President Darell D. Zimbelman, this Seminar was organized by an ad-hoc committee composed of Peter J.L. Gear, Chairman; Frederick F. Schantz; Peter D. Rabbon; Neil W. Schild; Ed Sing; and Larry Stephens, Executive Vice President of USCID, who also provided the major input to the planning and meeting set-up. The committee was much assisted by the strong support from the Corps of Engineers secured by Earl Eiker (Earl, and Jim Brown of the Iowa Department of Water Resources, who also participated in the Seminar, had been panelists at The Hague ICID Congress special flood session, which was chaired by Peter Gear).

CONTRIBUTIONS OF THE SCIENTIFIC ASSESSMENT AND STRATEGY TEAM TOWARDS THE MANAGEMENT OF FLOODPLAINS AND FLOODING

Gary E. Freeman[1]

ABSTRACT

As a result of the 1993 flood the White House established the Scientific Assessment and Strategy Team (SAST) to provide scientific advice and assistance to officials responsible for making decisions with respect to flood recovery in the Upper Mississippi River Basin. The SAST consisted an interdisciplinary team of senior scientists and engineers from NRCS, USGS, Corps or Engineers, NBS, FEMA, and EPA and developed a vast multi-layer, multi-resolution database covering the Upper Mississippi River basin. Much of this data is now available via the INTERNET. In addition to the data base that was produced, specific studies were undertaken by SAST. One of the specific studies conducted by the SAST dealt with the installation of best management practices on watershed to view their effects on flood peak reduction. The impact of levees on flooding was also evaluated.

INTRODUCTION

The Scientific Assessment and Strategy Team (SAST) was formed by a directive from the White House on November 24, 1993 to provide advice and assistance for federal officials responsible for making decisions with respect to flood recovery in the Upper Mississippi and Missouri River Basins (1). The Upper Mississippi River Basin is defined as the portion of the basin above the confluence with the Ohio River at Cairo, Illinois. The SAST studied primarily the portion of the Mississippi River basin above Cairo Illinois and below St. Paul, Minnesota and the Missouri River from Gavins Point Dam, near Sioux City, Iowa, to its confluence with the Mississippi River near St. Louis, Missouri.

The SAST is an interdisciplinary team of senior scientists and engineers from the Department of Agriculture (Natural Resource Conservation Service - NRCS), Department of Defense (U.S. Army Corps of Engineers - Corps), Department of Interior (Fish and Wildlife Service - FWS, National Biological Service - NBS, U.S. Geological Survey - USGS), Environmental Protection Agency (EPA), and the Federal Emergency Management Agency (FEMA).

The SAST was also incorporated as a part of the Interagency Floodplain Management Review Committee (IFMRC) on January 10, 1994, by directive from the Office of Management and Budget, Office of Environmental Policy, and Department of Agriculture. The SAST was given additional responsibilities to support the IFMRC in their effort to assess Governmental floodplain policies and make recommendations. As a part of the IFMRC, the SAST participated in the preparation and review of their report to the Administration Floodplain Management Task Force. The IFMRC report is now widely known as the Galloway Report after BG Gerald E.

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Galloway who headed up the IFMRC. Data and analysis provided by the SAST were either included directly or were the basis for a number of recommendations made within the report.

The SAST has plans to produce four report volumes. The planned (or complete volumes) are:

Volume 1 Preliminary Report to the IFMRC (1) - Published

Volume 2 Database Report - detailed description of SAST data base, including metadata, descriptions of strengths and weaknesses of data, acquisition methods, data maintenance plans, and data distribution methods.

Volume 3 Scientific Background Report - contains papers and studies commissioned by the SAST to answer specific questions. Includes reports on basin hydrology, ecology, model studies performed for SAST and etc.

Volume 4 Proceedings of the SAST Hydraulic, Hydrologic, and Ecologic Modeling Workshop - contains papers presented by workshop speakers and selected discussions of the workshop participants.

An additional volume was planned to present final analyses from data obtained by SAST. Funding was not available to produce this volume and final results are being presented in various journals and conferences in fields related to the studies performed.

SAST DATABASE

The SAST aggregated vast amounts of data for use in both nonspatial and GIS analyses. Numerous federal, state, and local government agencies undertook data collection efforts during the flood of 1993. Each agency collected data in the amount, type, and format that were most useful in fulfilling their mission. One of the largest problems facing the SAST was the location of data collected by the various agencies. Some agencies had collected large amounts of data but only those directly involved in its collection or use were aware the data's existence. Other agencies had data readily available but data validation was ongoing and data could not be obtained until validated. The data that was only known to those who obtained the data comprised a vast amount of valuable data but required a large amount of detective work to discover its existence. New data sets were uncovered throughout the SAST effort and it is certain that valuable existing data sets were not located during the SAST effort.

As a direct result of the vast amount of time and energy expended uncovering and locating data, SAST recommended a data clearinghouse be set up. In the clearinghouse data remains on-line or near-line, owned and maintained by the agency that collected the data and most logically can make use of the data, but is available electronically to other agencies who need the data in on-going operations, studies, or during emergency situations. Organizations which produce specialized data should at the very least produce a list of data available in an electronic format so the data can be located in an emergency situation and to reduce the duplication of effort in data collection.

The nonstandard formats of the data also created problems for the SAST effort. When data was obtained it may or may not have translated correctly with accompanying descriptors (attributes). Additionally the time required to convert the data was often long with numerous difficulties.

Data Collected by SAST

Data gathered during the SAST effort was used for analysis, to provide background, or as an aid in understanding related problems. The data came from a wide variety of sources and included:

1. Flood extent data: generated for SAST from satellite imagery for the major floodplains with widths greater than 1 kilometer;

2. Superfund sites on the National Priorities List with the exception of the Dakotas and Toxic Release Inventory (TRI) for Minnesota, Wisconsin and Illinois;

3. Permitted discharges under the Permit Compliance System;

4. Public water systems for the SAST study area;

5. Hydraulic data used for the modeling of the Mississippi River from near Hannibal, Missouri to Cairo, Illinois;

6. Levee location and elevation data, where available, for the Mississippi and Missouri Rivers as well as levee break information;

7. Period of record daily flow data for about 50 long-term USGS stations on the mainstem Mississippi, Missouri, Illinois, and Des Moines Rivers, plus a few major tributaries;

8. Peak flow data for the 154 gages at which major 1993 floods were reported in USGS Circular 1120-A;

9. Daily, monthly, and annual mean flow data (period of record through 1988) for selected long-term sites suitable for climate variation studies;

10. Daily reservoir stage data at major reservoirs in the study area for the 1993 water year;

11. Climate data for the period of record for climate divisions in Iowa, Illinois, Kansas, Minnesota, Missouri, North and South Dakota, Nebraska, and Wisconsin;

12. Daily precipitation and temperature data for April-September 1993 for individual observation sites in Iowa, Illinois, Minnesota, Missouri, and Wisconsin;

13. National Wetlands Inventory (NWI) data that have been completed to date for the basin - SAST has also contracted to have all remaining paper maps digitized;

14. Point locations of sightings of rare and endangered

species developed by The Nature Conservancy, generalized into vertebrate, invertebrate, plan, and community, limited to within six miles of the floodplains for major rivers and tributaries - data cannot be used outside the SAST by prior agreement with The Nature Conservancy;

15. The North American Waterfowl Plan Joint Venture Areas were digitized, consist of waterfowl habitat areas of major concern;

16. Resource inventories of floodplain and ecological data for the Mississippi River from Gutenberg, Iowa to Cairo, Illinois - includes sport and commercial fishing areas, spawning areas, mussel beds, and important wildlife areas such as cormorant rookeries and eagle wintering areas;

17. Ownership data for wildlife refuges in the floodplains of the Mississippi, Missouri, and Illinois Rivers, as well as state lands and natural preserves in Illinois, Wisconsin, and Minnesota;

18. Critical Infrastructure: a. hospitals, bridges, railroads, roads, point source facilities (in ARC/INFO format and for all nine states except Nebraska, Missouri, and the Dakotas); and b. wastewater treatment facilities for all states, airports, and electricity generating plants, and impacted water facilities (in tabular format) for all nine states except the Dakotas.

19. Land use/land cover for selected reaches of the Mississippi River for 1989 and 1891-94 and data for the Missouri River for 1879;

20. Numerous other data sets that may be for only one state or local area such as drainage ditch maps, digital elevation models of selected drainage basins, etc.

The data was all provided to SAST by the collectors/owners of the data. In many cases SAST provided for the conversion of the data to digital form whereas previously the data existed only in the form of paper maps or tables.

<u>Accessing the SAST Database</u>

The SAST database can be accessed via the Internet with an World Wide Web browser (Mosaic, Netscape, etc) using the following uniform resource locator (URL):

http://edcwww.cr.usgs.gov/sast-home.html

The SAST database is continuing to expand as more and more data is quality assured and placed on-line. A demo of the database is also available through an X-windows based interface at the same location as above. The demo requires an X Windows interface on you computer to function properly. The demo allows the overlaying of various data layers as well as the flood extend to view flood impacts on various resources.

ANALYSIS OF DATA BY SAST

The SAST was limited to ten weeks of continuous effort at the EROS data center. Due to the amount of time necessary to find, collect, translate, and transform the data into a usable form, the time available for analysis of data was very limited. In spite of the constraints placed on the team, significant amounts of data were analyzed and significant findings produced. Data analysis was divided into two areas - the natural system and the engineered system. Within the natural system analysis were the hydrology and physiography of the region, floodplain geomorphology, and floodplain ecology. The engineered system included the levee and flood protection systems, economic data, and upland management options.

SAST contributions to understanding the impacts of the 1993 flood varied by discipline due to differing amounts of data available and differing amounts of time available for analysis during the teams stay in Sioux Falls, South Dakota and after their return to their duty stations. Some of the SAST findings are well understood within the various technical communities but needed to be demonstrated in the context of the SAST exercise. This was necessary to assure balance in the study efforts and to demonstrate the effects of alternatives being discussed for analysis - both the uplands and within the floodplains.

ANALYSIS OF NATURAL SYSTEM DATA

The timing of the storms in the Upper Mississippi River basin exacerbated the 1993 flood. The early storms were in the upper areas of the basin and ensuing storm patterns moved southward following the peak of the flooding. The later storms added additional water to the peak flows moving down the rivers from the upper basin. Thus the flood peaks reinforced each other and increased flood peaks and durations.

The flood control reservoirs within the basin varied significantly in their capacities and effects on flooding depending on their storage volumes and location within the basin. In the Missouri River basin, nearly all rainfall fell below the location of the six large mainstem reservoirs and thus their effect, while still significant, was limited. Other reservoirs on the Missouri system were filled to maximum storage - and even beyond in some cases. Reservoirs on the Mississippi River were small compared to the size of their drainage areas and the amount of water passing through the reservoirs. These reservoirs usually had a significant impact on flooding and damages on the tributaries where they were located, but produced only minor effects on the Mississippi River stages.

The flood waters entering the system above Gavins point dam on the Missouri River were contained in the mainstem reservoirs and the base flow of the river was lowered as much as possible to reduce downstream flooding. Reservoirs on the Kansas River and its tributaries reduced Kansas River flows by about one third. One the Missouri River, reservoirs reduced the average flow for July at Hermann, Missouri by about 36%. Without the reservoir system in place the floodwalls at St Louis would have been overtopped as well as additional levee systems resulting in large amounts of additional damage.

A misconception that was being reported during and immediately after the flood was that the basin would have had the capability to store the floodwaters in the uplands either in the soil or in wetlands if man had not disrupted the natural system. Water holding capacities for the flooded areas were estimated from the USDA STATSGO database and compared with rainfall amounts. It is estimated that the soils in the flood area can hold about 10 inches of water while rainfall amounts over the flood area during the June to September 1993 period varied from 15 to 30 inches. Individual storms produced 4-6 inches within a few hours. Based on this analysis and other information it was concluded that the soils in the area could not have absorbed the rainfall and that major flood should be expected from rainfall events of this nature - whether the land is in agricultural production or in its natural state.

Large portions of the natural wetlands have been drained in the basin and converted to farmland. The amount of land considered to be wetlands in 1780 ranges from 5.5 percent in South Dakota to 28 percent in Minnesota. The states of Iowa, Missouri, and North Dakota are all estimated to have had about 11 percent wetlands while Illinois had about 23 percent and Wisconsin had 27% wetlands. The amount of these wetlands that have been converted to agricultural uses ranges from a low of 34 percent to a high of 93 percent in Iowa. Most of these wetlands and former wetlands were filled with water - at least to some extent - either by storms earlier in the winter and spring or by the early summer storms. This allowed more water to runoff that would occur in a more normal year when wetlands and low lying agricultural areas were more likely to retain water and reduce downstream flood peaks.

The geomorphology of the floodplains along the Mississippi and Missouri Rivers differs significantly. The upper Mississippi River's annual discharge volume is similar to that of the Missouri River but the Missouri's sediment discharge is five times that of the upper Mississippi River. This has resulted in a floodplain slope on the Missouri River that is about twice that of the Mississippi River below St. Louis. This steeper slope and relatively narrow floodplain resulted in higher velocity flows and more damage to the Missouri River floodplain from the 1993 flood. On the Missouri River numerous deep scour holes are present with associated sand splays while many fewer but relatively larger splays are present along the Mississippi River.

A part of the difference in floodplain damages is probably due to the relative number of levees along the rivers, however this aspect has not been fully analyzed. Along the middle Mississippi River, for example, levees tend to enclose large tracts of land where one or two levee breaches could flood tens of thousands of acres, while the numerous levees on the Missouri River may only protect several hundred to a few thousand acres. Each levee breach has an associated scour hole and sand splay which result in damages to land and nearby structures. Analysis indicates that in the Glasgow to St. Louis reach of the Missouri River approximately 5% to 7% of the land was substantially damaged with 90 to 95% of this damage due to scour and deposition directly associated with levee breaches.

A significant finding of the geomorphological analysis was the ability to delineate the "high-energy" zones of conveyance along the river and the zones of more passive flooding using conventional aerial photography. This corresponds closely to the conveyance zone used in hydraulic design and modeling. This delineation of high energy zones confirms the logic of the original Pick-Sloan plan that called for levee setbacks along the Missouri River to produce a floodway of 3,000 to 5,000 feet. This floodway has not been protected over most of the Missouri river's length. The Federal levees that have been built along the River have maintained this floodway but private levees have been built near the bank of the Missouri river throughout much of its length.

The current ecology of the basin's major rivers is greatly modified from that of the natural river. Many of the natural inhabitants of the basins rivers are under stress or endangered. The changing of sediment loads, the construction of levees, and changes in river hydrographs due to irrigation, navigation, municipal water supply, power production, and recreation have created these habitat problems for many species in the basin. The change of the basin and floodplains from natural prairie and forests to agricultural lands has also had an effect on habitat and the number of species found along the rivers. Commercial fishing in the Illinois River, for example, has dropped from 24 million pounds or 178 lbs/acre in 1908 to 4 lbs/acre in the 1970's (3).

Preliminary 1993 flood data indicate a resurgence in the numbers of young of the year for fish species where young of the year have not been seen in significant numbers for several years. The scour holes and associated features are currently providing habitat on the Missouri River for fish and other forms of wildlife.

ANALYSIS OF THE ENGINEERED SYSTEM

The descriptor, "engineered system" may be overly broad - attributing to engineering, actions undertaken by individual farmers, society in general, and governmental agencies which have resulted in modifications to the natural state of the basin. Engineering is here taken to include everything from the burning of prairie by the Native Americans during the hunting buffalo to the building of modern dams on the rivers and tributaries. It includes all impacts that man has had upon the floodplains and within the basin. This analysis focused on two aspects of the basin, the levee system and its effects, and the effects of man on the uplands and the amount of flood reductions possible from varying current land management practices.

The Uplands

The methods described herein as nonstructural methods of flood reduction have long been encouraged in the United States. Usually the methods have been associated with other goals such as capturing the maximum amount of rainfall for agricultural crops, restoring prairie potholes for the use of waterfowl, or preventing the erosion of soil. These methods, while practiced to accomplish other goals, can provide some flood reduction benefits. The NRCS for example, has encouraged the protection of farmland to reduce runoff and erosion - both of which affect flooding in a basin.

The effects of wetlands and other land practices were evaluated for four watersheds within the Upper Mississippi River Basin. The four basins evaluated were:

> Boone River Basin above the gage near Webster City, IA - a relatively flat watershed with low relief prairie pothole terrain, 840 square miles,

West Fork Cedar River above the gage near Finchford, IA - a relatively flat watershed but having a well defined drainage system, 850 sq. miles,

Whitebreast Creek above the gage near Dallas, IA - a relatively steep watershed with well incised drainage, 380 sq. miles,

Redwood River basin above Redwood Falls, MN - a high relief pothole watershed in the upper portion and a low relief pothole watershed in the lower portion of the basin, 700 sq. miles.

The object of the modeling effort was to demonstrate the effect of various management, land use, and storage practices on the outflow hydrographs for differing types of basins. Alternatives selected for the Boone River, West Fork Cedar River, and Whitebreast Creek were:

1. Maximizing wetland storage in upland and/or floodplain areas as applicable,

2. Demonstrating the effect of the Conservation Reserve Program (CRP) lands on flooding,

3. Maximizing infiltration by using all applicable land treatments such as conservation tillage, terraces, and permanent cover,

4. Flood prevention structures - i.e., traditional NRCS small (P.L. 566) watershed structures to temporarily store water and release it slowly,

5. A combination of all non-structural practices - i.e., alternatives 1-3, and,

6. A combination of all possible alternatives - alternative 5 plus alternative 4 to demonstrate the maximum possible reduction for the watershed without the inundation of large areas for medium to large reservoirs.

When treatments were used in an alternative, the treatment was assumed to apply to 100% of the acreage within the watershed. This assumption was unrealistically high but the object was to determine the maximum effect that could be obtained from a treatment. This tended to overestimate the obtainable effect.

Alternative 3, the maximum infiltration option, included conservation tillage on all agricultural lands, terraces on lands with slopes from 5 to 14 percent (C and D slopes), and permanent cover (grass, trees) on all lands with slopes greater than 14 percent. This alternative also included the effects of current CRP lands which were intended to be highly erodible lands.

The Redwood River basin was modeled with a different set of alternatives. The object of the Redwood River study was to model the affect of wetlands on flood peaks. The six alternatives studied evaluated the restoration of:

a. all depressional hydric soils with detention structures (19% of watershed),

b. 50% of all depressional hydric soils as in option a

(10% of watershed),

c. 25% of all depressional hydric soils as in option a (5% of watershed),

d. small wetlands with 50% assumed to be landlocked - i.e. 50% had no outlet to stream after restoration while the remaining 50% served as detention structures,

e. large wetlands and lakes over 100 acres in size, and

f. large and small wetlands (combine alternatives a and e) with no assumption of landlocked wetlands.

Since the goal of the Redwood River study was to determine the effect of wetlands, no NRCS land treatments (CRP or maximum infiltration) were applied to the Redwood River basin. Additionally, with the exception of alternative d, the wetlands were assumed to be restored as detention storage areas. This assumption means that the water stored in the wetland would be released slowly through a control structure over a period of several days, making full storage of the wetland available for a subsequent storm. Using the full storage maximized the effect of wetlands on flood peaks in the watershed. The cyclical filling and draining of the wetland by floodwaters may have negative effects on wetlands but could be designed to include a smaller wetland in the lower elevations and use additional lands during storm events to detain water on the upland areas surrounding the wetland.

The models for the various watersheds were calibrated to the conditions that existed at the time of the calibration storm. Since not all watersheds experienced major flooding during 1993, the models were calibrated to the largest storm for which sufficient rainfall and flow records existed. The Whitebreast Creek watershed, for example, was calibrated to a storm that occurred during the fall of 1992 which was larger than any event in that watershed during 1993. The West Fork Cedar River was calibrated to a July 1990 event since the watershed did not experience a large flood during 1993. Since CRP lands were in place for the 1992 event on Whitebreast Creek the model was calibrated with the CRP lands in place. The CRP lands were than removed from the model and the model rerun to give a base condition without CRP. Thus base conditions are for no practices in place (i.e. after adjustment to remove the effects of current CRP lands). The four events evaluated were the 1-, 5-, 25-, and 100-year storms.

The various land treatments and land practices are not all applicable to all watersheds. The construction of detention basins, for example, is most economically feasible in watersheds with incised drainage channels where a small dam can impound a relatively large amount of water. A tour of the West Fork Cedar River revealed very few sites for detention storage and, since the number was deemed too few to provide a significant impact, the detention basin option was not modeled for the West Fork Cedar River. Similarly, too few wetland sites were available to produce a noticeable impact; and this option was not modeled for the West Fork Cedar River as well. It should be noted that an off stream wildlife site exists in the basin, but a shallow depth of water (perhaps 4-5 feet) covers several hundred acres. This makes the construction of detention basins or wetlands a very land-intensive undertaking within the West Fork Cedar River Basin. This is not to say that there are no opportunities within the basin, but the opportunities were not deemed sufficient to make a noticeable difference in model results without involving large tracts of land.

The models used for the studies consisted of the NRCS TR-20 model for the Redwood River and Whitebreast Creek basins, and the CORPS HEC-1 model for the Boone and West Fork Cedar River basins.

Results of Watershed Studies: The results of the four watershed studies described above are presented in Table 1. The results of the Redwood River study is included for comparison, even though the studies are not totally comparable. The Redwood River, while not modeled for the same alternatives, did correspond to three cases studied for the other three basins. The maximum reduction for the Redwood basin is also shown in Table 1 for comparison, but it must be remembered that the Redwood basin included no upland land treatments which could increase the maximum flood peak reductions that could be expected. The maximum reduction results are plotted in Figure 1 for the four basins, with the best results for the Redwood basin coming from option d - small wetland restoration with 50% assumed to be landlocked.

The model studies indicated that for the basins studied, floodplain wetlands played only a minor role in flood peak reductions with a 3% maximum reduction in the Redwood River basin for the 100 year storm and no reductions in the incised Whitebreast Creek. Wetlands in the uplands produced a 10% reduction in flood peak for the 100 year storm in the Redwood River basin but only a 5% reduction in the Boone River basin. The modeling of wetlands in the Boone River basin was hampered by the lack of high resolution topographic data. The wetland areas were estimated from a 1:24,000 USGS topographic map. A more detailed studied using better elevation data may produce slightly different results but any wetland studies should be bounded on the upper limit by approximately the values obtained on the Redwood River watershed.

The CRP lands produced reductions in flood peaks ranging from 4% for Whitebreast Creek for the 100 year flood down to 1% for the Boone River Basin. The Maximum infiltration option produced reductions as high as 20% for Whitebreast Creek but only 2% to 4% on the Boone and West Fork Cedar River basins for the 100 year storm.

Detention structures were modeled only on Whitebreast Creek and in the Redwood River basin. Reductions ranged up to 28% on Whitebreast Creek for the 100 year flood - probably due to the routing of stored water - but amounted to 11% for the 100 year storm on the Redwood River. This is some concern about the trends demonstrated by the Whitebreast Creek study as compared to the Redwood River but additional investigation has not be accomplished.

The maximum flood peak reduction for all the basins for the 100 year storm ranged from 4% on the West Fork Cedar River where wetland and detention structure sites were not abundant to nearly 40% on Whitebreast Creek. The results from Whitebreast Creek caused some concern given the increasing reductions with storm size, and further analysis should be performed prior to extending the results from Whitebreast Creek to other areas within the basin. If larger storms were modeled in this basin (greater than

Table 1. Peak and Volume Reductions for Watershed Studies.

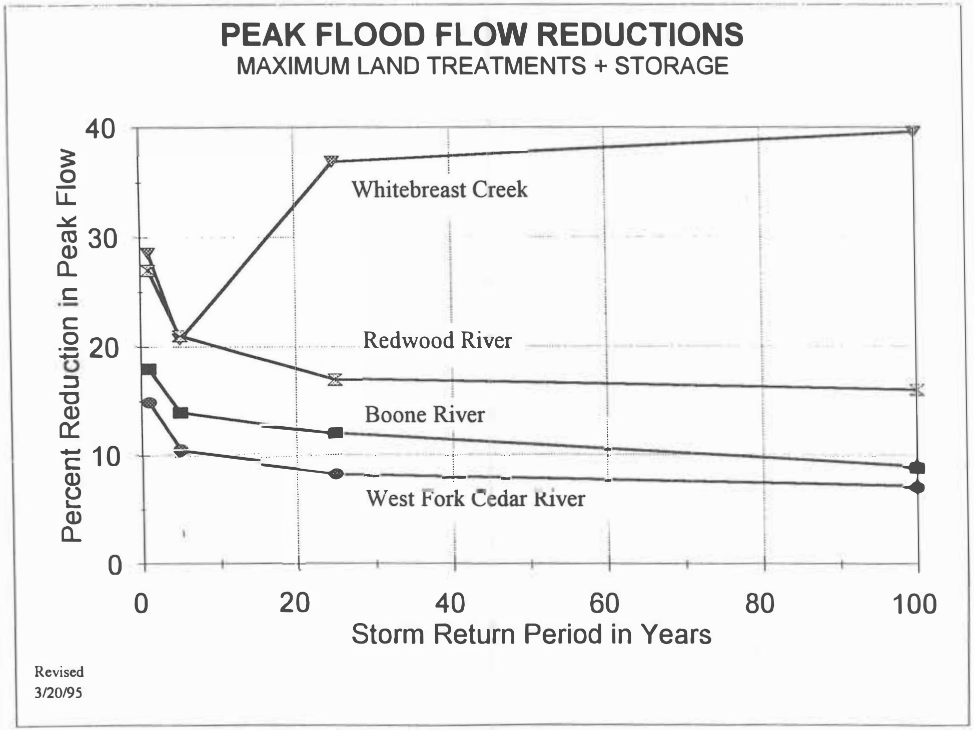
Flood Peak and Volume Reduction by Watershed and Treatment (%)								
Return Period	Boone River		West Fork Cedar River		Whitebreast Creek		Redwood River	
	Peak	Vol	Peak	Volume	Peak	Vol	Peak	Volume
Floodplain Wetlands							(Alt e)	
1	5	0			1	***	6	1
5	3	0			1		5	1
25	2	0			2		3	1
100	2	0			0		3	0
Upland Wetlands or Potholes							(Alt a)	
1	9	7					23	2
5	8	4					15	3
25	7	1					11	4
100	5	0					10	2
Conservation Reserve Program (CRP)								
1	3	2	7	6	4			
5	1	1	5	4	4			
25	1	1	4	3	4			
100	1	1	3	3	4			
Maximum Infiltration (FSA) - Includes CRP Reductions								
1	6	4	15*	14	21			
5	3	3	11*	10	15			
25	2	2	8*	8	18			
100	2	2	7*	7	20			
Detention Structures							(Alt f)	
1					8		26	4
5					15		16	4
25					27		12	5
100					28		11	3
Total of All Applicable Treatments							(Alt d)	
1	18	12	15*	14	29		27	11
5	14	8	11*	10	21		21	12
25	12	4	8*	8	37		17	12
100	9	2	7*	7	40		16	11

* In the original SAST Table these numbers were incorrectly reported without the CRP effects which are included in the FSA programs and are included in other watersheds.

** This table is taken from the Preliminary Report of the Scientific Assessment and Strategy Team with the Total of All Treatments for the West Fork Cedar River Revised to the correct peak values.

*** Adequate data could not be obtained to determine volume reductions for Whitebreast Creek.

Fig. 1. Peak Reductions for Test Watersheds using all Applicable Structural and Non-structural Alternatives.



100 year), the peak reductions should begin to decrease and eventually approach zero as detention structures exceeded their design capacities. Results of the Whitebreast Creek study should be used with caution.

The analysis of volume reductions by the various alternatives is also presented in Table 1. This work was accomplished in a follow-on effort funded by the Corps of Engineers. It can be noted that for alternatives where water is retained on the watershed (infiltrated or stored permanently) the volume reductions and the peak flow reductions are very similar. For cases where the water is simply stored and then released - such as in detention ponds - the volume reductions are minimal and only the timing of the flow is changed. The direct comparison of volume reductions between watersheds is not recommended since differing storm periods were used in the modeling effort to get the watersheds to peak.

Conclusions: The hydrologic model studies showed clearly that there is no single type of land treatment that is applicable to all watersheds in the upper Mississippi River basin. They also showed that while wetlands may be effective for smaller, more frequent storms, their effect is reduced as storm size increases. The NRCS practices can produce significant reductions in flood peaks in steeper watersheds where improved infiltration and detention structures can retain significant amounts of water on the watershed during a storm. These same practices have much less effect on flat watersheds where water moves slowly and has more time to infiltrate.

The Floodplains

Humans have lived in the upper Mississippi River Basin for several thousand years. The floodplain played an important role in some of these early cultures which had substantial populations, earthworks, and material production (4-6). Human impacts in the basin within the last 200 years have included clearing of the floodplains and upland areas for agricultural production, removal of snags from the channels for navigation, construction of navigation dams, protection of cities and floodplains by the construction of levees, and the construction of large multipurpose reservoirs to provide power, water for irrigation, municipal/ rural/industrial water supplies, recreation, flood control, and other public benefits. Thus man must not be viewed as an outsider to the floodplains but as an integral part of the river and surrounding areas - one who should be considered in the balance of competing interests.

Levees: As lands were developed for agriculture and commerce, and towns and cities began to grow on the floodplain, demands increased for protection from flooding. This led to the construction of levees and reservoirs to reduce flooding within the basin. During the 1993 flood many of these levees - especially the private levees - were overwhelmed by the huge volume of floodwaters. Where the levees breached large scour holes developed and concentrated velocities damaged nearby homes and structures. It should be noted that levees are designed to overtop at some flow and return the floodplain storage to the system. This storage in turn reduces flood stages and moderates flows downstream to some degree - depending on the amount of storage in relation to the flood volume.

The concerns of environmental groups and others raised serious questions regarding the effect of levees. Some groups indicated that the levee system was the cause of the flood while other groups wanted to evaluate the effect of the levees. In an attempt to answer these questions SAST commissioned Dr. Robert L. Barkau to test several levee scenarios with the UNET mathematical hydraulic model to demonstrate the effect of the levees on the flood of 1993.

The data were not readily available to allow the application of the UNET model for the entire river reaches that were flooded during the 1993 flood. The data were available to construct the model from near Hannibal, MO to Cairo, IL on the Mississippi River, from Hermann, MO to the mouth on the Missouri River, and from near Meridosia, IL to the mouth of the Illinois River. The results indicated that for a hypothetical system with no agricultural levees and short crops or grasslands over the entire floodplain, the levee system increased water surface profiles at St. Louis by about 2.5 feet. This combination was considered unlikely for a no levee condition. A more probable condition includes trees and tall crops as well as the grasslands which would result in a much lower change in stage as a result of the simulated removal of the levee system. The difference depends on the final mix of crops, forests, wetlands, meadows, etc. and the resulting resistance to flow. This simulation assumed the urban levees near St. Louis were left in place and only agricultural levees were removed. The results are shown in Table 2.

The highest reduction in flood stage was as Chester, IL where for the best case (Manning's n = 0.04 - again considered unlikely) the model indicated a 10.7 foot reduction in flood stage. Some of the Manning's n values used in this study are higher than those often associated with river modeling, the calibration of the model indicated that values in the .080 to .320 range would predict the floodplain roughness values for this simulation better than lower values. At the higher n values reductions in the flood elevation ranged from 7 feet at Chester (n = 0.080) to almost no change at most locations (n = 0.320) depending on the assumptions for the floodplain. If no conveyance were allowed on the floodplains and the floodplains were only used for storage, flood elevations would be higher than those of the 1993 flood as shown in Table 2 in the No Conveyance column.

Another option was the modeling of levees that were high enough and strong enough to prevent failure during the 1993 flood as shown in the Infinite Height Levee column. For this case, flood elevations increased by less than 2 feet in St. Louis with the maximum increase being 2.7 feet at Waters Point just downstream from St. Louis. The main reason for the increase in flood elevation at St. Louis and points downstream is that the failure of the Harrisonville and Columbia levee districts near the peak of the flood lowered flood stages in St. Louis and points downstream by about 2 feet or more. The effects of the levees on smaller floods were also analyzed and produced results that follow those of the 1993 flood with levee effects being less for smaller floods. The Corps follow-on study indicated that the effects extending the no levee overtopping scenario to the entire basin would have raised the flood stage at St. Louis by about 6 feet - enough to overtop the floodwall and produce several billion dollars in additional damages.

<u>CONCLUSION:</u> The hydraulic study indicated that the removal of levees would have an impact on flood stages, however the types,

Table 2. Differences in Stage from the 1993 Flood Observed Stages for Various Gages and Alternatives.

		CALCULATED STAGE CHANGES FROM OBSERVED 1993, 1973, AND 1986 FLOODS IN FEET						
		INFINITE LEVEES	NO LEVEES					
RIVER GAGE	YEAR	Infinitely High and Strong Levees	Manning's "n" Value Used to Model Floodplain 0.040	0.080	0.160	0.320	0.640	9999 (No Conveyance)
MISSISSIPPI RIVER								
GRAFTON	93	1.0	-1.4	-1.0	-0.6	-0.4	-0.2	0
	73	1.3	-0.9	-0.8	-0.8	-0.7	-0.6	-0.7
	86	0.7	-0.4	-0.3	-0.3	-0.2	-0.2	-0.3
ST. LOUIS	93	1.9	-2.5	-1.5	-0.5	0.2	0.7	1.4
	73	1.5	-2.7	-2.0	-1.5	-1.2	-1.0	-0.8
	86	1.0	-1.3	-0.8	-0.4	-0.1	0.0	0.2
CHESTER	93	2.1	-10.7	-7.3	-4.5	-2.5	-1.2	0.5
	73	1.5	-8.0	-5.7	-3.9	-2.7	-2.0	-1.2
	86	0.7	-5.2	-3.4	-1.9	-1.0	-0.4	0.1
GRAND TOWER	93	2.1	-7.8	-5.3	-3.3	-1.9	-1.0	0.1
	73	1.2	-6.4	-4.7	-3.5	-2.7	-2.2	-1.7
	86	0.7	-4.5	-3.2	-2.3	-1.6	-1.3	-1
ILLINOIS RIVER								
HARDIN	93	1.1	-1.2	-0.8	-0.5	-0.2	-0.1	0.2
	73	1.2	-0.8	-0.6	-0.7	-0.5	-0.5	-0.5
	86	0.6	-0.3	-0.2	-0.1	-0.1	-0.1	-0.1
MISSOURI RIVER								
WASHINGTON	93	0.5	-4.7	-3.0	-1.6	-0.6	0.1	0.8
	73	0.0	-2.6	-1.6	-0.9	-0.4	-0.2	0.1
	86	0.3	-3.5	-2.4	-1.4	-0.8	-0.4	0.1

density, and amount of vegetation on the floodplain has a major impact on flood stages. For very dense vegetation on the floodplain stages could actually increase and the vegetative effects could overcome any stage reduction from levee removal.

REPORT CONCLUSIONS

The SAST effort resulted in the assembling of huge amounts of data relating to the 1993 flood and to the Upper Mississippi River Basin. This data, some of which have not yet been fully analyzed, indicate that the 1993 flood was caused by nature; and, while man has had significant impacts within the basin, this event would have been a major flood even without man's intervention.

The impact of levees and upland land treatments were evaluated; and, while we cannot state that the levees had no overall impact on flooding, we can state that the levees did not cause this flood nor did man's intervention in the uplands. The fact that it rained for the proverbial 40 days and 40 nights was the major cause of flooding, and this flood is not unlike major floods of the past. Additionally, floods of this magnitude can be expected in the future.

This flood does, however, give us a chance to evaluate how we use our floodplains, how we value them, and what we feel we should use them for in the future. The data provided by SAST and those associated with SAST have helped provide a basis for discussions about floods, flooding, and land use for the present and the future.

This study also points out the importance of viewing the system as a whole, rather than viewing each piece individually and separately. The bringing together of senior scientists and engineers from the differing agencies and disciplines gave the project a synergism that is lacking in many studies. This synergism enabled those participating in this project to evaluate their ideas, biases, and beliefs from other perspectives. This gathering of disciplines and broadening of perspectives is, perhaps, the greatest contribution of SAST to the management of Floodplains and Flooding.

The mention of product names does not imply endorsement of products by the U.S. Government, any agency thereof or by SAST. The use of product names is for general reference only.

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FLOOD MANAGEMENT SYSTEM FOR BANGLADESH
THE STRATEGY OF THE GENERIC MODEL - GIS CONNECTION

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ABSTRACT

Known in the world for the frequent occurrences of floods, Bangladesh encounters a plethora of floods annually. Caused by the heavy monsoon rains aggravated by the melt water of the Himalayas, floods have been a major obstacle to the country's economic development because they lead to heavy government expenditures and because they interfere with many economic activities. Total flood prevention is unrealistic, but flood alleviation programs including both structural and non-structural measures are needed. Schemes which reduce flood damage and improve living standards are necessary for the country's development.

In order to study and predict the hydraulic behaviour of the complex river systems numerical flood modelling tools are used. These models are useful tools to study flood management problems. However, in the management of flood-prone areas, two of the seemingly simple, yet highly time-consuming and difficult tasks are delineating flood-prone land from the flood-free land and examining of the impacts of alternative flood mitigation and flood protection measures on flood levels and therefore flood extent. These needs are amenable to satisfaction by the application of advanced information technology. This paper presents a system called as the Flood Management Model (FMM) based on the integration of the generically different kinds of knowledge and information, namely those of hydraulics and geography. This integration has been realized by interfacing the existing generic and widely distributed fourth generation modelling system MIKE11 to the generic and widely used GIS ARC/INFO.

INTRODUCTION

Bangladesh is a flat delta at the confluence of three of the major river systems of the world: the Ganges, the Brahmaputra, and the Meghna. With more than half of the country under the 12.5 m contour, some 30% of the cultivable area of Bangladesh is flooded in a normal year. An estimated 50% is vulnerable to either monsoon or tidal floods. Only some 20% of the vulnerable area is

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protected. Flooding in Bangladesh is commonly caused by a combination of several factors such as overbank spilling of the main rivers, runoff generated by heavy local rainfall, and cyclone tidal bores or storm surges. The 1987 and 1988 flood in Bangladesh were two of the most severe on record. Widespread damage was caused to crops, roads, railways, cities, and towns, and more than three thousands people lost their lives.

The Surface Water Simulation Modelling Programme (SWSMP) was established in 1986 because of the recognition that the effective control and utilisation of water resources in Bangladesh was vital to the economics and social development of the country. Mathematical models of the complex river system were seen in this respect as indispensable tools for an integrated approach to planning and design. The SWSMP aimed at developing a suite of mathematical river models at two different scales based on the generalised fourth-generation software package MIKE11 developed at DHI. The models were the general model covering most of Bangladesh and six regional models which provide a finer resolution of the regional river and drainage networks.

The developed models were verified under existing conditions and then used to evaluate the effects of engineering works. One of the most central elements was a `compartmentalisation', allowing for a controlled flooding and drainage within and between compartments and between compartments, main rivers and drainage channels. The flows could be through non-gated, throttling structures and gated structures on the rim of the subcompartments and compartments. The identification of overall water-management strategies for compartment and the development of simple operational rules were essential to the successful implementation of compartmentalisation on a large scale. The output from the models gave the variation of in time of water level and flows throughout the model area considering also the storage characteristics of the flood plains.

In the management of flood-prone areas, two of the seemingly simple, yet highly time-consuming and difficult tasks are delineating the flood-prone land from the flood-free land and the examining of the impact of alternative flood mitigation and flood protection measures on flood levels and therefore flood extent. The system described here has been primarily designed for generating 2D and 3D water level and flood inundation maps and for the contouring of flood inundation depths. The system uses a 3 D ground surface or a digital elevation model typically generated by a geographic information system (GIS) and water levels simulated by the modelling system to calculate water depths and inundation maps.

Although inundation maps represent a very important and necessary first step, the full power of operating in a GIS environment is only exploited by the further integration of flood scenario maps with the other spatially related information to perform tasks such as the designation of the low-impact and high-impact development areas, the estimation of cost-benefit ratios for flood mitigation proposals, the estimation of warning time for possible emergency evacuation and the development of the on-line monitoring and real-time optimisation systems. A common problem in the flood plain management is the need to know the relative costs of different flood events and scenarios. The GIS offers a methods of gaining this information quickly, and for many different scenarios. Having used MIKE11-GIS to create a flood inundation information layer, the user can overlay a land use layer to create a table showing all the combination of land use and depth of inundation in the study area.

CONCEPTS OF THE FLOOD MANAGEMENT MODEL (FMM)

Flood management is about making decisions based on policies reflecting the needs of communities and the environment. It is complex and often without solutions which fully satisfy all concerned parties. The many components: land use; environment; infrastructure; flood control structures; irrigation needs; agriculture; economics; society; fisheries; flood preparedness and flood forecasting, render decision making and policy formulation extremely difficult.

Modelling floods in Bangladesh has been the primary role of MIKE11 flood models. The models output flood levels along the rivers and over the floodplains, and more importantly, simulate the impacts of interventions on flood levels.

However, flood models do not produce the flood maps needed for identifying and prioritising flood management zones, nor do they produce maps of impacts on flood levels which greatly assist in assessing alternative solutions and carrying out multi-sectoral flood impact analyses.

To produce these maps, and to perform multi-sectoral impact analyses, GIS technology is needed. Flood depths and levels are represented as layers of data in the GIS which can be geographically related and analysed with data from other flood management components. The maps and results of multi-sectoral analyses are easily assimilated using a combination of graphic and statistical formats.

FMM is an integrated MIKE11-GIS modelling system which has the potential to assist in clarifying and disseminating information through enhanced mapping of impacts on flood levels, communities, agriculture, fisheries and the environment. The maps would also help provide project design specifications; monitor and assess the performance of flood control and drainage structures; and help distribute flood forecasts in a readily acceptable form to the general public.

Flood Management Cycle

Flood management follows a cyclic pattern linking ideas, proposals, consultations, adopting proposals, preparing guidelines, design, construction/implementation, and operating and maintaining finished schemes. This is the flood management planning, design, implementation and operation cycle, in which FMM plays a useful role.

At the planning level FMM helps assess proposed flood mitigation options and prepare environmental impact assessments. For design, FMM functions as a tool for determining civil works design criteria, designing structure operation rules, and providing inputs to flood preparedness programmes. At the implementation stage, FMM may be useful for a range of needs from scheduling flood prone construction works to a flood preparedness training aid. Real-time FMM operation linked with flood forecasting would help guide structure operators and assists emergency relief operations. FMM would also help present the consequences on flooding due to repair and maintenance of structures.

MIKE11

The MIKE11 software package models flows and water levels in rivers and estuaries. It is used as a tool to simulate flooding behaviour of rivers and floodplains. Models numerically represent the river and floodplain topography and are calibrated to recorded flood levels and discharges. Once a base model is established, flood impacts from artificial or natural causes can be quantified as changes in flood level and discharge.

MIKE11 is based on an efficient numerical solution of the complete non-linear equations for 1-D flows. A network configuration represents the rivers and floodplains as a system of connected branches. At discrete points along the branches flood levels (at h-points) and discharges (at Q-points) are calculated as a function of time.

The menu based user interface is used for data capture and display, and carrying out simulations. For details refer to the *MIKE11 Reference Manual* and *MIKE11 User's Guide* (Danish Hydraulic Institute, 1992).

MIKE11 Models

The Surface Water Modelling Centre has developed a suite of mathematical river models at two different scales based on the MIKE11-software package. The models were:

- The General Model (GM), as shown in Fig. 1, covers the entire area of Bangladesh with the exception of Chittagong and the Hill Tracts. It includes the main rivers of the country, totalling 2,410 km in length. The GM currently serves as a planning and design tool for large-scale flood control, drainage and irrigation projects. It also provides the basis for an ongoing upgrading of flood-forecasting facilities. The GM also provides boundary conditions for:

- Six Regional Models, which provide a finer resolution of the regional river and drainage network than does the GM. They are used as planning and design tools within the particular region, describing the effects of embankments along minor rivers, polders, regulators, pumping stations, dredging activities, etc. They also provide the basis for accurate flood forecasting at a regional scale and provide boundary conditions for such local, subregional models as are required for detailed analyses of specific projects.

Figure 2 shows the areas of the six regional models. Each of the models contains a rainfall-runoff component to simulate the catchment runoff and a hydrodynamic component with an emphasis on simulating water levels and flows in rivers and khals. Two additional modules enhance the applicability of the MIKE11 software package, namely i) a salinity model for the simulation of salinity intrusion in rivers and ii) a sediment transport module which allows the simulation of cohesive and non-cohesive sediment-transport processes. Customized sediment transport models have been developed for each of the regional models as well as the GM, while customized salinity models are being developed for three of the regions. In the same vein, a Kalman-filter-based data assimilation capability has been introduced into the MIKE11 in other applications, whereby real-time measurements are used to correct model results, and this facility is also being incorporated into the flood-management system under another programme.

Geographic Information System (GIS)

The concept of GIS is best visualised as layers of data, where each layer has a theme. A layer may be a river network, rain gauge locations, a DEM or a water level surface. The most powerful feature of GIS is its capacity to display, query and analyse layers of data in relation to each other.

Data are related through a common coordinate system and can be displayed graphically on the computer screen to give the appearance of a map (for example, a map of roads, settlements, rivers and tube well locations could be displayed as four layers of data overlaid on one another). The data can also be queried and analysed in many ways (depending on the capabilities of the GIS software). For example, a simple exercise would be to highlight all tube wells which are within a 4 km distance of a settlement. These tube wells can be subjected to further queries, such as show which of them are within 2 km of a road, and so on. Through GIS, it is easy to make simple to complex analyses based on the spatial relationship(s) between data. Data, and output from queries and analyses, can also be presented in tabular and statistical formats.

FMM uses the ARC/INFO GIS, developed and maintained by Environmental Systems Research Institute (ESRI). It is one of the world's most established and well-known GIS.

MIKE11-GIS Interface

The MIKE11-GIS interface merges the technologies of MIKE11 flood modelling and GIS as a spatial decision support tool for river and floodplain management.

MIKE11-GIS requires information on flood model networks and simulations. A DEM (three-dimensional model of ground surface elevations) is the other essential input. Other useful inputs are maps of rivers, infrastructure, cadastre, land use, agricultural use, satellite imagery or other project specific data needs.

MIKE11-GIS's main outputs are flood maps and comparative flood maps. The flood maps show in graphic detail inundation depths, flood durations and flood phases, and can be used for flood damage assessments on infrastructure, agriculture, fisheries and other sectors. Flood map accuracy is very dependent on the accuracies of the flood models and the DEM.

Comparative flood maps show the differences between two flood maps illustrating the impacts or changes resulting from proposed works, structure failure, embankment breaching and other interventions. Statistical information on flood or comparison maps can also be output, providing a tabular summary of the map. MIKE11-GIS also outputs floodplain topographic data (cross-section profiles and flooded area versus elevation curves) from a DEM to improve a flood model's schematisation. Figure 3 shows the inputs and outputs of MIKE11-GIS.

EXAMPLES OF FMM OUTPUTS

Flood Model Topographic Data

Preparing floodplain topographic data for flood models has been one of the most difficult and time-consuming tasks. Because of this, the accuracy of the data and the quality of the model over the floodplain can be poor, resulting in inaccurate and misleading interpretation of flooding behaviour.

A DEM contains a wealth of floodplain topographic data. MIKE11-GIS extracts and outputs floodplain topographic data from a DEM to MIKE11. Two types of MIKE11 data are produced: cross-section profiles and flooded area versus elevation curves. Both types can be directly placed into a MIKE11 cross-section database. An additional facility merges MIKE11 river cross-sections with floodplain cross-sections from the DEM.

Flood Depth Maps

Flood depth maps show the variation in flood depth over the floodplain, along with the flood-free areas. They give a clear picture of the depth and extent of flood inundation. The maps are produced using the results from a flood model simulation, and can be at an instant in time, or based on the maximum flood levels over the entire simulation.

Figure 4 illustrates a flood depth map with annotation providing explanations.

Duration Depth and Crop Damage Maps

Duration depth maps are similar to flood depth maps, but take into account the critical duration of flooding (typically three days) which a crop can withstand without being damaged. From the duration depth map, crop damage maps are produced.

The normal procedure is to work with periods (10 to 15 days, or monthly) which correspond with the crop's growth stages. The critical depths (the depth of water which will damage a crop if it is inundated for longer than the critical duration) must be supplied for each period.

A crop damage map for a period is produced by comparing the depths on the duration depth map with the critical depth. If a duration depth exceeds the critical depth the crop is damaged. Other criteria such as once the crop is damaged it remains damaged must also be applied.

Figure 5 shows an example of a duration depth map and a crop damage map.

Comparison Maps

Comparison maps show the change between two flood maps. The two types of comparison maps are:

- The impact of a flood intervention.
- The change in flooding over time.

For the first type, two flood maps of the same theme and/or time are needed, one based on a MIKE11 simulation of the pre-intervention conditions, and the other on the post-intervention conditions. By comparing the two flood maps, the impact or change in flooding can be readily observed. The second type requires two flood maps at two different times from the same MIKE11 simulation. The map shows the change in flooding between the two times. An illustration of a flood depth comparison map in presented in Fig. 6 and an example of a comparison map is given in Fig. 7.

CONCLUSIONS

The merging and integration of knowledge arising from two or more different disciplines is greatly expedited by the appropriate linking and consequent integration of their corresponding domain knowledge encapsulators. Although this process is usually motivated by the immediate, domain-specific needs of practice, as exemplified here by the acute problems of flood management in Bangladesh, these problems none the less lend themselves best to generic solutions. In the present case, in which hydraulic and geographic knowledge and data have to be integrated, this leads to a generalised interfacing of a fourth-generation modelling system to a geographic information system.

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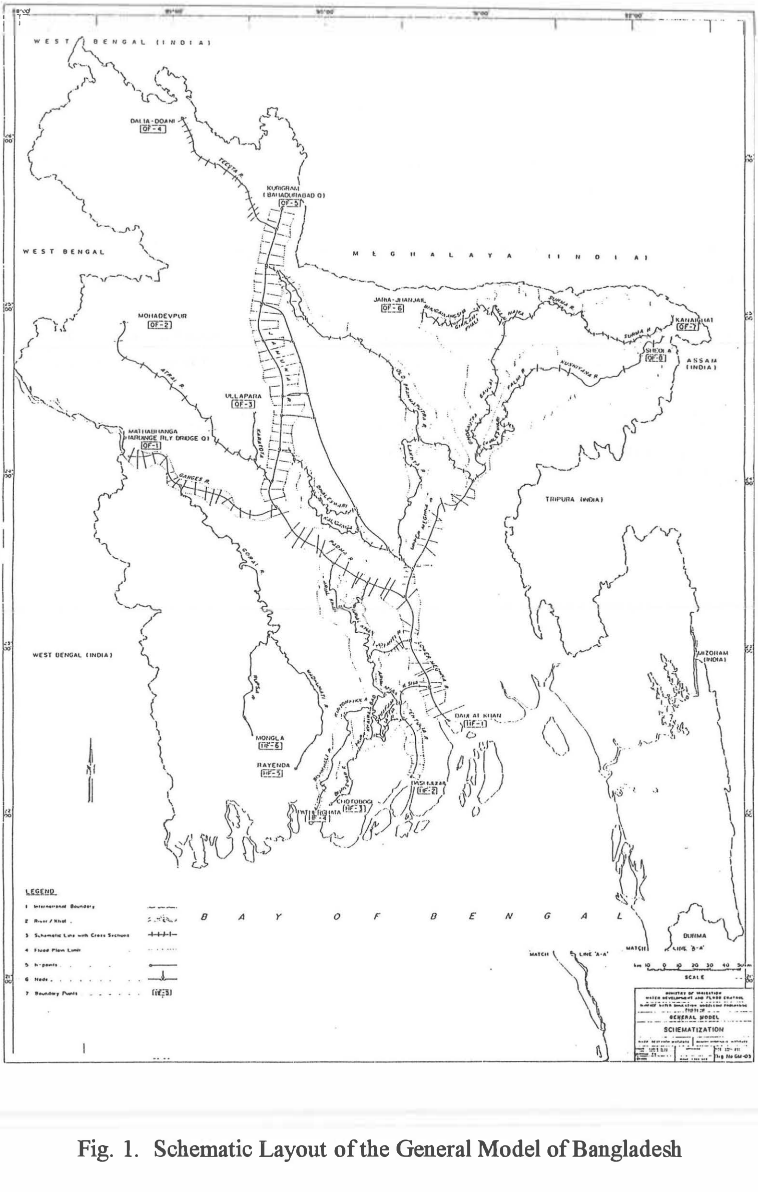


Fig. 1. Schematic Layout of the General Model of Bangladesh

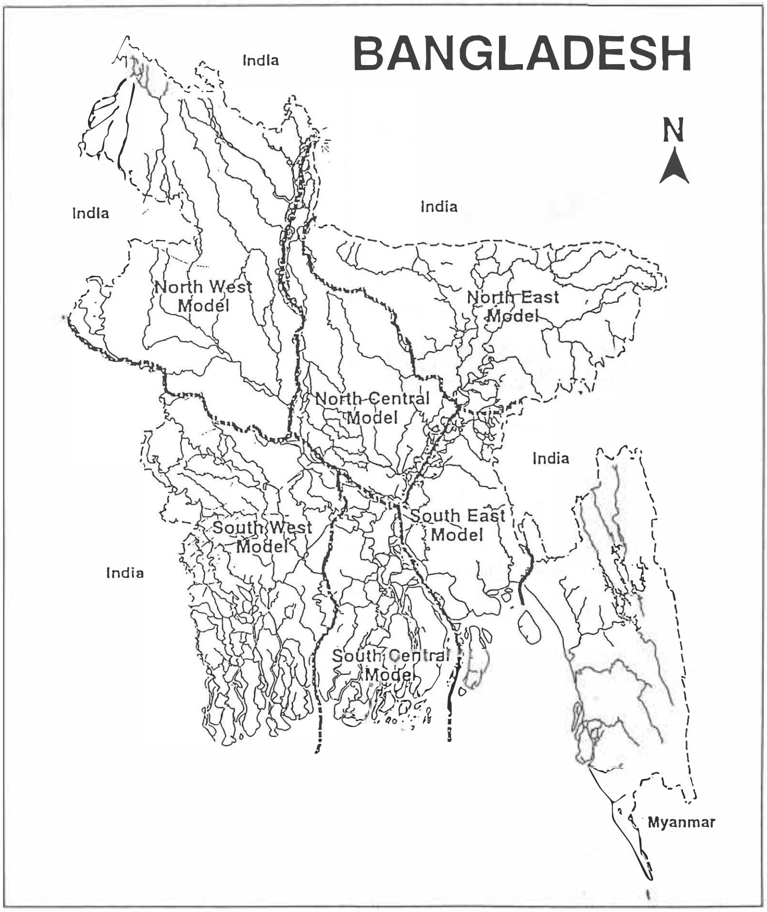
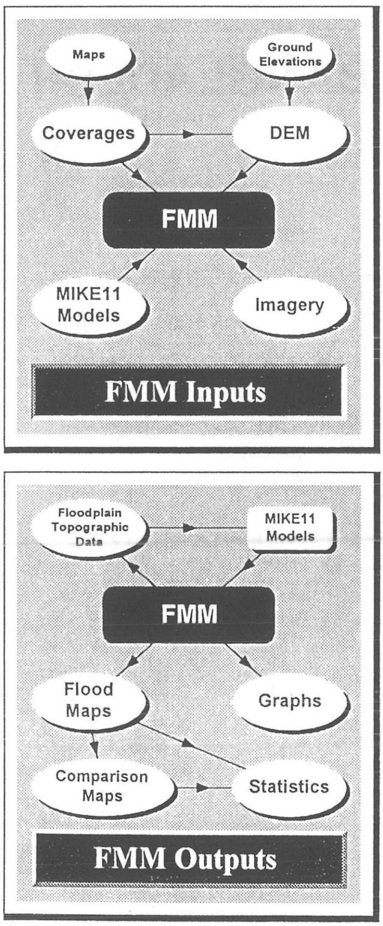


Fig. 2. Regional Model Area



FMM requires inputs of coverages (roads, rivers, settlements), a DEM, flood models and, if available, satellite and photo imagery.

FMM outputs topographic data for use in flood models and post-processes flood model simulation results into flood maps, comparison maps and graphs. Statistics are produced from the flood and comparison maps.

Fig. 3. **Inputs and outputs of the Flood Management Model**

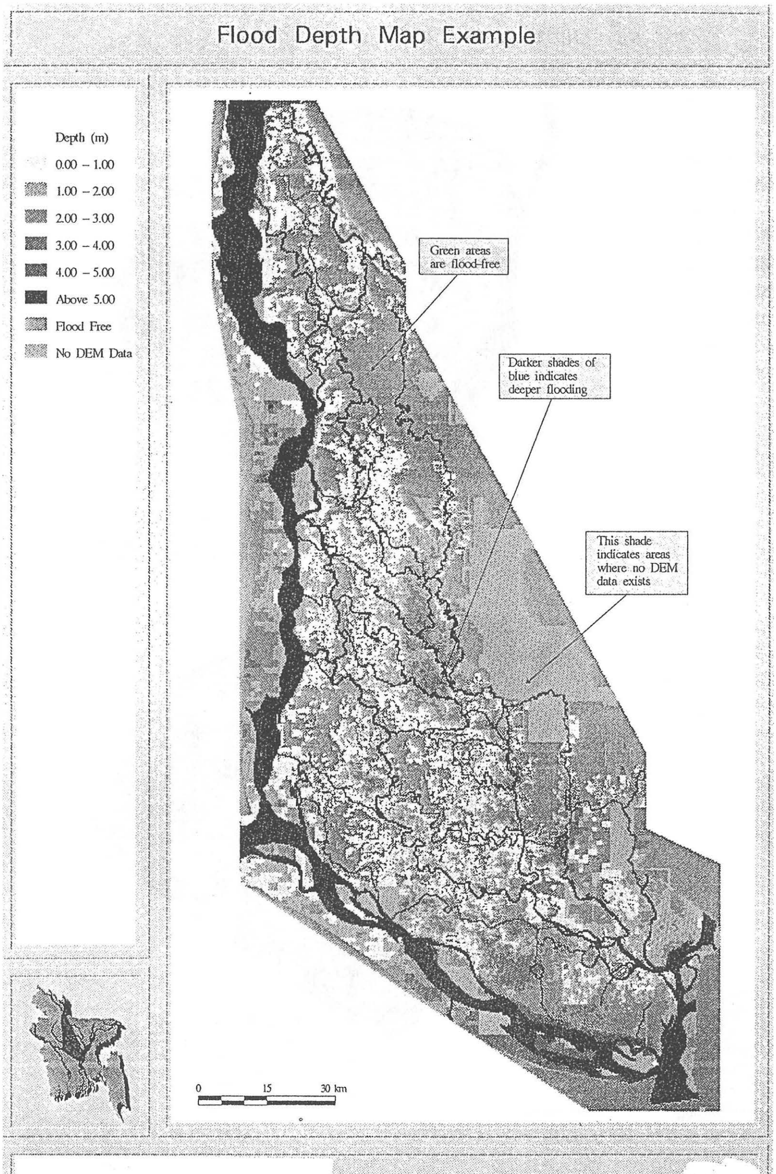


Fig. 4. Flood Depth Map Example

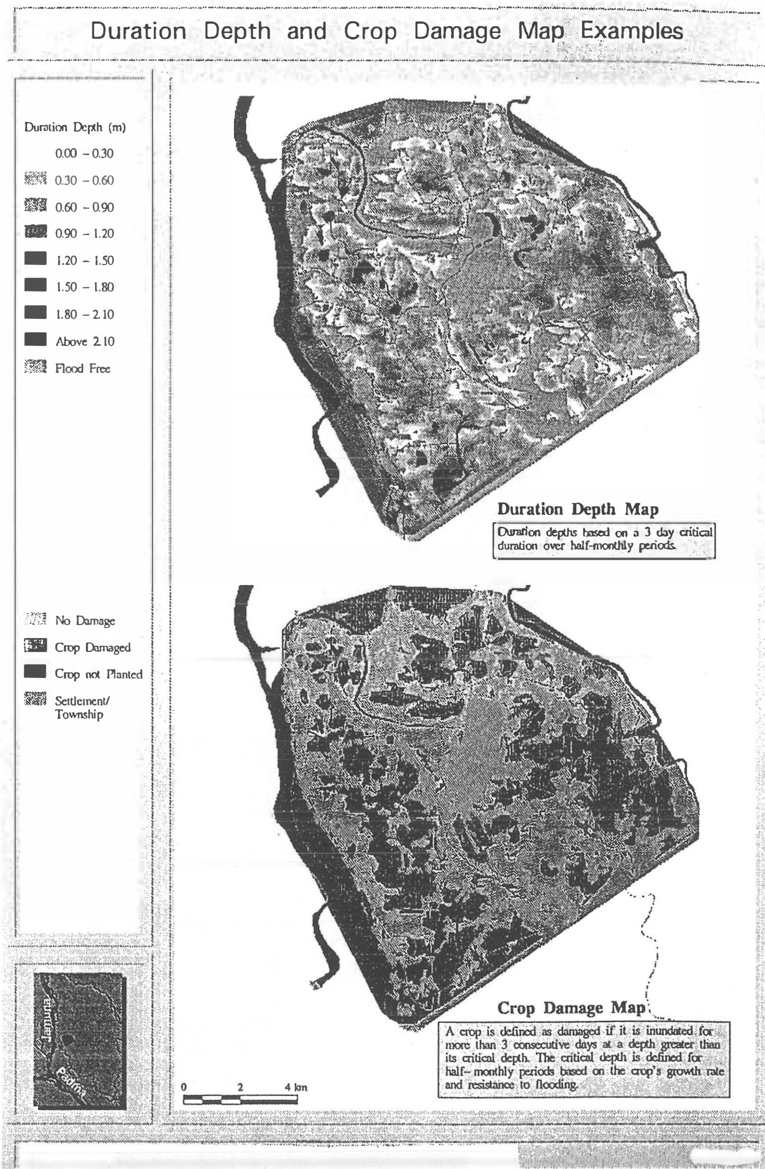
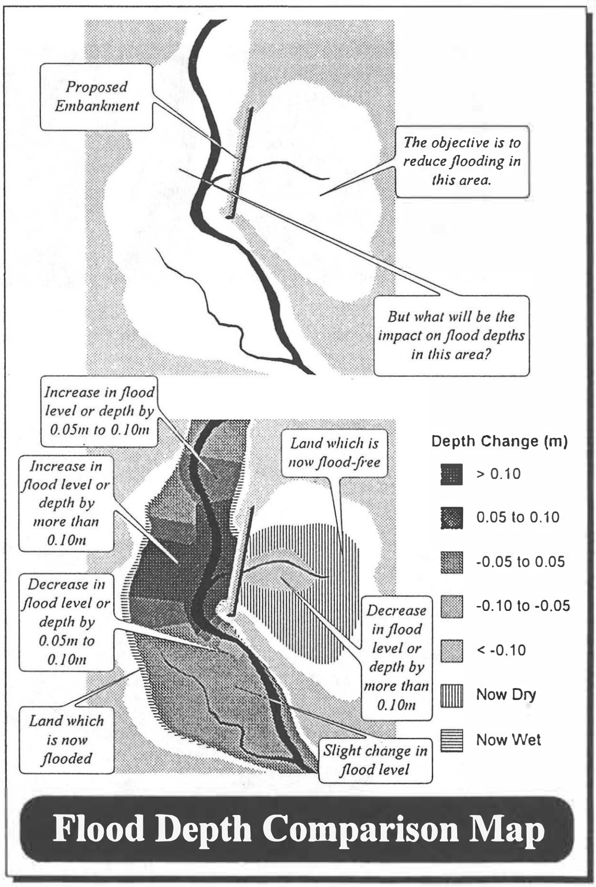


Fig. 5. Duration Depth and Crop Damage Map Examples



Comparison maps are a powerful medium for showing the extent of the impact from a flood intervention.

Fig. 6. Illustration of a Flood Depth Comparison

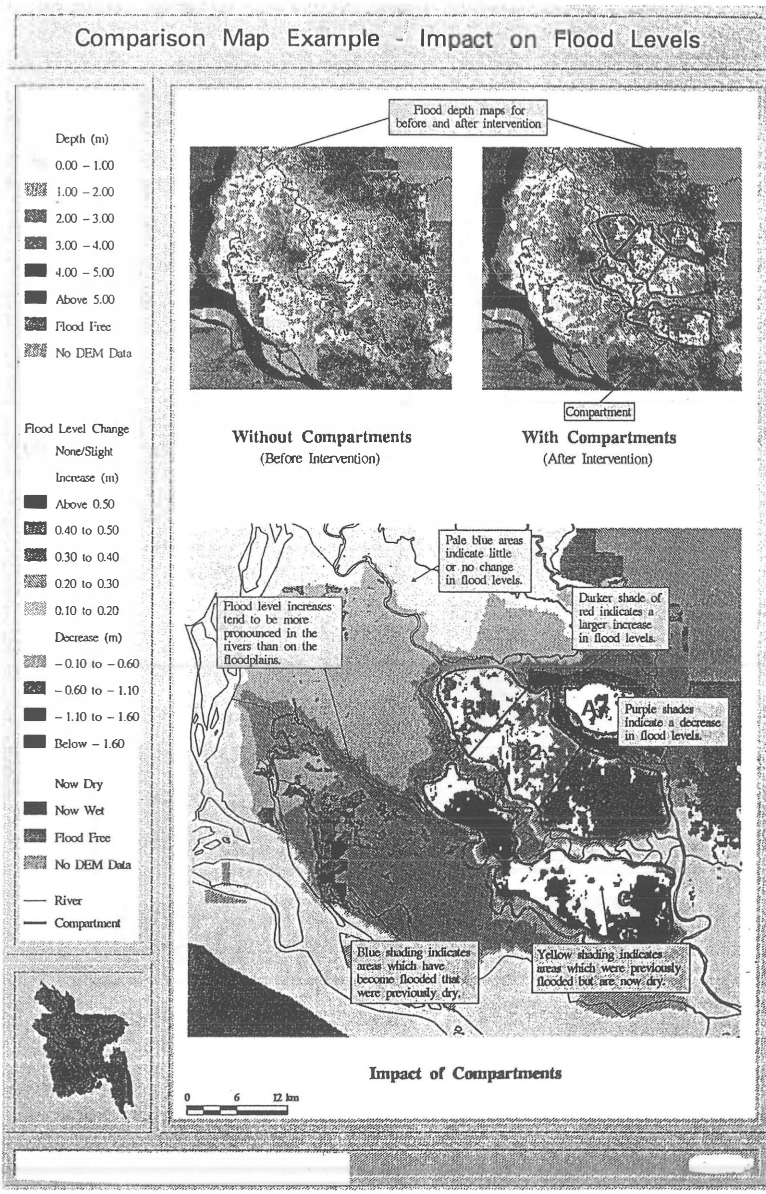


Fig. 7. Comparison Map Examples

FLOOD CONTROL PROBLEMS AND SOLUTIONS
BANGLADESH CASE STUDY

Amjad Hossain Khan*

ABSTRACT

Floods in Bangladesh is a recurring phenomenon. About 60 percent of the country is flood prone while 30 percent of the land inundated in the monsoon in a normal year.

Most of Bangladesh is located in the flood plain of the three great rivers: the Ganges,the Brahmaputra and the Meghna. These rivers drains a catchment of about 1.72 million Sq.Km.in China,Nepal,Bhutan,India and Bangladesh. Owing to geographical location about 93 percent of the total stream flow with high sediment load pass through Bangladesh.

Bangladesh experienced worst flood in 1988 when more than 60 percent of the land was flooded and 50 percent of the population was affected. Bangladesh with a population of 120 million is frequently affected by floods during monsoon and drought during the dry season. The country is also ravaged by other natural hazards like cyclones and storm surges.

Recurring floods and non cooperation by upper riparian countries has forced Bangladesh to prepare a Flood Action Plan. The Flood Action Plan (FAP) aims at the identification, planning and possible construction of technically, economically, environmentally and socially feasible projects. The Flood Action Plan regional and supporting studies will provide input to the planning and design of the main components of the Action Plan. The plan will investigate the feasibility of embankments, river training, channel improvement and protective infrastructures for major towns and key installations.

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It will also develope improvements to flood forecasting and warning systems and study the issues of water management, coastal afforestation and sustainable development of agriculture and fisheries.

INTRODUCTION

Flood in Bangladesh is a recurring phenomenon. About 60 percent of the country is flood prone while 30 percent of the land is flooded during monsoon in a normal year.

Bangladesh with an area of 147,570 Sq.Kilometers is lying in the delta of the World's three great rivers -- the Ganges, the Brahmaputra and the Meghna. These rivers drain a catchment area of 1.72 million Sq.Kilometers in China, Nepal, India, Bhutan and Bangladesh. As a lower riparian of these three rivers, Bangladesh occupies only seven percent of the total catchment area of the 3 river basins. Due to its geographical situation,about 93 percent of flood flows with high sediment load pass through Bangladesh.

STUDIES FOR MITIGATION OF FLOOD PROBLEM

Bangladesh experienced a catastrophic flood in 1988 which inundated more than 60 percent of the land and more than 50 percent of the population was directly affected. It caused wide spread damage to crops,properties, human lives and infrastructures.

Having failed to persuade the upper riparian countries for mitigation of the chronic flood problem, the Government of Bangladesh prepared a National Flood Protection Programme in December,1988. This was followed by four other studies each supported by UNDP, France, USAID and Japan. Bilateral studies were also carried out with India,Nepal and Bhutan.

Bangladesh in association with China prepared a long Term plan for river training and flood mitigation programme for the Brahmaputra River in 1990.

The Government of Bangladesh study recommended construction of embankments on both banks of the major rivers to confine the flood flow within the channel, reexcavation of distributaries of major rivers, rehabilitation of all existing Flood Control projects damaged by floods and improvement of Flood Forecasting and Warning System.

The UNDP study prepared a long term plan for Bangladesh for protecting large areas from floods by strengthening existing embankments with proper river training works. The concept of controlled flooding was introduced. The study recommended both structural and non-structural measures with particular emphasis on flood forecasting and disaster preparedness. The concept of beneficiary participation was stressed.

The French study proposed large scale flood protection project with construction of embankment for passage of flood flow in the main rivers and drainage pumping from the protected areas.

The Eastern Water Study of USAID was a review of the water resources development of the Ganges and the Brahmaputra basins in Nepal,India and Bangladesh. The study did not recommend any structural measures for solving the flood problem. It emphasized on the non -structural meeasures like flood forecasting and warning, disaster management,flood proofing etc.

The Japanese study recommended early implementation of flood protection of Dhaka and other cities, and improvement of the flood forecasting and flood preparedness programmes.

A Joint Team of Official from Bangladesh and Bhutan studied the problem of floods in the region and emphasized the need for cooperation, collaboration in improving the flood forecasting and warning system. It stressed the need for joint study, and investigation of watershed management.

The Bangladesh-Nepal joint study team recognized the flood problem of the region and recommended flood mitigation through development of flood forecasting and warning, catchment management, afforestation and harnessing of water resources of the region by constructing reservoirs at upstream reaches of the Ganges basin.

The Indo-Bangladesh Task Force on Flood Management recommended cooperation for effective flood management by tying up of embankments along the common river, river training works, drainage improvement and exchange of flood forecasting data.

The China-Bangladesh study on the Brahmaputra made an indepth analysis of the hehavior of the Brahmaputra and recommended solutions for flood control and river training works. The concept of active flood plain management was also recommended.

In June, 1989, the Government of Bangladesh requested the World Bank to coordinate the various studies made by different Governments and Agencies for finding a lasting solution of the flood problem.

The G-7 Summit held in Paris in July, 1989 endorsed a flood mitigation plan under the aegis of the World Bank.

The World Bank meeting in Washington in July, 1989 attended by GOB officials and leading experts involved in the four studies decided to prepare a 5 year programme plan for formulating a long term flood management plan.

The Flood Action Plan was presented in a meeting in London in December, 1989 to the development partner who endorsed a $ 150 million plan activities for 5 years.

RIVER SYSTEMS OF BANGLADESH

Bangladesh is a great delta formed by the alluvial deposits of three mighty rivers of the World: the Ganges, the Brahmaputra and the Meghna (Fig-1). The country has more than 200 rivers including 57 common/border rivers. The three main international rivers the Ganges, the Brahmaputra and the Meghna are briefly described below:

THE GANGES

The Ganges covers an area of about 1,087,300 Sq.Km.spread over India (860,000 Sq.Km.), Nepal (147,480 Sq.Km.), China (33,520 Sq.Km.) and Bangladesh(46,300 Sq.Km.). The Ganges rises from the Gangotri Glacier in the Himalayas at an elevation of about 7010 metres near the Indo-Chinese border. The river flows generally in a south-easternly direction and in the lower reaches it flows eastward and enter Bangladesh near Rajshahi.

The length of the main river is about 2550 Km. Three major tributaries of the Ganges, the Karnali, the Gandaki and the Kosi rise in China and flow through Nepal to join the Ganges in India, contributing 71 percent of the dry season flows and about 41 percent of the annual flows.

The Ganges forms the common boundary between India and Bangladesh at about 18 Km.below Farakka and continues for about 104 Km. The river then flows south eastward inside Bangladesh for about 157 Km.and joins the Brahmaputra at Goalundo. The recorded maximum and minimum flows in the Ganges at Hardinge Bridge were 76,000 cumec and 263 cumec.

THE BRAHMAPUTRA

The Brahmaputra has a total catchment area of 552,000 Km.in China (270,900 Sq.Km.), Bhutan (47,000 Sq.Km.), India (195,000 Sq.Km.) and Bangladesh (39,100 Sq.Km.). The Brahmaputra originates in the Himalayan range and collects snowmelt and runnoff from the huge catchment lying in China, Bhutan, India and Bangladesh. The river after entering Bangladesh flows southward and continues to its confluence with the Ganges near Arich. The total length of the Brahmaputra is about,2900 Km.upto Arich. The recorded maximum flow in the Brahmaputra at Bahadurabad was 98,300 cumec while the minimum was 2,860 cumec.

THE MEGHNA

The Barak, headstream of the Meghna rises in the hills of Manipur in India. Near the Indo-Bangladesh border, the Barak bifurcates into two rivers: the Surma and the Kushiyara. The Surma receives a number of tributaries from the Khasi and the Garo hills while the Kushiyara receives the tributaries from Tripura Hills. The Surma and the Kushiyara again join together at Ajmirigonj in Bangladesh. The combined flow takes the names of Meghna and flows in a south westernly direction to meet the Padma at Chandpur. Below Chandpur the combined flow is known as the lower Meghna. The total length of the river is about 902 Km.of which 403 Km.is in Bangladesh. The total catchment area of Barak/Meghna is 82,000 Sq.Km.out of which 47,000 Sq.Km.and 35,000 Sq.Km.lie in India and Bangladesh respectively. The recorded maximum discharge of the Meghna at Bhairab Bazar was 19,800 cumec.

CAUSES OF FLOOD IN BANGLADESH

Flooding in Bangladesh is caused by a combination of several factors:

NATURAL

0 Huge flows generated from rainfall occurring in a short span of time in the upstream catchment and consequent over bank spilling of the main rivers;

0 Runoff generated by heavy local precipitation that can not drain out due to high stage in the outfall rivers;

0 Landside and glacial lake outbursts that result in high sedimentation in the river course;

0 High tide in the Bay of Bengal coupled with windsetup caused by south westernly monsoon winds that obstruct drainage of the upland discharge, and

0 Synchronization of the peak flows of the major rivers.

MAN MADE

0 Deforestation in the upper catchment;

0 Drainage congestion due to uncoordinated development activities.

TYPES OF FLOODS

In Bangladesh, the following types of floods are normally encountered:

0 Flash Flood in the eastern and northern rivers are characterized by a sharp rise followed by a relatively rapid recession often causing high flow velocities that damages crops and properties;

0 Local Flood due to high rainfalls of long duration in the monsoon generating water volume in excess of the drainage capacity causing localized flood;

0 Major Floods from the three principal rivers generally rise slowly and the period of rise and fall may extend over 1-20 days or more. Spilling through distributaries and over the banks of the rivers cause the most extensive flood damage, particularly when the three rivers rise simultaneously, and

0 Floods due to Storm Surge in the coastal areas of Bangladesh which are generated by tropical cyclones cause extensive damage to life and property. These cyclones are predominant during the post-monsoon period (October-November) and during pre-monsoon period (April to June).

FLOOD ACTION PLAN

The Flood Action Plan (FAP) was taken up to provide a comprehensive and durable solution to the recurrent flood problem and to create an environment of sustained growth and social uplift.

The plan provides tools and framework for issues relating to water management, river training, flood mitigation and drainage which will lead to:

- adequate protection against natural hazards like floods, river bank erosion and drought.
- Sustainable development of water resources for economic benefit.
- Preparation of Water Management Plan for the country.
- Preparation of environment management plan;
- Participatory approach in planning and implementation.

The Flood Action Plan (FAP) programme consisted of 11 main and 15 supporting studies (Table 1). FAP studies can be grouped into following categories (Table 2).

- Regional Studies;
- Project Preparation Studies;
- Pilot Projects;

Table-1

STUDIES CONDUCTED UNDER FAP

FAP No.	The Studies	Funding Source	Final commitme (M.US$)
	Main Studies		
1	Brahmaputra Right Embankment Strengthening	IDA	3.36
2	Northwest Regional Study	UK,Japan	4.6
3	North Central Regional Study	EU,France	3.56
3.1	Jamalpur Priority Project	"	2.[illegible]6
4	Southwest Area Study	UNDP,ADB	3.83
5	Southeast Regional Study	UNDP	2.2
6	Northeast Regional Study	Canada	14.6
7	Cyclone Protection Project	EU,IDA	1.0
8A	Greater Dhaka Protection Project	Japan	3.0
8B	Dhaka Integrated Protection Project	ADB,Finland	.5
9A	Secondary Towns Integrated Protection Project	ADB	o.55
9B	Meghna River Bank Protection Project	IDA	1.15
10	Flood Forecasting and Warning	UNDP,Japan	5.7
11	Disaster Preparedness	UNDP	1.10
	Supporting Studies		
12	FCD/Review	UK,Japan	1.6
13	Operation and Maintenance Study	"	0.6
14	Flood Response Study	USA	0.9
15	Land Acquisition and Resettlement Study	Sweden	0.4
16	Environmental Study	USA	3.77
17	Fisheries Study and Pilot Project	UK	3.4
18	Surveys and Mapping	F.Land,France Switzerland	6.71
19	Geographic Information System	USA	4.07
20	Compartmentalization Pilot Project	NL,Germany	17.09
21/ 22	BankProtection,River Training and AFPM Pilot Project	Germany, France	40.0
23	Flood Proofing Pilot Project	USA	0.3
24	River Survey Programme	EU	14.70
25	Flood Modelling and Management	D.mark,Fr.NL	4.39
26	Institutional Development Programme	UNDP,FR.	3.60
-	Micro Economic Study	France	0.41

Table-2

NEW GROUPING OF FAP ACTIVITIES

Regional Studies

- Northwest
- Northcentral
- Southwest/Southcentral-Southwest area
- Southeast
- Northeast

Project Preparation Studies

- Brahmaputra Right Embankment Strengthening
- Jamalpur Priority Project
- Cyclone Protection
- Dhaka Flood Protection
- Secondary Towns Protection
- Meghna River Bank Protection
- Flood Forecasting and Warning
- Disaster Preparedness

Pilot Projects

- Compartmentalization and Pilot Project
- Bank Protection,River Training, and Active Flood Plain Management

Planning Resources

- FCD/l Review
- Operation and Maintenance Study
- Flood Response Study
- Land Acquisition and Resettlement Study
- Environmental Study
- Fisheries Study
- Flood Proofing Study

Data Collection and Analysis

- Surveys and Mapping
- Geographic Information System
- River Surveys Programme
- Flood Modelling and Management

Guidelines

- Project Assessment
- People's Participation
- Environmental Impact Assessment

- Planning of Resources;
- Data Collection and Analyses;
- Guide Lines.

The Flood Action Plan (FAP) activities are supervised by Flood Plan Coordination Organization (FPCO) under the Ministry of Water Resources. A panel of local and foreign experts help FPCO in technical scrutiny of the studies. A Review Committee and a Technical Committee composed of representatives from relevant Ministries and Agencies, FPCO, Panel of Experts (POE) and the World Bank assist the Ministry of Water Resources in review and approval of the various studies.

INTEGRATED APPROACH OF MODELLING

The FAP studies made extensive use of mathematical model of surface water systems as a tool for an integrated approach to Flood Management. A hydro dynamic model of unsteady flow in rivers has been used. Computer simulation of flood flows has been carried out at local, regional and national level. Models have provided an insight into the complex problem of flooding.

GUIDE LINES

Guide Lines were prepared by FPCO during the course of the study for uniformity in project planning for Water Resources Management for the country.

PROJECT ASSESSMENT

The Guide Lines for Project Assessment (GPA) was prepared to ensure that all FAP planning and feasibility studies are done on a common approach to project appraisal and impact assessment. The assessment comprises of a multi criteria analysis which organizes and brings together in a single framework, costs and benefits, impacts and effects of a project. The guidelines set procedures for economic analysis follwo the widely accepted techniques for the appraisal of investment projects as used by International Financial Institutions and development agencies. The guidelines require collection of data and analysis of potential impacts on Fisheries, non-agricultural activities, different social groups and bio-physical environment.

PEOPLE'S PARTICIPATION

The guidelines for People"s Participation (GPP) provided the frame work and basic methodology for assuring the people affected by recurring floods, to establish better control over national resources to safeguard life and property and create a sustainable pattern of development that balances the competing needs of agriculture, fisheries, navigation, ground water and environment.

The GPP guidelines underscope the need to unify technical and economic analysis of potential investment decisions with comprehensive impact assessments.

The Bangladesh Water Development Board has drafted a legislation on People's Participation and collection of water charges.

ENVIRONMENTAL IMPACT ASSESSMENT

In the past Flood Control, Drainage/Irrigation projects attention was not paid to environmental impacts on Flood Control, Drainage and Irrigation projects. The bio-physical components of the project often suffered. Environmental Impact Assessment is now a mandatory study to assess and predict the environmental consequences of an existing or proposed project. The EIA delinate any environmental management measures which must be integrated into the plan to ensure that the project is technically, economically, socially and environmentally acceptable.

FINDINGS OF THE STUDY

The main objectives for undertaking the Flood Action Plan in 1989 was to find a long lasting solution for floods in Bangladesh. Bangladesh has not found a solution yet but the FAP studies have identified the inter disciplinary nature of Flood Management and developed methodologies for project planning, people's participation and enviornmental impact assessment. The concept of controlled flooding, river training and Active Flood Plain Management (AFPM) was introduced in pilot projects.

Some of the key water management and development issues for Bangladesh was identified.

- Constraints of being a lower riparian of the three river basins - the Ganges, the Brahmaputra - the Meghna and withdrawal of water of the common rivers in the upper region.

- Flood hazards as 93 percent of the flood flow of the three river basin pass through Bangladesh.

- Drought in northern and north western region of Bangladesh due to insufficient precipitation and inadequate dry season flow.

- River bank erosion.

- Need for an integrated National Water Management Plan.

OPTIONS FOR LONG TERM PLAN

The options for long term water management plan of Bangladesh is quite complex due to reason stated above. The various option that can be taken up are mentioned below:

- Minimum intervention: Non-structural

- Selective intervention: Combination of structural and non-structural.

- Major intervention: Structural

CONCLUSION

The South Asian region with three of the largest river systems of the World has problems of floods, droughts and shortage of water during the dry season. Bangladesh being the lower riparian of all the three river basins, is at a great disadvantageous position as she has to give passage to the entire flood flows. The dry season flow of the rivers system is inadequate for meeting the needs of irrigation and maintenance of ecology and environment of the country. The massive withdrawal of the Ganges flows at Farakka and upstream by India and intervention on the other transboundary rivers both medium and minor has aggravated the situation.

The debate of structural and non-structural measures for flood mitigation in Bangladesh is complex. The country has gone through different phases in long history starting with IECO Master Plan of 1964, IBRD report of 1972, National Water Plan of 1989. Bangladesh expect that the development partners would understand the problems. The country did not get a solution in last 40 years. Let us hope to get it in the next 5 years when the National Water Management Plan will be ready.

Individual efforts of a country for mitigation of flood is not adequate. There is greater need for combination of structural and non-structural measures for the benefit of all the co-riparian countries concerned of the region. There is now a greater need for regional cooperation for a long lasting solution of the twin problems - floods and droughts in South Asia.

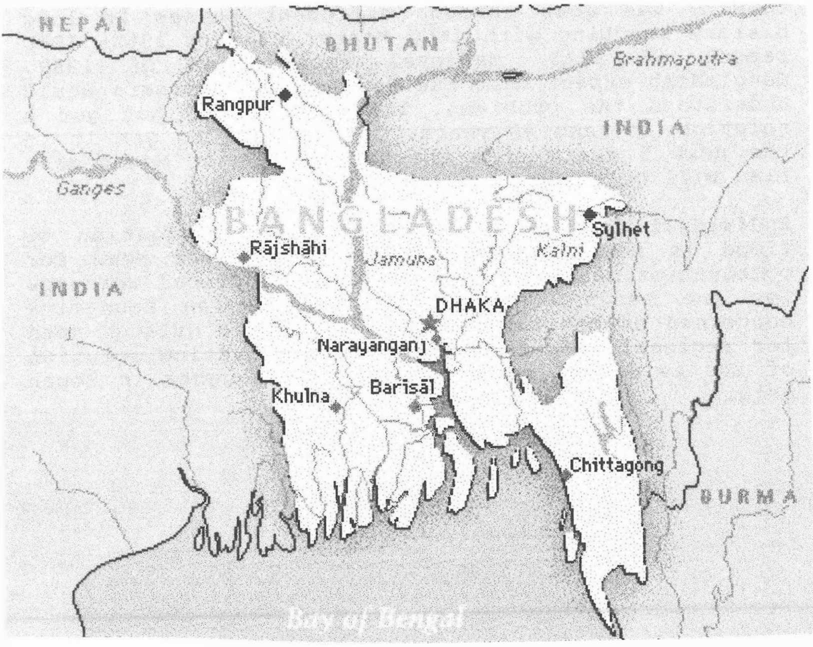
NEPAL
BHUTAN
Brahmaputra
Rangpur
INDIA
Ganges
BANGLADESH
Sylhet
Rājshāhi
Jamuna
Kalni
INDIA
DHAKA
Narayanganj
Khulna
Barisāl
Chittagong
BURMA
Bay of Bengal

Figure 1

THE DHAKA INTEGRATED FLOOD PROTECTION PROJECT

Frederick F. Schantz[1]

ABSTRACT

The disastrous floods that occurred in Bangladesh in 1987-89 caused extensive loss of human life and property damage and prompted the Government of Bangladesh (GOB) to work with a number of international agencies to establish a comprehensive Flood Action Plan (FAP) for the country. In December, 1989 during a conference of donor countries held in London, the FAP was formulated and endorsed by the GOB.

A vital component of the FAP, the Dhaka Integrated Flood Protection Project (DIFPP), begun in 1991, encompasses an intense effort to provide for the populations living in the affected areas relatively flood-free and secure living conditions and improved environmental conditions aimed at promoting a sustainable long-term development of the area. This project constitutes the first Asian Development Bank (ADB) investment in urban flood protection in Bangladesh and was formulated in an integrated framework of flood protection, drainage and environmental improvements.

DIFPP components, included (1) Improvement of flood protection by improving existing embankments and roadways, adding slope protection, expanding existing concrete flood walls, adding drainage sluices and pumping stations, and implementing an operation and maintenance program; (2) Improvement of drainage within project areas by rehabilitating open drains and piped facilities and implementing an operation and maintenance program; and (3) Establishment of an environmental improvement program consisting of slum and squatter area improvements, establishment of a water supply, sanitation, footpaths, street lighting, roadside drainage, and solid waste storage; and improvement and upgradation of solid waste collection, and public toilets, bathing and washing facilities and public water supply stand pipes.

As of June 1995, the project is in full operation and is scheduled to terminate in June 1997.

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INTRODUCTION

The following paper is an overview of the Dhaka Integrated Flood Protection Project (DIFPP), one of the components of a comprehensive Flood Action Plan which was approved by the Bangladesh Water Development Board (BWDB)/ Government of Bangladesh (GOB) in 1991 to control flooding in Bangladesh. This Asian Development Bank-funded effort was able to begin initial remedial works of embankment rehabilitation, construction of sluices and construction and rehabilitation of drainage works in 1991 and is programmed to terminate in June, 1997. The organization of the effort involved an ambitious attempt to coordinate ongoing efforts by the BWDB, the Dhaka Water Supply and Sewage Authority (DWASA), the Dhaka City Corporation (DCC), the Capital Development Authority (RAJUK), and other concerned agencies.

The scope of the DIFPP encompassed an intense effort to provide for the populations living in the affected areas relatively flood-free and secure living conditions and improved environmental conditions aimed at promoting a sustainable long-term development of the area. This project constituted the first Asian Development Bank (ADB) investment in urban flood protection in Bangladesh and was formulated in an integrated framework of flood protection, drainage and environmental improvements.

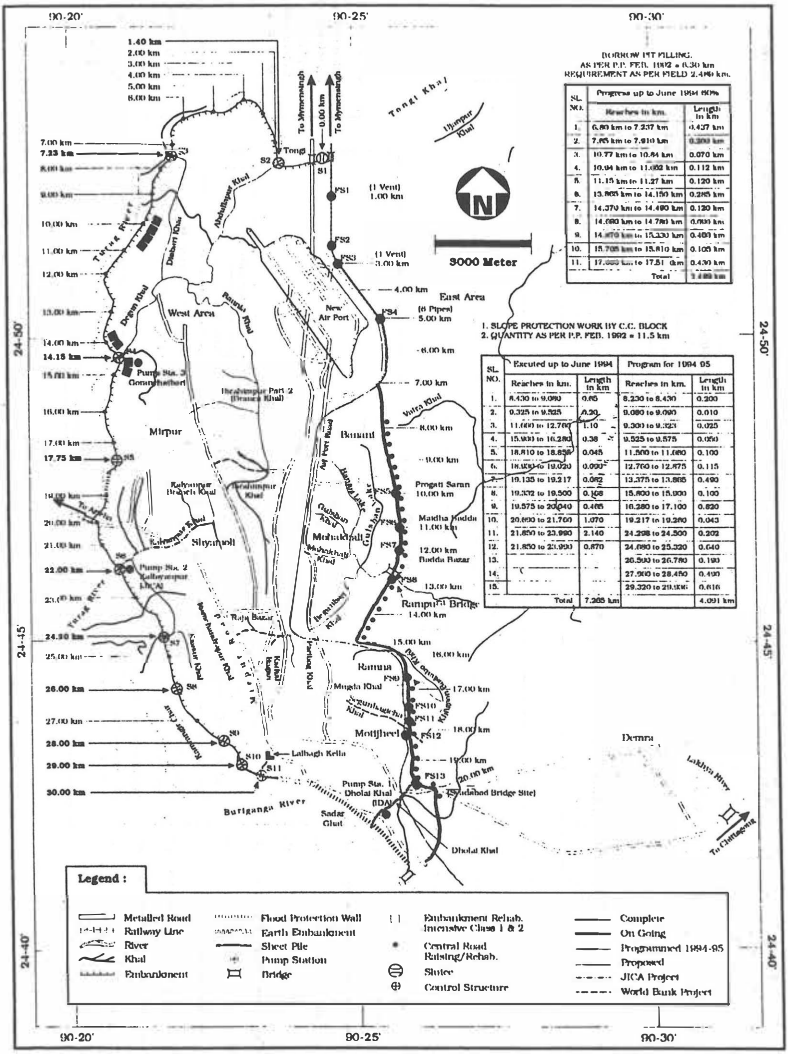
PROJECT AREAS AND ORGANIZATION

The physical areas selected for the effort, as shown on the map below, were identified as those the most in need of immediate attention. These areas included the Tongi Khal river (northern border boundary), the Turag and Buriganga rivers (western boundary), the Buriganga river, up to the Friendship bridge and by the road from Friendship bridge to Demra via Jatrabarithe (southern boundary), and Balu river (eastern boundary.

The organization of the project (see chart below) included the Project Management Office (PMO) as the lead executing agency. The PMO was established to provide overall coordination, technical assistance and quality assurance/control during the project period. The PMO is managed by a Project Director who plans, implements, and evaluates all project activities.

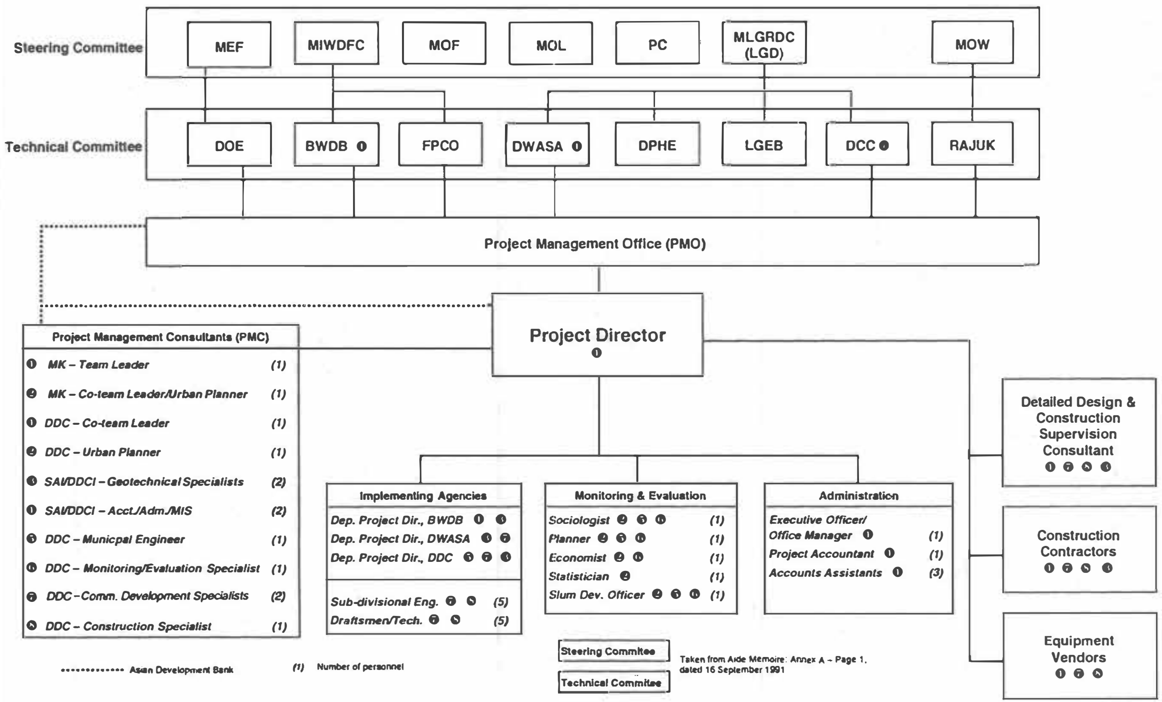
Dhaka Integrated Flood Protection Project

Project Area Map



Dhaka Integrated Flood Protection Project

Project Organization Chart



To assist the PMO, the services of two consulting engineering consortiums, called the Project Management Consultants (PMC), were employed and included (1) detailed engineering design and construction supervision; and (2) advisory services to the PMO in the management of the project. From the beginning of the project, the PMO has been staffed with full-time representatives from the BWDB, DWASA and DCC, and part-time representatives from RAJUK, the Department of Government (DOE), and Flood Plain Coordination Organization (FPCO). The PMC services were approved and begun after the project began implementation activities.

The PMCs assist and support the PMO in overall coordination, planning, implementation, supervision and monitoring project activities with the overall objective of achieving the physical, financial and scheduling targets established under this project.
Monitoring of the Action Plan includes cost recovery measures, financial management, Project Benefit Monitoring and Evaluation (PBME) system activities, community development programs, standards and procedures for O&M, and on-the-job training of counter-part staff.

Together with assisting the PMO with the preparation of supporting papers, documents and reports requested by the

Technical Committee, Steering Committee, FPCO and ADB, the PMC assists the PMO in the coordination with other donor-assisted programs which have a bearing on the Project now being undertaken by the ADB, UNDP, the World Bank, UNICEF, USAID, Japan and France. This has been done to help ensure that the project considers ongoing and planned donor countries's activities.

PROJECT ACTIVITIES AND IMPLEMENTATION SCHEDULE

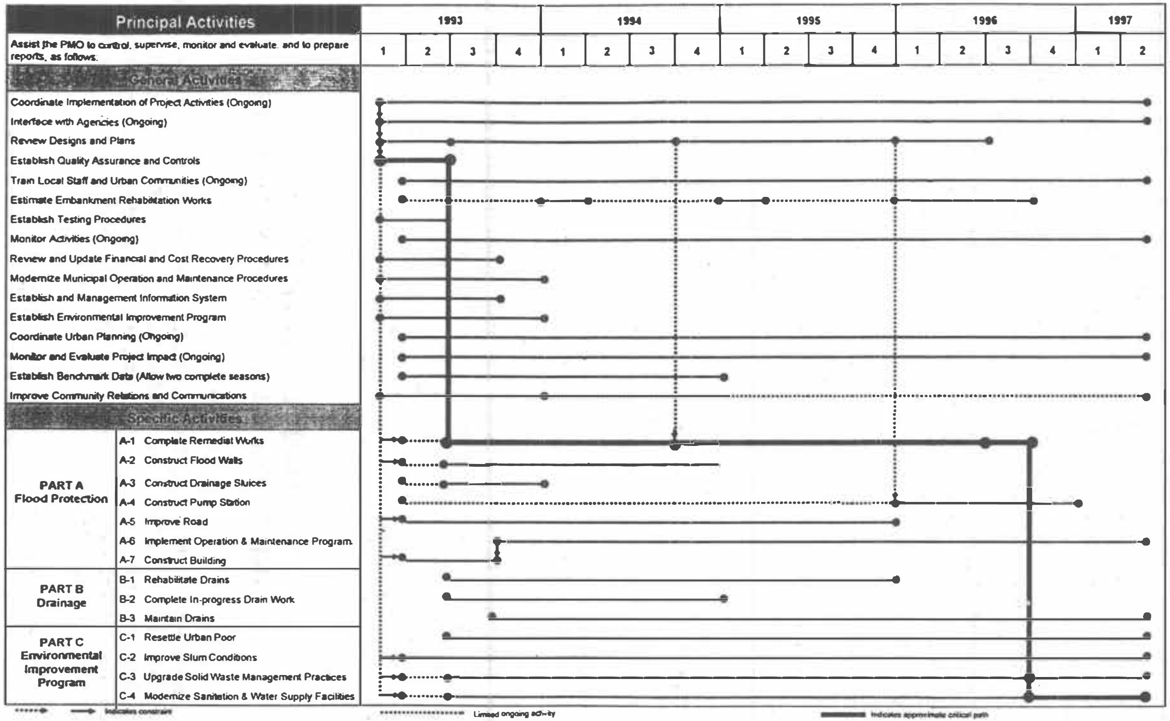
Presented in the Implementation/Network Schedule (chart) below, in a conscious attempt to blend engineering with environmental and population concerns, the project's design included three interrelated parts with the following activities:

Part A: Flood Protection Program

The flood protection activities of the DIFPP to be completed by the Bangladesh Water Development Board (BWDB) encompasses the following tasks:

Dhaka Integrated Flood Protection Project

Implementation/Network Schedule



- Specialized remedial works and foundation stabilization on 7.8 km of the existing embankment;
- Erosion control and slope protection over 11.5 km;
- Minor remedial works and slope protection over 24.2 km;
- Repair and stabilization of parts of 5.3 km of existing concrete flood wall;
- Construction of 1.6 km of new flood wall/embankment;
- Construction of 5 additional sluices along the existing embankment;
- Raising and flood proofing of the Central Spine Road (Tongi Railway Bridge to Friendship Bridge);
- Construction of the first stage (22.5 cms) of Pump Station No. 3 at Goranchatbari along the westerly embankment;
- Establishment of a maintenance program and supply of maintenance of equipment to safeguard the flood protection investment.

Part B: Drainage Improvement Program

The drainage improvement activities to be completed by the Dhaka Water Supply and Sewage Authority (DWASA) include the following tasks:

- Rehabilitation and upgrading of 21 existing priority khals (including completion of the crash program initiated by the Government), for a total length of 78.60 km;
- Rehabilitation and construction of 50.70 km of pipe drains;
- Establishment of a maintenance program and supply of maintenance equipment to safeguard the drainage improvement investment.

Part C: Environmental Improvement Program

The environmental improvement program activities to be completed by the Dhaka City Corporation (DCC) include the following tasks:

- Slum and squatter area improvements covering about 8,725 beneficiary families;
- Solid waste management, including the supply of 30 new trucks and complementary waste handling equipment;
- Sanitation improvements, including 30 public toilets and 5 mobile toilets, 5,500 low cost sanitary latrines for low income residence, and 2 septic tanks desludging trucks;

- 1,000 public water standpipes for low income communities;
- Rehabilitation and extension of 251 km of minor local drains, and supply of 1 drain cleaning truck.

SUMMARY

As of March 1995, the project is in its third year of implementation. Presented in the Quarterly Progress Report No. 2 (dated March 1995), the progress of the three project parts are as follows:

Component	Per Cent Completed
Part A:	20.90 %
Part B:	46.01 %
Part C:	16.70 %

In early May 1995 the ADB completed a review of the project's activities and encouraged project staff to increase their implementation efforts to ensure that all planned activities are completed by June 1997 when the project is due to terminate.

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FLOOD MANAGEMENT ON THE DANUBE DOWNSTREAM OF BRATISLAVA

Miroslav B. Liška,[1]

ABSTRACT

Danube on the section downstream of Bratislava and the granite sill of the "Devin Gate", has developped a huge sedimentation cone, pushed into the ground into a depth up to 400 metres. On the top of this cone Danube meandered in hundreds of arms with the Malý (Little) Danube on the northern perimeter and the Mosoni Danube on the southern. Settlers began to build levees to protect their dwellings already in 14th century and three centuries later continuous protecting lines were built, with levees two to five kilometres apart.

The sedimentation on the flood plane continued with increased speed. Floods breached the levees five to seven times during the last two centuries. Since the end of the last century the levees were heightened and strenghtened three times, but the cause of the breach was rather the subsoil degraded by piping.

In the Danube basin, there is no possibility to build a retention reservoir large enough to flatten the flood peak. The capacity of the flood plain prooved to be again unsufficient, but the location of the Bratislava historic center did not allow to heighten the levees any more. The only alternatives were : either to cleen the floodplain of forests, to diminish the roughness, or to fork half of the flood flow into a lined canal, built in the framework of a multipurpose development, including also production of electric energy.

The second solution proved more efficient and an interstate Treaty between the former Czechoslovakia and Hungary, concerning the development of the border section of the Danube, was signed in 1977. Unexpected complications started in 1989, just before setting the Gabčíkovo part of the system in operation. After two years of delays and unfruitful negotiations, an alternative, unilateral solution had to be realised, to diminish the enormous damages.

The reason given for the breach of the treaty was a scientifically unsubstantiated suspicion that the operation of Nagymaros - and later also Gabčíkovo - would trigger an environmental catastrophe. In the third year of operation of the Gabčíkovo Project, there are no traces of adverse development and the surrounbdingn nature is in a better state then before.

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1. GEOLOGIC CONDITIONS AND HISTORICAL DEVELEPMENT

Danube in its section downstream of Bratislava developed special features in the past. Cutting its way through the granite ridge of Small Karpathian Mountains, there remained in the socalled Devin Gate a rocky bed, without sediments. Both sections - upstream and downstream - developped the same, relatively high gradient of the bottom and water-level: about 40 cm/km. The whole flow of solid material - gravel and sand carried by the speedy stream from the Alps in the quaternary era, passed this section and started to accumulate on a deep layer of tertiary fine-grain sea sediments, where the gradient diminishes suddenly to only about 9 cm/km. The ever increasing alluvial cone was gradually pushed into the ground and created in the section with the changing gradient around Gabčíkovo a dish-like formation with up to 400 meter deep layers of gravel. Downstreamwards, the layer of sediments grew thinner and also their grain became gradually finer - sand instead of gravel. Just upstream of Nagymaros, the Danube crosses another ridge of andesite mountains creating the Pilis Gate, where the rocky sill of the river-bed prevents the moving of sand benches downstream (see fig.1).

The Danube, flowing on the top of the alluvial cone, tended to meander, creating many side-arms and changing their course after every bigger flood. The whole area developped a swamp-like character drained on the perimeter of the alluvial cone by branches of Maly (Little) Danube on the left side and Mosoni Danube on the right side. When people started to grow crops on the fertile islands, since the 14^{th} century, they started to protect the inhabited areas and their fields by flood levees. From about the 17^{th} century, there was developped a continuous protection line limiting the inundation area to a strip about two to five kilometer wide. The quicker advanced the sedimentation process and the flood levees had to be gradually heightened and strenghtened, because each brake of the protecting line caused inundation of large areas and significant damages.

In the seventies of the last century a new main bed was cut through the center of the system of arms, to improve or create conditions for steam ship navigation. The shortened main bed, having an increased gradient and flow velocity, started to erode its bed, leaving the side arms gradually more and more without direct flow, or even totally dried-up. This aggravated severely during the last thirty years, when a sharp bend downstream of Bratislava was streightened to

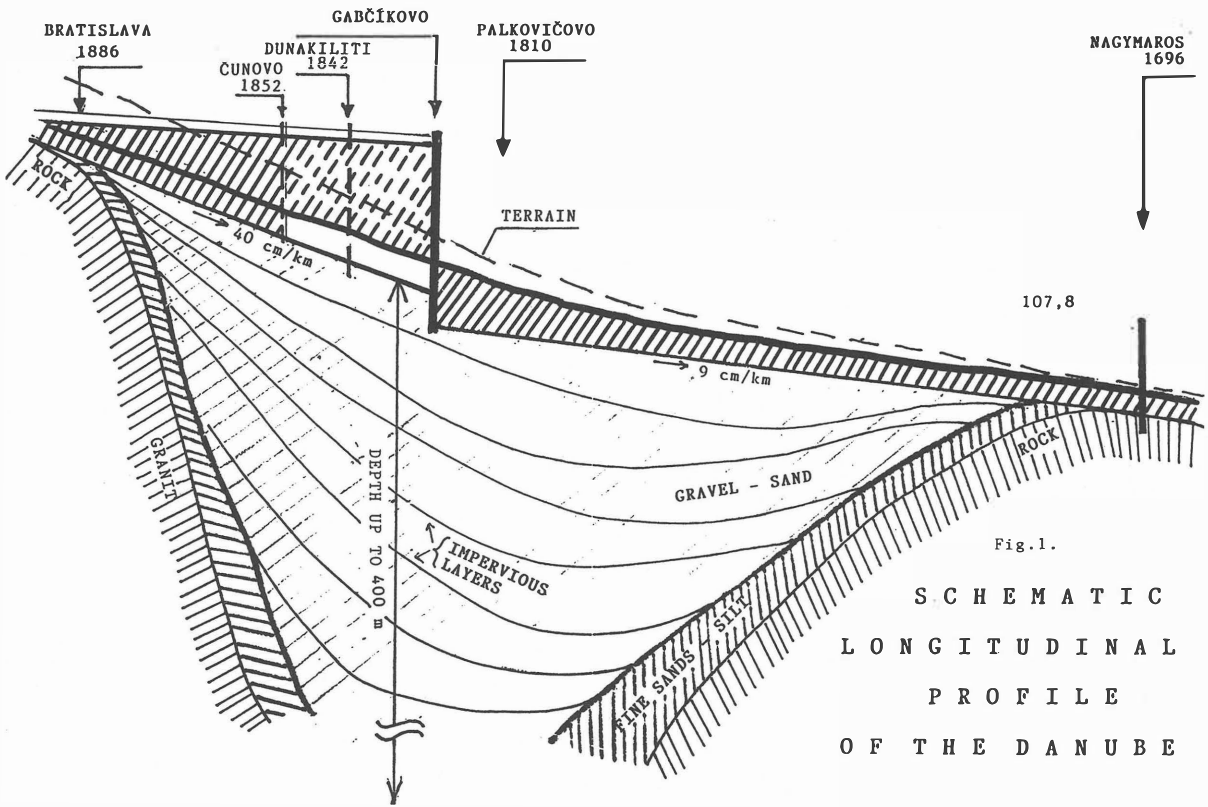


Fig.1.

SCHEMATIC LONGITUDINAL PROFILE OF THE DANUBE improve the flood protection of the Bratislava down-town, besides the regular excavation of the river-bed, maintaining acceptable navigation conditions at least at higher water levels. At the same time, the river steps built on the Austrian stretch of the Danube, practically stopped all the solid flow of the Danube, exchanging thus the former sedimentation process downstream of Bratislava by erosion, deepening the river-bed and drawing down the adjacent ground water level. Wing dams concentrated the low flows into the central part of the river-bed and closures of the side-branches prevented a part of the medium flows to enter the branches.

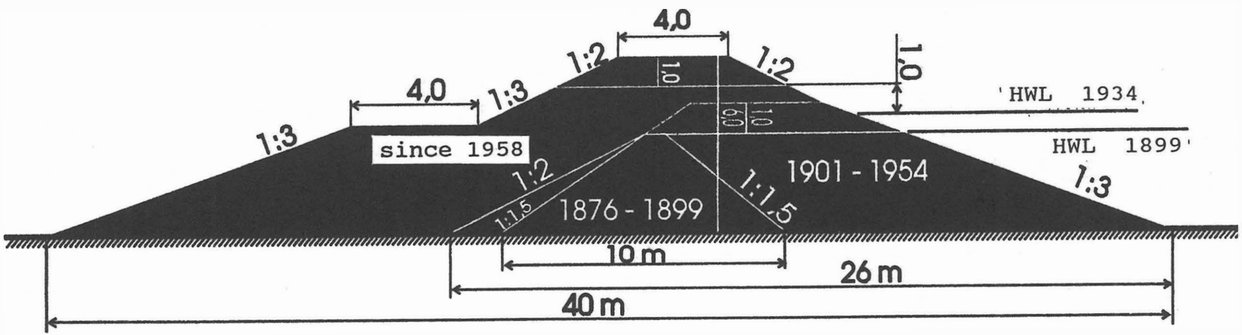
2. EXPERIENCE FROM FLOOD MANAGEMENT

Inspite of the deepening of the river bed and lowering of the low-flow water levels, the terrain of the innundation continued to grow, while the flood peaks showed also an increasing trend. There was started a race between the mankind and the Danube. The Danube levees had to be periodically strenghtened, but the frequency of a levee-breaches continued to grow. In the 19th century there occured two breaches in summer (1897, 1899) and three in winter (1809, 1838, 1850), while in the 95 years of the 20th century there were three breaches in summer (1923, 1954, 1965) and four in winter (1929, 1947, 1956, 1962). Fig.2 shows the development of the typical levee profile in time.

The breaches in 1899 and 1965 occured approximately on the same place, both around ten o'clock in the morning. The eyewitnesses described both breaches very similarly. On the protected side there appeared wells with water leaping to a height of about 15 cm. The water was muddy, depositing fine material around the well. If the well was encircled with sand bags, to create counterpressure, another well appeared outside. On the water level, opposite the well appeared a vortex growing in size. Between the vortex and the wells the dam collapsed, leaving for a while the crest bridging the gap, water flowing underneath. The width of the breach grew to about 80 meters, the amount of water flowing into the protected region reached about 1300 cumecs, with a flow velocity af about 3 m.s^{-1}.

These descriptions confirm that the cause of both breaches was internal erosion of the underground by piping, what could occur on places where inbetween of very permeable gravel layers there there are deposits of finer material. The erodable material is flushed out from the interface of the gravel and sand/silt layers

Fig.2. DEVELOPMENT OF THE TYPICAL LEVEE PROFILE IN TIME



until a cavern is created. The collapse of this cavern can cause a local lowering of the crest and overtopping of the levee, or opening of a shortcut of seepage turned into turbulent flow with high velocities, both leading to a destruction of the adjacent part of the levee.

The current in the breach was so strong that it proved impossible to close it. Even heavy rocks thrown into the gap were flushed away and the submerged fully loded boats were burried into a depth of about 20 metres, without damming the gap. The access to the breach from the Danube side was very difficult, because of forests reaching up to the levee. Three attempts to dam the breach by a increasingly larger circular dams were unsuccessful. The breach was repaired only after the receding of the flood peak, from a pontoon bridge.

Fig.3 : Situation of the breach and attempts of its closure

Fig.4 : Spreading of the inundation in time.

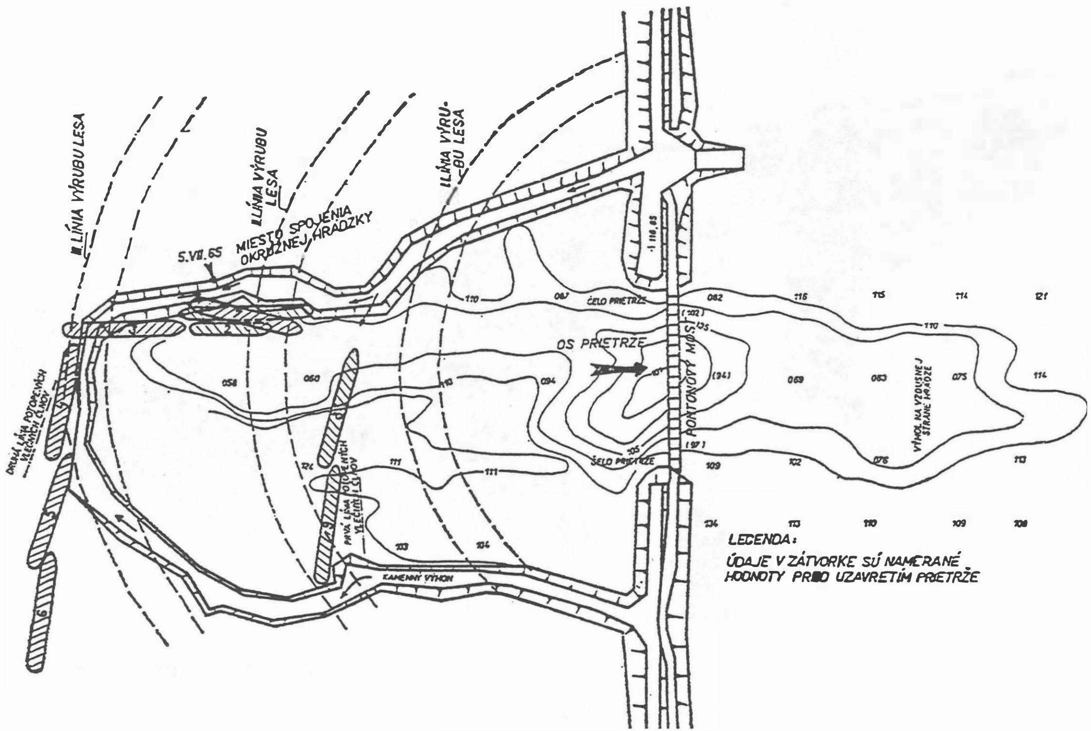
3. FLOOD DAMAGES OF THE MOST RECENT FLOODS

In 1954, when three levee breaches occured on the Hungarian side, the flooded area reached there about 40000 hectars with damages estimated to 14 bill.Forint.

Direct damages caused by the two levee breaches on the Slovak territory were much larger. There was inundated a surface of over 100000 hectars of farmland. 49 villages were heavily damaged and 54 thousand inhabitants evacuated. Nearly 4000 houses, mostly made of unfired bricks collapsed and further 6000 were badly damaged. Over 36 thousand of cows and horses, 67 thousand of pigs, sheep and goats and over 83 thousand of poultry and small houshold animals were drowned. The forest animals and game died in quantities over 100 thousand, finding no refuge in the flooded area. Only the direct damages (registred by the insurance companies) reached 3,5 bill.Crowns (about 400mill.US$). Together with lost production, intervention of about 13000 soldiers, costs of reconstructed houses, roads and infrastructure, brigades of helpers from the whole republic, costs connected with the accomodation of refugees - the total damages reach at least four times the officially estimated figure.

The breach near Čičov occured in the lower part of the island between the main Danube and its branch Little Danube. If the same would occur in the upper part, where the number of piping wells also indicates a very degraded subsoil, the flooded area and the caused damaged could be also twice as high.

Fig.3. SITUATION OF THE BREACH AND ATTEMPTS OF ITS CLOSURE



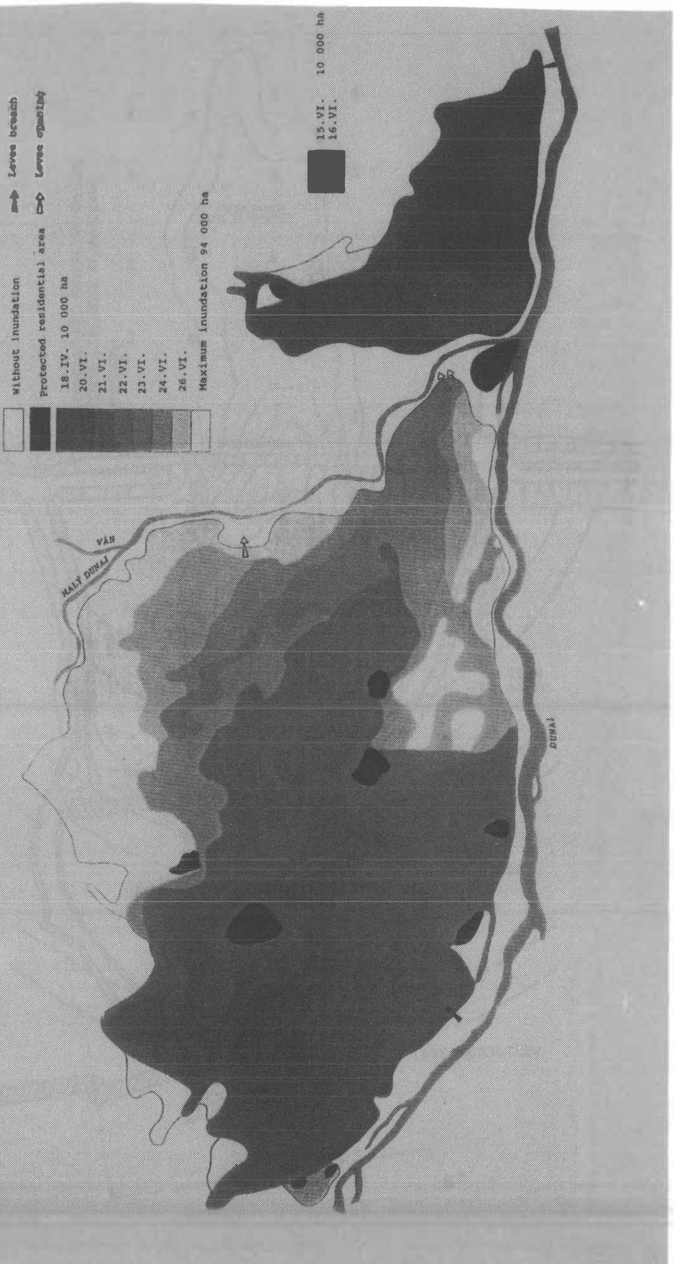


Fig. 4. SPREADING OF INUNDATION IN TIME 1965

Due to solidarity actions from the whole republic, not asking what language do the afflicted inhabitants speak (most of them were ethnic Hungarians), the whole region was reconstructed to a much better state as there prevailed before. But this also increased the value of potential damages of floods in the future. The inhabitants therefore requested the government, to secure a flood protection ensuring that such a catastrophe would be definitively prevented and an economic development of the formerly underdevelopped region would be fostered.

4. POSSIBILITIES OF INCREASING THE FLOOD PROTECTION

In the sectiom of the Danube downstream of Bratislava, in the socalled "inland delta of the Danube" having a relatively high gradient of the terrain, two main possibilities of flood protection improvement were studied.

First, the one-purpose solution providing the cutting off the priviledged ways of seepage underneath the levees by underground walls and prolonging also horizontally the seepage path by sealing aprons. This solution is expensive, bringing no revenue, while the horizontal sealing element (apron) exposed most of the time to the influence of climatic changes and self growing vegetation might deteriorate in time.

Second, the same measures applied only on the upper section, where a reservoir with permanent impoundment (protecting the horizontal sealing element) would be created, while the lower section would be paralelly bypassed by a canal into which a half of the flood flow would be forked from the main stream, where the risk of a breach would thus be reduced practically to zero. This solution includes also additional structures (weir, canal, locks, power station) but provides also additional revenues in the form of improvement of navigation conditions (leading to reduction of transportation costs) and of the value of produced electric energy, improving significantly the cost/benefit ratio of the investment.

5. RISK OF FLOODING, BENEFITS OF FLOOD PROTECTION

The potential damages of flooding are a function of the surface of the flooded area and :
- type of landuse (farmland, inhabited area, industrial area) - density of communications and power lines,
- structural material and height of buildings),

- age of structures,
- probability of flooding.

The risk of occurence of a breach in certain section of the levee is a function of registered number of piping wells occuring during a flood (this number is increasing after each major flood).

To each section of the levee corresponds a different potential flooded area. A breach of the more upstream sections would cause flooding of a larger area - possibly the whole area of the Žitný ostrov - the island between the Danube and the Little Danube, while a breach in the lower section endangers only a more limited area given by the morphology of the terrain and flood-water level on the place of breach.

When, in a concrete case, a detailed design of a one-purpose flood protection investment already exists, the costs that can be saved by the implementation of a multipurpose development of the given river section can be considered as one of the benefits of this development.

Besides reaching the planned goals of investment, a multipurpose development has usually also more or less significant environmental benefits accruing from the fostering of water transport, of non-polluting production of electric energy and of the possibility to influence beneficially the state of the surrounding nature.

6. BRIEF DESCRIPTION OF THE MULTIPURPOSE DEVELOPMENT OF THE DANUBE DOWNSTREAM OF BRATISLAVA

The Gabčíkovo-Nagymaros Hydroelectric System (GNHES), developing the whole 142 km long common Slovak-Hungarian border section of the Danube plus, adjacent national sections of additional about 40 km, consists of the following main structures :
- reservoir 26 km long (total/useful volumes 240/60 million m³), created by former flood levees and by the weir Dunakiliti situated on the Hungarian side at the rkm 1842,
- 17 km long headrace canal with a hydraulic capacity of 5300 cumecs (half of the 100-year flood),
- canal step Gabčíkovo containing twin locks 34 x 275 m and a hydropower station with an installed capacity of 720 MW, producig at peak operation in average 2,7 billion kWh yearly,
- tail-race canal 8 km long, ending in rkm 1811,
- deepening of the river up to rkm 1791, increasing the

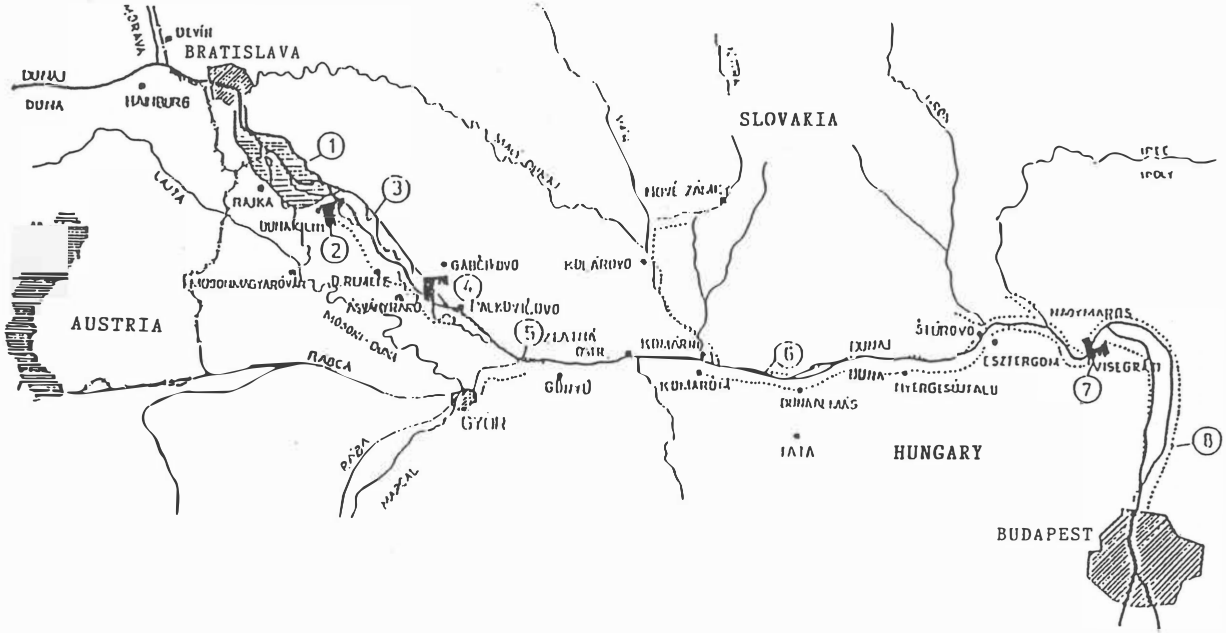


Fig. 5. GENERAL LAYOUT OF G-N SYSTEM

1 Reservoir, 2 Dunakiliti weir, 3 Bypass canal, 4 Gabčíkovo canal step, 5,8 Deepening of the Danube channel, 6 Lateral dams, Seepage canals and pumping stations, 7 River step Nagymaros

local flood protection and improving conditions for navigation and energy production,
- implementing measures compensating the diminished flow in the old river bed,
- reconstructed levees along the Nagymaros reservoir, serving for transformation of peak discharges from Gabčíkovo; levees are complemented with seepage canals and pumping stations improving the state of flood protection,
- river step Nagymaros situated in rkm 1696 (in Hungary, about 14 km downstream of the end of the common border section), consisting of a weir, hydropower station with installed capacity of 158 MW and average yearly production of 1 billion kWh of base energy,
- deepening of the downstream part of the Danube on a length of 40 km.

Fig.5 : General layout of the Gabčíkovo-Nagymaros System

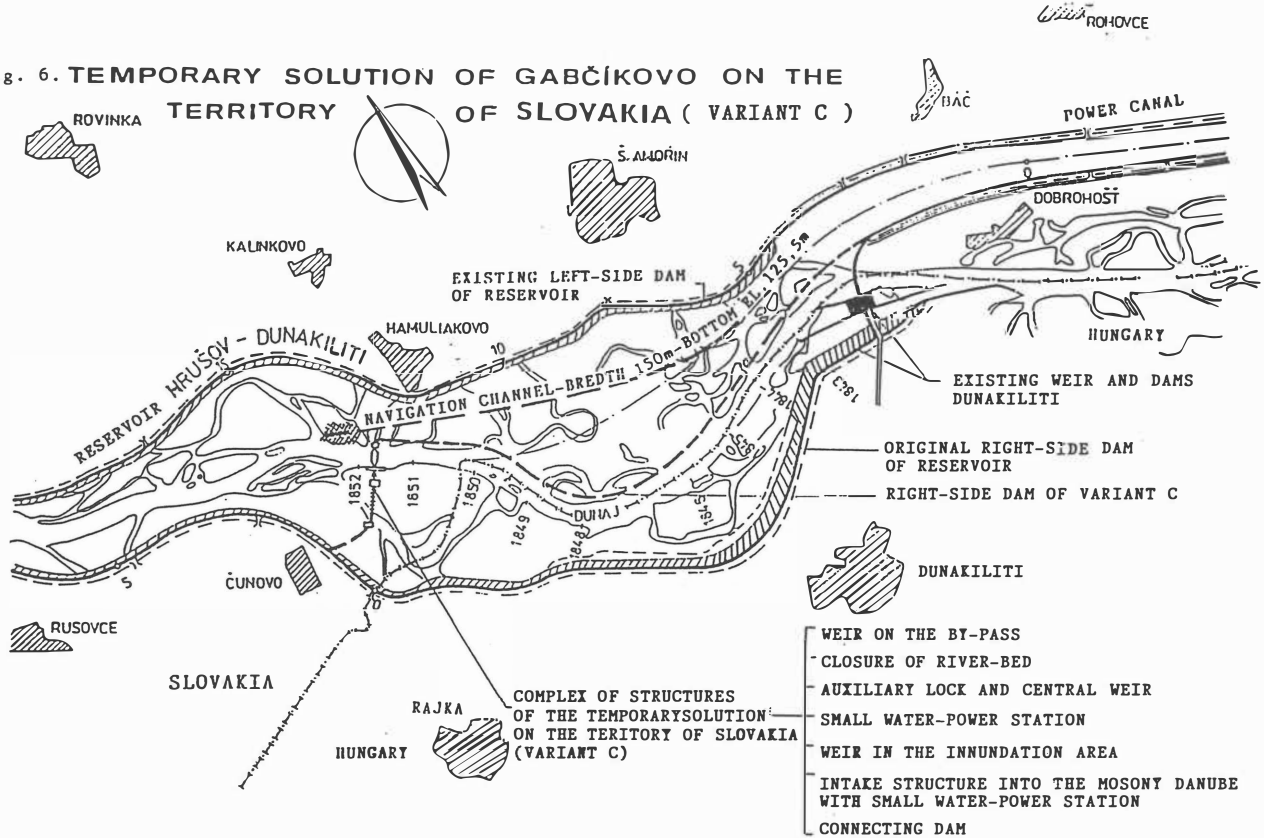
Just before the setting the Gabčíkovo part of the system in operation, the environmental and political opponents of the GNHES succeeded in 1989 to stop the implementation on the Hungarian side. After two years of negotiations leading to no positive results, the governments of Slovakia and of the CSFR decided to implement unilateral measures diminishing the reservoir by one third, excluding the Hungarian part of the impoundment. Additional structures that had to be built in 1992, included besides the dividing dam also a complex replacing the function of Dunakiliti (weir, auxiliary ship-lock and power station), increasing the original investment costs by 50 percent

Fig.6 : Layout of the Gabčíkovo reservoir in original solution and in variant "C"

7. EFFECTS AND IMPACTS OF THE GABČÍKOVO PART OF THE GNHES

Intrigues of the political oponents of GNHES, striving also for severing relations between Hungary and Slovakia, did not succeede in stopping the whole Project and in abolishing the 1977 Treaty. This treaty voluntarily confirmed the Trianon Peace Treaty borders between Slovakia and Hungary, situated in the talweg of the Danube between Bratislava and Štúrovo/Esztergom, what did not match into the idea of Great Hungary which still haunts the mind of some nationalistic groups (since 1920, Hungarian troups three times occuppied parts of Slovakia). However, to make arguments acceptable for European public opinion, nationalistic actions had to be disguised as environmentalistic, what

Fig. 6. TEMPORARY SOLUTION OF GABČÍKOVO ON THE TERRITORY OF SLOVAKIA (VARIANT C)



was gladly accepted by WWF, Global 2000, Eurochain and other international NGO-s spreading diligently prophecies about an environmental catastophe that would alleguedly be triggered by filling the reservoir Gabčíkovo and by diverting a significant part of the Danube flows into the bypass canal.

The Gabčíkovo Part of the GNHES is in operation the third year. The three main goals : flood protection, improvement of navigation conditions and electric energy production - are fulfilled, only the value of electricity produced is lower, being only of base-load quality. However, none of the catastrophic environmental consequences materialised and the carefully monitored data of ground water level and quality show no signs of deterioration. To the contrary, several environmental improvements have been achieved :

(a) stabilisation of water regime, stopping of river-bed erosion and of the continuing lowering of ground-water levels,

(b) increase of ground-water levels and of ground-water recharge along the whole influenced section of the Danube, where the planned measures were implemented,

(c) increase of capacity of fresh-water wells along the Danube, without influencing the good water quality (in one case even improving the low free oxygen content),

(d) revitalisation of nearly 200 km of once "live" branches of the Danube outside the levees, turned during last decades into a sewer-like state,

(e) sufficient supply of water into side-arms situated in the flood plain, retaining the dynamicity of water-level fluctuation and gaining the possibility of creation of artificial inundations whenever necessary,

(f) increase of number the fish and water-fowel population, together with increasing biodiversity,

(g) after implementation of necessary measures (overflown weirs in the Danube bed, the realisation of which depends on the willingness of the Hungarian side to cooperate) interconnection of ecosystems of the main bed and of the side branches can be obtained. These ecosystems bave been separated since a long time by the great difference of water levels and by cutting-off the side arms from the main river-bed.

However, the GNHES remained a torso without the Nagymaros part. Flod protection and improvement of navigation conditions downstream of Gabčíkovo remained unsolved. The non-existence of this functionally inseparable part of the system causes a yearly damage of at least 2 bill.Crowns (in purchase value about 200 mill.US$/year) only on the Slovak side.

3. CONCLUSIONS

Experiences gained on the Danube confirm that an optimal development of a floodplain can be reached preferably in a multipurpose project, which can cure also environmental problems accumulated in the past. However, it is necessary to trust to the civil (hydraulic) engineers, who are very far from being enemies of own environment.

The worst possible solution, also from the environmental point of view, is to realise a hydroelectric project up to its final stage of setting in operation, when all the unavoidable environmental effects (mainly occupation of terrirory) are materialised, and to stop it just before it can provide the expected benefits. Politicians certainly should take the decision about the realisation of large infrastructure investments, but should leave the optimal implementation to experts, not changing the decision according to the change of direction of political winds.

If both sides would agree to stop the investment just before its setting in operation, nobody would compensate the enormous losses and the partners never would be sure, whether the decision was right or wrong. If the abolishiong of the treaty would not be a matter of political principle, much more efficient would be - to set the project (or part of the project) in operation and monitor the results of the 1:1 model. When joining the effort in optimising the operation and the environmental impacts, the resuls would be even better. The positive solution is the more recommendable, as no sudden, unexpected and unpreventable irreversible change was threatening. If really such tendency would appear, there still would be enough time for remedial actions or even for the possibility of emptying the reservoir - without great additional costs, or increased risk.

Realisation of mutual investments on shared rivers and keeping the signed treaties is the best test of maturity for joining the unifying Europe, where a well funktioning transcontinental water transport arthery fosters economical integration of East-European states and enables the environmentally optimal solution of transport of bulky goods across Europe.

MITIGATION IN ILLINOIS: ACQUISITION, ELEVATION AND RELOCATION FOLLOWING THE GREAT FLOOD OF 1993

Patrick J. Massey[1]

ABSTRACT

The acquisition, elevation and relocation of damaged/destroyed structures in the aftermath of the Great Flood of 1993 has proven to be an effective mitigation measure in numerous flood-prone communities throughout Illinois. Approximately 1,600 structures and 100 vacant lots are being purchased by the State of Illinois under the auspices of the Hazard Mitigation Grant Program, commonly referred to as the flood buyout. The purpose of the flood buyout is three-fold: (1) to assist flood victims find new housing out of the floodplain; (2) to alleviate future flood losses thereby aiding the American taxpayer; and, (3) to enhance the riparian environment. Forty communities along the Mississippi and Illinois rivers are participating in the buyout at a cost of approximately $52 million. In addition, some 116 structures are being elevated in 20 Illinois communities. The mitigation mission also includes the relocation of one entire community, and the partial relocation of five others.

The study conclusions will address the overall purpose of flood acquisition, elevation and relocation projects in the State of Illinois. The primary discussion will focus on the acquisition (buyout) process: funding, project approval, environmental assessments, flood insurance, farm easements, appraisals, offers/closings, demolition, and numerous other hurdles that were addressed by the Illinois Emergency Management Agency (IEMA) and the Federal Emergency Management Agency (FEMA) throughout the buyout process in Illinois.

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OVERVIEW OF FLOOD MITIGATION EFFORTS IN ILLINOIS

The Great Flood of 1993 was so devastating that thousands of Illinois homeowners were finally willing to discuss alternatives to living in the floodplain. Following directives from the President, the FEMA Director and the Governor of Illinois, a federal-state team was established in December of 1993 to carry out the flood mitigation mission in Illinois.

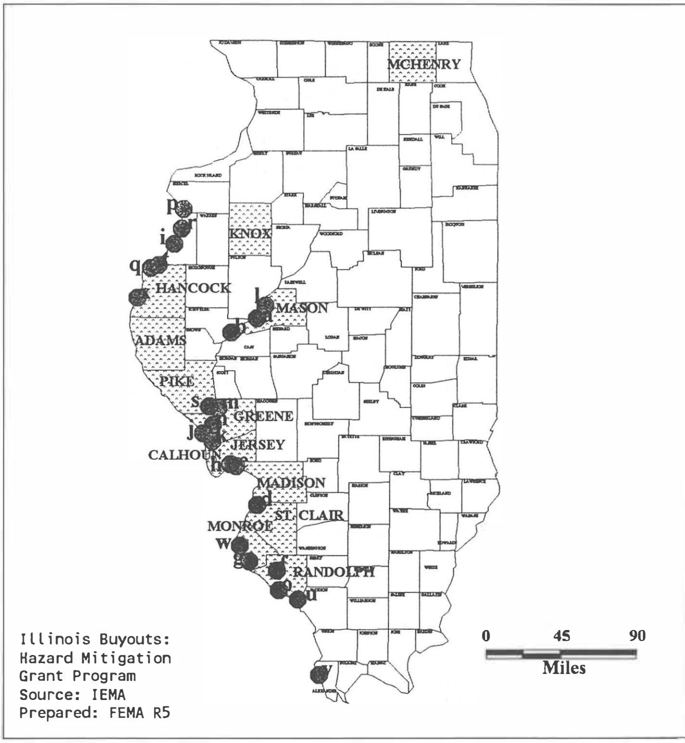
Acquisitions

Approximately 1,600 structures and 100 vacant lots are being acquired across forty jurisdictions in Illinois as a result of the Great Flood of 1993 under the auspices of the Hazard Mitigation Grant Program (HMGP), or more simply "the buyout" (see Fig. 1). Ownership of property acquired in the buyout is transferred to the local jurisdiction which agrees to maintain the land as "open space" (e.g., park, wetland or agriculture) in perpetuity. A total of nearly $52 million in taxpayer's dollars are being used to fund the buyout in Illinois. An additional $15 million has been earmarked to demolish the acquired structures.

There are two primary funding agencies involved in the buyout: (1) the Illinois Emergency Management Agency (IEMA, the lead agency) which receives its funds from the Federal Emergency Management Agency (FEMA) under Section 404 of the Stafford Act; and, (2) the Illinois Department of Commerce and Community Affairs (DCCA) which receives its funds from the U.S. Department of Housing and Urban Development under the Community Development Block Grant Program.

Elevations

The Illinois Department of Commerce and Community Affairs (DCCA) is also funding elevation projects in Illinois. A total of 193 structures have been approved for elevation at a cost of $3.6 million. Currently, 116 structures will actually be elevated. FEMA is providing technical assistance for elevations.



Number of Acquired Properties

ID	Community	Approved	Anticipated
a	Bath	25	25
b	Browning	3	3
d	East St. Louis	32	82
e	Elsah	3	2
f	Evansville	17	15
g	Fults	27	25
h	Grafton	136	162
i	Gulfport	1	1
j	Hamburg	7	7
k	Hardin	43	43
l	Havana	20	56
m	Hillview	25	15
n	Kampsville	20	13
o	Kaskaskia Vil.	11	11
p	Keithsburg	92	116
q	Niota	92	65
r	Oquawka	57	45
s	Pearl	5	5
t	Pontoosuc	31	37
u	Rockwood	8	11
v	Thebes	1	0
w	Valmeyer	265	242
x	Warsaw	11	4

County	Approved	Anticipated
ADAMS	48	60
CALHOUN	140	120
GREENE	81	90
HANCOCK - Niota	92	65
HANCOCK- R.Run	16	16
JERSEY	69	100
KNOX	14	14
MADISON	41	36
MCHENRY	3	2
MONROE	192	170
PIKE	70	60
RANDOLPH	16	33
ST. CLAIR	2	2
MASON	37	37
Total Properties:	1661	1725

As of 3/27/95

Fig. 1 Flood Buyout Jurisdictions in Illinois

Relocations

There are five Illinois communities which are building relocation sites (subdivisions) as a result of the Great Flood: Keithsburg, Hardin, Grafton, Appleton, and Prairie Du Rocher. These subdivisions range in size from 15 to 120 lots. Funding for these relocation sites is being provided primarily by the U.S. Economic Development Administration (EDA), DCCA, and FEMA Public Assistance.

The Village of Valmeyer, Illinois is a unique relocation community in that the entire town is moving to a new site atop a bluff overlooking the old town. Valmeyer is the largest acquisition project with 250+ properties with an additional 92 properties purchased under the National Flood Insurance Program's 1362 program. The new Valmeyer will include 350 residential and 25 commercial lots, and will indeed be "new" with brand new streets, water distribution system, sanitary sewer collection system, sewer treatment plant, stormwater collection system, community center, public safety building, and school.

BUYOUT GOALS

There are three primary goals of the flood buyout in Illinois: (1) to assist flood victims find new housing out of the floodplain; (2) to alleviate future flood losses thereby aiding the American taxpayer; and, (3) to enhance the riparian environment.

PAST MITIGATION IN ILLINOIS

Between 1981 and 1993, about 300 structures have been removed from the floodplain either through Section 1362 of the National Flood Insurance Program (NFIP) or by the Illinois Department of Transportation, Division of Water Resources (IDOT-DWR). Many of these earlier buyouts were in communities along the Mississippi and Illinois rivers which suffered severe damage in the Great Flood of 1993.

INTERAGENCY MITIGATION ADVISORY GROUP (IMAG)

The Illinois IMAG is comprised of representatives of 22 State and Federal agencies. The purpose of the IMAG is to provide technical expertise from a multi-disciplinary perspective. There are two primary subcommittees of the IMAG: (1) the Acquisition/Relocation Subcommittee which reviews and approves buyout applications and discusses major policy issues; and, (2) the Infrastructure Subcommittee which reviews and recommends funding of infrastructure projects (e.g. water/wastewater facilities, pump stations, roads, and relocation sites).

REGIONAL PLANNING COUNCILS

Many of the buyout jurisdictions in Illinois are using the services of Regional Planning Councils (RPCs) to administer their respective grant programs. Aside from grantsmanship expertise and planning skills, RPC's serve as a liaison between project applicants (villages and counties) and the state/federal staff at the Disaster Recovery Office (DRO).

THE ACQUISITION PROCESS

Individuals participating in the buyout program are offered pre-flood fair market value for their structures. All structures are appraised based on their market value as of March or April 1993. There are several steps that must occur before an individual or family can receive money for their flood damaged or destroyed home:

Project Applications

To be considered for funding, a community/county must submit a buyout application to the Disaster Recovery Office (DRO) to be reviewed by the A/R Subcommittee. In order for a project (jurisdiction) to be approved for funding, all structures must be in a Flood Zone A (100-year floodplain). These structures did not have to be damaged or destroyed by the Great Flood of 1993, although the vast majority were. In addition, top consideration for funding went to projects in which the structures or lots to be acquired were contiguous (e.g. an entire block or blocks are to be purchased). Unfortunately, due to the voluntary nature of the buyout, not all projects contained contiguous acquisition areas.

Buyout applications for all forty participating jurisdictions were submitted prior to March 1994. Due to the necessity to "get buyouts moving" acquisition projects were approved based on pre-applications, not full applications. This was one of the many trade-offs between the quality of data and the timeliness of the program.

Buyout Grant Agreements

Once a project is approved, buyout grant agreements (contracts) are sent to the jurisdiction. Thirty-four of the 40 buyout jurisdictions are being funded jointly by FEMA/IEMA (75%) and DCCA (25%). The remaining 7 projects are being funded solely by DCCA.

Appraisals and the Review Appraisal Process

All buyout communities must have each potentially acquired structure appraised by a licensed appraiser. Each appraisal must meet specific standards, and be sent to the DRO in Springfield to be certified by one of three review appraisers hired under contract by IEMA. The purpose of the review appraisal process is to ensure that the submitted appraisals meet minimum requirements, and that the indicated pre-flood fair market value can be properly substantiated.

Buyout Offers

Once an appraisal is reviewed and certified, the jurisdiction or RPC sends a buyout offer letter to the individual property owner. The buyout offer letter lists the certified appraised value of the property and subtracts out any deductions, leaving the final offer price.

Some of the duplication of federal benefits that are deducted from the certified appraised value include Flood Insurance structural claims, and Individual and Family Grant structural payments. Small Business Administration loans, taxes, and any liens are then paid from the seller's proceeds.

In the offer letter, the seller agrees to abide by the rules of the buyout program. Some of the seller's obligations under the terms of the Hazard Mitigation Grant Program (HMGP) which are highlighted in the text of the offer letter include: (1) sellers agree and understand that any replacement housing may not be in any Flood Zone A (100 year flood zone) as identified in the Flood Insurance Rate Maps of any applicable jurisdiction; (2) no materials can be salvaged from the structure at any time; (3) the buyout is voluntary; and, (4) sellers have no more than 90 days after closing to vacate the property.

Closings

Once an individual property owner signs and returns the offer letter to the jurisdiction or RPC, the final closing meeting can then be arranged. At the closing, the property owner receives a check for the amount listed in the offer letter. At that point the title of the property is officially transferred to the village or county. A deed restriction is then placed on that parcel stating that the land must remain in open space in perpetuity.

Contested Appraisals

If a property owner feels that the certified appraised value of the structure is too low, then that individual can hire another appraiser to appraise the property again. This second appraisal, however, must be paid for by the property owner (the first one is paid by FEMA/IEMA), and must also be reviewed and certified. To date about 8% of all originally certified appraisals have been contested.

Demolition

Once all properties have been acquired in a project jurisdiction, the demolition process can begin. Similar to the hiring of an appraiser, a jurisdiction must put forward a request for demolition bids, review the bids and then hire a demolition contractor. FEMA is paying 90% of the cost of demolition, and DCCA is picking up the remaining 10%.

FLEXIBLE PROJECTS

Throughout the buyout process, the FEMA/IEMA team at the DRO in Springfield has endeavored to make the entire buyout process as flexible as possible. Jurisdictions are allowed to add and delete buyout participants at will. Up until the March 1, 1995, deadline, all requests for additional funds for existing buyout grants have been approved. Aside from the acquisition of flood damaged structures, numerous other mitigation options were made available including elevations, farm easements, flood proofing, and relocation.

ENVIRONMENTAL REVIEW

Under the guidelines of the National Environmental Policy Act (NEPA) all jurisdictions participating in the HMGP (flood buyout) had to undergo an environmental review. The six communities that are building subdivisions and are relocating needed a full Environmental Assessment (EA). Depending on the outcome of the EA, either a Finding of No Significant Impact (FONSI) or an Environmental Impact Statement (EIS) is prepared. Fortunately, all the relocation sites in Illinois have received a FONSI on each of the EAs. If this had not been the case, an EIS could have extended the buyout process by two years or more.

All other buyout jurisdictions not relocating needed a Categorical Exclusion (CE) to the environmental review process. In order to get a CE approved, four State agencies needed to okay each project: Agriculture, Conservation, Historic Preservation and Environmental Protection. Historic Preservation required a photo of each structure to be acquired in order to assess its historical significance. Any structure found to be historically significant could not be acquired with buyout funds.

Credit should be given to FEMA for expediting the environmental review process. The majority of Categorical Exclusions (CEs) were completed in less than 90 days. Most Environmental Assessments (EAs) were completed in under six months.

ELEVATION WORKSHOPS

Two elevation workshop series were held in April and August of 1994 in twenty Illinois communities. The Workshops visited communities with either a current elevation grant or an elevation application. The workshops visited 10 communities each and lasted 12 days. The purpose was twofold: (1) to disseminate technical information on elevation techniques, options and requirements; and, (2) to provide homeowners receiving elevation grants with cost estimates for elevating their particular home. The workshops consisted of an introductory evening meeting with various agencies represented. The meeting concluded with making appointments for the free one-hour counseling sessions to be held the following day. The counseling sessions provided the cost estimate while the evening meetings provided an introduction to the technical information.

AGRICULTURAL EASEMENTS

Farm residences posed a special dilemma in the buyout program. If a county purchased a farm home with FEMA/IEMA or DCCA funds, there was nothing preventing the farmer from building a new, albeit elevated, home back in the floodplain just a few feet from their old structure. The county did not want to acquire the structure, because once demolished the county would have to maintain dozens of these scattered parcels. Many farmers did not want the buyout, because they would have to relocate out of the floodplain several miles or more away from their fields and equipment.

In an attempt to please both the farmer and the county, FEMA/IEMA developed the policy of purchasing the development rights on that portion of the farm property in the floodplain. This farm easement is based on 5.75% of the value of an acre of farmland in the immediate area (township or county) multiplied by the number of acres in the floodplain. Because of the easement, farmers have an extra incentive to take the buyout, future development in the floodplain is forbidden, and the county does not need to maintain any acquired farm parcels.

NATIONAL FLOOD INSURANCE PROGRAM NON-COMPLIANCE

Several buyout jurisdictions were not in compliance with their own floodplain ordinances following the Great Flood of 1993. Some counties/villages failed to do damage assessments, others allowed new structures to be placed in the floodplain at grade. FEMA and the Illinois Division of Water Resources (DWR) conducted several Community Assessment Visits (CAVs) in each buyout jurisdiction in the 12 months following the Great Flood of 1993. The purpose of these CAVs was to determine if a community/county was complying with the provisions of the National Flood Insurance Program (NFIP) as stated in the local ordinance.

In August of 1994, acquisition funds were withheld from seven Illinois buyout jurisdictions for failure to comply with the provisions of the NFIP. The view of FEMA/IEMA was that taxpayer's money should not be given to a jurisdiction to get people out of the floodplain, while at the same time that jurisdiction was allowing new structures to be placed in the same floodplain at grade. Within 60 days or so, five of the seven jurisdictions had come back into compliance with the NFIP, and buyout funds were subsequently released. Work is still in progress in the other two non-compliant jurisdictions.

MODEL MITIGATION PLAN

Several weeks ago, DRO staff began visiting communities to discuss mitigation planning. FEMA/DWR developed a complete and concise Model Mitigation Plan. The purpose of the plan is to assess the ongoing mitigation activities in the community, to evaluate additional mitigation measures that should be undertaken, and to outline a strategy for implementation of mitigation projects.

In the short term, a community or county may use the mitigation plan as a tool to apply for additional buyout funds. The Illinois DWR is holding back $4.1 million in buyout funds for the purpose of acquiring additional properties; in particular properties that would make an area more contiguous in nature, since many communities have a checkerboard pattern of buyouts. In the long term, mitigation funds from FEMA may only be made available if a community/county has a mitigation plan.

SPENDING AUTHORITY

FEMA has provided $34 million to the State of Illinois to carry out the buyout program. In June of 1994, the Illinois Legislature granted $27 million in spending authority to IEMA for the buyout. IEMA has since exhausted all of this $27 million, and is therefore short some $7 million in buyout funds. Two supplemental state budgets which would have granted IEMA the additional spending authority to continue the buyout program have both been defeated. As of February 17, 1995, IEMA is unable to forward additional buyout funds to jurisdictions, and is also unable to certify any appraisals until the supplemental budget is passed. However, DCCA funding remains safe, for now anyway.

POLICY MEMORANDUMS

Below is a list of policy memorandums that have been generated by IEMA/FEMA in the Disaster Recovery Office (DRO) over the last 12 months. The purpose of listing these memos is to show the complexity of carrying out a major flood recovery effort.

Flood Recovery Policy Memorandums

1. Acquisition project appraisal costs
2. Submission of acquisition/relocation projects
3. Acquisition of public buildings and vacant lots
4. Salvage of flooded building material (with letter from the Illinois Department of Public Health)
5. "Standard" buyout offer contract
6. Questions concerning buyout funds
7. Policy regarding acquisition of businesses, vacant lots and churches using 404 funds
8. Policy regarding elevation
9. Amendment to Grant Agreement
10. Cover letter to Grant Agreement Amendment
11. Underground storage tanks policy
12. Requesting and receiving funds from IEMA and/or DCCA
13. Demolition of acquired structures
14. Cover letter for proceeding memos and newspaper article
15. Demolition procedures, documentation and contractor requirements
16. Compensation formula for purchasing developmental rights for agricultural properties
17. Correction to memo regarding agricultural properties
18. Revision to memo regarding demolition procedures
19. Samples of demolition forms
20. Closing Information Form
21. Farm Easement and Disaster Assistance
22. Required paperwork to receive demolition funds
23. Buyout updates and reminders
24. Final deadline for acquisition and elevation projects
25. Individual buyout participant file checklist
26. Supplemental Elevation Policy
27. Second (contested) appraisals
28. Suspension of future flood buyout funds and appraisal certifications
29. Liability concerns and demolition requirements

The preceding list does not include the numerous memorandums and letters that are produced everyday in the DRO and sent to individual flood victims, Regional Planning Commissions, other state/federal agencies, and buyout/elevation jurisdictions.

CONCLUSION

Hopefully by this time next year, all of the structures acquired in the buyout will be demolished, and recreational and natural open spaces will have taken the place of the blighted flood ravaged buildings that now comprise large portions of the floodplains of the Mississippi and Illinois rivers. The Great Flood of 1993 has demonstrated that structural flood control measures should not be solely relied upon to prevent flood losses. The floodplain belongs to the river. Extensive flood mitigation efforts are the only way to lessen future economic losses caused by floods, while at the same time enhancing the riparian environment. It is time to start keeping people away from the water, instead of keeping the water away from the people.

FSA AND FACTA
EFFECTS ON FLOODING

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ABSTRACT

Flooding was unusually severe throughout the upper Midwest during the spring and summer of 1993. These floods resulted in locally great economic damages, but provided an ideal "field laboratory" for evaluation of national erosion control programs.

This paper documents the amount of runoff reduction and corresponding flood damage reduction resulting from the Food Security Act (FSA) and the Food, Agriculture, Conservation, and Trade Act (FACTA) to agricultural areas and rural infrastructure. Specifically, the impact on runoff and flooding of single storms with one-, five-, twenty-five-, and one hundred-year frequency probabilities was calculated using existing, commonly accepted methods of determining rainfall runoff. This procedure was applied to nine midwestern states (Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin) on a county basis. Conservation practices studied were those applied through FSA and FACTA. Results indicate the FSA and FACTA total programs were consistently more successful in reducing runoff than was the Conservation Reserve Program (CRP) alone. Runoff reductions range from a high of 39% for the one-year storm, to a low of 19% for the 100-year storm for the FSA and FACTA programs. Runoff reductions for the CRP range from 20% for the one-year storm to 10% for the 100-storm. Additionally, FSA and FACTA programs were shown to be highly successful in reducing flood damage to agricultural areas and rural infrastructure. Damage reduction to agricultural areas ranges from 6% to 17% for the FSA and FACTA programs. For CRP, this reduction ranges from 3% to 8%. Rural infrastructure damages are estimated to be reduced from 9% to 23% with the total program, and 4% to 11% by CRP alone.

These conservation programs are effectively reducing runoff and flood damages.

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INTRODUCTION

Flooding was severe throughout the upper Midwest during the spring and summer of 1993. These floods caused great economic damage to rural and urban properties. Large acreages of crops were destroyed, rural and urban infrastructure damage was very great, residences and businesses flooded, and peoples lives severely disrupted. For the first time Des Moines' water works were flooded so that service was suspended for about two weeks with drinking water not available for three weeks. A part of our national government's response to this disaster was initiation of the Scientific Assessment and Strategy Team (SAST) to review effectiveness of structural and non-structural flood control measures. A portion of this study was done by the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), with one aspect being to examine runoff reduction effects stemming from current farm programs.

The 1985 Food Security Act (FSA) and its successor, the 1990 Food, Agriculture, Conservation, and Trade Act (FACTA), which contains sections extended from the FSA, were enacted primarily to reduce soil erosion at an accelerated rate compared with then current progress, and to reduce production of certain crops. An additional benefit was landowner income stability. The Acts were developed with strong input from a coalition of environmental groups which recognized need for more rapid and comprehensive application of resource conservation measures. As a consequence, these Acts have had impact throughout the nation.

The purpose of this investigation was to develop answers to two questions relating to flooding in the nine-state upper Midwest study region. Those two questions are:

1. "What effect does the total FSA-FACTA program have on flooding"?

2. "What effect does only the Conservation Reserve Program (CRP) section of FSA-FACTA have on flooding"?

This paper documents estimated runoff, peak flow, and damage reduction resulting from FSA-FACTA in nine Upper Midwest states.

BASIC INFORMATION AND METHODS

Nine states included in the study were: Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin. These states were selected because they represent a region with extensive flooding in 1993, and have significant participation in FSA-FACTA programs.

The Iowa SCS Water Resources Planning Staff was chosen to perform this investigation. Personnel from Michigan SCS, Indiana SCS, and Iowa Division of Soil Conservation were detailed to assist with this activity at the Des Moines SCS state office. Personnel involved have extensive knowledge of FSA-FACTA, flood hydrology, and agricultural land treatment practices in the study region. Basic data were secured from SCS state offices in each of the nine states.

Land use and treatment affect the rate of water infiltration. Runoff curve numbers (CN) [1] are used to quantify rainfall runoff expected under various conditions of soil type, land use, and land treatment. Increased infiltration (resulting in reduced runoff) is represented by a lower CN [2]. Generally, land treatment practices which reduce erosion also provide increased infiltration [3].

Practices installed for erosion control through FSA-FACTA activities are at the same time reducing runoff. Since runoff reduction, due to application of soil conservation practices can be measured, estimates can be made of flood reduction effects.

Soil surface cover is the variable most easily quantified and is an important factor in the amount of runoff. Land use and treatment affect soil tilth, a physical property of soils. Tilth is improved through use of residue management and by growing crops which form deep, or dense, root systems. Improved tilth and added organic material in the soil increases hydrologic condition, causing the CN to decrease.

Land treatment soil conservation practices generally included in FSA-FACTA compliance plans were listed. Practices which significantly increase rainfall infiltration were selected for analysis.

Areas of installed and planned FSA-FACTA land treatment practices were tabulated on a county basis. County area, cropland area, predominant hydrologic soil group, highly erodible land (HEL) area, and CRP area for each county were obtained. A computer spreadsheet for each state was used for tabulation and computation.

Reductions of CN were used to measure effects on storm runoff stemming from FSA-FACTA programs. A combination of hydrologic soil group (HSG), with land use and treatment (cover), determines a soil-cover complex. Curve numbers are assigned to complexes and indicate runoff potential of a complex during periods when soil is not frozen. Smaller CN's are indicative of less runoff than larger CN's.

Soil mapping units are each assigned an HSG designation which depends on the rate water moves in the soil as controlled by soil characteristics. Ratings were determined after prolonged, thorough wetting of bare soil. Four HSG's, as defined by SCS soil scientists are named A, B, C, and D. The "A" soils have a high rate of water transmission and the least runoff, while "D" soils have a very slow rate of water transmission and the most runoff. Land use and treatment changes do not affect HSG designation.

In this study area, the great preponderance of soils are in HSG's B and C. For most practices, curve number change was essentially the same for B soils and C soils. One exception to this generalization was the CRP practice wherein there was necessity to use a specific HSG by county to account for a large spread in CN reduction across the four HSG's. The CN reductions shown below were used throughout the nine states.

Practice	CN Reduction
Conservation Tillage	3
Terrace	6
Conservation Cropping System	4 1/
Field Border	4
Water and Sediment Control Basin	6
Conversion to Permanent Vegetation	7
Strip Cropping	4 1/
Conservation Reserve Program (CRP)	6 to 30 2/
Pasture and Hayland Management	8
Forest Land Management	5
Contour Farming	2

1/ CN reduction applied only to annual increase in close growing vegetative covered area.
2/ CN reduction varied by HSG; greatest for "A", least for "D".

South central Iowa was the location for which 24-hour rainfall amounts were selected [4]. Although rainfall depth-frequency varies across the nine states, use of site specific rainfall data does not affect findings presented as percent change. Percent reduction in runoff due to CN reduction was shown to be essentially independent of baseline runoff depth.

This was the step-by-step procedure:

1. The dominant hydrologic soil group (HSG) for each county was obtained from the State Soil Geographic Data Base (STATSGO) [5].

2. Curve number reduction that would occur with installation of each practice was determined.

3. The effect of applying the area of each practice was proportioned to the total county area to determine a weighted runoff curve number change attributable to each practice by county.

4. All weighted effects were summed to show the total curve number reduction achieved by applying all practices installed or planned for each county.

5. Percent change in runoff per curve number reduction was determined for each of four storm events. These four storm events are 1-year, 5-year, 25-year and 100-year events. The percent change in runoff per CN reduction was then multiplied by the appropriate CN reduction to obtain percentage reduction of runoff provided by CRP, and the total for FSA-FACTA, including CRP.

RESULTS AND DISCUSSION

There is a small, but significant reduction in flood runoff due to a fully implemented FSA-FACTA in each of the nine studied states. As expected, greatest reductions were for the 1-year and least for the 100-year floods. Largest reductions were in Iowa where the statewide 1-year runoff was reduced 12.6 percent and the 100-year runoff was reduced 6.1 percent when the total FSA-FACTA planned amounts are installed. South Dakota and Minnesota showed the least statewide average reduction in runoff with FSA-FACTA installed. In these two states, decreases for the above two floods were 4.4 percent and 2.2 percent.

Regarding CRP alone, North Dakota led with 5.7 percent runoff reduction at the 1-year flood and 2.8 percent runoff reduction at the 100-year flood. Smallest reductions were in Illinois and Wisconsin with about 1.9 percent and 0.9 percent for the small and large floods respectively.

See summary runoff reduction data for FSA-FACTA, Table 1. For CRP alone, refer to Table 2. Upper line data in these tables show range in reduction among counties. The lower number is statewide average reduction. A bar graph in Figure 1 compares results among states.

Change in peak flood flow rate is linearly related with change in runoff volume. Therefore, runoff reductions shown are also valid indicators of estimated changes in peak flood flows. Not accounted for in this study is the phenomenon of water runoff velocity being slowed due to the practices. Slowing runoff lessens peak flows. Percentage reduction in peak flow from small

Table 1 - Summary of Runoff Reduction By FSA-FACTA 1/

State	1-year	5-year	25-year	100-year
		Storm Frequency		
	percent	percent	percent	percent
Illinois	0-14 2/ 7.0 3/	0-10 5.3	0-8 4.0	0-7 3.4
Iowa	3-34 12.6	2-26 9.5	2-20 7.3	1-17 6.1
Kansas	0-24 7.7	0-18 5.9	0-14 4.4	0-12 3.8
Minnesota	0-17 4.4	0-12 3.3	0-10 2.6	0-8 2.1
Missouri	0-30 7.0	0-23 5.4	0-17 4.1	0-15 3.5
Nebraska	0-39 10.7	0-30 7.8	0-23 6.0	0-19 5.1
North Dakota	2-16 8.2	2-12 6.3	1-9 4.7	1-8 4.1
South Dakota	0-16 4.4	0-12 3.3	0-9 2.5	0-8 2.2
Wisconsin	0-20 5.6	0-15 4.1	0-12 3.3	0-10 2.7

1/ Pertains to watersheds less than 400,000 acres drainage area

2/ The range of runoff reduction shows the lowest and highest percent runoff reduction by county for each storm frequency.

3/ The average runoff reduction is an average of all counties in each state for each storm frequency.

Table 2 - Summary of Runoff Rduction By CRP Only 1/

State	Storm Frequency 1-year	5-year	25-year	100-year
	percent	percent	percent	percent
Illinois	0-7 2/ 1.8 3/	0-5 1.3	0-4 1.0	0-3 0.9
Iowa	1-15 5.1	0-11 3.8	0-9 2.9	0-7 2.5
Kansas	0-20 4.3	0-15 3.3	0-12 2.5	0-10 2.1
Minnesota	0-15 3.1	0-11 2.4	0-9 1.8	0-7 1.5
Missouri	0-12 2.3	0-9 1.7	0-7 1.3	0-6 1.1
Nebraska	0-16 3.0	0-12 2.2	0-9 1.7	0-8 1.3
North Dakota	1-12 5.7	0-9 4.3	0-7 3.3	0-6 2.8
South Dakota	0-15 2.7	0-12 2.0	0-9 1.5	0-7 1.3
Wisconsin	0-9 1.9	0-7 1.5	0-5 1.1	0-4 0.9

1/ Pertains to watersheds less than 400,000 acres drainage area

2/ The range of runoff reduction shows the lowest and highest percent runoff reduction by county for each storm frequency.

3/ The average runoff reduction is an average of all counties in each state for each storm frequency.

watersheds is probably greater than values for reduction in runoff presented here. Water surface elevations at peak flood stage vary according to peak flow. Actual reductions of peak flood stage due to FSA-FACTA will vary depending on drainage area and channel-floodplain shapes and sizes.

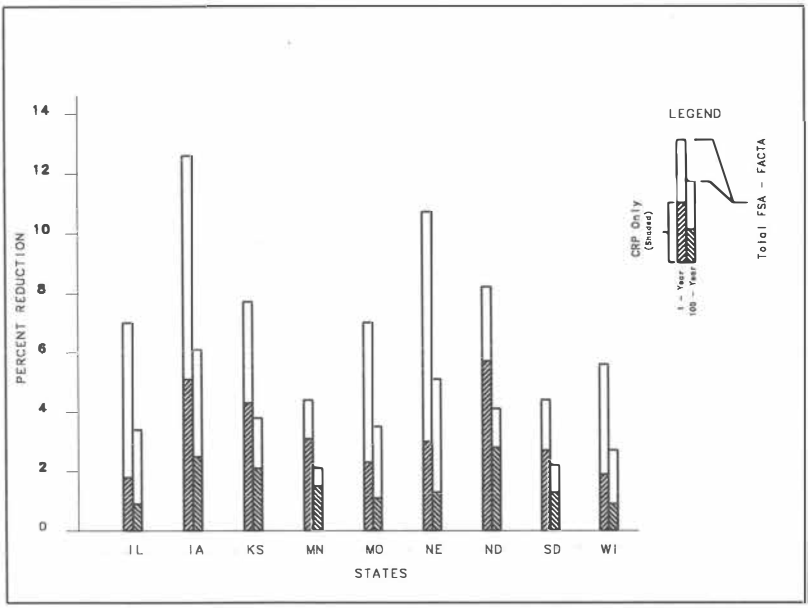

Fig. 1. Runoff and Peak Reduction (Watersheds Less than 400,000 acres)

Flood damage reduction follows as a result of less peak discharge. A relationship between CN reduction and reduced flood damage was derived based on detailed hydrologic and economic evaluations of a county size watershed previously studied in south central Iowa [6]. That relationship was applied to this study. Table 3 and Figure 2 show estimated flood damage reduction by state. Iowa has a statewide average flood damage reduction from FSA-FACTA of 17 percent to agricultural and 23 percent to non-agricultural properties. Comparable data in Iowa for CRP alone were seven percent and ten percent. Minnesota and South Dakota had the least damage reduction due to these programs.

Flood reduction effects presented relate to watersheds with drainage area about the size of a typical county in the study, up to approximately 400,000 acres. Effects are most pronounced at upstream locations where drainage leaves fields on which land treatment practices are applied. Changing land use from typical

Table 3 - Flood Damage Reduction Due to FSA-FACTA and CRP Only Average for State 1/

State	Agricultural FSA-FACTA	Agricultural CRP	Non-agricultural FSA-FACTA	Non-agricultural CRP
	percent	percent	percent	percent
Illinois	10	3	14	4
Iowa	17	7	23	10
Kansas	10	6	15	9
Minnesota	6	4	9	6
Missouri	10	3	14	5
Nebraska	14	4	19	6
North Dakota	11	8	16	11
South Dakota	6	3	9	5
Wisconsin	8	3	11	4

1/ Pertains to watersheds less than 400,000 acres drainage area

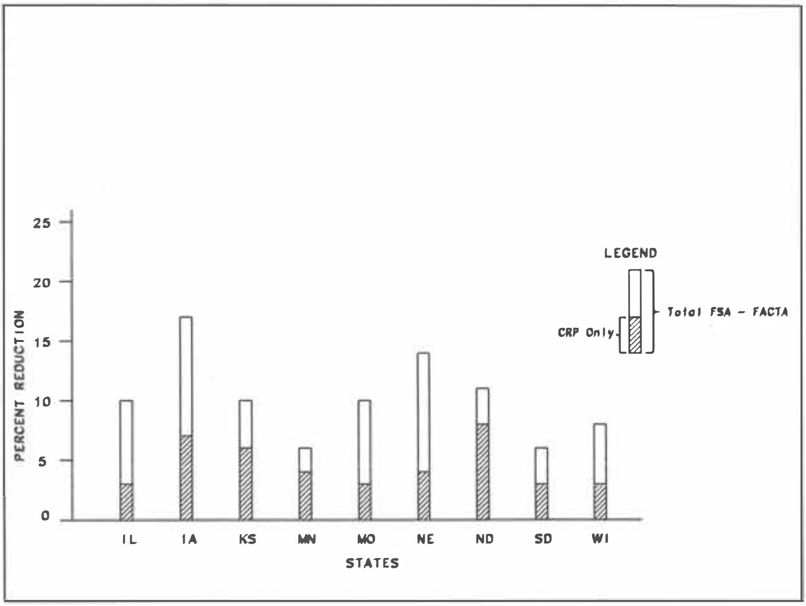

Fig. 2. Average Annual Agricultural Flood Damage Reduction - State Average (Watersheds less than 400,000 acres)

row crop farming to permanent vegetation (i.e. CRP) results in the largest CN reduction on site. Flood reduction effects become less than reported here as drainage area increases beyond county size. Thus, primary flood reduction benefits from conservation practices occur within small watersheds and become less measurable in flood plains of major rivers.

Summary data in this report are useful for estimating long-term averages. Changes to floods from specific rainstorm events will vary. This report is premised on soil moisture prior to rainfall being wet, but not saturated. When rains occur on drier soil, FSA-FACTA will have greater effect in reducing runoff. Saturated soil conditions before rainfall would result in less effect from FSA-FACTA than reported in this paper.

Factors accounting for variance in effects among states include:

* Degree of participation in FSA-FACTA.
* Amount of cropland as a percent of total land area.
* Relative popularity of certain land treatment practices.

* States with much cropland tend to use conservation tillage, an effective treatment for reducing CN.
* States with large areas of cropland, with a sizeable part of this in CRP, have greater runoff reduction.
* Areas where terraces are popular have less flood runoff.

CONCLUSIONS

National farm Acts, FSA-FACTA, impose restrictions on persons who participate in certain USDA programs and who plant agricultural commodities on highly erodible lands. Erosion provisions of the FSA-FACTA farm bills relate to surface water runoff. Practices that feature close-growing vegetation, increased surface residue, contouring, or temporary storage of runoff result in greater infiltration and consequently less flood runoff. Reduction of surface water runoff directly affects peak flows of streams resulting in less flood damage.

Beneficial effects are most pronounced in smaller watersheds, with the most benefits on site. Lesser effects accrue as drainage areas increase. Above 400,000 acres FSA-FACTA flood reduction effects are minimal.

Maintenance of practices is necessary to assure continuance of benefits. For practices that increase hydrologic condition of soil, such as conservation tillage, greater runoff reduction will occur with continued use.

REFERENCES

1. USDA-SCS National Engineering Handbook 4, Hydrology, 1972 as amended.

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3. USDA-SCS Technical Release No. 16, Rainfall-Runoff Tables, 1957 as amended.

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FLOOD CONTROL PLANNING ON THE AMERICAN RIVER, CALIFORNIA

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ABSTRACT

In February 1986, the storm of record occurred in the American River watershed and caused flows in the lower American River to exceed the system's flood-carrying capacity. The high flows on the American River and concurrent high flows on the Sacramento River nearly resulted in catastrophic flooding in the American River floodplain which is protected by high levees and incorporates the City of Sacramento and portions of unincorporated Sacramento and Sutter Counties. Within the floodplain, approximately 400,000 residents and over $37 billion in developed property and infrastructure are at risk. According to the U.S. Army Corps of Engineers, the Sacramento area is the most developed area at risk from major flooding in the United States.

Since 1986, the Corps, the State of California, and the Sacramento Area Flood Control Agency (SAFCA) have implemented levee reconstruction projects and studies with the goal of increasing the existing level of flood protection for the Sacramento area to a level commensurate with the level of development and the extreme risk to public safety in the area subject to flooding.

A project to reinforce 35 miles of levee on the Sacramento River was completed in 1992 and SAFCA is in the process of improving levees in the Natomas basin north of the State Capital. The Corps completed a reconnaissance study in 1988 and in cooperation with the State Reclamation Board and SAFCA, has nearly completed a second feasibility report. The original feasibility report completed in 1992 recommended construction of a 545,000-acre-foot flood control detention dam near the City of Auburn.

To reach consensus among diverse groups, innovative approaches to flood control planning were adopted for the formulation of the alternatives, including an operations plan for the proposed dry dam which minimizes impacts to the reservoir area, the reoperation of Folsom Reservoir, environmentally sensitive river bank protection plans, use of seepage cutoff walls to reinforce existing levees, restoration of habitat in the lower American River, and hydraulic mitigation features to offset an increase in the maximum design release on the lower American River. Risk Based Analysis was utilized to determine the performance of alternatives and a professional facilitation firm was hired to assist the flood control agencies reach consensus on non-Auburn Dam alternatives with a wide range of stakeholders.

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BACKGROUND AND HISTORY

The City of Sacramento is well known as being the state capital of California which boasts of having the eighth largest economy of the world. In addition to its fame as the center of California politics and nationally known governors, Sacramento is also known as the "River City" based on its proximity to the confluence of the American River and the Sacramento River which drains to the San Francisco Bay.

Since its founding as a trading post and fort by Captain John Sutter in 1839, flooding in Sacramento has been a problem with major floods occurring in 1850, 1862, 1878, 1902, and 1909. Flooding was so bad as to motivate city leaders to raise a portion of the downtown area above the natural grade converting first floors to basements and second floors to storefronts. Most older homes in the downtown area were built with the first floors elevated up to five feet above street level.

Major growth in Sacramento began with the discovery of gold in 1848 on the American River near Coloma. With the advent of the gold rush, Sacramento was converted from a supply station to a jump off point for gold miners seeking their fortune in the nearby Sierra foothills. When gold deposits in the river beds thinned out, hydraulic works were developed to blast away hillsides with high pressure jets of water which washed down the soil for processing on large sluices. The processed material was discharged into the river channel of the Sacramento River and its tributaries where it settled out, choking the river channels and drastically reducing the capacity of the system to pass floodflows.

Due to the need to protect new population centers and valuable farmland on the Sacramento River and its tributaries, local communities and farmers began to build levees to protect their homes and properties. With the federal Flood Control Act of 1917 and subsequent amendments, the Sacramento River Flood Control Project was authorized by Congress and built by the U.S. Army Corps of Engineers in cooperation with The Reclamation Board of the State of California. The project, which incorporated at least 400 miles of existing levees, was essentially completed in 1960 and has provided billions of dollars in flood damage reduction benefits since its construction.

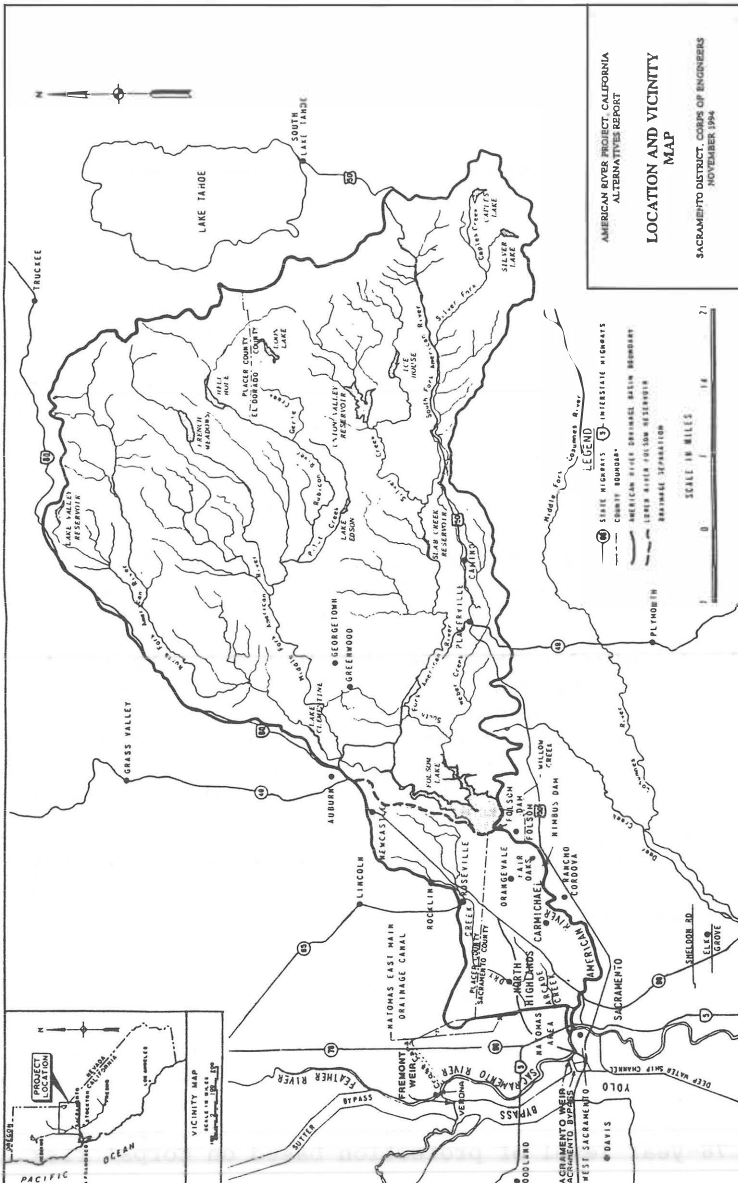
AMERICAN RIVER LEVEE SYSTEM

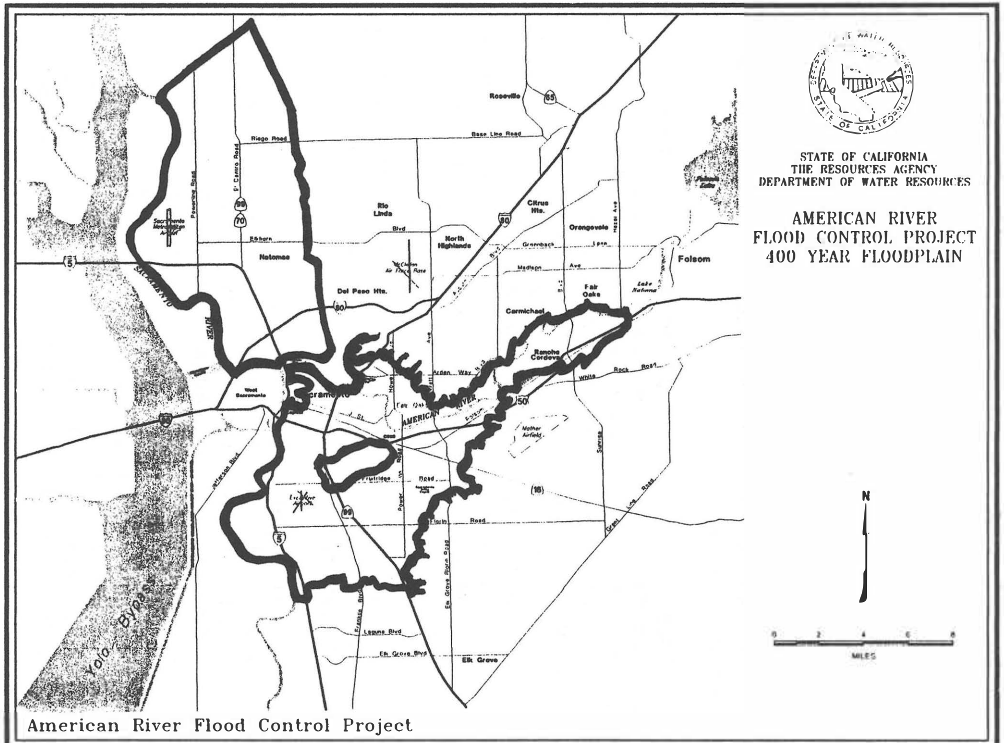
Approximately 26 miles of levee are located in the lower American River below Folsom Dam. The levees extend from the river's confluence with the Sacramento River to high ground approximately 11 miles upstream. Portions of the levees were originally constructed by local and private interests and have since been upgraded by the Corps of Engineers to federal standards. The lower American River Parkway contains the Jedediah Smith Recreation Trail along which over a million visitors a year hike, walk, and ride. The lower American River is recognized as a National Canoe Trail and recreation river in both the State and federal Wild and Scenic River Systems.

Since its completion in 1956, Folsom Dam and the downstream levees have protected Sacramento from potentially disastrous floods generated in the 2,100 square mile watershed which ranges in elevation from near 9,000 feet at its eastern edge near Lake Tahoe to approximately 15 feet in Sacramento. The flood control system has contributed to the area's prosperity and continued growth. With the State Capital at its center, the American River floodplain has a population of over 400,000 people and contains over $37 billion in developed property and infrastructure. Due to the near flood in February 1986 and the potentially disastrous consequences of a major flood, local, State, and federal planners have been striving to develop a flood control plan that will increase the area's level of protection to at least a 200-year level.

RISK OF FLOODING

The current 400,000 acre-feet of dedicated flood control space in Folsom Reservoir, an objective reservoir release of 115,000 cfs, and 26 miles of levees provides the Sacramento area with approximately a 78-year level of protection based on Corps' risk


AMERICAN RIVER PROJECT, CALIFORNIA
ALTERNATIVES REPORT
LOCATION AND VICINITY MAP
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
NOVEMBER 1994
LEGEND
STATE HIGHWAYS
INTERSTATE HIGHWAYS
COUNTY BOUNDARY
SCALE IN MILES
LAKE TAHOE
SOUTH LAKE TAHOE
TRUCKEE
GRASS VALLEY
AUBURN
LINCOLN
ROCKLIN
ROSEVILLE
NEWCASTLE
FOLSOM LAKE
FOLSOM DAM
FOLSOM
NIMBUS DAM
ORANGEVALE
FAIR OAKS
CARMICHAEL
RANCHO CORDOVA
NORTH HIGHLANDS
SACRAMENTO
WEST SACRAMENTO
DAVIS
WOODLAND
ELK GROVE
PLACERVILLE
PLYMOUTH
GEORGETOWN
GREENWOOD
CAMINO
AMERICAN RIVER
FEATHER RIVER
SACRAMENTO RIVER
FREMONT WEIR
SACRAMENTO WEIR
YOLO BYPASS
DEEP WATER SHIP CHANNEL
NATOMAS EAST MAIN DRAINAGE CANAL
LAKE VALLEY RESERVOIR
SILVER LAKE
VICINITY MAP
PROJECT LOCATION
PACIFIC OCEAN



American River Flood Control Project

based analysis. With the interim reoperation of Folsom Reservoir by SAFCA and the U.S. Bureau of Reclamation, the level of protection is increased about 20 years.

The reservoir reoperation agreement is valid for a five year period and can be renewed until a permanent flood control plan that may incorporate reoperation is authorized and implemented. The reoperation of Folsom Reservoir increases the flood control space in Folsom, but also gives flood control credit to empty space in upper watershed hydroelectric power supply reservoirs that normally begin the winter season nearly empty. While the reoperation of Folsom Reservoir provides about a 100-year level of protection, FEMA will not credit the added protection since the reoperation agreement is interim.

When Folsom Reservoir was planned by the Corps in the 1940s, its flood control space was sized to provide the downstream area from floods with magnitudes up to the 1937 storm which was the most severe storm of record for the region. When frequency analysis was applied to this storm (reservoir design flood), the frequency of recurrence was calculated at about 125 years. Subsequent large storms in or in nearby watersheds have steepened the peak discharge frequency curve and reduced the calculated level of protection to about 78 years. This level is well below the 200-year plus level or Standard Project Flood level appropriate for a community of its size and importance as California's center of government.

Flood control experts believe that the risk of major flooding and subsequent damages in the Sacramento area is comparable and potentially more devastating than the risk and damages of earthquakes in the San Francisco Bay area and Southern California. The following table shows the estimated damages from various frequency events and the cumulative risk of flooding over time with the current in place system. While damages shown in the table are large in magnitude, they do not include damages with "intangible" costs such as:

Table 1

AMERICAN RIVER BASIN EXISTING CONDITIONS - FLOOD DAMAGE POTENTIAL OCTOBER 1993 PRICE LEVELS		
PERCENT CHANCE OF BEING FLOODED IN ANY YEAR	FLOOD EVENT RETURN PERIOD IN YEARS	FLOOD DAMAGES IN $ BILLIONS
1.0	100	9
.5	200	12
.33	300	15
.25	400	16
.20	500	18

Table 2

RISK OF FLOODING OVER TIME		
FLOOD EVENT RETURN PERIOD IN YEARS	25-YEAR PERIOD	50-YEAR PERIOD
100	22%	39%
200	12%	22%
300	8%	15%
400	6%	12%
500	5%	10%

- loss of approximately 100 lives;
- toxic and hazardous waste contamination;
- disruption to traffic;
- disruption to commerce;
- disruption to State and local government; and
- temporary housing and essential services for displaced residents.

PLANNING ASSUMPTIONS

In the development of flood control alternatives to increase Sacramento's level of protection, the Corps has made the following planning assumptions:

- The interim reoperation of Folsom Reservoir will continue into the future if a larger flood control project is not authorized;

- Twenty-two miles of levee along the lower American River can safely sustain flows of up to 130,000 cfs for extended periods of time;

- River banks near the levees are protected from erosion by a project implemented under existing Sacramento River Bank Protection Project authority. Within the next five years, the estimated amount of bank protection needed to prevent undercutting of the levees is between 9,500 and 13,800 lineal feet;

- The levee improvement project in the Natomas Basin being constructed by SAFCA is complete and will provide the Natomas Basin with an approximate 100-year level of flood protection. SAFCA estimates that the Natomas project will be completed by 1997. Federal cost sharing for Natomas improvements will be available if a larger American River project is authorized by Congress and if the Natomas project does not induce development in "deep floodplains." What the intent of this language was in the authorizing legislation continues to be a point of debate among flood control and environmental groups.

LOWER AMERICAN RIVER BANK PROTECTION

Over the last five years, it has been nearly impossible for the State Reclamation Board and Corps of Engineers to construct needed bank protection works except under emergency conditions when their is imminent threat to the integrity of a levee. The stalemate has centered on impacts to endangered species, high cost of mitigation, and the need to preserve "Shaded Riverine Aquatic Habitat" which exists along the eroding river banks.

The unique condition associated with the eroding banks on the lower American River is that once the narrow existing riparian edge is eroded away, it is essentially gone. Revegetation of the riparian corridor is not occurring due to lack of sediment transport in river flows released from Folsom Dam and scouring of the river channel due to the lack of sediment. This has left some areas behind the riparian corridor at an elevation at which flows infrequently reach. Due to the lack of water for natural tree growth, many areas of the lower American River parkway are devoid of trees and infested with star thistle.

USE OF RISK BASED ANALYSIS

The updated feasibility report for the American River Project incorporates the use of Risk Based Analysis as described in the Corps' Engineering Circular 1105-2-205.

Risk Based Analysis is an innovative approach employed by the Corps to better quantify the uncertainty associated in the relationships of reservoir inflow-outflow, discharge-frequency, stage-discharge, and stage-damage. Through the use of Risk Based Analysis, standard levee freeboard to account for uncertainty is no longer used. Levees will be designed to essentially hold water to the top and full credit for flood protection will be assigned to the actual levee height.

LOWER AMERICAN RIVER TASK FORCE

After nationwide environmental and river preservationists opposed authorization of the flood control detention dam at Auburn, flood control planners for the Corps, State, and SAFCA decided that the planning process for the updated feasibility report needed to be expanded to directly include environmental interests and the local community. This effort was to only focus on the lower American River and was to parallel and enhance the study efforts led by the Corps.

After a joint meeting to determine the task force's goals and objectives, the LAR Task Force was formed to develop recommendations for lower American River flow elements, including bank protection, levee improvements, floodway management, hydraulic mitigation, infrastructure, environmental restoration, and recreational enhancement. The task force was funded by SAFCA and managed by the firm of CONCUR of Santa Cruz, California.

Thirty-two task force members representing twenty-eight agencies and groups have ratified the Phase One and Two proceedings of the task force. These proceedings form the consensus of a flood control plan centered on lower American River flow elements. The task force recommendations have been presented to the Corps and to the SAFCA Board and Reclamation Board for consideration in flood control plan recommendation. The SAFCA Board and The Reclamation Board have adopted the task force lower American River plan as the preferred downstream alternative. The Boards have also recommended consideration of an upstream detention dam alternative.

It is important to note that the task force developed its recommendations based on information provided by the Corps and local agencies and that the overall task was broken down into eight working groups headed by a technical expert in the particular field. Working groups met on a regular basis and developed recommendations that were reviewed by the larger plenary group.

Phase III of the task force is currently underway and is finalizing plans associated with bank protection, environmental restoration, and recreational enhancement.

FLOOD CONTROL MEASURES

To develop a new matrix of alternatives for evaluation as part of the supplemental study, a wide array of flood control measures were analyzed by the Corps, SAFCA, and Reclamation Board. Measures were screened to determine their technical feasibility, costs, benefits, and environmental and social impacts and acceptability.

Feasible measures were retained and combined to form alternatives. These alternatives were then screened for economic efficiency and environmental impacts. Eight alternatives, including two plans recommended for comprehensive analysis by the SAFCA Board and The Reclamation Board, will be included in the draft feasibility report.

The flood control measures that were evaluated for improvements to the flood control system were grouped into three general categories:

1. Increase the flood control outlet efficiency of Folsom Dam and Reservoir.

2. Increase flood releases from Folsom Reservoir.

3. Increase flood control storage in the American River basin.

Based on screening criteria, eight measures were retained for development into alternatives and are **highlighted in bold** in the list below.

Increase the Outlet Efficiency of Folsom Dam and Reservoir

- Normalized use of auxiliary spillway
- **Lower main spillway**
- Conjunctive use of river outlets and main spillway
- **Enlarge river outlets**
- **New river outlets**
- Use of existing diversion tunnel
- **New outlet tunnels**
- Early flood releases prior to storm based on wether prediction

Increase Flood releases from Folsom Reservoir

- **Levee modifications**
- Setback levees
- Flood control bypass south of Sacramento

Increase Flood Storage in the American River Basin

- **Flood detention dam at Auburn**
- Acquire flood space in existing upstream reservoirs
- Develop multiple small detention reservoirs
- Offstream storage on Deer Creek
- **Increase Folsom Reservoir Flood control storage space**
- Raise Folsom Dam and spillway

FLOOD CONTROL ALTERNATIVES

The attached table describes the eight alternatives that have been formulated from the measures which were carried forward. Three sizes of flood control dams at Auburn were analyzed. The largest detention dam with a storage of 894,000 acre feet corresponds to the plan which maximizes net National Economic Development benefits (annual benefits - annual costs).

The 130 kcfs, 145 kcfs, 180 kcfs, and Stepped Release Plan are plans that increase the objective release from Folsom Reservoir, modify the outlets at Folsom by lowering the spillway, and enlarging the river outlets, adding flood control space in Folsom Reservoir above the current 400,000 acre feet, and modifying the downstream levee system through levee raising, installation of a stability berm, or installation of a seepage cutoff wall along most of the 22 miles of downstream levees. Typical levee improvement cross sections are shown on the attached figures. The higher objective releases require hydraulic mitigation work in the area downstream of Sacramento in order to maintain their level of flood protection.

The Stepped Release Plan has a dual criteria for objective release in which the 180 kcfs release will only be made for extremely large flood events that will occur about once every 200 years. The Stepped Release Plan also normalizes the use of Folsom Reservoir surcharge storage with minor modifications to the dam

AMERICAN RIVER WATERSHED PROJECT
INITIAL ARRAY OF ALTERNATIVES

	Protection (years)	Deten. Dam Storage kAF	Folsom Flood Storage kAF	Folsom Outlet Modif.	Objective Release kcfs	AR Levees /Bridges	Sac Bypass Wide./D.S. Levees (miles)	Total First Costs (millions)	Annual Benefits / Annual Costs (millions)	B/C
Deten. Dam (1)	270	545	400	No	115	No/No	No/No	732	86/60	1.4
Deten. Dam (2)	200	380	400	No	115	No/No	No/No	661	65/54	1.2
Deten. Dam (3)[1]	455	894	400	No	115	No/No	No/No	843	105/68	1.5
180 kcfs Plan	244	----	425/670	Yes	180	Yes/3	2,700'/64	648	62/53	1.2
145 kcfs Plan	217	----	450/670	Yes	145	Yes/3	1,000'/47	563	54/46	1.2
130 kcfs Plan	185	----	475/670	Yes	130	Yes/1	600'/43	459	45/38	1.2
Stepped Release Plan[2]	225	----	400/670	Yes	145/180	Yes/2	1,000'/47	515	60/42	1.4
Folsom Only Plan	152	----	495/670	Yes	115	No/No	No	258	34/22	1.6

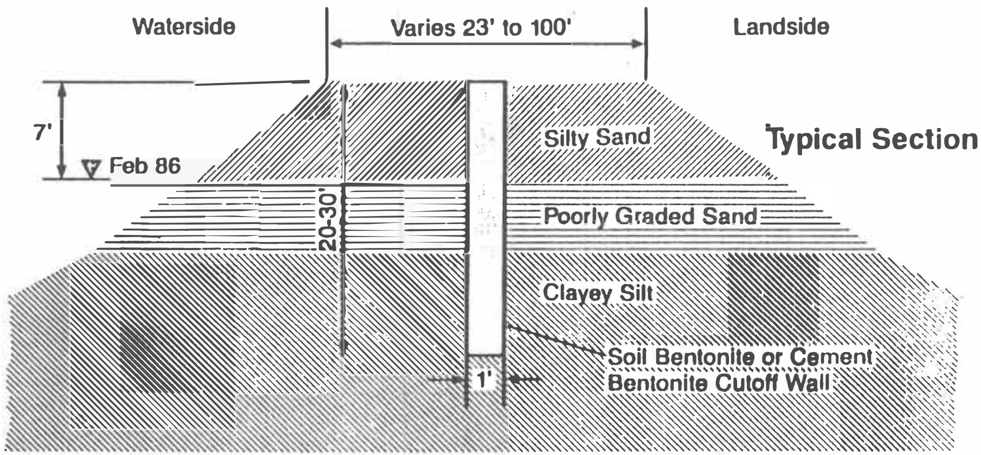
[1]NED Plan

[2]Preferred Downstream Alternative

Sacramento River Flood Control System Evaluation

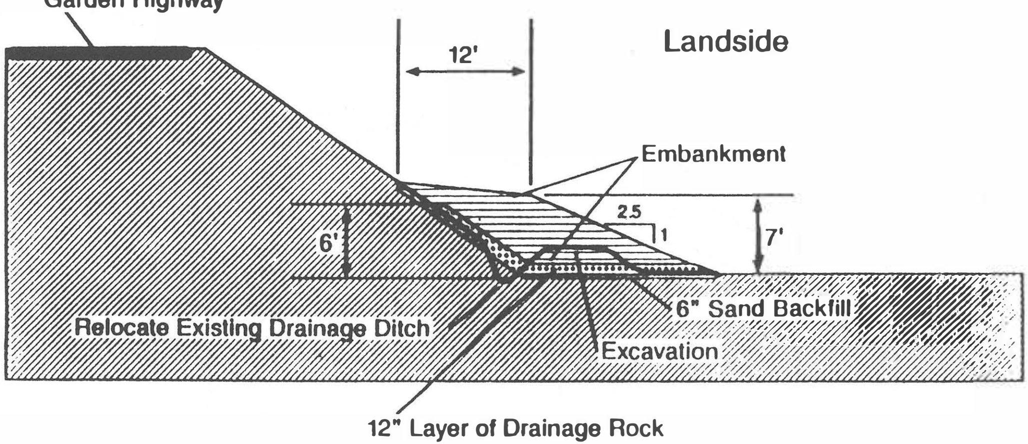
Sacramento Urban Area Levee Reconstruction

Levee Improvement - Seepage Cutoff Wall

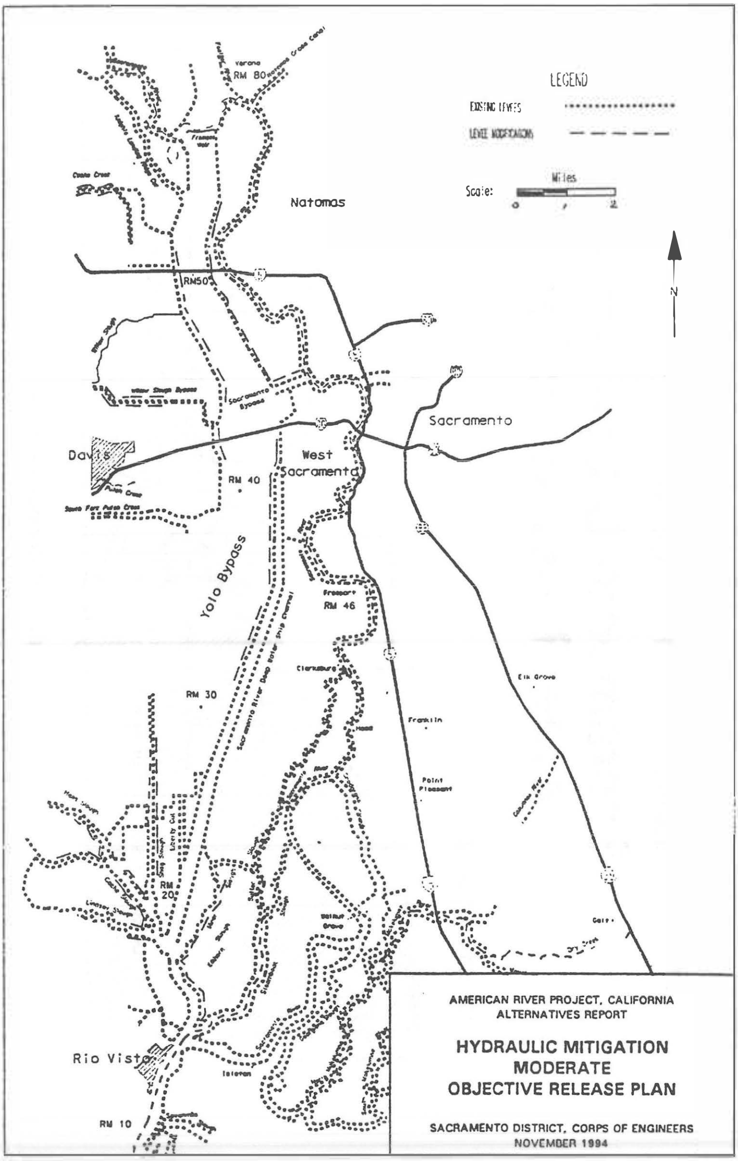


Sacramento River Flood Control System Evaluation

Sacramento Urban Area Levee Reconstruction



Levee Improvement - Landside Stability Berm


LEGEND
Scale:
Miles
N
Natomas
Sacramento
West Sacramento
Davis
Yolo Bypass
RM 80
RM50
RM 40
RM 46
RM 30
RM 20
RM 10
Rio Vista
Sacramento Bypass
Freeport
Clarksburg
Franklin
Point Pleasant
Elk Grove
Galt
Walnut Grove
Isleton
Verona
Sacramento River Deep Water Ship Channel
AMERICAN RIVER PROJECT, CALIFORNIA
ALTERNATIVES REPORT
HYDRAULIC MITIGATION
MODERATE
OBJECTIVE RELEASE PLAN
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
NOVEMBER 1994

and outlet gates. The Stepped Release Plan is essentially the plan that maximizes flood protection without an Auburn Dam and without severe reoperation of Folsom Reservoir.

The Folsom Only Plan is the least costly plan and has the highest benefit to cost ratio. SAFCA and The Reclamation Board do not support this plan because it does not meet the nonfederal goal of minimizing the residual risk of flooding and its public safety consequences by providing at least a 200-year level of protection.

PUBLIC INFORMATION PROCESS

The Corps, SAFCA, and The Reclamation Board have gone to great lengths to keep the public informed of the progress of the studies. In 1991 and 1992, over 17 workshops and hearings were held in the Sacramento and Auburn area and over 6,000 comments were received and responded to.

A newsletter was published after the second feasibility study was authorized and sent to the parties who had previously submitted comments on the proposed project. Executive Coordinating Committee and Lower American River Task Force meetings are open to a wide range of interested groups and an additional means of keeping the public informed. In May 1995, the second of two flood control forums was held. The first forum was sponsored by the Society of Military Engineers in December 1994 and the May forum by the Water Education Foundation.

Due to heavy rains and local flooding during January and March 1995, the local press has recognized the urgent need to develop community consensus on a flood control plan and many articles and editorials have appeared in the local paper (Sacramento Bee).

In September 1995, the local Public Broadcasting System television station will air a documentary that will highlight the areas at risk of flooding and the alternatives being considered. The goal of the documentary is to better inform the public on the risk to lives and property and the costs versus benefits of the proposed flood control solutions.

WHERE DO WE GO FROM HERE?

At their meetings in February 1995, the SAFCA Board and Reclamation Board unanimously approved resolutions that supported identification of two alternatives as locally preferred options. The NED flood control detention dam (preferred upstream plan) and the Stepped Release Plan (preferred downstream plan) both achieve the nonfederal planning objective of providing Sacramento with a minimum 200-year level of protection.

Some citizens believe that a multipurpose dam at Auburn should be constructed in order to provide flood control, clean energy, recreation, and future water supply. Other people feel that the north and middle fork canyons of the American River should be preserved for their intrinsic environmental, aesthetic, recreational, and historical value. The flood control dam, which could in the future be expanded to a multipurpose dam, is gaining the support of some multipurpose dam supporters who see it as an incremental step in implementing the full service dam.

The less costly Stepped Release Plan (which provides half the level of protection of the NED detention dam) has the broad support of environmental groups, taxpayer groups, and others who oppose a dam at Auburn. Opponents of the preferred downstream alternative (Stepped Release Plan) include multipurpose dam supporters concerned about losing flood control benefits that would help justify a multipurpose dam, residents of the Folsom area who oppose any reoperation for flood control that lowers the lake level, and some flood control districts in the downstream bypass system who are concerned about increased releases from Folsom Dam during rare flood events. Project planners have proposed hydraulic mitigation features (see attached figure) to offset the impacts of higher releases from Folsom.

After the draft report is released in July 1995, public workshops and hearings will be held and the SAFCA Board and Reclamation Board will recommend a single plan by September 1995 for description in the final feasibility report and EIS/EIR.

It is hoped that the final recommended plan will receive broad community support, including the support of local congressmen John Doolittle, Richard Pombo, Vic Fazio, and Robert Matsui and California Senators Diane Feinstein and Barbara Boxer.

Without strong community consensus and support of a single plan by congressional representatives, it is unclear whether a comprehensive plan will be authorized by Congress. Without a federal plan, Sacramento will either have to accept the public safety risk of the existing system or finance a local plan with little or no State or federal financial support. Current State statute only allows the State to cost share in new flood control projects authorized by the federal government and constructed by the Corps of Engineers.

THE FLOOD OF 1993

Loyd A. Waite[1]

ABSTRACT

The flood of 1993 was the most significant flood of the century in the upper midwest in Missouri. Record peak stages and discharges occurred on the Missouri and Mississippi Rivers and other rivers in northern Missouri. The magnitude and timing of several intense rainstorms in late June through August, combined with wet antecedent climatic conditions, were the principal causes of the flooding.

During the flood, personnel from the U.S. Geological Survey were involved in data-collection efforts at gaging stations on rivers and streams in northern Missouri. They measured depths, widths, and velocities of floodwaters; obtained water-quality and sediment samples; investigated levee breaks; serviced and repaired damaged streamgaging and stage-sensing equipment; and retrieved equipment out of inundated gaging station structures. Also, extensive bridge scour data were collected around the base of piers at several bridges on the Mississippi River. These data were collected in cooperation with the U.S. Army Corps of Engineers.

Peak stages (the maximum elevation of the river during a flood event) exceeded or were near historic records at many gaging stations. The Mississippi River at St. Louis reached the peak stage of 49.58 feet on August 1, 1993 (flood stage is 30 feet and the height of the flood wall at St. Louis is 52 feet), at the gaging station on the Eads Bridge. The peak discharge was 1,080,000 cubic feet per second or 8,080,000 gallons per second flowing under the bridge. The peak stage at the gaging station on the Missouri River at Hermann was 36.97 feet on July 31, 1993 (flood stage is 21 feet), and the peak discharge was 750,000 cubic feet per second or 5,610,000 gallons per second. The Grand River at Gallatin reached a peak stage of 41.5 feet and discharge of 89,800 cubic feet per second. Since 1921, the previous maximum peak stage and discharge at Gallatin was 35.0 feet and 69,100 cubic feet per second in June 1947.

Five gaging stations on the Missouri River and three gaging stations on the Mississippi River had flood volumes (mean flow for 30, 60, or 90 days) that exceeded the 100-year recurrence interval (average interval of time within which a given flood volume will be exceeded once).

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